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WITH THE ASSISTANCE OF

GENTLEMEN EMINENT IN SCIENCE AND LITERATURE.

IN EIGHTEEN VOLUMES.

VOLUME XI.

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Job.

structive ignorance of barbarians. Several are alluded to in the Sacred Scriptures; and we are clearly of opinion with Scheuchzer (*Natural History of the Book of Job**) and Dr Young, (*Notes on his Paraphrase on Job,*) that the sublime description of leviathan given in the 41st chapter of the book of Job, applies to no other animal with which we are acquainted, if not to the crocodile. His ample jaws and dreadful teeth, his compact impenetrable scales, his large and fiery eyes, his strength, ferocity, and courage, agree exactly with our best descriptions of the crocodile; and though some passages might lead us to conclude that the poet was describing an inhabitant of the ocean, this objection is trivial, when we reflect that the large rivers and lakes, which form the ordinary habitation of crocodiles, might, in the glowing and figurative languages of the East, without too much hyperbolical exaggeration, be designated by the terms *deep* and *ocean.*

Aristotle and Pliny.

Of the ancient classic naturalists who have written on reptiles, we need mention only Aristotle and Pliny. The former, in his *Historia Animalium,* has described the crocodile, the salamander, and some other species; but the latter, in his *Historia Naturalis,* has furnished the fullest account of reptiles, especially in his second, eighth, ninth, tenth, and twenty-eighth books, in which he relates all that was then known, and all that was believed respecting the crocodile, the sea and land tortoises, the chameleon, and the basilisk. In the second book, he shews himself acquainted with the fact, that reptiles are not destroyed by cutting off their limbs or tail; in the eighth, he mentions the spectacle of five living crocodiles exhibited by Scaurus, the edile, to the people of Rome; in the ninth, he describes the mode then practised in India, for taking turtles; in the tenth, speaking of the crocodile, he tells us very gravely, that the male and female sit alternately on the eggs laid by the latter; and in the twenty-eighth, besides mentioning the utility of the skink, and several parts of the crocodile, as medicines, he details at considerable length the fabulous history of the chameleon.

Gesner.

Among the modern writers on natural history, Gesner, in part of his *Historia Animalium,* treats of oviparous quadrupeds, though the number which he describes, is by no means very considerable. As usual, with the writers of his time, he imitates the ancient naturalists in mingling truth with fable, especially in his second book, in which he describes the chameleon. In some respects, however, he is very judicious. He notices the wonderful tenacity of life in reptiles, and particularly exemplifies it in the heart of the salamander.

Rondelet.

About the same time with Gesner, viz. in the middle of the 16th century, lived Rondelet, a native of Languedoc in France; who, in his work on fishes, has described some species of turtles as having been seen by him upon the coast of France.

Aldrovandi.

That laborious collector and compiler, Aldrovandi, in that portion of his works which is dedicated to quadrupeds, describes many reptiles, especially the tortoise, the crocodile, the chameleon, and the salamander; but as his accounts are derived almost entirely from preceding authors, and abound with marvellous fictions, they are now rarely consulted.

Johnston.

In that part of Johnston's *Historia Animalium* which is dedicated to *quadrupeds,* we have also an account of several reptiles, among others the crocodile and the chameleon.

Blasius.

In the latter end of the 17th century, Blasius published his *Anatomia Animalium figuris variis illustrata,* which contains some useful observations on the structure of reptiles. He particularly remarks the imperfection of their secreting organs. He also describes the manners of a tame tortoise which he kept, and its remarkable abstinence.

Sibbald.

About the same time appeared Sibbald's *Prodromus Historiæ naturalis Scotiæ,* in which he describes some species of *turtles,* as being found on the western coast of Scotland.

Redi.

In 1685, Francis Redi published his *Experimenta circa Varias res Naturales,* and about the same time his Italian work on the same subject. The experiments which Redi made on various species of tortoise, are sufficiently cruel; but they illustrate, in an eminent degree, the surprising tenacity of life possessed by these animals. They will be particularly noticed hereafter.

Ray.

Our learned and scientific countryman Ray, was the first naturalist who gave any thing like a rational account of reptiles, in his *Synopsis Animalium.* He describes more species of tortoise than were known before; and besides the crocodile, enumerates several rare species of lizards.

Linnæus.

The immortal Swedish naturalist, in his *Systema Naturæ,* divided the class of amphibia into four orders,—reptiles having feet, serpents without feet, gliding reptiles, (*meantes,*) and swimming reptiles, (*nantes*). As the last order was afterwards removed to the class of fishes, and some other important emendations were introduced into subsequent editions of that laborious work, we shall defer any observations on Linnæus's method till we notice his last and best editor, Gmelin.

Seba.

In Seba's *Thesaurus Naturæ,* published about the middle of last century, a considerable number of the most remarkable reptiles is figured; and though the engravings are not in the first style, they give a sufficiently just idea of the objects which they represent.

Pennant.

All the British species then known are described, and some of them figured in the *British Zoology* of Pennant, published in 1749, in 4 vols. He particularly describes the coriaceous, or *leathern turtle,* as having been found on the British coast.

Mr Pennant also contributed some of the very few papers on reptiles, to be found in the *Philosophical Transactions,* especially a description and figure of the *Testudo ferox,* or soft tortoise, and the *T. coriacea,* or leathern turtle. Some species are also noticed in his *Arctic Zoology.*

Klein.

In 1755, professor Klein of Leipsic, published his *Tentamen Erpetologiæ;* but as that work is confined chiefly to serpents, we cannot properly do more than notice it here.

Laurenti.

In 1768, appeared the *Specimen Medicum exhibens Synopsin Reptilium* of Laurenti, in which a new arrangement of these animals was attempted. He distributes all reptiles (except tortoises, which he unaccountably omits altogether) into three orders,—*leaping reptiles, walking reptiles,* and *serpents.* Of the first order, he characterizes five genera, *Pipa, Bufo, Rana, Hyla,* and *Proteus;* and in his second order thirteen genera, viz. *Triton, Salamandra, Caudiverbera, Gecko, Chameleo, Iguana, Basiliscus, Draco, Cordylus, Crocodilus, Scincus, Stellio, Seps.* Among the serpents he places the *Chalcides,* which certainly belong to the second as properly as the *Seps.*

Scopoli.

Nine years after the "Specimen" of Laurenti, Scopoli published his *Introductio ad Historiam Naturalem,* in which he divides the reptiles into legitimate or true,

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* See his *Physica Sacra,* published in 1731.

and bastard or spurious, reptiles, the latter term being applied to the cartilaginous fishes. The true reptiles, including serpents, he divides into two classes; the first containing the serpents, and the second the subjects of our present inquiry. This latter he subdivides into two orders. The first order comprises those reptiles that have tails, viz. the siren, lizards, dragons, and tortoises, including under lizards the crocodiles, iguanas, cordyli, salamanders, chameleons, and skinks. The second order contains only one genus *Rana*; but this comprehends toads and tree frogs. The chalcides he ranks among the serpents.

Gmelin.

In 1789, Professor Gmelin published his edition of Linnæus's *Systema Naturæ*. In this work, which, though little more than a compilation, reflects much credit on the industry and abilities of its author, the *amphibia* are divided into two orders, reptiles and serpents. The reptiles are characterized as being furnished with feet, respiring by means of lungs or gills, and having a simple penis.

Of the reptiles, he forms only four principal genera, viz. *Testudo, Draco, Lacerta*, and *Rana*; but most of these are subdivided. Of the tortoises, there are three subdivisions, *sea tortoises, fresh water tortoises*, and *land tortoises*. Of the genus *Lacerta*, there are eleven sub-genera; *crocodiles, cordyli, stelliones, iguanas, salamanders, geckos, chameleons, ameivas, lizards, skinks*, and *chalcides*. Of the genus *Rana*, there are three subdivisions: *bufones*, or land toads; *ranæ*, or frogs; and *hylæ*, or tree frogs.

The principal defects of this arrangement, are the ranking the salamanders among the *Lacertæ*, from which, as will appear hereafter, they are separated by well marked characters; and omitting the *siren*, which Gmelin has placed in the genus *Murena*, among the fishes. For the small number of his species Gmelin is scarcely accountable, as many have been discovered since his time; and for the small number of his *genera*, his numerous subdivisions in a great measure compensate. It is of little consequence whether we call these *genera*, or *sub-genera*. The effect of the subdivisions in ascertaining the species is much the same; and this, added to their scientific accuracy, is one great merit of the French naturalists, whose writings we are presently to notice.

Turton.

That part of Gmelin's work which comprises the *Animal Kingdom*, has been translated, with some additional matter, by Dr Turton, and published in four thick volumes 8vo.

Lacepede.

In 1788 and 1790, the Count de Lacepede published his *Histoire Naturelle des Quadrupedes Ovipaires et Serpens*. This work had been projected by Buffon as a sequel to his Natural History general and particular, and he had collected considerable materials towards its composition; but finding himself unable to pursue the arduous task, he deputed Lacepede to supply his place, and caused the materials to be put into his hands. The result shewed how ably Buffon had selected his successor; for, though since this work was published much additional information has been obtained, and many scientific improvements introduced into systematic Herpetology, the work of Lacepede will long be regarded as one of the most classical and elegant publications on this part of natural history.

The whole work is divided into two nearly equal parts, which may be considered as distinct and independant treatises, each being prefaced by a preliminary discourse. The first part, with which we alone are at present concerned, treats of oviparous quadrupeds; and these are classed under four general heads, tortoises, lizards, oviparous quadrupeds without tails, and two-footed reptiles, each being more or less subdivided. The tortoises have only two subdivisions: 1st, *Sea tortoises*, of which six species are described; and 2d, *Fresh water* and *land tortoises*, of which there are twenty species noticed. The lizards are divided into, 1st, Those which have flat tails, and five toes before, including four species of crocodile, the dragon, tupinambis, and five other species; 2d, Those which have round tails, five toes before, and a crested back, comprehending the guana, the basilisk, the agama, and three other species; 3d, Those that have round tails, five toes before, and fillets on the belly containing eight species, among which are the cordylus and ameiva; 4th, Those that have five toes before, but no transverse bands on the belly, including the chameleon, the skink, and twenty other species; 5th, Those having large imbricated scales on the under surface of the toes, containing the geckos and two other analogous species; 6th, Those that have only three or four toes, to which belong the seps and chalcides; 7th, Those that have membranous wings, the dragon or flying lizard; 8th, Those which have three or four toes on each fore foot, and four or five on each hind foot, including the salamander, ask, and four others.

Of the oviparous quadrupeds without tails, there are three subdivisions: 1st, Frogs having their heads and bodies angular and elongated, of which there are thirteen species; 2d, Tree frogs, having a small viscous pellet under each toe, comprehending seven species; 3d, Toads with compact rounded bodies, of which there are fourteen species, including the pipa, or Surinam toad. The last head, which is not subdivided, contains only two species.

This work of M. Lacepede was translated into English by Mr Kerr, and published at Edinburgh in 4 vols. 8vo. in 1802.

Schoepff.

In 1792, was published at Erlang the *Historia Testudinum* of J. D. Schoepff, an excellent work, left imperfect by the death of its ingenious author.

Townson.

We must not here omit to notice two ingenious publications in Latin on the physiology of reptiles, by Dr Robert Townson: 1st, *De Amphibiis* published at Gottingen in 1794; and 2d, *Observationes Physiologicæ de Respiratione Amphibiorum*, published at Vienna in 1796.

Brongniart.

According to Daudin, the most natural classification of reptiles that has yet appeared, is that of M. Alexandre Brongniart, published in 1799 in the *Magazin Encyclopedique*. As we shall fully explain this classification, after having noticed the principal naturalists who have adopted and modified it, we shall here merely give an outline of this author's subdivisions. He distributes all reptiles under four general orders: *Cheloniens*, or tortoises, of which he makes two genera, *Chelonia* and *Testudo*, corresponding exactly thus far with the division of Lacepede; 2d, *Sauriens*, of which there are nine genera, viz. *Crocodilus, Iguana, Draco, Stellio, Gecko, Chameleo, Lacerta, Scincus* and *Chalcides*; 3d, *Ophidiens*, or serpents; and 4th, *Batraciens*, of which there are four genera, *Rana, Bufo, Hyla*, and *Salamandra*.

Latreille.

At the very commencement of the present century, M. Latreille published *L'Histoire Naturelle des Reptiles*, the arrangement of which differs little from that of Lacepede, except in placing the Salamander under the same head with the frogs and toads, and a species of Proteus, which appears to be a tadpole of the water salamander, and the Siren, among the serpents. His generic characters, however, are more precise than those of Lacepede; but his method, on the whole, is inferior to that of Brongniart. M. Latreille also published *L'Histoire Naturelle des Salamandres.*

Cuvier.

Between the years 1800 and 1803, the celebrated anatomist and naturalist Cuvier, and his disciple and assistant Dumeril, published his *Leçons Anatomie Comparée,* in 5 vols. 8vo. with 52 plates at the end of the fifth volume. Cuvier had, in 1798, published an elementary work on natural history, under the title of *Tableau Elementaire de l'Histoire Naturelle des Animaux,* in which he gave a general description of reptiles.

Attached to the first volume of his Lectures, Cuvier has given a systematic arrangement of the various classes and orders of animals; and in the classification of reptiles, he has adopted an arrangement radically the same with that of Brongniart. In the first place, he divides reptiles into two sections; 1st, Those which have two auricles to the heart; 2d, Those that have but one. Each of these sections is subdivided into two orders. The first order consists of those reptiles that have a shell or carapace, and their jaws defended by horn. These are the *cheloniens,* or tortoises. The second order consists of those that have the body covered with scales, and are furnished with teeth like the *sauriens,* or lizards, the genera of which are, with the addition of seps, the same with those of Brongniart. The first order of the second section contains the serpents. The second order comprehends those reptiles that have a naked skin, feet, and gills at an early stage of their existence. Of this order (the Batraciens) there are three families; *Rana,* or frog, including the three sub-genera of *Rana, Hyla,* and *Bufo; Salamandra,* including the sub-genera of *Salamandra* and *Triton;* and *Siren.*

These excellent Lectures contain a very full account of the anatomical structure and physiology of reptiles, and to them we are almost entirely indebted for our chapters on that subject. The first two volumes of this work were translated into English under the inspection of Mr Macartney, lecturer on comparative anatomy in London, and published there in 1801.

Shaw.

In 1800, Dr George Shaw began his *General Zoology,* which was intended to include all the genera and species of animals at present known. The third volume contains the reptiles and serpents. In giving our opinion of this extensive work, we are somewhat at a loss. As a systematic arrangement of animals, it is very defective, and the references to other authors are extremely few. As a popular descriptive work, it is scarcely deserving our attention; for, though almost all the species are described, as well as figured, there is scarcely any thing like a history of the species. The arrangement is that of Linnæus, and the characters are in general derived from Gmelin's edition of the *Systema Naturæ.* The work, however, abounds in excellent plates, the figures of which are in general well delineated, and beautifully engraved.

We need scarcely mention the *Naturalist's Miscellany* of the same author, as but few reptiles are there figured.

Daudin.

Perhaps the most complete account of reptiles, up to the present day, has been given by M. Daudin, who has long devoted most of his attention to this part of zoology, and has published several treatises on the subject. Besides his *Histoire Naturelle des Reptiles,* published separately, and the sequel of the same work, entitled, *Histoire Naturelle des Rainettes des Grenouilles et des Crapauds,* he has contributed eight volumes octavo, with numerous plates, to the voluminous and expensive collection of natural history published by Sonnini. These volumes were published at different times, from 1802 to 1805. The first volume contains some historical notices of several writers on Herpetology, and a copious introductory treatise on the structure and physiology of reptiles, illustrated by fifteen plates. The second volume contains the natural history of the CHELONIAN order, in which are described fifty-seven species of *tortoise;* and the same volume commences the history of the SAURIAN order, and describes seven species of *crocodile.* In the third and fourth volumes, the history of the Saurian order is completed, by a description of one species of *Dracæna,* fourteen of *Tupinambis,* thirty-two of *Lacerta,* two of *Takydromus,* three of *Iguano,* three of *Draco,* two of *Basiliscus,* twenty-five of *Agama,* nine of *Stellio,* eight of *Anolis,* fifteen of *Gecko,* four of *Chamæleo,* twenty-one of *Scincus,* six of *Seps,* and four of *Chalcides.* The fifth, sixth, and seventh volumes are occupied with the OPHIDIAN order, or *serpents,* and the eighth completes the work with the history of the BATRACIAN order, containing a description of twenty-seven species of *Hyla,* sixteen species of *Rana,* thirty-two of *Bufo,* fourteen of *Salamandra,* one of *Proteus,* and one of *Siren.* The specific characters in the body of the work are in Latin; but, at the end of the eighth volume, the whole genera and species are arranged together, with their characters in French, under the title of *Tableau Methodique des Reptiles.*

Daudin's Natural History of Reptiles has considerably increased the number of species, and has brought us acquainted with many that were either not known before, or whose place in the systematic arrangement had not been distinctly ascertained. Though the matter of this work is excellent, we cannot, however, say so much for the execution of the plates. The figures are in general so deeply shaded, as to render it difficult to observe the characteristic lines, scales, and dots, that distinguish the species.

Dumeril.

Dumeril, whom we have already noticed as the assistant of Cuvier, has published two works on natural history, which contain, among other animals, the new systematic arrangement of reptiles. These are, *Zoologie Analytique,* published in 1806, and *Traité Elementaire d'Histoire Naturelle,* in two volumes, of which the second contains the animal kingdom. His arrangement is so near that of the other distinguished naturalists of the French school, that we need not detail it here, especially as we have already given a summary view of it under the article AMPHIBIA.

We might have extended these historical notices to a much greater length; but we consider it unnecessary. We have given a succinct account of the principal writings on Herpetology, and shall now conclude this Part of our subject with a list of other works, to which the reader may refer for additional information.

Reference to works on Herpetology.

On the anatomy, physiology, and classification of reptiles, see Swammerdam, *Biblia Naturæ;* Roësel, *Historia Naturalis Ranarum;* Schneider, *Amphibiorum Physiologiæ Specimen;* and his *Historia Amphibiorum;* Caldesi, *Osservazioni Anatomiche intorno alle Tartarughe;* Spallanzani, *De Fenomini della Circolatione;* his *Tracts on the Natural History of Animals and Vegetables;* and his *Memoires sur la Respiration,* lately published by Sennebier; Blumenbach, *Abbildungen Natur Historischer gigenstande;* and his *Handbuch,* or manual of the same subject; Schmid, *Historia Testudinum;* Daubenton, *Dictionaire d'Erpetologie,* forming a part of *L'Encyclopedie Methodique;* Perault, *Memoires pour servir a l'Histoire Naturelle des Animaux;* Humboldt, *Recueil d'Observations de Zoologie et d'Anatomie comparée;* Walbaum, *Chelonographia;* the com-

History.

Reference to works on Herpetology.

pendious system of Comparative Anatomy translated from Blumenbach, with much additional information from Cuvier, and lately published by Mr Lawrence; Ellis's *Inquiry into the changes produced in Atmospheric Air by Respiration, &c.*; several papers by Cuvier, Geoffroy, Daudin, Lacepede, &c. in the *Annales de Museum d'Histoire Naturelle*, more particularly in the 2d, 10th, 12th, and 14th volumes, and a single paper by Mr Revet Sheppard on the British lizards, in the seventh volume of the *Linnean Transactions*.

On the history and manners of the species, much interesting information may be derived from Sloane's *Natural History of Jamaica, Barbadoes, &c.*; Brown's *Natural and Civil History of Jamaica*; Catesby's *Natural History of Carolina*; Russel's *Natural History of Aleppo*; White's *Natural History of Selborne*; Cetti, *Storia Naturale della Sardegna*, or his *Historia Amphibiorum et Piscium Sardiniæ*; Bingley's *Animal Biography*, vol. iii.; Forskal, *Fauna Arabica*, and the Voyages or Travels of Hasselquist, Bruce, Sonnini, Olivier, Cook, Stedman, Bartram, Denon, Barrow, Marchand, &c.

Before commencing our account of the structure and economy of reptiles, it is necessary, in order to render that account intelligible, that we should here give a comprehensive view of the arrangement which we mean to follow in the Second Part of this article.

On carefully comparing the various arrangements of reptiles which have been adopted by modern naturalists, we are disposed to prefer that of the French school, though we think it unnecessary to carry the subdivision of the genera so far as has been done by Dumeril and some of his associates.

General arrangement.

Exclusive then of the serpents, which, as we have seen, constitute the third order in this new arrangement, the reptile tribes are distributed into three orders, CHELONIANS, SAURIANS, and BATRACIANS.

Chelonians.

The CHELONIANS have a short, thick, oval body, covered with a horny shell or membranaceous coat. The upper or *dorsal* part of this is called the *shield*, and is formed of the vertebræ and ribs cemented together within or beneath the outer covering; and the lower or *sternal* part is called the *breastplate*. The head is supported by a pretty long neck, and the mouth is furnished with two mandibles, generally resembling the bill of a bird. These tribes are in general slow in motion, possess little sensibility, and have a languid circulation and slow respiration. They live chiefly on vegetables. They generate by copulation, in which act they remain for several days. Their eggs are covered with a shell, and are deposited by the female in the sand, or among loose earth or gravel. The young are hatched in the form which they are to preserve through life.

The Chelonian order is divided by Dumeril into four genera, *Chelonia*, *Emys*, *Chelys*, and *Testudo*; but as the third of these comprehends only one species, and the second is distinguished from the fourth only by a few minute differences, we shall continue the division of Cuvier into two genera, *Chelonia* and *Testudo*; the former, comprehending the sea tortoises, or turtles, which have the articulated members in the form rather of swimming paws than feet; and the latter, or the tortoises having feet more or less digitated, and furnished with distinct claws.

History.

Saurians.

The SAURIANS, or lizards, have a lengthened scaly body, feet armed with claws; a tail that is often of considerable length, and the jaws beset with teeth. Their legs are in general short, and consequently their pace, though quicker than that of the former order, is slower than that of most quadrupeds; and as their legs are set wide from the body, their progress is unsteady and oblique. The reptiles of this order also copulate, and deposite their eggs to be hatched by chance. The young are extruded in a perfect state.

Of the Saurian order, Daudin reckons sixteen genera, which we shall divide, with Dumeril, into two Sections, *Plani caudata*, or flat tailed, and *Tereticaudata*, or round tailed. Of the flat-tailed Saurians we have four genera: *Crocodilus* having a flattened head, the scales on the back of unequal size, and the hind feet palmated; *Dracæna*, having a square head, and the toes distinct; *Basiliscus*, having equal dorsal scales and a crested ridge along the back, supported by bony rays, and *Tupinambis*, having equal scales but no dorsal ridge. Of the round-tailed section there are twelve genera, viz. *Iguana*, having a crest on the back, and a serrated crest on the throat; *Draco*, having the sides furnished with membranes resembling wings; *Agama*, having an oblong scaly body and tail, an inflated throat, and the feet long and thin, each furnished with five slender separate toes; *Stellio*, having a spinous tail covered with carinated scales; *Chamæleo*, having feet formed for climbing; *Gecko*, having a thick body, and a throat capable of being dilated by inflation; *Anolis*, having a long thin body, and dilatable throat; *Lacerta*, having a plated head, but no inflation of the throat; *Tachydromus*, having the body long and thin, and a row of very small granular pores along each thigh; *Scincus*, having a long scaly body and tail, and distinct legs; *Seps* and *Chalcides*, agreeing in having a very long and slender body, with either two or four very small short feet, and differing in some minute particulars, which will be noticed hereafter.

Batracians.

In the third order, BATRACIANS, the body is naked, *i. e.* covered neither with shell nor scales; the feet are always distinct and without claws; the two sexes do not enter into perfect copulation, and the young undergo a metamorphosis.

This order is subdivided into two sections, those without tails and those with tails, and in each of these sections are reckoned three genera.

The genera of the Batracians without tails are *Hyla*, or tree-frog, having a long body a little compressed; a short fleshy tongue; four toes on the fore feet, terminated by lenticular knobs; *Rana*, or frog, differing from the former in having the toes pointed and not knobbed; and *Bufo*, or toad, having a thick broad body beset with warty tubercles, especially two upon the neck. The genera belonging to the second section are *Salamandra*, having a long body terminated by a tail that is generally cylindrical, three or four toes on the fore feet, and five on the hind; *Proteus*, having a long body terminated by a compressed fin-like tail, three toes on the fore feet, and two on the hind, with persistent branchiæ; and *Siren*, having a lengthened body, a compressed fin-like tail, fore feet furnished with claws, but no hind feet and persistent branchiæ.

PART I. ON THE ANATOMY AND PHYSIOLOGY OF REPTILES.

Anatomy and Physiology of Reptiles.

HAVING now given a general description of reptiles, and explained the classification which we intend to follow in the subsequent pages; we shall proceed to exhibit a comprehensive view of their anatomy and physiology, pursuing the same order which we have observed in the comparative part of our ANATOMY.

CHAP. I.

Of the Motions of Reptiles.

THE organs of motion in reptiles do not differ so much from those of quadrupeds as some other parts of their organical structure, though there is considerable variety in the several tribes of this class.

Bones.

The bones of most species are as firm as those of quadrupeds; but in the smaller reptiles, as the frogs, they are more cartilaginous. It is asserted by some naturalists, that the bones of tortoises have no medullary cavities; but in the larger lizards, these are sufficiently apparent. The skeleton of a Saurian reptile is figured in Plate CCXCV. Fig. 1.

PLATE CCXCV. Fig. 1.

Skull.

The skull of reptiles is generally very small in proportion to the body; but in many species, the jaws are proportionally very large. The cavity of the skull is either exceedingly small, or not half filled by the brain. A remarkable change takes place in the head of the crocodile in proportion as the animal advances in growth after its extrusion from the shell. When first hatched, the skull is thick and rounded, and the forehead prominent, and the eyes are nearly at an equal distance between the fore and back parts of the head. In proportion as the animal grows, the frontal prominence gradually disappears, and the jaws lengthen forwards; and in the adult state, the head is quite flat, and the eyes three times as far distant from the snout as they are from the back of the head.

The skull of the crocodile resembles a truncated pyramid, of which the cavity for the brain forms the base; that of frogs and salamanders is of a form between the cylindrical and the prismatic; that of tortoises considerably resembles that of the crocodile. The cavity of the skull, in reptiles, is of an oblong form, and nearly of an equal breadth. Of the jaws and teeth, we shall speak under the organs of digestion.

Vertebræ.

With respect to the vertebral column, we may remark, that the number and proportions of its component vertebræ vary more in this class than in all the other vertebral animals. The tortoises have generally seven vertebræ in the neck, from eight to eleven in the back, and generally three or four in the sacrum. In this genus all the vertebræ, except those of the neck and tail, are immoveably fixed with what is analogous to ribs, in the horny shield with which they are covered. The crocodile has seven cervical, twelve dorsal, five lumbar, two sacral, and thirty-four caudal vertebræ; but in the other saurians, the proportional numbers vary in almost every species. Frogs and toads having no ribs, the ordinary division of the vertebral column cannot be distinctly made. The common frog has in all ten vertebræ, and the pipa, or Surinam toad, has in all eight.

The muscles attached to the spine also vary considerably. In tortoises, where only the head and tail are moveable, the spinal muscles are confined chiefly to these two organs, and those of the neck possess many peculiarities. The chief motions of the neck in this genus are those by which the head is thrust out from the shell, and drawn back within it. The spinal muscles of frogs and salamanders are few in number, except that in the latter, the crocodiles, and other saurians, the muscles of the tail are proportionally numerous and powerful.

Thorax.

The thorax is very differently formed in the different orders. In the tortoises, the sternum or breast bone is lost in the breast plate or lower shell, while the ribs are, as we have said, firmly cemented in the shield. Of the saurians, the crocodile has the anterior part of the sternum bony and prolonged, so as to receive the clavicles; while the rest is cartilaginous, and extends backward to the pubis, furnishing eight cylindrical cartilages that surround the belly. The ribs of this animal are twelve in number; but the two most atlantal or forward, and the two most sacral or backward, are not united to the sternum. In the guana and tupinambis, only six of the ribs are united to the sternum. The chameleon has a small sternum, but all the ribs are made to meet round the thorax, by means of intermediate cartilages. In the salamanders the ribs are extremely short, so as to appear like appendages of the vertebræ. The frogs have a sternum though no ribs.

In most of the reptiles, there is little peculiar in the muscles of the thorax and abdomen. In the tortoises, however, where the ribs are immoveable, and where the place of abdominal muscles is supplied by the breastplate, the muscles which would be attached to the sternum are inserted into the pelvis, upon which they act; and in frogs which have no ribs, the muscles are united to the sternum by strong membranes.

Atlantal extremity.

The superficial or glenoid cavity, in which the humerus or large bone of the atlantal or anterior extremity moves, is in reptiles formed partly by the scapula and partly by the clavicle. The scapula has no spine; it is elongated, and retracts and becomes thicker towards its neck. The clavicle is simple, short and flat. In tortoises, the disposition of the bones that form the shoulder is most remarkable, and is thus described by Cuvier. Besides the scapula and the clavicle, there is a bone which he calls the *fork*; one of the bones stretches from the base of the rudiment of the first rib, to which it is attached by a ligament as high as the glenoid cavity, where it is intimately united with the other two. The second bone, which appears like the continuation of the former, is attached by its other extremity to the breast plate, and this extremity is bound by strong ligaments to that of the bone behind it. These bones thus united are slightly curved outward, so as to leave between them, and those on the opposite side, an oval space for the passage of the gullet, the windpipe, and numerous muscles. Lastly, the third bone is placed below the abdominal and thoracic viscera, nearest the breastplate, and is extended from the glenoid cavity as far as the abdomen. It gives attachment to numerous muscles, and resembles the scapula in every thing but situation. See Cuvier, *Leçons d'Anat. Comparée*, Sec. IV.

The humerus presents nothing remarkable except in the tortoises, where it is united somewhat in the manner of birds, with the scapula, the clavicle, and the fork.

In the tortoise tribes, numerous and strong muscles are attached to the humerus; while in frogs many of the muscles which are found in this region, in quadrupeds, are wanting.

The distal part of the atlantal extremity, or what comparative anatomists chuse to call the fore-arm, consists as in quadrupeds of two bones, except in the frog and toad. These are analogous to the radius and ulna, but have several peculiarities of structure. In particular, the tortoises have them so fixed in a state of pronation, as to confine the action of these extremities to swimming.

What is called the hand or paw is in reptiles considerably varied. In the sea turtles or chelonians, it is whole without, though consisting within of many separate bones. In the saurians it is digitated, and consists in some species of five divisions, in others of four, three, and even one: these toes are generally furnished with claws. These digitated paws, according to the number, length, and armour of their divisions, are adapted to the various actions of walking, climbing, grasping, and seizing, or tearing prey.

Pelvis.

The pelvis, and especially that part of it which corresponds to the pubis, is of considerable size, and it is extraordinary that in these animals the pelvis is moveable on the vertebral column.

Sacral extremity.

The thigh bone of reptiles is similar to that of other animals, except that it has a double curvature more or less remarkable, presenting a convexity forward towards the tibial or distal extremity, and a concavity towards the pelvis. In the tortoises it has well marked trochanters; but these are wanting in lizards and frogs. It is generally round, except in the Surinam toad, in which it is much flattened. There are few peculiarities in the muscles of this region.

The leg is composed of a tibia and fibula, distinct throughout their whole length, except in frogs, in which they are united. When separate, they are nearly of equal size, and in general are articulated immediately with the thigh bone. The muscles of the leg are most remarkable in the turtles and frogs. In the former, they are adapted to the act of swimming; in the latter, they form a prominence behind, resembling the calf of the leg in man. The bones and muscles of the hinder feet are in most cases similar to those of the paws.[*]

Motions of reptiles.

From the very different form and position of the limbs of reptiles, their progressive motions, and even their mode of standing, vary considerably in the different tribes and species. In standing, turtles rest as much on their breastplate as on their paws, while the land tortoises stand with their belly a little above the ground. The *batracians*, and especially frogs, rest in a kind of sitting posture, with the fore part of their body elevated on the fore legs. Those lizards, whose bodies resemble those of serpents, as the *chalcides*, are coiled up in a state of rest.

The turtles rather scramble than walk like seals; but tortoises walk well though slowly. Some saurians move along with great agility, while others, as the crocodile, have a comparatively slow progression. Few reptiles climb well, if we except the chameleon, which is much assisted by its prehensile tail. The guanas and tupinambes are the best leapers among the saurians; and frogs and toads, though they cannot walk well, are excellent jumpers.

A great variety of reptiles swim well, especially turtles, crocodiles, and frogs. The only species that can be said to fly is the dragon, whose motion through the air resembles that of the flying squirrels.

CHAP. II.

Of Sensation in Reptiles.

Brain.

As the cavity of the cranium in reptiles is very small, and not nearly filled by the brain, it follows that the size of this organ is very inconsiderable. It is calculated that, in the turtle, the brain is little larger than $\frac{1}{5000}$ part of the whole body, though in the frog it is proportionally much larger, being as 1 to 172. It consists chiefly of five rounded eminences, without convolutions, and with a smooth base. There is no *corpus callosum*, *fornix*, *pons varolii*, or *arbor vitæ*, and what are called the *thalami* of the optic nerves, are situated behind the hemispheres. The distribution of the nerves in the head has no remarkable peculiarities.

Nerves.

The number of spinal nerves in the different orders and tribes of reptiles, is proportional to the number of vertebræ of which the spinal column is composed, and their distribution is so little different from that in man and quadrupeds, that it need not be here described. The nerves of the atlantal, or fore legs, are derived from the cervical nerves, and sometimes the dorsal, uniting to form a brachial plexus or net-work. Those of tortoises are extremely complex; those of lizards more simple; and those of frogs proceed from a very thick cord coming from between the second and third vertebræ, and forming the largest nerve in the body.

The nerves of the sacral extremity in lizards, after emerging from the pelvis, form a single cord, which runs down the inside of the thigh, and thence supplies the leg and toes. In frogs this large cord passes to the posterior part of the thigh, like the sciatic nerve in man.

Senses.

It appears that reptiles possess all the five senses found in the other vertebral animals, though in very different proportions and degrees. Their sight appears to be very acute, and their eyes are in general large and prominent. The sense of hearing, if we may judge from their want of external ears, is much less perfect than that of sight. Their smelling is supposed for a similar reason, and from the little use they appear to make of this sense in seeking their food, to be still less acute; and it is doubted whether many of them possess the faculty of tasting at all. With respect to touch, it is probable that those which have soft skins and digitated feet, possess considerable acuteness in that sense; while those which have scaly, shelly, or coriaceous coverings, and more especially the turtles, are capable of exercising touch in a very slight degree, if at all. We shall examine the organs of all these senses in the order which we have laid down in the article ANATOMY, and exemplified in CETOLOGY, except that we shall defer the organs of feeling, if they deserve that name, to the head of *Integumation*.

Tasting.

All reptiles appear to possess a tongue, but it varies much in substance and degree of mobility. In the tor-

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[*] In the twelfth volume of the *Annales du Museum*, is an elaborate Memoir by Cuvier on the Osteology of the crocodile, to which we refer the reader for details, which it would be inconsistent with our plan to introduce in this place.

toises, it is covered on the upper part with long soft close papillæ, giving it the appearance of velvet. In crocodiles, these papillæ are extremely short, and more like wrinkles. In these animals it is entirely fleshy, but is so completely attached by the point and edges to the basilar or lower jaw, as to admit of scarcely any motion; and it was long doubted whether crocodiles had a tongue. In stelliones, again, it is very moveable; and in the common lizards, and the tupinambes, it is considerably extensile. In these latter reptiles, the tongue terminates in two long flexible cartilaginous points; and in the skinks and geckos it is notched at the tip.

The tongue of salamanders is rough with papillæ, but that of frogs and toads has a smooth slimy surface. The chameleon has the tongue of a cylindrical form, covered on its surface with deep regular transverse furrows; and it is so constructed, as to be easily thrust out of the mouth, to collect the proper food of the animal.

Smelling.

The organs of smelling are imperfect, and consist chiefly of cavities opening in front of the snout, and communicating backward with the mouth, lined like the nostrils of *mammalia* with a pituitary membrane, for the ramification of the nerves. This membrane is in several species divided into several folds, supported by bony plates. Tortoises have three of these. The external nostrils are furnished with muscular fibres, by which they may be occasionally contracted and dilated. The nostrils are very close together in crocodiles, while in some of the other saurians, as the tupinambes, stelliones, and chameleons, they are more apart and lateral. In the tortoises, they are very small and close together; and they are also extremely small in salamanders. In short, from the small extent of the nasal cavities in reptiles, compared with those in quadrupeds, it appears that they are rather organs of respiration than of smelling.

Hearing.

These animals have, as we before hinted, no auricles or external ears, though their internal organs of hearing are sufficiently apparent. These consist of a tympanum, (except in the salamander,) and a labyrinth with their attending bones and cavities. In turtles the membrane of the tympanum is cartilaginous, and covered externally by the integuments. The tympanum contains only a single little bone, and from it proceeds a Eustachian tube. In this order there are semicircular canals. The saurians, with the exception of the salamander, have the same parts, and several little bones, besides several soft stony substances in the vestibule. The crocodile is the only instance among reptiles, in which there is any appearance of external passage to the organ of hearing. The batracians, especially frogs, have a large membrane of the tympanum, level with the surface of the body. The tympanum contains two cartilaginous ossicles, and has a wide opening of the Eustachian tube next the throat. The vestibule contains rudiments of those soft stony substances just mentioned, as occurring in the saurians. In the salamander, the vestibule contains one of these stony bodies, and the oval hole leading to the labyrinth is closed by cartilage. In general the vestibule and membranous canals in these animals are much smaller than the bony or cartilaginous cavities in which they are contained.

Seeing.

There is, we believe, only one instance in reptiles where the eyes appear of little use. This is in that singular species the *proteus*, in which the eyeballs are so covered with the integuments, as not to be visible till these have been removed.

In the tortoise tribes there is a bony ring, composed of thin plates at the anterior part of the sclerotic coat; and a similar structure occurs in frogs, chameleons, the guana, and some other saurians. The iris is variously coloured, but generally yellow, red, or brown. The pupil varies in figure. In the crocodile it resembles that of the cat, being vertically oblong; in frogs and geckos it is rhomboidal; and in tortoises, the chameleon, and common lizards, it is round. The crystalline lens resembles that of fishes in its spheroidal figure.

Besides the two eye-lids common to reptiles, and the superior classes of animals, the former have, like birds, a third, or nictitating membrane, which is vertical in tortoises and crocodiles, but horizontal in frogs. In the crocodile there is a bony substance in the upper eye-lid. In the common lizards, instead of eye-lids, there is a kind of circular veil extended before the eye, with a sphincter muscle by which it may be closed.

There is considerable variety among reptiles with respect to the lachrymal gland. Turtles have it very large, and situated at the lateral or posterior angle. In the fresh water tortoises again, as well as in frogs and toads, there are two small blackish glands.

Thus it appears that the eyes of reptiles are well adapted to perfect vision, and provided with ample defence against the too stimulating power of the rays of light. It is well known that many of them are very quick in perceiving their prey; and some species, as the green lizard and green frog, appear extremely fond of the brightest light. Some few, however, shun the day-light, and seek their prey chiefly by night, having for this purpose the power of contracting or dilating the pupil in a very considerable degree. It is said that the chameleon can move both eyes at once, in different directions, a circumstance scarcely noticed in any other animal.

Sensation.

The general phenomena respecting the nervous system of reptiles, and the influence of the brain on the other organic functions, cannot properly be considered till these functions shall have been examined. The remarkable tenacity of life in reptiles, their great reproductive power, and the phenomena of the torpid state which they undergo, all of which are more or less connected with the nervous system, must also be deferred till we have treated of the functions of circulation and respiration.

CHAP. III.

Of Digestion in Reptiles.

Prehension.

DIGESTION in reptiles is divisible into what we may call prehension, deglutition, and digestion, properly so called.* We shall here consider the organs and phenomena of these functions, in the order in which we have named them.

Jaws.

We have seen that the mouth of the *chelonians* is furnished with mandibles. These close over each other somewhat like the parts of a box, and frequently have their edges so deeply indented, as to have led to the mistake that some tortoises have teeth. The horny

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* Properly speaking there is no mastication in reptiles, and the jaws and teeth are used entirely for seizing and holding their prey. We have therefore taken the liberty of borrowing a word from the Latin, and have called this action *prehension*.

part of the mandibles is connected with the bony jaw, nearly in the same manner in which the hoof of the horse is united to the coffin bone: (See MAMMALIA and VETERINARY MEDICINE.) In the upper jaw there is an intermaxillary bone. The lower jaw is articulated with the skull, by means of a bony eminence of the latter. The lower jaw only is moveable, and its motion consists of little more than opening and shutting the mouth. Many of this order possess great strength in the jaws.

The jaws, in many of the *Saurians*, especially in the crocodile tribe, are of very considerable length, and, in most instances, beset with numerous strong and sharp teeth. In most of the species, the lower jaw is moveable on the upper, in the usual manner; but in the crocodile there is a peculiarity in this articulation which merits particular notice, especially as it has been made a subject of dispute among naturalists from the earliest ages.

Herodotus was, we believe, the first to assert, that the upper jaw of the crocodile was moveable on the lower, which he supposed to be fixed. This opinion was followed by Aristotle and Pliny, and of course by the earlier modern naturalists, who copied from them. Of late, this general ancient opinion of the mobility of the upper jaw has been warmly called in question; and some of the French academicians believed they had demonstrated its absurdity. The more recent observations of M. Geoffroy, however, shew that the ancient supposition was wrong only so far as respects the lower jaw, as, in fact, both the jaws are moveable on each other. This peculiar articulation is well illustrated by Fig. 2. of Plate CCXCV. from which it appears, that the posterior extremities of the lateral branches of the upper jaw-bone are received into hollows in the lower, so as to admit of free and extensive motion. See *Annales du Museum*, tom. ii. p. 39.

PLATE CCXCV. Fig. 2.

We are not, however, to suppose, that the upper jaw of the crocodile moves upon the cranium. The fact is, that the cranium is very small, and is so fixed within the branches of the upper jaw-bone, as to move along with this latter: the articulation of the two jaws being behind the cranium. None of the other *Saurians* have the maxillary articulation similar to that in the crocodile; but in many the length of the jaws, and consequently the opening of the mouth, is very considerable. The lower jaw in most of these animals is very complex, consisting of from eight to twelve pieces. In the *Batracian* order it is also complex, consisting generally of six pieces.

That part of the jaws which corresponds to the snout, has a very different degree of rotundity in the several orders of reptiles. It is most obtuse in the *Batracians*; less so, though still considerably rounded, in the *Chelonians*; while in the *Saurians*, the angle formed by the meeting of the branches of the jaw is generally very acute.

The muscles attached to the jaws are most powerful in the *Chelonians* and *Saurians*. In the former, the temporal muscles are the strongest; while in the latter, the digastric and the masseter appear most prominent. The force with which some turtles close the jaws is astonishing. It is even asserted, that when once closed with violence, it is impossible to open them; and that even when the head is cut off, the contraction of the muscles continues to act for many hours. A turtle has been known to tear asunder a large rope, by means of the indentations in its mandibles.

Teeth.

All the *Saurians* have teeth in both jaws, and in the *Guana* there are besides teeth set in the palate. All these teeth resemble the cutting and pointed teeth of the predacious quadrupeds, and seem entirely adapted to seizing and retaining prey. The number of teeth is seldom constant in the same species, and evidently depends on the age of the animal.

Among the *Batracians*, the frogs have teeth only in the upper jaw; salamanders have them in both; but toads have teeth in neither jaw. All these tribes, however, have them in the palate. The siren has teeth attached to the inner surface of the jaws.

Deglutition.

The organs of deglutition in reptiles have a considerable variety in point of structure. We have already briefly noticed the tongue under the organs of sensation, but must here treat of that organ and its appendages at greater length.

Tongue.

In the *Chelonians*, the tongue is small and pyramidal, with the base turned backwards, and the point forwards. The *os hyoides*, or bone of the tongue, varies in different species. It is more or less cartilaginous.

The mechanism of the tongue in the Chameleon is extremely curious. The tongue itself is not larger than a goose quill, but is five or six inches long, growing broader towards its extremity, where it is covered with a glutinous matter. In the usual state of the animal, this organ lies within a sheath at the bottom of the mouth, and is so contracted as to appear not more than an inch in length; but when the animal is in search of prey, the tongue is, by peculiar muscles, darted out to the length we have described, and catching the insects on which the chameleon feeds, by means of its glutinous secretion, is again withdrawn into the mouth.

In many of the reptiles, the tongue is composed chiefly of a thick glandular mass, formed of a great number of small pipes, united towards the base, and diverging towards the surface of the tongue. In fact, in these cases the tongue forms a salivary gland, and the same saliva prepared in it is poured out by numerous orifices along the sides of the organ. This is particularly the case in the *Chelonians*, and many of the *Saurians*; and a similar structure, though to a less extent, prevails in the *Batracians*.

In those reptiles that have a scaly tongue, there are two oblong sub-maxillary glands.

What is called the *pharynx*, or swallow, is in reptiles not easily distinguished from the gullet, to which it forms the opening, its diameter being nearly the same with that of the gullet.

Gullet.

The gullet in reptiles is nearly of equal diameter through its whole length, and this diameter is greater in proportion to the stomach than in quadrupeds. In the *Chelonians*, its internal surface is sometimes beset with hard long conical papillæ, with their points directed backwards, apparently for the purpose of preventing the return of the food from the stomach. In this order, swallowing is also facilitated by the action of muscles placed along the neck, and inserted into the gullet, as well as by the bone of the tongue and its muscles. The same mechanism is evident in the *Batracians*, especially in the frogs and toads; and in all this class there are usually in the gullet numerous longitudinal folds, which, by admitting a considerable degree of expansion in the tube, as the food passes through it, greatly facilitate deglutition.

Stomach.

The *stomach* of reptiles is of very various figure and dimensions, in the different orders, tribes, and species. In the *Chelonians* this organ appears as if doubled back upon itself; and that portion which is opposite the principal curvature, has its sides thicker than the rest, and is internally plaited with longitudinal folds. The insertion of the gullet in these animals is distinguished by the sudden dilatation formed by the stomach. Among the *Saurians*, the crocodile has the stomach of a globular figure, divided, however, into two unequal portions. The stomach of the *Guana* is oval, and very long, without curvature, and not easily distinguished from the gullet. In the Tupinambis the stomach forms a long tube, bent nearly into a circle. The stomach of the Chameleon begins by an inflated portion, then takes the form of a long cylinder, and bends back upon itself. In the Dragon, this organ is strait, and has nearly the shape of a pear. In the *Batracians*, the form of the stomach resembles that in tortoises, but is proportionally more dilated. In *Salamanders* it is long, not much expanded, and strait, except near its farthest extremity.

PLATE CCXCV. Fig. 4.

Fig. 5, 6.

Fig. 7.

Intestines.

The intestinal canal of reptiles is not easily to be divided into small and large by any particular appendage, like the *cœcum* of quadrupeds; though the distinction, in point of diameter, holds in most species. All the *Chelonians*, most of the *Saurians*, and all the *Batracians* except the *Siren*, have a long small intestine inserted into one extremity of a short great gut, into which it is usually prolonged, so as to form a valve. In the *Iguana* only is there any thing like a *cœcum*.

The intestines of reptiles in general are very short.

In the *Chelonians*, what may be called the small intestine, is largest at its juncture with the stomach, and gradually diminishes in diameter till it terminates in the great intestine, where its diameter is only about one-fourth of that of the latter. The coats of the intestines in this order are thicker than in those of most other reptiles. See Fig. 8.

Fig. 8.

In the *nilotic crocodile*, the small intestine is divided into two portions, of which one is of greater diameter, and has thinner coats than the other. This intestine is remarkable for a thin layer of a pulpy glandular substance, between the muscular and the villous coats. The large intestine of the *nilotic crocodile* is cylindrical; but in another species, the *gavial*, it is pear-shaped. In the *lizard tribe*, the large intestine is cylindrical, and of much greater diameter than the rest of the canal. In the *chameleon*, the whole intestinal canal is nearly of equal diameter, except at one part, where it forms a sort of valve. In the *dragon*, the intestines make about two circumvolutions and a half, before terminating in the anus. In most of the *smaller saurians* the coats of the intestines are thin and transparent.

Fig. 9, 10.

The most remarkable differences in the intestinal canal of the *Batracians*, are those which take place in the same species at different periods of its existence. In the *tadpole*, or young animal, the intestines are very long, small, and nearly of equal diameter, without any valvular distinction, and have numerous circumvolutions. In the perfect animal, the whole intestinal canal is much shorter, the distinction into small and large intestines very evident, and the circumvolutions much fewer. In frogs, the large intestine is cylindrical; in toads, it is more or less conical. The difference of diameter between the large and small intestines is most evident in *salamanders*, whereas in the *siren* this distinction is scarcely to be noticed. See Fig. 11.

Fig. 11.

Food of reptiles.

The food of most reptiles consists of worms, insects, and other small animals, which they swallow whole. Of course the process of digestion takes place almost entirely in the stomach, where the gastric juice is evidently possessed of considerable solvent power. Some of the Chelonian order, indeed, feed partly on sea-plants, thence called turtle grass, which they bite off with their horny mandibles, and swallow whole.

Many of these animals are extremely voracious, and will gorge themselves with living worms or insects, till they become nearly incapable of motion, and till the animals they have swallowed crawl again out of their mouths.

The process of *deglutition*, in most reptiles, is effected by repeated contractions and dilatations of the throat and gullet, which are very evident to an observer. It is supposed by some physiologists, that part of the prey in some species undergoes a degree of solution in the gullet; but this seems to us not very probable.

Though the solvent power of the gastric juice in reptiles is undoubted, its action is sometimes very slow, especially on living animals, these having been found undissolved, and sometimes even still alive at the end of several days.

Abstinence of reptiles.

Notwithstanding the voracity of some reptiles, it is astonishing how long almost all these tribes can support the want of food. Turtles and tortoises, even when not in a torpid state, have lived for 10, or even 18 months, without taking any kind of food. Newts have lived for two months, a chameleon for eight, salamanders for an equal period, protei for two years, and toads for a much longer time under the most perfect abstinence. It is most extraordinary, and the circumstance forms a strange anomaly in animal physiology, that although these reptiles gradually lose their vitality from the want of food, they do not lose weight in proportion, and in some instances suffer no sensible diminution or flaccidity of muscle.

CHAP. IV.

Of Circulation and Absorption in Reptiles.

There are several peculiarities in the circulation of reptiles, and the organs vary considerably in the different orders. In some they are similar to those of the higher classes of animals, except that the principal cavities of the heart communicate more or less freely with each other; in others, the circulating system is entirely different from that of *Mammalia*, and much more simple.

Chelonians.

In the Chelonian tribes, the heart is very broad in proportion to its length, but differs in figure in the two genera, being nearly hemispherical in the proper *Cheloniæ*, and of an oblong square form in the *Testudines*. In both it has two auricles, and a ventricle divided into compartments. It is situated below the lungs, and between the lobes of the liver. The auricles are very large, forming each about one-third of the whole heart, and spread wide at the base of the ventricle. Their sides are thin, and their cavities do not communicate. The ventricle is strong and fleshy, and its cavity, which is naturally small, is still more diminished by numerous fleshy bundles that proceed from its sides, and are separated from each other in such a manner as to leave spaces between them. The auricles communicate with the ventricle by large apertures, guarded by membranous valves; and on each side of the ventricle are orifices, also furnished with valves, that lead to the great arterial trunks. The pericardium is large, and closely attached to the contiguous membrane, as to the diaphragm in quadrupeds.

Saurians.

In the *Saurians*, the heart is also provided with two auricles; and in one tribe, the crocodiles, is even more complicated than that of the first order. It is in the crocodiles, indeed, that its structure has been most accurately examined, and to this tribe we shall here confine ourselves.

PLATE CCXCV. Figs. 12, 13, 14.

The heart of the crocodile is situated partly between the lungs, and partly between the lobes of the liver. Its auricles are proportionally less than in the *Chelonians*, but their sides are thicker, and strengthened by fleshy bundles, diverging in various directions. The ventricle is of an oval form, and has very thick sides. Its cavity is divided into three compartments, communicating with each other by numerous orifices. One of these is below, and towards the right, and communicates with the right auricle by a large opening contracted by two valves, that direct the blood through its upper part. On the left side of this cavity is the passage to a large artery on the left, that distributes blood to the sacral or hind parts of the body; and behind this an orifice leads to the smallest of the three compartments, situated at the middle of the base of the heart; and from this arises the common trunk of the pulmonary arteries.

Hence the blood that is poured by the right auricle into the compartment on that side, flows chiefly in two directions; 1*st*, Into what may be called the *right systemic* compartment of the ventricle, which throws it into the left *sacral aorta*: 2*dly*, Into the *pulmonic* compartment, which impels it into the pulmonary artery, though some of it probably oozes into the left systemic compartment. The left auricle receives the blood from the pulmonary veins, and pours it into the left compartment; and from this latter it is thrown into the left systemic artery, the carotids, and axillary arteries.

Batracians.

The *Batracian* order have a heart extremely simple, consisting of a single auricle, and a single undivided ventricle, of a conical form, from which arises one arterial trunk, that by its branches transmits the blood to all parts of the body.

We cannot here enter into an examination of the number and course of the principal blood-vessels in the reptile tribes; but must refer the reader to Cuvier's *Anatomie Comparée*, Leçon xxv. Art. 3. vol. iv. where they are minutely described.

Blood.

There is not that well marked distinction between the arterial and venous blood in reptiles, which is found in *mammalia*, *cetacea*, and birds; but in some species there is a manifest difference, as Caldesi has observed in tortoises. It is said that reptiles which have fasted long have the blood of a paler colour than the same species regularly fed.

The absolute quantity of blood in the circulating system of reptiles, is proportionally much smaller than in *mammalia* and birds; hence their muscles are whiter, and their lungs of a paler colour than in those classes. The circulation in these animals, though not so complicated as in the higher classes of animals, is yet a perfect circulation; and, as in the higher classes, though not in the same degree, the blood takes a double course, some of it passing through the lungs before it be distributed to the rest of the body. We shall see, in the succeeding Chapter, that although the lungs of reptiles are larger in proportion than those of *mammalia* and birds, they are less vascular, and therefore contain a smaller quantity of blood. It is this imperfection of what has been called the lesser circulation, and the slight difference between the *systemic* and *pulmonic* blood, that lay the foundation for some of the most remarkable circumstances in the physiology of these animals. We are now prepared to consider two of these circumstances — the remarkable faculty of reproduction of parts that have been mutilated or destroyed, and the great tenacity of life at which we have already hinted.

Reproduction of parts.

It is chiefly in the lizard tribe and salamander, that experiments and observations on the reproduction of parts have been made; but it is reasonable, from analogy, to infer, that similar phenomena may take place in other tribes. The lizards are peculiarly liable, from their smallness and the numerous enemies to which they are exposed, to partial injury or destruction of their members. This is particularly the case with respect to the tail, which is long and slender, and in many species so brittle as to break short on being handled. In these cases it has been repeatedly observed, that the part lost has been in no long time reproduced, generally similar to the original, but sometimes a double tail has appeared.

The reproduction of lost parts in reptiles, has been made the subject of numerous and satisfactory experiments, especially by Spallanzani, Bonnet, and Blumenbach. From these it appears, that when part of either extremity, or of the tail, is cut off, from two species of lizard, the *lacerta agilis*, and *lacustris* or water newt, the wound is followed, for two or three minutes, by an effusion of blood, after which the stump gradually heals, and in the course of a few days the rudiments of a new limb or tail begin to make their appearance; that these rudiments are gradually developed, till in a few months, or sometimes a little more than a year, there is formed a perfect member, similar in size and proportions to that which had been cut off, only retaining for some time a delicacy of structure and transparency of appearance not found in the original organ. It is further proved, that these regenerated parts may be again repeatedly removed and reproduced. The most surprising of these experiments, however, are those of Bonnet and Blumenbach on the reproduction of the whole eye in the water newt. These have taught us, that when the eye of that animal is dissected from the orbit, so as to leave about a fifth of the membranes in contact with the optic nerve, the vacant orbit is first closed by the eyelids, and gradually the vacuity is filled up with a growth of new parts, which in about a year acquire the perfect structure of an eye, with its investing membranes, contained humours, transparent cornea, and coloured iris.

Tenacity of life.

We have already remarked the great power of abstinence possessed by reptiles, and have now to notice some other unfavourable circumstances under which they continue to live, and perform most of their functions.

Most reptiles possess the faculty of resisting extremes of heat and cold, and the effect of chemical agents, better than other animals. Though nobody now believes the ridiculous stories of salamanders living in the fire, it is still a curious fact, that lizards and alligators live with ease, and apparent satisfaction, in the waters of hot springs, heated to a degree very considerably higher than the hottest temperature of the torrid zone. Frogs and newts are often exposed to a degree of cold far below the freezing point, while in a state of torpidity, and they have even been known to remain imbedded in a block of ice for many hours, without having their vitality extinguished. Some of these animals, that have been put alive into spirit of wine, for the purpose of preserving them as specimens, have remained alive for several hours; and other instances are recorded of their existing for a considerable time in the exhausted receiver of an air-pump. Frogs and water-lizards have lived, and moved with agility, many hours after having been deprived of their hearts; and Redi, by a curious but cruel experiment, proved that a land-tortoise, after having the cavity of the skull laid open, and the brain dissected out, walked away with apparent unconcern; and, except that its eyes closed, and never afterwards opened, it appeared for several months to enjoy life, and exercise its functions nearly as before the loss of the brain. Frogs, which were subjected to a similar experiment by Spallanzani, lived for five days. Nay, a turtle has been known to live and move its limbs for thirteen days after its head had been cut off.

Not only is the body in general of reptiles thus tenacious of life, but the parts and organs that have been cut off shew signs of vitality and irritability, for hours and even days together. The tails of water newts have exhibited very lively motions for more than ten hours; the heart of a frog has continued to palpitate, when irritated, for several hours after being taken from the body: the head of a turtle has not only opened and closed its jaws, but has closed upon a stick with considerable force, two days after having been amputated.

Absorbent system.

The *absorbent system* of reptiles has been very little examined, and the investigation has scarcely extended beyond the Chelonian order. We find that the thoracic duct of turtles is double, and that the mesentery in these animals abounds with lacteals. Numerous lymphatics are seen running in a longitudinal direction, both on the superficial and central coats of the intestines; but it is not certain that these animals possess lymphatic glands.

If we may judge from the little waste that takes place in the body of reptiles during a long abstinence, and while in the torpid state, it would seem that their absorbent system possesses less activity than that of most other animals.

CHAP. V.

Of Respiration and Voice in Reptiles.

The lungs of reptiles are proportionally much larger than those of quadrupeds and birds, and they are also of a much looser texture; their structure is most complicated in the Chelonian order, in which they are of a uniform texture, but the air vesicles are very large. In the *Saurian* order, the lungs form two large vesicular bags, one on each side the heart, and have their internal substance divided by membranous plates into numerous polygonal cells, which are again subdivided into smaller. All the *Batracian* order have lungs, which resemble those of most of the Saurians in largeness and simplicity; but in the tadpole state, they have also gills, which disappear in the perfect animal, except in two tribes, in which they are permanent.

Lungs.

In all, the lungs float loose with the other viscera in the same cavity, and appear to have no innate contractile power.

The windpipe, except in one or two instances, divides into branches or *bronchi*, before it reaches the lungs; but this division takes place nearer the head in some tribes than in others. In the Chelonians, it commences very early, while in the crocodile the trachea continues undivided for a considerable extent. In general, however, the bronchi are very short, and in most instances they terminate abruptly in the lungs.

The extent of the lungs is greatest in the Chelonians, in whom they reach along the whole length of the back. The lungs of reptiles are supplied with blood by the pulmonary arteries, there being in general no bronchial vessels.

Branchiæ.

The gills or branchiæ of tadpoles, and of the proteus and siren, resemble the gills of fishes in their general structure, but are not, like them, inclosed within a particular covering, but hang loose and floating on each side of the neck. They form three or four rows of small tufts or fringes, supported by small cartilaginous arches; and these arches are articulated on one side behind the cranium, while on the other they are united to a bone resembling the os hyoides. They have between the rows intervals, by which the water in which the animal floats is freely admitted to the mouth. The branchiæ of the siren consists of three tufts.

Respiration.

The spongy texture and little vascularity of the lungs in reptiles, enable them to take in a greater quantity of air than other animals at a single inspiration, and this capacity appears to be increased by the expansive power of the air cells. It is remarkable, that reptiles not only receive air into the lungs in the ordinary way of inspiration, but swallow it by the mouth, in which action they are assisted by the muscles of the throat. In fact, it is only by deglutition that the Chelonians inspire, and in expiration the animals of this order employ chiefly two pairs of muscles, situated in two layers near the tail, between the shield and breastplate. In the Saurians, the mechanism of respiration is executed chiefly by the abdominal muscles, and by those which move the ribs.

From the large quantity of air which reptiles can inspire at once, there is the less occasion for frequent respiration; and, accordingly, in these animals, the breathing is remarkably slow. It is least slow in the Chelonian tribes, and it appears to be slowest when the animals are asleep. What is most remarkable, however, in the respiration of reptiles, is the power they possess of suspending respiration. Tortoises have been known to live more than a month with their jaws closely tied, and their nostrils stopped with wax; and there seems little reason to doubt the remarkable instances that are on record, of toads being found alive in the trunks of trees and blocks of solid stone, where the function of respiration must have been suspended for years together. It also appears that reptiles can live for a longer time uninjured in deoxygenated or impure air than other animals; a circumstance that is explained on similar principles. This continued vitality in vitiated air, has its limits however; for it is found, that when these animals are confined in atmospheric air, they cease to exist when the oxygenous portion is expended.

The changes produced on atmospheric air by the respiration of reptiles, are similar to those produced by the breathing of other animals, viz. the consumption of oxygen and formation of carbonic acid. On this subject we may refer our readers to Mr Ellis's *Inquiry into the changes produced on Atmospheric Air*, published in 1807, and *Further Inquiry* in 1811, in which the experiments and observations made by the ingenious author, and collected by him from former writers, are fully and satisfactorily detailed.

Vital heat.

Intimately connected with the function of respiration, is the vital heat of animals. We have already seen that this in reptiles is very low. It appears, however, that, under the ordinary temperature of the atmosphere, the heat of these animals is generally a few degrees above that of the surrounding medium; and while life continues, they have the power of preserving a moderate temperature, and of resisting, to a certain degree, considerably inferior indeed to man and quadrupeds, the extremes of either heat or cold. See Chap. IV.

Voice.

Almost all reptiles utter sounds more or less loud; the salamander and the green lizard being almost the only known exceptions; and it is even not certain whether the former should be entirely excluded. Turtles and tortoises hiss or sigh; crocodiles low or roar, sometimes in so loud a tone as to resemble distant thunder, while the young of these animals are said to make a noise like a cat, (but whether *mewing* or *purring* we are not told), and to utter piercing cries if attacked, when first extruded from the egg. Iguanas make a sort of whistling sound as they run along the trees, and the croaking of frogs and toads is sufficiently known.

The organs of voice in these animals are very simple, consisting of a single *larynx*, without *epiglottis*, but including ligamentous chords of the *glottis*, moved by appropriate muscles. In some species of frogs, especially the males, there are also membranous bags connected with the glottis, or pouches in the cheeks, which, when inflated, serve to increase or modify the sound.

CHAP. VI.

Of Secretion and Excretion in Reptiles.

Organs.

The most important of the secreting organs, which we are to notice in reptiles, are the liver, pancreas, spleen, and urinary organs.

Liver.

The liver of these animals is always large, and in some instances, as in the salamander, its proportional magnitude is very considerable. In the Chelonians it is divided into two rounded irregular lobes, the one occupying the right hypochondrium, and the other connected to the stomach at its small curvature. It is also divided into two lobes in the crocodile and the chameleon; but in the other Saurians, it forms only one lobe, differing in size and figure in the several tribes. In all the Batracians except the salamander, the liver is composed of two lobes.

Gall bladder.

All reptiles have a gall bladder, which is more intimately connected with the liver, but is proportionally smaller than in quadrupeds and birds. In the Chelonians, it is almost wholly concealed in the right lobe of the liver, and is found in a similar situation in crocodiles. There are generally two ducts leading to the intestines; one from the liver, the hepatic duct, and the other, the cystic, from the gall-bladder, and these, in most instances, run separate from each other.

Pancreas.

The position and size of the pancreas are very various. In most of the Chelonians it is triangular, and generally entire. In the crocodile it is divided into lobes. In some of the Batracians, as the frog, it is lodged in the arch of the stomach towards the sternal part of the body; in others, as the salamander, it is situated in the first curve of the intestines. The pancreatic duct is commonly single, but in some instances, as in the Nilotic crocodile, it is double.

Spleen.

The spleen exists in all reptiles; but its structure, form, and situation in these animals, has been very imperfectly investigated. In the Chelonians, it is shaped like the kidney; in the Saurians, it is elongated; in most of the Batracians, as frogs and toads, it is small and spherical, and in the former tribe is situated in the mesentery; while in salamanders it is of an oblong form.

Kidneys.

All reptiles appear to have kidneys; but the structure of these organs is extremely simple and uniform, as they have no distinction of cortical and medullary substance, and no parts corresponding to the *infundibula* and *pelvis* in mammalia. In figure and situation, however, they vary in the several orders. In the Chelonians they are short and thick, and lie far back in the cavity of the abdomen. In the Saurians they are of an oval form, more or less flattened and elongated, and in general they lie far back under the sacrum or near the tail. It is uncertain whether their form varies with age in all these animals; but it appears that in young crocodiles they are entire, while in full grown individuals of the same tribe, they are divided into several lobes. In the Batracians, they are situated pretty far forward and very near each other, and resemble those of the Saurians in form.

Urinary bladder.

All the reptile tribes have not a urinary bladder. It is found in the Chelonians, in whom it is very large, and is more or less divided into two portions. Of the Saurians, only the tupinambis, iguanas, stellios, chameleons, and dragons, have an urinary bladder. It is found in the Batracians, in some of whom it consists of two membranous bags, while in others it is single.

Cloaca.

In reptiles there is a common receptacle or passage for the urine and *fæces*, called *cloaca*; and in those tribes that have no urinary bladder, the ureters, or pipes from the kidneys, open immediately into this receptacle.

Peculiar secretions.

Several secretions of a peculiar nature take place in reptiles. Thus, in the crocodile, there is a gland situated on each side of the lower jaw, just beneath the skin, having a duct opening externally, and secreting a substance that smells like musk; while glands of a similar nature are found in the cayman, near the anus. In several of these animals, as in toads and salamanders, an acrid fluid exudes through numerous pores of the skin when they are irritated. This fluid is not, however, poisonous, as has been supposed; but, among the Saurians, the geckos secrete from between their toes a matter which is really of a venomous nature. See GECKO in the subsequent Part.

CHAP. VII.

Of Integumation in Reptiles.

A CONSIDERABLE variety is found among the reptiles with respect to their integuments; and as these varieties constitute many of the generic and specific characters, it is necessary to examine them with some minuteness.

Cuticle.

In all these animals there is the usual distinction of cuticle, true skin, and *rete mucosum*. The structure of the skin and *rete mucosum* differs but little from that of other animals, except in the frog and toad, where there is this peculiarity, that the skin adheres to the parts beneath only at a few points, so that it forms a sort of loose bag about the animal, susceptible of occasional inflation. The cuticle is extremely various in the different orders and tribes. In the Chelonians, though only the head, tail, and extremities, appear to be covered with skin, yet in reality the whole body within the shell is enveloped with a thin transparent cuticle, capable of being detached in plates. In most of these animals, the cuticle, when exposed, is covered with scales of a horny texture, and differing very much in number, situation and figure. A thin membrane resembling cuticle, also covers the shell of the Chelonians; and in several species, the upper shell, or shield, is covered with a dense and strong membrane resembling leather or parchment. Among the Saurians there is first a cuticle enveloping the true skin, then scales, plates, or tubercles, and over these again another cuticle, as in the Chelonians. In the crocodiles and *Dracæna*, there are strong and broad plates differently shaped and arranged, as we shall see hereafter; in the tupinambes, the scales are disposed in circular rows or transverse bands; in the basilisks, they are diffused over the whole body, while in the lizards again, they are arranged in transverse bands. The Batracians have the epidermis smooth, and in general slimy.

Muscles of the skin.

The Saurians have generally very strong and numerous subcutaneous muscles, especially in the tail; and in most cases, there is an intimate connection or adhesion between these muscles and the skin.

Tortoise shells.

We have already seen that the Chelonians are covered, both on the upper and lower parts of their body, with a strong and hard shell, of which the upper part may be termed the shield, and the lower the breastplate. Each of these is divided into a considerable number of separate plates, united together by their edges, sometimes in a smooth and even manner, at others overlapping each other. A row of these plates lies along the middle of the back over the vertebræ, and these are surrounded on each side by several others, which, together with the vertebral plates, constitute what is called the *disc*. The other plates of the shield, lying between the disc and the breastplate, are called *marginal*, and are generally from twenty-one to twenty-five in number. They are of a more irregular figure than those of the disc, and generally of an oblong form. The shield is more or less convex. The shield and breastplate are united only at their sides, leaving a space at the fore and back parts for the head, tail, and extremities. This shelly covering, in general, resembles the hoofs of quadrupeds in its texture, though in some instances, as in what is called tortoise-shell, it is purer and more transparent than the finest horn.

Change of skin.

The Saurians and Batracians occasionally change the cuticle, throwing off the old, and acquiring a new one. This is particularly the case while they are young, and after leaving their winter quarters. In these animals, the change is not made at once, as in serpents, (see OPHIOLOGY,) but the cuticle is detached in scales or plates, till the whole is thrown off.

CHAP. VIII.

Of Generation in Reptiles.

THERE is no part of the economy of reptiles more curious, none more interesting to the naturalist, than that function by which these animals generate their like. The differences, with respect both to organs and phenomena, which are found in this class, admirably illustrate the observation of a celebrated naturalist, that a systematic arrangement of animals, as well as plants, might be composed merely from a comparison of their generative organs.

Sexes.

A difference of sexes prevails in all reptiles, and the distinction of male and female organs is in most instances very manifest. There is one part of the structure, however, found in both sexes. The *cloaca*, which has been already noticed as forming the common outlet for the urine and fæces, also forms, as in birds, the common receptacle of the external organs, and the outlet for the ova.

Male organs.

All male reptiles have *testes*, but these organs differ in form and situation. In the Chelonians, they lie within the abdominal cavity, (as is the case in all these animals,) contiguous to the kidneys, and united to their inferior or sacral surface. In the Saurians, they lie in front, or on the sternal side of the kidneys, on each side of the vertebral column; and in the Batracians they are situated immediately below the anterior surface of those organs. In the first order, the *testes* are composed of large vascular bundles, disposed in various directions; and the *epididymis* is formed in the usual way, by the convolutions of the vessels, particularly of the seminal duct, or *vas deferens*. It is not certain whether these animals have seminal vesicles. The *testes* of the crocodile are long and narrow, and communicate with two organs that are supposed by some anatomists to be seminal vesicles, and if so, form the only instance of these organs among the reptile tribes. In salamanders, each of the *testes* is divided into two spherical bodies, placed one before the other: and their texture consists, as in all the Batracians, of an agglomeration of small whitish granular bodies, interspersed with blood-vessels.

The *penis* is single in all the Chelonians, and in most of the Saurians. The Batracians have no organ of this kind; but, in some of that order, its place appears to be supplied by a small *papilla* within the *cloaca*. This organ is most remarkable in the Chelonians, in some of whom it is of very considerable length. It is cylindrical, terminates in a point, and has a deep furrow along the whole extent of its upper surface. It is furnished with two retractor muscles, by which it is withdrawn within the cloaca, where it usually lies concealed, and from which it is thrust out in preparing for copulation. In the Saurians, this organ is short, cylindrical, and beset with numerous spiny processes, resembling the bristles of the hedgehog. In the usual state, it is drawn up under the skin of the tail, and, when erected, appears externally at the slit of the *cloaca*.

We must here notice a peculiarity of structure in the males of those reptiles which do not immediately copulate with the female. There are found in these males, during the copulating season, hard brown or blackish *papillæ* or tubercles, attached to the thumb and palm of the fore feet, which assist in grasping the female. These tubercles are found chiefly in the frog and toad. Salamanders have, during the same season, a crest with divided edge upon the back and tail, which afterwards disappears.

Female organs.

The female reptiles have ovaries, and most of them a *uterus*, or an expansion of the oviducts, which answers a similar purpose. The ovaries of the Chelonians resemble those of birds, (see ORNITHOLOGY.) They are two in number, and have each a duct opening into a *uterus*. The *uteri* are thick and fleshy, and have openings by which they communicate with the *cloaca*. The ovaries of the Saurians and Batracians are much alike; but the former contain fewer eggs, and have larger and shorter oviducts. Those of frogs lie below the liver.

A curious structure prevails in the female of the Surinam toad, or *Bufo dorsiger*. The skin of the back in

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this animal is hollowed out into a great number of cells, in which the ova, after being extruded by the female, and fecundated by the male, are placed by the latter; and here they remain enveloped in the skin, which contracts round them till they are hatched, and ready for enjoying a separate existence.

Copulation.

Only the Chelonians and Saurians enter into actual copulation, and this act is different in the two orders. It is not certainly known in what manner the male and female turtles and tortoises perform this act. It is supposed, and even asserted by some, that they unite breastplate to breastplate, while others affirm, that the union takes place in the manner of quadrupeds. We are not disposed to enter into the minutiæ of these reptilian amours, as we do not think them calculated for a work addressed to general readers. Those who wish to gratify their curiosity on this part of comparative physiology, may consult the dissertations of Spallanzani, and the works of Roësel, Swammerdam, and Daudin, already mentioned in our historical notices.

The season of copulation commences early in spring, or as soon as the animals are roused from their winter state of torpor, and seems to return only once a year: it continues for a longer or shorter time, in different orders and tribes, generally longest among the frogs and toads.

Eggs.

All reptiles are properly oviparous, though in one instance, the salamander, the ova are hatched in the oviduct. In most of the tribes, the eggs, though numerous, are laid distinct from each other; and, in that case, they are enveloped either by a calcareous shell, or a membrane resembling parchment. Frogs and toads, however, lay eggs that are connected together in a kind of bunch, and are of a gelatinous consistence, each egg containing in its centre a dark spot, which is the rudiment of the future young, (see Fig. 15.) These connected eggs are extruded gradually by the female, and each is fecundated by the male as it escapes from the cloaca. What may be considered as perfect eggs, which are those of the Chelonians and Saurians, are very similar to those of birds, except that the transparent fluid, which corresponds to the *albumen* in the latter, does not coagulate by heat. The eggs of the Chelonians, and, according to some authors, those of the crocodile, afford good and wholesome nourishment to man.

Plate CCXCV. Fig. 15.

Metamorphosis.

We have said, that the young of the Batracians undergo a *metamorphosis*; and this is not the least interesting part in the physiology of generation in these animals. M. Roësel, in his *Historia Ranarum Nostratium*, has given a minute account, illustrated by figures, of the progress of the common frog, from the time when the egg is first fecundated to the completion of the perfect animal. We shall here present our readers with an abstract of this account.

Progress of the tadpole.

Two days after the ovum is excluded, the central spot is somewhat enlarged, but still spherical, and is enveloped by an immediate albuminous covering, very distinct from the exterior mucilage. In four days, the central germ has assumed the shape of a kidney bean, and its albuminous covering is enlarged. In five days, the kidney-shaped embryo has changed its form to that of a half crescent, though still scarcely increased in size; but the following day it has become longer, thicker, and straighter, and the distinction between the outer and inner mucilage is no longer visible. The head, eyes, and mouth are also now obscurely visible, and there is some appearance of a tail. By the seventh day, the size of the tadpole is increased, and the distinction of head and tail more evident; and there are also visible the rudiments of the fore feet and of the gills. It has now quitted the egg. At the end of nine days, the head and body are enlarged, and the tail considerably lengthened. Soon after this, the *branchiæ* are so much increased as to be distinctly observed; but, about the twentieth day, these appendages are withdrawn below the skin, as no longer necessary; and about four days after, the fore legs, which till now had been almost entirely concealed below the skin, appear externally. The body of the tadpole is still transparent, and its long intestines are seen extending from head to tail, (see Fig. 16.) In a few days after this, the tail gradually disappears; the hind legs are developed; and, in about two months from the first exclusion of the ovum, the animal becomes a perfect frog.

Plate CCXCV. Fig. 16.

The metamorphosis of all the Batracians does not proceed exactly in the manner above described. In particular, the tadpole of the *Rana paradoxa* undergoes such remarkable changes, as to have been mistaken for an animal of a very different class. These will be noticed in a subsequent part of this article. The young of salamanders also differ from the tadpoles of frogs, and have been denominated *larvæ*. They remain four months in the tadpole state.

CHAP. IX.

On Hybernation in Reptiles.

Having, in the preceding Chapters, described the organization of reptiles, and given a comprehensive view of their organic functions, we have only to consider the phenomena that take place in these animals at that season when they begin to lose sense and motion, and sink into a state of torpor.

Effects of heat and cold.

If we except the insect tribes, there are no animals to whom heat appears more necessary for enabling them to exercise their functions with vigour and activity than reptiles. We shall find presently, that by far the greater number of the species are natives of the torrid zone, and indeed the few which inhabit these colder regions are comparatively lifeless and inactive. The heat of the sun seems to increase not only their vivacity and agility, but their sensibility. Cold produces the contrary effects; and when this takes place in any considerable degree, they become listless and inactive, and would probably perish, if they did not seek for refuge in some situation where they are in some measure sheltered from the cold in its extreme degree. Accordingly, we find that, on the approach of winter, these animals betake themselves to some retreat corresponding to their natural situation. Turtles and fresh water tortoises imbed themselves in the muddy or the sandy bottoms of lakes and rivers, while land tortoises make an excavation in the earth, and there find a temporary grave. Crocodiles, and those other Saurians which resemble them in their usual habitation, find retreats in sand-banks; while others, especially the Batracians, retire to crevices of walls, cavities of stones, clefts of trees, and caverns of mountains; while a few seek a precarious continuance of warmth by creeping into dunghills. In these retreats, where they can no longer find their accustomed prey, they gradually sink into a state of insensibility, and appear in a profound sleep, scarcely to be distinguished from actual death.

Phenomena of hybernation.

As this torpidity approaches, their circulation becomes languid, their respiration is extremely slow, their appetite for food appears to cease, and their temperature sinks below its natural standard. So complete is their want of sensation, that they may be cut, torn, and in some cases broken to pieces, without expressing the least degree of pain, or showing any signs of motion.

In this state they continue generally during the whole winter; and, as the genial heat of the spring returns, or in those climates where the changes of season are not so remarkable, when the analogous revolution of the season takes place, the animal begins to shew signs of returning life, gradually recovers sense and motion, its heart beats with a gradually increased velocity, its respiration becomes more frequent and regular, its temperature increases, it quits its retreat, resumes its ordinary functions, searches after prey, and seeks a mate.

It is remarkable that this hybernation of reptiles is not confined to those species which inhabit a cold or temperate region, but seems to extend even to the hotter climates of Barbary, Egypt, and South America. It is also worthy of remark, that this continued state of torpor, unlike the winter sleep of bears, marmots, and other hybernating quadrupeds, does not produce any very evident emaciation or loss of weight in the torpid animal. Land tortoises have been repeatedly weighed just before retiring to their winter quarters, and after emerging from them, and were found in some cases not to have lost above two ounces.

It is found that when some of these animals, as tortoises, in a state of domestication, are taken from their winter retreat, and exposed to a more elevated temperature, they recover, in some degree, their sense and motion, though they scarcely ever take food during this period. We have known a land tortoise kept in a room where there was almost a constant fire, lie for several weeks together in the box that formed its retreat, without making any attempt to come out, and though when taken from the box, it opened its eyes, moved its head, and sometimes walked a little, it could not be prevailed upon to eat till its usual period of hybernation was completed. The person with whom it lived, with officious kindness, would sometimes force a little broth or soup into its mouth; but the animal never showed any desire to eat of its own accord. See HYBERNATION.

PART II. CLASSIFICATION AND NATURAL HISTORY OF THE SPECIES.

ORDER I. CHELONIAN REPTILES.

CHELONIANS.

WE have seen that most of this order, comprehending the animals called turtles and tortoises, are inclosed within a horny covering, consisting of two parts, one covering the back, and usually called the *shield*; the other supplying the place of a sternum, and called the *breastplate*. Each of these is composed of numerous *plates*; those of the shield being most numerous, and divided into those of the *disc*, or middle part, and those of the margin. The plates of the *disc* are generally thirteen in number; and those which are ranged along the back from head to tail, are denominated *vertebral* plates. The plates of the margin vary in the different species from 21 to 25. There are several terms applicable to these plates, which occur in the following characters, and therefore require explanation here. When the plates rise in a ridge in the middle, they are said to be *carinated*; when they have depressions in the contrary direction, they are *furrowed*; when they are uniformly highest in the centre, they are *convex* or *subconvex*, according to the degree of elevation; when they lie upon each other like tiles or slates upon a roof, they are *imbricated*; when they are notched about the edge like the teeth of a saw, they are *serrated*.

The shield and breastplate of these animals are more or less firmly united together at the edges, leaving openings for the head, legs, and tail. Some species have the power of withdrawing all these parts within the shell, where they lie as if shut up in a box, safe from the attacks of almost every animal but man.

The legs of these animals are very short, but so strong, that one of the larger turtles has been known to walk with apparent ease, while several men stood on its back. In their motions they are slow and awkward, and, with very few exceptions, they are inoffensive, and submit, without resistance, to the most cruel treatment. They pass the winter in a torpid state.

GENUS I. CHELONIA. TURTLES.

Chelonia.

The feet flattened, so as to resemble the broad part of an oar; the toes of unequal length, united together so as to form a broad expanded surface, with flat nails inserted into its margin.

The *Cheloniæ* comprise the largest species of this order; some having been found that weighed seven or eight hundred pounds. They are inhabitants of the ocean, and feed partly on fuci or sea-weeds, and partly on the mollusca and other small sea-animals that harbour among these submarine plants. The eggs of all the species, and the flesh of most of them, afford a delicious repast even to the epicure.

Of this genus only six species are distinctly marked by naturalists, though it is understood that Schoepff, the Prussian naturalist, was acquainted with eight. These six species may be thus distinguished.

Mydas. PLATE CCXCVI. Fig. 1.

SPECIES 1. *Chelonia mydas*. Green turtle. Plates of the shield neither imbricated nor carinated, in number thirty; four feet, furnished with two nails. See Plate CCXCVI. Fig. 1.

La Tortue Franche. Daudin, *Hist. Nat. des Reptiles*, par Sonnini, i. p. 10. Lacepede *Hist. Nat. des Quad. Ovip.* i. Art. 1. (Translation by Kerr.)

Testudo mydas, Linn. *Syst. Nat.* a Gmelin, p. 1037. Schoepff, *Hist. Nat. Testudinum*, p. 73. pl. xvii. fig. 2.

Green turtle, Shaw, *General Zoology*, iii. pl. xxii.

Rugosa.

2. *C. rugosa*. Wrinkled T. Plates marked with three transverse black furrows; body of the shield chesnut-coloured, with a yellow margin.

T. ridée, Daudin, i. p. 37.

Caretta.

3. *C. caretta*. Caret, or Hawksbill T. Shell elliptical, subcarinated, serrated; dorsal plates 30, imbricated.

T. caret, Daudin, i. p. 39. Lacepede, i. Art. 5.

T. imbricata, Linn. a Gmelin, p. 1036. Schoepff, p. 83. pl. xviii.

Imbricated turtle, Shaw, iii. 89. pl. 26. xxvi.

Cepediana.

4. *C. cepediana*. Cepedian T. Feet thin shaped, furnished with one nail; plates of the breastplate 14.

T. cépédienne, Daudin, i. p. 49.

Caouanna.

5. *C. caouanna*. Loggerhead T. Shell ovato-cordate, serrated; plates of the disc 15; vertebral plates gibbous behind.

T. caouanne, Daudin, i. p. 54. Lacepede, i. art. 3.

T. caretta, Linn. a Gmelin, 1038. Schoepff, p. 67. pl. xvi.

Loggerhead turtle, Shaw, iii. pl. 23, 24, 25.

Coriacea.

6. *C. Coriacea.* Coriaceous T. Body not shelled, but covered with a leathery coat plaited longitudinally; feet fin-shaped.

T. luth, Daudin, i. p. 62. Lacepede, i. art. 6.

T. ferox, Linn. a Gmelin, 1036.

Soft-shelled turtle, Pennant, *Phil. Trans.* lxi. 275.

Spinous tortoise? *British Zoology,* vol. iv. p. 1.

Coriaceous turtle. Shaw, iii. p. 77. pl. 21.

Of these six species, we shall notice the first, third, fifth, and sixth more particularly.

Green Turtle.

Species 1. *Chelonia mydas.* Esculent, or green turtle.

Of all the Chelonian reptiles, this is deservedly held in the highest esteem, from the very nourishing and palatable food which it affords to the human race. It is also one of the largest of these tribes, and is not less interesting from its habits and manners, than from its utility as an article of diet.

A full grown turtle often measures six or seven feet in length from the nose to the tip of its short tail, three or four feet in breadth, and nearly as much in thickness at the middle of the body. It sometimes weighs eight hundred pounds. The body appears of an oval form, and the head is of considerable size in proportion to the body. The tail is short and thick. The feet are long, and much better adapted to the action of swimming than that of walking. The head, feet, and tail, are covered with scales. The breast-plate is shorter than the shield, and has twenty-three or twenty-four plates disposed in four rows. The prevailing colour of this turtle's shell, when in its usual situation, is bright brown, with spots of a yellow colour; and when the shell becomes dry, the brown assumes a darker hue.

This species frequents the coasts both of the islands and continents of the intra-tropical regions, and is found in great abundance both in the East and West Indies. It sometimes enters the mouths of large rivers, and occasionally goes to some distance from the shore into the sheltered woody parts of the country. It swims with great facility, keeping its head and part of its shell above the surface of the water; but when it fears the approach of danger, or seeks its prey among the rocks, it dives to the bottom, and may be seen browsing at its ease among the weeds. It is said, however, that it does not dive very readily, as the specific gravity of its body but little exceeds that of the salt water. When it quits the water, its motion on the land is rather a scramble than a walk, and resembles that of seals and walruses among quadrupeds, except that it is much slower.

The great purpose for which turtles go on shore, is to deposit their eggs in the sand. This process is generally begun in the month of April, and takes up several weeks, as the eggs are laid at intervals of about fourteen days. When preparing to lay her eggs, the female turtle digs a hole about two feet deep, a little above high water mark, and into this cavity she drops about a hundred eggs at one time. While thus employed, her attention is so completely taken up with the business for which she has come ashore, that a person may easily approach her from behind, and catch the eggs as they are let fall; but if disturbed before she begins to lay, she quits the place, and seeks a more secluded spot. After having deposited all the eggs which she is to lay at one time, she scratches the sand over them, and leaves them to be hatched by the heat of the sun. The eggs of this species are round, about the size of a tennis ball, and covered with a white skin resembling parchment. It is said that that part of turtles eggs which is analogous to the albumen or white in the eggs of birds, does not coagulate by the heat of boiling water.

As the female turtle lays her eggs at three or four times, with intervals of about a fortnight, the young are of course hatched at different periods, the eggs of each laying requiring about three weeks before the young are ready for extrusion. The little animals are of the same shape with their parent, but have only a soft covering instead of a shell. As soon as they are released from their confinement, they make directly for the water; and though this be sometimes at a considerable distance, they shape their course towards it in a straight direction. But a small proportion of them, however, in general, reach their natural habitation. Great numbers of them are seized by various predacious animals, especially cormorants and other large birds, which hover about the shore from May to September, for the purpose of seizing such a desirable prize.

The individuals of this species are often found collected into numerous groups, though it does not appear that they have much enjoyment of a social intercourse, but are rather attracted to the same place by the abundance of their natural food which it affords. During the coupling season, the male and female seem warmly attached to each other, and are said to continue their connubial embraces for near a fortnight together.

To what age the green turtle is capable of living, were it to remain unmolested, cannot be ascertained; but it is conjectured by those naturalists who suppose the age of an animal to depend on its size, and the number of years required for attaining its full growth, that this species must live for at least a century. We shall see hereafter that this is no uncommon age for species of a much more diminutive size.

Even in the time of Pliny, the taking of turtles for the tables of the great was practised in the East Indies; and if we may credit the accounts of Ælian and Diodorus Siculus, the barbarous nations of the East were accustomed to employ the shields of the largest individuals as canoes. It is believed that it is only within these hundred years that turtles have been imported into Europe for the purposes of food.

Various methods are resorted to in different countries for catching turtles. A very common mode is, to watch them as they go on shore, or return, during the season of laying their eggs, when they are easily arrested; and, by the united force of several persons, are turned on their backs, a position from which they find it extremely difficult to escape. Several individuals are thus turned, and when a sufficient number has been thus partly secured, they are dragged away by ropes, and carried in boats to their place of destination. This is the method practised by the inhabitants of the Bahama islands, and is often employed with success by sailors, while touching at the islands between the tropics during their long voyages. Turtles are also taken while swimming in the sea. Some fishers of great dexterity dive for such as they see at the bottom, in the shallows, and getting on their backs, press down the hind part, and raise the fore part of their body, so as to compel them to rise to the surface, where an assistant is ready to slip a noose over the head, and thus secure the captured animal. The most common mode, however, of catching turtles out at sea, is by means of a kind of spear, or harpoon, with a long wooden shaft, to which the head of the spear is but loosely attached. This kind of fishing, as it is termed, is generally carried on by two men in a small light boat or canoe. One of those persons manages the boat, while the other stands ready to dart the spear into the back of his destined victim. It is not long before a turtle is seen either swimming at the surface, or, what is more usual, feeding at the bottom, where the water is about a fathom deep. Sometimes the animal discovers the approach of his enemies, and endeavours to escape; but the men paddle after him, and generally contrive to tire him out in about half an hour's chace. The spearman then hurls his weapon, the head of which, from the peculiar construction of the instrument, generally sticks fast in the shell, while its attachment to the shaft is secured by a long string. The animal thus wounded again, makes off, unless he has been so much fatigued in the chace, as to be incapable of further exertion. In either case, he soon becomes an easy prey to his pursuers.

It is only for its flesh that this species is so much esteemed, its shell being of no use. In many of the West India islands, turtles are exposed in the open market, and a turtle-steak is there as common as a beef-steak in Britain. The flesh of the turtle is extremely nutritious, and is considered an excellent restorative in cases of debility and emaciation.

Hawksbill turtle.

Sp. 3. Chelonia caretta. The imbricated or hawksbill turtle.

This species, though of considerable size, is much less than the preceding, the largest individuals seldom weighing more than three or four hundred pounds. The shield is of an oval and almost heart-shaped form, slightly sinuated before, and narrowest behind. The disk is covered with thirteen plates, that are two or three lines thick, of a smooth surface, nearly transparent, lying over each other like tiles upon a roof. The five vertebral plates are of unequal size and figure, though each is ridged longitudinally in the middle. That nearest the head is very large and quadrangular, with a semicircular margin anteriorly. The three next plates are hexagonal, and have their greatest length across the body. The fifth is pentagonal, with one angle directed backwards, and a little prolonged towards the tail. The eight lateral plates are very large, and of an irregular pentagonal figure. There are twenty-five marginal plates, which are so much imbricated as to give the sides of the animal a serrated appearance. The colour of all these plates is generally black, with irregular transparent shades of red or yellow; all of them together sometimes weigh from four to eight pounds.

We have been thus particular in describing the plates of this species, because they constitute its most valuable product. They form what in Europe is denominated *tortoise-shell,* which, by the inhabitants of the West Indies, is more properly called *turtle-shell.* The head and neck of the caret turtle are considerably longer than those of the green turtle; and the upper mandible projects so much over the lower, as to give the snout a distant resemblance to the bill of a bird of prey, whence English sailors have given it the name of hawksbill.

This species is found in the Asiatic seas, and on the Atlantic coasts of America; but is said not to be met with in the South Sea.

Though so much smaller than the green turtle, the hawksbill possesses considerable strength; and when attacked, defends itself with much ferocity, giving very severe and painful bites. It is also more difficult to secure, as its shield is more convex, and its feet longer than those of the first species; so that when turned on its back, it more readily regains its natural position. The female begins to lay her eggs in May, and continues with intervals till July. She is said not to deposit them in fine sand, but in gravel mixed with shells. The young of this species very nearly resemble those of the former.

The eggs of the hawksbill turtle are esteemed very delicious; but its flesh is unwholesome, and affects those who eat of it with fever and dysentery. It is almost entirely for the plates of tortoise-shell that it is made an object of search.

The use of tortoise-shell was known to the ancients, but it is only in modern times that the manufacture of it has been brought to perfection. In selecting the plates, those are preferred which are thick, clear, and transparent, and variegated with dark-brown, golden-yellow, red, and white. In preparing them for use, the plates are softened in warm water, and then reduced to the desired shape, by pressing them in warm iron moulds. After they are cooled, they are taken from the mould, smoothed and polished. For the purposes of inlaying in cabinet work, the moistened plates are pressed perfectly flat, and kept in that state till cool and dry. It is usual to place below them metallic leaves of such a colour as it is wished should appear through the transparent part of the shell.

Loggerhead turtle.

Sp. 5. Chelonia caouanna. Loggerhead, or Mediterranean turtle.

This has been sometimes confounded with the last species, under the name of *caret,* but Lacepede restricted this name to the hawksbill, in which he has been followed by succeeding naturalists.

This is a very large species of turtle, and is said by Lacepede even to exceed the green turtle in size. Its head is much larger in proportion than that of either of the former species. The mouth, and especially the upper mandible, is also of considerable size. The neck is thick, and covered with a loose wrinkled skin, thinly beset with horny scales. The shield is of an oval form, narrowest behind. It is of a yellow colour, with black spots. The legs, especially the fore legs, are proportionally longer than in many other species; and both the fore and hind feet are furnished with two sharp claws.

The individuals of this species are most abundant in the tropical seas, especially about the West India islands; but they are also found in the Mediterranean, particularly on the coasts of Sicily and Sardinia.

In its manners, this is one of the fiercest of the Chelonian tribe; it defends itself with great courage and activity, both with its mouth and claws, and has been known to snap a moderate sized walking-stick with a single stroke of its jaws. It appears to be the most predacious of all the turtles, not only feeding on shell-fish of considerable size, the habitations of which it easily breaks with its strong mandibles, but attacking the young crocodiles, seizing them by the tail as they retire backwards into the water. Thus these animals instinctively perform an act of retributive justice. The older crocodiles make a prey of the eggs and young of those turtles which inhabit the shores to which they resort, and the turtles in return seize on the young crocodiles while they are too weak to defend themselves.

The loggerhead turtle wanders very far from land. It has been seen apparently sleeping on the surface of the ocean, about midway between the Azores and Bahama islands, at a distance of many hundred miles from land. The female lays her eggs in the sand.

The flesh of this species is coarse and rank, and eaten only by the lowest classes of the people. Its body, however, affords a considerable quantity of oil, which is used for burning in lamps, and dressing leather. The plates of its shell are too thin for most purposes, but have been employed in cabinet-work.

An individual of this species, which was caught on the coast of Provence in France, was kept by Rondelet. It emitted a confused kind of noise resembling sighing.

M. Daudin reckons as varieties of this species, the *Nasicorne* of Lacepede, the Box tortoise of Catesby, the Thickheaded tortoise of Dampier, and the *Testudo macropus* of Walbaume.

Coriaceous Turtle.

Sp. 6. *Chelonia coriacea*, coriaceous turtle.

We notice this species here, only for the purpose of remarking, that it is sometimes confounded with the first species of the next tribe. The distinguishing characters of both will be considered more properly in a subsequent page.

GENUS II. TESTUDO. TORTOISES.

Testudo Genus.

THE *Tortoises*, under which we include the *Emydes*, *Chelydes*, and *Testudines* of Dumeril, have all the toes furnished with claws, but not distinct in all species, some having them separate, while in others the distinction is marked only by the projecting claws. The shell is generally hard and horny, but in a few species it is of a soft consistence. The tortoises feed partly on vegetables, and partly on insects, worms, snails, and similar small animals Some of them reside on the borders of lakes and rivers; others live entirely on land. There are about 52 species, which may be divided into two Sections, according as they live most commonly on water or on land.

SECT. I. *Fresh-water Tortoises.*

These have the toes distinct, and generally terminated by crooked claws In some species the toes are entirely separate; in others they are more or less connected by membranes, or the feet are palmated. They live in or near fresh water, but walk easily on land. Of this Section there are about 36 species, distinguished by the following names and characters.

Ferox.

SPECIES 1. *Testudo Ferox*. Fierce or soft tortoise. Shell ovate, brown, leathery, tuberculated before and behind; three toes, furnished with nails; muzzle prominent, cylindrical.

T. Ferox, Pennant, *Phil. Trans.* vol. lxi. p. 266. Linn. a Gmelin, p. 1039. Schoepff, *Hist. Testud.* p. 88. pl. xix.

La Tortue de Pennant, Daudin, i. p. 69. pl. xviii. fig. 2.

Fierce T. Shaw, iii. p. 64. pl. xvii.

La Tortue Molle, Lacepede, i. art. xiv.

Le Trionyx de Georgie, Geoffroy, *Ann. de Mus.* xiv. p. 17.[*]

Euphratica.

2. *T. Euphratica*, Euphratian T. Shield of an obscure green, leathery, not tuberculated; breastplate white and smooth.

La T. de l'Euphrate, Daud. i. p. 305.

Le Trionyx de l'Euphrate, Geoff. *Ann.* xiv. p. 17.

Bartrami.

3. *T. bartrami.* Cirrhated T. Shell soft; feet five-toed, all the toes nailed; nose elongated, and furnished with retractile cirrhi.

La Tortue de Bartram, Daud. i. p. 74.

Testudo Verrucosa Bartrami, Schoepff, p. 90.

Rostrata.

4. *T. rostrata.* Beaked T. Shell orbiculo-ovate, leathery, carinated, rough, streaked with oblique furrows from elevated points; nose cylindrical; three toes, furnished with claws.

La tortue a bec, Daud. i. p. 77.

T. rostrata, Schoepff, p. 93. pl. xx.

T. membranacea, Linn. a Gmelin.

Le trionyx de carène, Geoff *Ann.* xiv. p. 14.

Granulata.

5. *T. granulata.* Shagreen T. Plates of the shield granulated, naked, hard; breastplate and margin of the shield cartilaginous.

La tortue chagrinée, Daud. i. p. 81. Lacepede, i. art. xxiv.

Le trionyx de Coromandel, Geoff. *Ann.* xiv. p. 16.

Matamata.

6. *T. matamata.* Matamata T. Shell oval, subconvex, triply carinated; feet subdigitated; nose cylindrical, lengthened into a proboscis; neck fimbriated on each side.

La tortue matamata, Daud. i. p. 86. pl. xx. fig. 1.

T. fimbriata, Schoepff, p. 97. pl. xxi. Linn. a Gmelin.

Fimbriated T. Shaw, iii. p. 70. pl. xviii.

Chelys fimbriata,[†] Dumeril, *Zoolog. Analyt.*

Bispinosa.

7. *T. bispinosa.* Two-spined T. Dorsal plates 13, elongated, posteriorly subimbricated, wrinkled, acutely carinated; two of the marginal plates above the tail acutely two-forked.

La tortue double epine, Daud. i. p. 94.

Serpentina.

8 *T. serpentina.* Serpentine T. Dorsal plates subcarinated behind; shield marked behind with five or six tooth-like processes; feet digitated.

La tortue serpentine, Daud. i. p. 98. pl. xx. fig. 2. Lacepede, i. art x.

T. serpentina, Linn. a Gmelin, p. 1042. Schoepff, p 28. pl. vi.

Snake tortoise, Shaw, iii. pl. xix.

Spengleri.

9 *T. spengleri.* Spenglerian T. Shield yellow, subcarinated, posteriorly six-toothed; scales imbricated.

La tortue spenglerienne, Daud i. p. 103.

Testudo spengleri, Linn. a Gmelin, p. 1043.

Flava.

10. *T. flava.* Yellow T. Shield of a blackish-brown colour, with yellow dots and lines radiated on each plate.

La tortue jaune, Daud. i. p. 107. Lacepede, i. art. xiii.

T. orbicularis, Linn. a Gmelin, p. 1039.

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[*] This and the other Testudines, which agree in having the shield more or less coriaceous or cartilaginous, have been lately arranged under a new genus by M. Geoffroy St Hilaire, under the name of *Trionyx*, so called from their having but three claws on each foot. Of this tribe he characterizes eight species, four of which we have noticed in the list as synonymes. The rest are as follow.

1. *Tr. subplanus.* Le Trionyx Aplati. *Ann. de Mus.* xiv. p. 11.
2. *Tr. Egyptiacus.* Le Tr. d'Egypte, p. 12.
   The same with the *Testudo triunguis* of Gmelin.
3. *Tr. stellatus.* Le Tr. etoilé, p. 13.
   The *Tr. cartilagineus* of Gmelin.
4. *Tr. Javanicus.* Le Tr. de Java, p. 15.

[†] This singular animal has occasioned the introduction of a new genus (*Chelys*) in the modern French arrangement; a nicety of distinction which we have not at present ventured to adopt. Of this genus M. Geoffroy reckons two species, and thinks there may be three. See *Ann. de Mus.* xiv. p. 18.

T. Europæa, Schoepff, p. i. pl. i.

Speckled T. Shaw, iii. p. 30.

Lutaria.

11. *T. lutaria.* Mud tortoise. Shield of a uniform dark brown colour; fibular or outermost toe of the hind feet without claw.

La tortue bourbeuse, Daud. i. p. 115. Lacepede, i. art. vii.

T. lutaria, Linn. a Gmelin, p. 1040.

Mud tortoise, Shaw, iii. p. 32. pl. 6.

Caspica.

12. *T. caspica.* Caspian T. Shell orbicular; five nails on the fore-feet, and four on the hind; head scaly; no tail.

La tortue caspienne, Daud. i. p. 124.

T. caspica, Linn. a Gmel. p. 1041.

Melanocephala.

13. *T. melanocephala.* Blackheaded T. Shell chesnut-coloured; head and feet black; tail short.

La tortue a tête noire, Daud. i. p. 128.

Scabra.

14. *T. scabra.* Rough T. Upper part of the shield rough, yellowish, irregularly spotted and striped with brown; marginal plates 25; feet palmated; one hind toe without claw.

La tortue raboteuse, Daud. i. p. 129. Lacepede, i. art. xviii.

T. scabra, Linn. a Gmel. p. 1040.

Subrufa.

15. *T. subrufa.* Reddish or brown T. Shell chesnut-coloured; plates of the disk flattened, smooth in the middle, streaked on the margin; plates of the breastplate 13; all the feet five-clawed.

La tortue roussâtre, Daud. i. p. 132. Lacepede, i. art. xxv.

Verrucosa.

16. *T. verrucosa.* Warty T. Shell covered with warty prominences; notched round the margin; all the feet four-clawed.

La tortue a verrues, Daud. i. p. 134.

T. verrucosa, Walbaum, *Chelonograph*, p. 116.

T. scabra, Linn. a Gmelin, p. 1040.

Galeata.

17. *T. Galeata.* Helmeted tortoise. Shell oval, depressed; three dorsal intermediate plates, acutely carinated; marginal plates 24; head plated; lower mandible furnished with filiform cirrhi.

La tortue a casque, Daud. i. p. 136.

T. galeata, Schoepff, p. 12. pl. iii. fig. 1.

Galeated T. Shaw, iii. p. 57. pl. xii.

Scripta.

18. *T. scripta.* Manuscript T. Shell orbicular, depressed; plates marked above with characters; marginal plates 25, spotted on the lower part.

La tortue ecrite, Daud. i. p. 140.

T. scripta, Schoepff, p. 16 pl. iii. fig. 4. and 5.

Lettered T. Shaw, iii. p. 57. pl. xii.

Porphyrea.

19. *T. porphyrea.* Porphyry T. Shell of an ochry red colour, scantily spotted with obscure green and brown; four squamous tubercles at the anus.

La tortue porphyrée, Daud. i. p. 142.

Reticulata.

20. *T. reticulata.* Reticulated T. Shield streaked and reticulated with black and brown, with yellowish lines in the middle of the plates; marginal plates not toothed, three spotted at the juncture with the breastplate.

La tortue reticulaire, Daud. i. p. 144. pl. xxi. fig. 3.

Serrata.

21. *T. serrata.* Serrated T. Shell marked above with transverse brown and yellow bands; posterior marginal plates not toothed; lateral margin at the juncture of the breastplate five-spotted.

La tortue a bord en scie, Daud. i. p. 148. pl. xxi. fig. 1, 2.

Centrata.

22. *T. centrata.* Concentric T. Dorsal and marginal plates marked with two or four black concentric circles; breastplate yellow, without spots, notched behind.

La tortue a lignes concentriques, Daud. i. p. 153.

Concentric tortoise, Shaw, p. 43. pl. ix.

Punctata.

23. *T. punctata.* Dotted T. Shell oval, moderately convex; dorsal plates and head smooth and black dotted with yellow.

La tortue ponctuée, Daud. i. p. 159. pl. xxii.

T. punctata, Schoepff, p. 25. pl. v.

Spotted T. Shaw, iii. p. 47. pl. x.

Picta.

24. *T. picta.* Painted T. Shield oblong, convex, very smooth; plates nearly square, brown, bordered with yellow; breastplate as long as the shield.

La tortue peinte, Daud. i. p. 164.

T. picta, Linn. a Gmelin, p. 1045. Schoepff, p. 20. pl. iv.

Painted tortoise, Shaw, iii. p. 45. pl. x.

Martinella.

25. *T. martinella.* Martinella T. Shell a little flattened, oval, marked on the back with two longitudinal ridges; plates of the breastplate 13.

La tortue martinelle, Daud. viii. p. 344.

Tricarinata.

26. *T. tricarinata.* Three-ridged T. Shell orbicular; three-ridged, vertebral plates transverse.

La tortue retzienne, Daud. i. p. 174.

T. tricarinata retzii, Schoepff, p. 9. pl. ii.

Tortue a trois carênes, Latreille, *Hist. des Rep.* i. p. 118.

Tricarinated T. Shaw, iii. p. 54. pl. xi.

Scorpioides.

27. *T. scorpioides.* Scorpion T. Shell oval, longitudinally three-ridged; vertebral plates oblong, posteriorly imbricated.

La tortue a trois carênes, Daud. i. p. 178.

La tortue scorpion, Lacepede, i. art. xii.

T. scorpioides, Linn. a Gmelin, p. 1041.

Amboinensis.

28. *T. amboinensis.* Amboyna T. Shield convex, smooth, brown, both it and breastplate bordered with yellow; head compressed, brown, cheeks and beak radiated with yellow; feet palmated.

La tortue d'amboine, Daud. viii. p. 345.

Pennsylvanica.

29. *T. Pennsylvanica.* Pennsylvanian T. Upper part of the shield smooth, uniformly reddish, flattish in the middle; three of the vertebral plates hexagonal, oblong, imbricated behind, the first and fifth being elongated, and nearly triangular; marginal plates 25; tail tipped with a claw.

T. rougeatre, Daud. i. 182. pl. xxiv. Lacepede, i. art. 2.

T. Pennsylvanica, Linn. a Gmel. i. 1042. Schoepff, pl. xxiv. fig. A.

Pennsylvanian T. Shaw, iii. p. 60. pl. xiv.

Odorata.

30. *T. odorata.* Odorous T. Shield smooth, uniformly brownish, flattish in the middle; marginal plates 23; breastplate moveable only in front; tail tipped with a claw.

T. odorante, Daud. 1. 189.

Glutinata.

31. *T. glutinata.* *T. a batans soudées*, Daud. i. 194. This, which is marked by Daudin as a distinct species, seems to be only a variety of the preceding, differing in the immobility of the breastplate.

Subnigra.

32. *T. subnigra.* Blackish T. Shield rounded, convex; plates streaked at the margin, smooth in the middle; vertebral plates carinated; plates of breastplate 13.

T. noiratre, Daud. i. 197. Lacep. i. art. 28.

Virgulata.

33. *T. virgulata.* Striped T. Shell dark brown, with numerous yellow spots; vertebral plates longitudinally carinated.

T. a goutellettes, Daud. i. 201.

Clausa.

34. *T. clausa.* Close T. Shell brownish, striped on the back with yellow; vertebral plates longitudinally subcarinated; middle of the breastplate a little compressed.

T. a baite, Daud. i. 207.

Close tortoise, Shaw, iii. p. 36. pl. vii.

Carolineana.

35. *T. carolineana:* Carolina T. Shell brown bay, marked above with yellow lines and spots; dorsal plates striated; vertebral plates longitudinally carinated, lateral subgibbous.

T. courte-queue, Daud. i. 207. Lacep. i. art. xxv.

T. carolina, Linn. a Gmel. 1041, 1042.

T. clausa, Schoepff, p. 32. pl. vii.

Squamata.

36. *T. squamata.* Scaly T. Shell ovate; body, neck, tail and feet scaly above, smooth and soft below.

T. ecailleuse de Bontius. Daud. i. 216.

T. squamata, Linn. a Gmel. 1040. No. 2.

SECT. II. *Land Tortoises.*

In the species that belong to this section, the toes are not distinct from each other, but are united below the skin into one broad expansion, from the margin of which appear the claws. They however walk, though with a very slow pace, on the ground; and live chiefly on worms and insects. There are 16 species, viz.

Græca.

Species 37. T. græca. Common land T. Shield hemispherical; plates of the disc subconvex, vertebral plates subgibbous; marginal 25, obtuse at the sides; the whole shield black and yellow. See Plate CCXCVI. Fig. 2.

PLATE CCXCVI. *Fig.* 2.

La T. grecque, Daud. i. 218. Lacepede, v. i. p. 1. art. xvi. pl. 8.

Testudo græca, Linn. a Gmelin, p. 1043. Schoepff, p. 38. pl. viii.

Common tortoise, Shaw, iii. p. 9.

Marginata.

38. *T. marginata.* Bordered T. Shield oblong, convex, gibbous; dorsal plates blackish-brown, with a shade of yellow in the middle; marginal 23 or 24, obliquely marked with black and yellow.

T. bordée, Daud. i. 233.

T. marginata, Schoepff, p. 52 pl. ii.

Marginated tortoise, Shaw, iii. p. 17.

Tabulata.

39. *T. tabulata.* Inlaid T. Shield oblong, gibbous; plates of the disc rectangular, subgibbous, furrowed, black, with yellow lines; marginal plates 23, black with yellow below.

T. a marqueterie, Daud. i. 242.

T. tabulata, Linn. a Gmel. 1045.

Tabular tortoise, Shaw, iii. p. 41. pl. viii.

Punctularia.

40. *T. punctularia.* Spotted T. Shell a little flattened, broad, subcarinated; breastplate nearly of the same length with the shield; head black above, spotted with yellow, entirely yellow below. Daud. i. 249.

Polyphemus.

41. *T. polyphemus.* Gopher T. Snout slender and sharp; plates thin, of a greyish ash colour; claws flat and roundish. Daud. i. 256.

T. gopher, Bertram's *Travels*.

Geometrica.

42. *T. geometrica.* Geometrical T. Shell ovate; all the plates elevated, but flat on the top, marked with yellow streaks radiating from a centre in each plate.

T. geometrique, Daud. i. 260. Lacepede, i. art. xvii.

T. geometrica, Linn. a Gmelin, p. 1044. Schoepff, p. 49. pl. x.

Geometrical tortoise. Shaw, iii. p. 20.

Elegans.

43. *T. elegans.* Elegant T. Shell hemispherical; plates furrowed, convex, four-striped, with flat areolæ broader than long.

T. elegante, Daud. i. 266.

T. elegans, Schoepff, p. 111. pl. xxv.

Coui.

44. *T. coui.* Shield round, highly convex; plates furrowed, flattened, with prominent red areolæ; three middle vertebral plates radiated of a deep yellow laterally; lateral plates radiated below.

La Tortue coui, Daud. i. 271. pl. xxvi.

Luteola.

45. *T. luteola.* Yellowish T. Shield rounded, gibbous, yellow, with sub-gibbous plates.

T. luteole, Daud. i. 277.

Indica.

46. *T. indica.* Indian T. Shield convex; anterior marginal plates reflected upwards.

La tortue indienne, Daud. i. 280.

T. indica, Linn. a Gmelin. Schoepff, p. 101. pl. xxii.

Indian tortoise, Shaw, iii. p. 25.

Areolata.

47. *T. areolata.* Areolated T. Shield ovato-oblong, moderately convex; plates nearly square, elevated, deeply furrowed, with rough depressed areolæ.

La T. areolée, Daud. i. 287.

T. areolata, Schoepff, p. 104. pl. xxiii.

Cafra.

48. *T. cafra.* Cafre T. Shield flattish, broad; plates flat, except the last vertebral, which is gibbous; yellow, elegantly sprinkled with black dots; marginal plates of the shield 27.

La T. cafre, Daud. i. 291.

Juvencula.

49. *T. juvencula.* Juvencula T. Shield square oblong, little gibbous, with concave grained areolæ; plates of the disc 13, yellow, with black radiated points; marginal plates 26.

La T. juvencule, Daud. viii. p. 348.

Fasciata.

50. *T. fasciata.* Banded T. Shield brown-bay, with a white transverse band in the plates of the disc; first vertebral plate carinated; marginal plates 27.

La T. a fasciés blanches a Ceilon, Daud. i. p. 294.

Pusilla.

51. *T. pusilla.* Dwarf T. Plates of the shield variegated with black, white, purple, green, and yellow; breastplate white; a red tubercle on the neck.

La T. vermillon, Daud. i. 299. Lacepede i. art. xxii.

T. pusilla, Linn. a Gmelin, p. 1044.

African land tortoise, Edwards' *Gleanings*.

Denticulata.

52 *T. denticulata.* Denticulated T. Shield orbiculate cordate, denticulated at the margin; plates hexagonal; feet four-clawed.

La T. dentilée, Daud. i. p. 303. Lacepede, i. art. xix.

T. denticulata, Linn. a Gmelin, p. 1043.

Denticulated T. Shaw, p. 59. pl. xiii.

Fierce tortoise.

SPECIES 1. *Testudo ferox.* Fierce tortoise.

There are several species of the Chelonian order which have the shield softer than the ordinary shell of most species. This is the case with the 6th species of the former tribe, and with at least four of the present. The coriaceous turtle, or *Luth* of the French writers, and the soft-shelled tortoise of Pennant, though agreeing in the comparative softness of their external covering, differ very materially in general form, habitation, and manners. The coriaceous turtle has an oblong body, covered immediately with a bony shell; but that shell is invested with a tough membranous coat resembling leather, plaited longitudinally, and the shield terminates behind in an acute point, overhanging the tail. The body of the fierce tortoise is rounder and more convex, and the middle part of the shield is hard; but its margin, especially towards the tail, is soft and pliable, resembling thin sole-leather, and the hind part is rounded. The tail of the first species is long, and very thick at the root; that of the second very short and small. The head of the former is small, round, and terminates in a beak, resembling the bill of a bird; that of the latter is proportionally larger and longer, with a long tapering cylindrical snout, having some resemblance to that of the mole. The coriaceous turtle is an inhabitant of the sea, is frequently found in the Mediterranean, and has been seen even on the coast of Britain. The fierce tortoise has yet been found only in the rivers and fresh water lakes of America, especially in Florida and Carolina. The former is a large species, often measuring above seven feet in length; the latter seldom weighs above seventy pounds.

The fierce tortoise frequents lakes and muddy rivers, and hides itself among the water plants that grow at the bottom, from which it is said to spring suddenly on its prey. This consists of small water animals, and, in some places, more particularly of young crocodiles, of which this species is extremely fond. They seize their prey by suddenly darting forward their long and strong neck, which they do with great celerity.

This species is among the strongest and most active of its tribe, and, as its trivial name implies, is possessed of ferocity and courage. When attacked, it boldly defends itself, rising on its hind legs, and leaping forward to seize on its assailant; and if once it fixes with its jaws on any part, it is scarcely made to let go its hold without cutting off its head.

The fierce tortoise forms an excellent article of food, at least not inferior to the green turtle.

Mud tortoise.

Sp. 11. *T. lutaria.* The mud tortoise.

This is one of the smallest of the fresh water tortoises; its whole length, from the snout to the tip of the tail, seldom exceeding eight inches, while in breadth it is not more than three or four. It is of a blackish or dark brown colour. Its tail is nearly half the length of the shield, and is stretched out when the animal walks. Hence the mud tortoise has been sometimes called by the ancients *mus aquatilis,* or water rat.

This is a very frequent inhabitant of lakes and muddy rivers in the south of Europe, and in many parts of Asia. It is very plentiful in France, especially in the provinces of Languedoc and Provence. It lives almost entirely in the water, only going on land to lay its eggs, which it covers with mould. It moves with a quicker pace on land than many of this tribe; when disturbed, it utters a kind of interrupted hissing sound. It feeds on fish, snails, and worms, and often proves a troublesome inmate in fish-ponds, killing many of the fish, and biting others till they are nearly exhausted from loss of blood.

It has been proposed to employ the mud tortoise for destroying vermin in gardens; but it is necessary to have a pond or large vessel of water for its ordinary residence. With such a convenience, it may be rendered tame and domestic.

The young of this species, when first hatched, are not an inch in diameter. They continue to grow for a long time, and are known to live for at least twenty-four years.

Common land tortoise.

Sp. 36. *T. Græca.* Common land tortoise.

Several varieties of tortoise, known both to ancient and modern naturalists, have been described under the name of *Greek;* and, according to Daudin, Schoepff was the first to remedy this confusion, and to mark each by its distinctive characters. The species of which we are now treating seldom exceeds ten inches in length; is of an oval form, with a very convex shield, broader behind than before. The breastplate is nearly of equal size with the shield, and is of a pale yellow colour, with a broad dark stripe down each side, while the middle part of the shield is of a blackish brown, mixed with yellow. The head is small, and covered on its upper part with irregular scales; the mouth is small, the legs short, and the feet pretty broad, and covered with strong ovate scales. The tail is very short, scaly, and terminated at its extremity with a curved horny process. It seldom weighs above three pounds.

Common land tortoise.

This species is entirely confined to the land, and prefers elevated woody situations. It is found in Europe, Asia, and Africa, and is very common on all the coasts of the Mediterranean Sea, especially in Sardinia, Barbary, and probably in Egypt. It is not a little curious, that, even in the warmer climates, this species regularly retires to its subterranean quarters during the winter months; thus proving what we have before remarked, that the hybernation of these animals does not depend solely on the degree of cold. It begins to bury itself in October, and usually makes a hole about two feet below the surface, where it continues till April.

The males of this species are in summer tolerably active, and very fierce towards each other. The female lays her eggs towards the end of June, depositing them in a hole, and covering them with sand or mould. They seldom exceed five in number at one time, and are of a white colour, and about the size of those of a pigeon. They are hatched towards the end of September; and the young, when first extruded, are scarcely bigger than walnut-shells.

The individuals of this species live on roots, fruits, worms, and insects, the shells of which latter they easily break with their strong jaws.*

The land tortoise is often domesticated, especially in gardens. We shall select the account of a tame tortoise, given by the Rev. Mr White of Selborne, as a pleasing specimen of the manners of these animals in a state of captivity. This individual had been in possession of a lady for upwards of thirty years. It regularly retired below ground about the middle of November, and did not emerge till the middle of April. Its appetite was voracious in the middle of summer, but it ate very little in spring and autumn. It seemed greatly alarmed if surprised by a shower of rain during its peregrinations in search of food; and though its shell was so thick that it could scarcely have been injured by the wheel of a loaded cart, it discovered as much solicitude to avoid rain, as a fine lady in her gayest attire, shuffling away on the first sprinklings, and making for some shelter. Whenever the old lady, its mistress, who usually waited on it, came in sight, it always hobbled, with awkward alacrity, towards its benefactress, though to strangers it appeared quite inattentive. It never stirred out after dark; often appeared abroad only for a few hours in the middle of the day; and in wet days never came from its retreat. Though it loved warm weather, it carefully avoided the hot sun, and passed the more sultry hours under the shelter of a large cabbage leaf, or amid the friendly shades of an asparagus bed. Towards autumn, however, he appeared anxious to improve the effect of the

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* We do not remember to have seen, in any author with which we are acquainted, that land tortoises are accustomed to drink. The writer of this article has lately, however, ascertained the fact, that although they can live without drink for years, they swallow liquids with pleasure and avidity when offered to them in the spring. A land tortoise, which has been in the possession of a carpenter at Portobello, near Edinburgh, for above six years, was never known to drink of its own accord till the spring of this year (1816), when it has repeatedly drunk water set before it. Its mode of drinking is peculiar. It puts down its head deep into the fluid, so as to cover even its eyes, and then gradually, and almost imperceptibly, sucks it up, so as to drink some ounces in the course of a quarter of an hour.

faint sunbeams, by getting under the reflection of a wall, and inclining its shell towards the sun. In scraping the ground to form its winter retreat, it dug with its fore feet, and threw up the earth over its back with its hinder feet; but the motion of its legs was so slow, as scarcely to be observed; and though it worked with the greatest assiduity both night and day, it was more than a fortnight before it had completed its inhumation.

How long an animal of this species may live, we cannot determine; but it is known at least, that their age may exceed a century. One of them was introduced into the garden of Lambeth palace in the time of Archbishop Laud, was living a hundred and twenty years afterwards, and died at last rather from the neglect of the gardener than from excessive age.

The land tortoise forms an excellent article of food, though it is scarcely employed for that purpose, except in Greece. The eggs, however, are eaten very commonly in Italy.

Daudin enumerates eight varieties of the Greek tortoise, all of which are of a very diminutive size, and differ chiefly in the surface and variegations of the shield.

Among the numerous fossil remains of an ancient world that have lately been discovered, are several that belong to the tortoise tribes. These have been found at Malta; in the environs of Berlin; in the forest of Leipsic; at Aix in the south of France; in the neighbourhood of Brussels; in the mountains of St Pierre near Maestricht; and in the plaster quarries near Paris. These remains have been described by Faujas de St Fond in his account of the mountain of St Pierre, and by Cuvier in the 14th vol. of the *Annales de Museum*, p. 229. From these accounts we gather, that, besides many species either now extinct, or to us unknown, remains have been found of the *green turtle*, of the *imbricated*, *caretta*, and *coriaceous* turtles; and of at least one species (*T. flava*, or *Europea*) of fresh water tortoises.

ORDER II. SAURIAN REPTILES.

Saurian Order.

Besides what we have said respecting this order, in our general arrangement, p. 5. we may remark, that, in most of the species, there is no sensible neck, or remarkable contraction between the head and body; that they have all a lengthened thorax, protected by the ribs; that their tail is most commonly rounded, though in some tribes it is compressed laterally, then serving the purpose of a fin, being very seldom prehensile. The limbs, which are always short, are in a few instances only two in number. The number of the toes and of their component joints, as well as their form and respective situation, differ considerably. All the species change their skin every spring. Their jaws, though they commonly expand very considerably, never separate from each other at the articulation, as we shall hereafter find to be the case with serpents. They all feed on living animals. Their voice is weak, and resembles a dull hiss or whistle. They copulate, lay eggs covered with a calcareous or membranous shell, which they deposit in the earth or sand, but do not assist in hatching them. They are in general very active and voracious. Most of the species are inhabitants of the warmer climates, few of them being found in the northern countries. It has been remarked, that in this order are found nearly the largest and the smallest of the perfect animals.

FAMILY I. *Sauri Planicaudati.* FLAT-TAILED SAURIANS.

GENUS I. CROCODILUS. CROCODILES.

Crocodile Genus.

In this tribe, the back and belly are covered with large plates; the head is broad and flat; the tongue short, fleshy, and adhering to the lower jaw; the tail very much compressed, and armed above with a serrated crest, at first double, but single towards the tip. They have four strong feet, of which the hinder have five toes, more or less palmated, only three being furnished with nails. All the species are capable of living both in water and on land; they generally inhabit the former, but move with ease upon the latter.

Daudin has enumerated seven species, which he arranges under three Sections, as follows.

SECT. I. *Crocodiles properly so called.*

Snout long and flat; one tooth on each side of the lower jaw, prolonged outwards, and shutting into a groove in the upper jaw. Species.

SPECIES 1. *Crocodilus niloticus.* Nilotic crocodile. Muzzle flat and oblong; fourth tooth of the lower jaw resting against the edge of the upper jaw; six large carinated plates upon the neck. Plate CCXCVI. Fig. 3. Niloticus. Plate CCXCVI. Fig. 3.

Le crocodile de Nil, Daud. ii. p. 367, pl. xxvii. fig. 1.

Le crocodile, Lacepede, i. part ii. art. 1.

Lacerta crocodilus, Linn. a Gmelin, p. 1057.

Common crocodile, Shaw iii. pl. lv. lvi. lvii.

Under this species, Daudin ranks as varieties the crocodile of Senegal, the black crocodile, and the Indian crocodile.

SECT. II. *Gavials.*

Muzzle lengthened, narrow, nearly cylindrical; two teeth at least on each side of the lower jaw, prolonged upwards beside the upper jaw.

Sp. 2. *C. longirostris.* Long-beaked crocodile. Muzzle double the length of the head; both jaws furnished with 27 teeth on each side; four carinated plates, disposed in a square upon the neck. Longirostris.

Le crocodile à long bec, ou le petit gavial, Daud. i. 389.

Sp. 3. *C. Arctirostris.* Narrow-beaked C. Gangetic C. Muzzle narrow, as long as the head; upper jaw furnished with 28 teeth on each side; lower jaw with only 25 on each side; two carinated plates upon the neck. Arctirostris.

Le crocodile à bec etroit, ou le grand gavial, Daud. i. 393. pl. xxvii. fig. 2.

Le gavial, Lacepede, vol. i. part ii. art. 3. pl. xii. fig. 2.

Lacerta gangetica, Linn. a Gmel. p. 1057.

Long-nosed crocodile, Edwards, *Phil. Trans.* xlix. p. 639. pl. xix.

Gangetic crocodile, Shaw, iii. p. 197. pl. lx.

SECT. III. *Caïmans.*

Muzzle broad, flat, and obtuse; the fourth tooth of the lower jaw received into a particular cavity of the upper jaw, by which it is concealed.

Sp. 4. *C. caiman.* Caiman crocodile. Beak flat, a little narrower than the head; jaws furnished with 19 teeth on each side; 14 carinated plates, disposed in five rows upon the neck. Caiman.

Le crocodile caiman, Daud. i. p. 399.

Lacerta alligator, Linn. a Gmel. p. 1058. No. li.

Alligator, Shaw, iii. p. 192. pl. lix.

Sp. 5. *C. yacare.* Yacare C. Muzzle blunt, a little Yacare.

Saurian Reptiles.

elevated; jaws furnished with 19 teeth on each side; two fore teeth of the lower jaw elongated, and passing through the upper jaw. Daud. i. p. 407.

Mississippiensis.

Sp 6. *C. Mississippiensis.* Mississippi C. or alligator. Muzzle broad and flattened; four carinated scales, disposed in a square upon the neck.

Le crocodile du Mississippi, Daud. i. p. 412.

Alligator, or *Florida crocodile*, Bartram's *Travels in South America.*

Latirostris.

Sp. 7. *C. latirostris.* Broad-beaked crocodile Muzzle broad and flattened; jaws furnished with 19 teeth on each side; eight scales, disposed in four pairs upon the neck.

Le crocodile à large museau, Daud. i. p. 417.

Perhaps this may be considered as a variety of the alligator, from which it appears to differ only in the number and disposition of the plates on the neck.

Such is the arrangement of Daudin. We must now notice the classification of Cuvier, as given in the 10th volume of the *Annales de Museum.*

Essential Characters of the Genus.

Tail flattened at the sides; hind feet palmated or semipalmated; tongue fleshy, attached to the floor of the mouth, except at its edge; teeth sharp, simple, ranged in a single row; penis single.

Subgenera and Species, with their essential Characters.

SUBGENUS I. *Alligators.* (Sect. III. Daudin.)

SPECIES 1. *Cr. lucius.* Muzzle parabolic, depressed; scales on the neck four. Native of North America.

2. *Cr. sclerops.* A transverse ridge between the orbits; neck furnished with four bony bands. Native of Guiana and Brasil.

3. *Cr. palpebrosus.* Bony palpebræ; neck furnished with four bony bands.

4. *Cr. trigonatus.* Bony palpebræ; neck furnished with irregular triangular carinated scales.

SUBGENUS II. *Crocodiles.* (Sect. I. Daudin.)

5. *Cr. vulgaris.* Muzzle equal; scales of the neck six; those of the back in sixes, square. Native of Africa.

6. *Cr. biporcatus.* Muzzle furnished with two ridges nearly parallel; plates of the neck six; scales of the back in eights, oval. Native of the Indian islands.

7. *Cr. rhombifer.* Muzzle sub-convex, with two converging ridges; plates of the neck six; scales of the back in sixes, square, those of the limbs thick and carinated.

8. *Cr. galeatus.* Top of the head furnished with a two-toothed elevated crest; plates of the neck six. Native of India beyond the Ganges.

9. *Cr. biscutatus.* Intermediate scales of the back square; outer ones irregular both in form and situation; plates of the neck two.

10. *Cr. acutus.* Intermediate scales of the back square; outer ones irregular; plates of the neck six; muzzle elongated and convex at the base. Native of the Antilles.

SUBGENUS III. *Longirostres, or Gavials.* (Sect. II. Daud.)

11. *Cr. gangeticus.* Top of the head and orbits transverse; two small plates on the neck.

12. *Cr. tenuirostris.* Top of the head and orbits contracted; four small plates on the neck.

M. Geoffroy St Hilaire, in a second Memoir on Crocodiles, in the tenth volume of the *Annales de Museum*, has formed another species of Nilotic crocodile, under the trivial name *Suchos*; but his account of it is not sufficiently precise to determine its specific differences.

Saurian Reptiles.

As we have already, under the article CROCODILE, given a comprehensive account of the three principal species of this tribe, viz. the crocodile of the Nile, the alligator, and the Gangetic crocodile, or *caïman*, we shall at present dispense with any thing more on the natural history of these animals.

GENUS II. DRACÆNA. DRAGON.

DRACÆNA Genus.

In this genus the body is covered with large rounded scales, (those upon the back being carinated,) disposed in transverse bands, and separated by numerous other very small scales that are round and carinated. The head is thick, compressed laterally, and covered at the top with several smooth scales. Some of the teeth in the fore part of the jaws are sharp-pointed, and those behind are broad and flat like the molares of quadrupeds. The tongue is forked at its distal extremity; and the tympanum of the ear is apparent externally of a round form. The lower part of the body is covered with smooth scales, disposed in transverse bands. The tail is covered on that half next the body with plates, which form on its upper part first four, and then two toothed ridges, while the remaining half is covered with rough rhomboidal scales, carinated and imbricated. The four feet are each furnished with five long toes completely separated from each other, and terminated by claws.

Species.

There is only one species, viz.

Guianensis.

SPECIES 1. *Dracæna guianensis.* Guiana dragon.

La Dragone de la Guian, Daud. i. p. 423. pl. xxviii.

La Dragone, Lacepede, vol i. part ii. art. 5. pl. xiii.

Lacerta dracæna, Linn. a Gmelin, p. 1059.

Dracæna lizard, Shaw, iii. p. 218. pl. 67.

See Plate CCXCVI. Fig. 4.

PLATE CCXCVI. Fig. 4.

This animal in many respects resembles the smaller crocodiles, differing from them chiefly in its forked tongue and distinct toes. It is of a reddish-brown colour, shaded with green. It is from two to four feet in length, of which the tail is about one half. This latter organ is very thick at its proximal extremity, tapering gradually towards the point, and is strong and flexible.

The dragon has hitherto been found only in South America, and chiefly in Guiana. It is a land animal, frequents the savannahs and marshy plains; readily climbs trees, and hides itself when in danger from crocodiles or other enemies. Both its flesh and eggs are used as articles of food.

GENUS III. BASILISCUS. BASILISK.

BASILISCUS Genus.

The body in this tribe is thicker in proportion to its length than many of the order, and its whole surface, as well as that of the head, neck, tail, and limbs, is covered with small scales that are generally rhomboidal, and a little carinated. The head is short and pretty thick, especially towards the back part; the tongue broad, thick, flat, rounded at its tip, not extensile, and almost wholly attached within the lower jaw. The throat is susceptible of inflation. The tail is long, very much compressed laterally, and surmounted at least along its anterior half, with a high vertical crest that is radiated, capable of being folded together, and scaly.

The feet are rather thick and long, and furnished each with five toes, terminating in claws.

There are two species, viz.

Species.

Mitratus.

PLATE CCXCVI. Fig 5.

Species 1. *Basiliscus mitratus.* Mitred basilisk. Tail long and pointed; back of the head surmounted with a very high mitre-shaped membrane. See Plate CCXCVI. Fig. 5.

Le Basilic proprement dit, ou a capuchon, Daud. iii. p. 310. pl. xlii.

Le Basilic, Lacepede, vol. i. part ii. art. 14.

Lacerta basiliscus, Linn. a Gmelin, 1062.

Amboinensis.

2. *B. amboinensis.* Amboina B. Tail long; head naked, dorsal crest pectinated.

Le B. porte-crête d'Amboine, Daud. iii. p. 322.

Le porte-crête, Lacepede, vol. i. part ii. art. 15.

Lacerta amboinensis, Linn. a Gmelin, p. 1064.

The animals above characterised, though singular in their external appearance, have nothing of the terrible aspect and deadly properties of the basilisk, so renowned among the writers of antiquity. See BASILISK. They are harmless inoffensive creatures, enlivening the woods of America and Asia with their active motions. Assisted by the crest on their back and tail, they leap with agility from branch to branch, though they have no pretensions to flying, as was supposed by Seba. It is not certain whether they frequent the water, but if they do, their crested membranes must act as fins.

GENUS IV. TUPINAMBIS.

TUPINAMBIS Genus.

The animals of this tribe have the back and belly covered with small scales disposed in transverse lines. The head is covered with numerous small scales, and, as well as the neck, is long and thin. The tongue is long, extensile, and forked. The body is long and slender, but of a robust make. The tail is very long, and taper; rounded at its base, slightly verticillated, or ringed, furnished with a very small double ridge in some species, but smooth in others. The feet are strong, and have each five toes separated and furnished with claws.

The tupinambes are very active, live both on land and in the water, feed on insects, snails, and worms, and sometimes on wood mice, fruits, and fishes. The larger species seek greedily after the eggs of crocodiles, although they carefully avoid the young of those animals, which, in their turn, prey on the tupinambes. They are all natives of warm climates, and are found chiefly in South America, Egypt, and the East Indies.

Daudin has characterised fourteen species, which he distributes under two Sections as follows:

SECT. I. *Tupinambes with the Tail compressed and simple.*

Monitor.

Species 1. *Tupinambis monitor.* Safeguard tupinambis. Head covered with pretty large scales; back black, with four longitudinal lines and transverse white bands, irregularly disposed; belly whitish, with black shades; tail very little compressed.

Le Tupinambis proprement dit, ou Sauvegard, Daud. iii. p. 20.

Le Tupinambis, Lacep. i. part ii. art. 6. pl. xiii. fig. 2.

Lacerta monitor, Linn. a Gmelin, p. 1059.

Monitory lizard, Shaw, iii. p. 214. pl. lxvi.

Elegans.

2. *T. elegans.* Elegant T. Brownish with white concentric lines above the head and neck, nine transverse bands of round white spots upon the back; the belly white with interrupted transverse brown lines; tail very much compressed.

Le T. elegans, Daud. iii. p. 36.

Cepedianus.

3. *T. cepedianus.* Cepedian T. Brownish above, with from 23 to 24 transverse rows of spots; white on the fore part of the body, and black on the hinder; whitish below, with interrupted transverse brown lines.

Le T. cepedian, Daud. iii. p. 43. pl. xxix.

Indicus.

4. *T. indicus.* Indian T. Black above, with confusedly scattered white dots.

Le T. indien, Daud. iii. p. 46. pl. xxx.

Maculatus.

5. *T. maculatus.* Spotted T. Black above, irregularly marked with transverse bands, and seven longitudinal rows of greenish spots on the upper part; neck plaited below; tail half the length of the body.

Le T. a taches vertes, Daud. iii. p. 48.

Griseus.

6. *T. griseus.* Gray T. Yellowish-gray without spots, paler below; scales nearly hexagonal, granulated on their margin; tail nearly cylindrical, and as long as the body.

Le T. gris d'Egypte, Daud. viii. p. 352.

SECT. II. *Tupinambes having the Tail surmounted with a small double Crest, slightly serrated.*

Stellatus.

7. *T. stellatus.* Stellated T. Blackish-brown above, with transverse bands of small whitish circular spots, interspersed with whitish dots; tail long.

Le T. etoilé d'Afrique, Daud. iii. p. 59. pl. xxxi.

Niloticus.

8. *T. niloticus.* T. of the Nile. Differs from the former in having the acellated spots and dots irregularly disposed. Probably a variety. See Daud. viii. p. 353.

Bengalensis.

9. *T. bengalensis.* Bengal T. Ash-coloured above, spotted with white and black; black bands across the cheeks; throat dotted with black; whitish below; tail long.

Le T. piqueté de Bengale, Daud. iii. p. 67.

Ornatus.

PLATE CCXCVI. Fig. 6.

10. *T. ornatus.* Ornamented T. Body black; throat white, radiated with nine transverse black bands; with seven transverse rows of round white spots upon the back; and from twelve to eighteen whitish rings round the tail. See Plate CCXCVI. Fig. 6.

Le T. orne, Daud. viii. p. 307. *Ann. de Mus. de Hist. Natur.* tom. ii. p. 240. pl. xlviii.

Albigularis.

11. *T. albigularis.* White-throated T. Lower part and sides of the head and neck whitish, spotted with brown; two whitish lines extending from the eyes to the neck; tail long.

Le T. a gorge blanche, Daud. iii. p. 72. pl. xxxii.

Variegatus.

12. *T. variegatus.* Variegated T. Blackish above, variegated with double transverse rows of round yellow lines and shades; tail twice as long as the body.

Le T. bigarré, Daud. iii. p. 76.

Variegated lizard, White, *Voyage to N.S. Wales,* p. 253.

Exanthematicus.

13. *T. exanthematicus.* Pimply T. Black-coloured, with roundish white spots irregularly disposed; belly marked with brown bands; two black lines behind the eyes; head scaly above; tail of moderate length.

Le T. exanthematique de Senegal, Daud. iii. p. 80.

Lacertinus.

14. *T. lacertinus.* Lizard T. Some carinated scales along the back; eight longitudinal rows of smooth plates below the belly; tail long, with a small double crest at its base.

Le T. lizardet, Daud. iii. p. 85.

Le Silonné, Lacepede, i. part ii. art. 11.

Lacerta bicarinata, Linn. a Gmelin, p. 1060.

GENUS V. IGUANA. GUANAS.

IGUANA Genus.

The individuals of this tribe resemble those of the last, in having the body and tail surrounded with numerous small rings of minute scales that are nearly of a square figure, and in sometimes having the tail a little compressed at the sides, though this is in a small degree. A high crest composed of numerous pointed scales, resembling the teeth of a comb, extends along the *vertebræ* from the neck to near the tip of the tail. The head is somewhat pyramidal, and has four sides; the tongue is broad, flat, fleshy, but little extensile, and a little notched at its tip; and below the throat is a pendulous inflated skin, compressed laterally, and furnished at its fore part with a crest resembling that on the back and tail. The feet are strong, each having five toes ending in claws, and under each thigh is a row of small porous tubercles. The Guanas are found both in the E. and W. Indies; and chiefly inhabit the woods, sporting among the trees. There are three species, viz.

Species.

Delicatissima.

Species 1. *Iguana delicatissima.* Common guana. Swelling of the throat pectinated anteriorly; dorsal and caudal crest pectinated; forehead and muzzle covered with smooth plates. Plate CCXCVI. Fig. 7.

PLATE CCXCVI. Fig. 7.

L'Iguane ordinaire, Daud. iii. 263. pl xl.
L'Iguane, Lacepede, vol i. part ii. art 12.
Lacerta iguana, Linn. a Gmelin. p. 1062.
Common guana, Shaw, iii. pl. lxi.

Cornuta.

2. *I. cornuta.* Horned G. Swelling of the throat anteriorly pectinated; forehead beset with tubercles, especially one resembling a horn.

L'Iguane cornu, Daud. iii. 282.
Le lezard cornu, Lacepede, vol. i. part ii. art. 13.

Cærulea.

3. *I. cœrulea.* Blue G. Bluish-black, without spots; a longitudinal row of pointed scales on each side of the neck.

L'Iguane ardoisé, Daud. iii. p. 286.

Common guana

Species 1. *Iguana delicatissima.* Common guana. This animal, after the crocodile and the dragon, is one of the largest of the Saurian order, being not unfrequently found from four to six feet long from the muzzle to the tip of the tail. In its general appearance, exclusive of its colours, it is clumsy and unsightly, and occasionally even assumes a terrific aspect. Its head is large and thick; its belly protuberant; its tail very long, thick at its commencement, and tapering gradually towards a sharp point. Its serrated back, tail, and throat, its long toes armed with sharp crooked claws, and its jaws with numerous sharp teeth, are sufficient to alarm an observer who is unacquainted with its history. To counterbalance these deformities, however, its whole surface is covered with numerous shining scales, of the most brilliant appearance, reflecting various colours when viewed in the sunshine, though the prevailing tint is a brownish green.

The guana is found both in South America and the West Indies, where it inhabits the forests, especially near the borders of lakes or the banks of rivers. It sometimes ascends the highest trees in quest of insects; at others, seeks its prey among the grass and underwood. It is a harmless, inoffensive animal, and soon becomes familiar with mankind. Its flesh forms a delicious article of food. and is either roasted fresh, or salted and barrelled up for exportation, by the inhabitants of those islands where it is most frequent. It is said that the negroes are very expert in catching this animal, amusing it by whistling, and, when it suffers them to approach, tickling it with the end of a rod, having attached to it a cord with a running noose, which they gradually slip over the head of the animal, and thus secure their prey.

GENUS VI. DRACO. FLYING DRAGONS.

DRACO Genus.

The extraordinary reptiles comprehended under this name differ from all the other oviparous quadrupeds, in having a membranous expansion resembling a wing, supported by bony rays, and capable of being folded and unfolded, extending from the flanks along each side of the body to the shoulders. In other respects they resemble the guanas, having, like them, a crest along the back and part of the tail, and an inflated membrane below the throat. Their tail is, however, proportionally longer, smaller, and more cylindrical, and their limbs more delicately formed. Naturalists of the present day reckon three species, which Daudin has distinguished by the following names and characters.

Species.

Lineatus.

Species 1. *Draco lineatus.* Radiated flying dragon. Body beautifully variegated with blue and grey above; wings brown, longitudinally streaked with white.

Le Dragon rayé, Daud. iii p. 298.

Viridis.

2. *D. viridis.* Green flying D. Body green, rather scaly; wings grey, transversely marked with four brown bands and connected with the thighs. See Plate CCXCVI. Fig. 8.

PLATE CCXCVI. Fig. 8.

Le D. verd. Daud. iii. p. 301. pl. xli.
Draco volans, Linn. a Gmel. p. 1056.
Le Dragon, Lacepede, vol. ii. part ii. art. 53.

Fuscus.

3. *D. fuscus.* Brown dragon. Body brown, paler beneath, scarcely scaly; wings brown.

Le D. brun, Daud. iii. p. 307.

These animals so far resemble each other in habits, manners, and habitation, that it is unnecessary to describe each species. They are usually of small size, seldom exceeding eight inches in length.

From this small size, and the membranous wings with which they are furnished, they readily support themselves for some time in the air, though their flight seldom extends beyond thirty paces, darting from tree to tree in the manner of the flying squirrels; animals which they much resemble, as well in their motions as in their manner of life. They are supported chiefly by insects, which they sometimes take while on their flight. Flying dragons are found in Asia, Africa, and America, especially in the island of Java.

We need scarcely remark, that the fantastic animals described by the older writers of natural history, under the name of dragons, are mere creatures of the imagination; though it may be proper to observe, that specimens are not unfrequently met with, in cabinets of animals, that nearly resemble the figures given by those writers. It is now known that these specimens are artificial, and are formed by designing people, who make a trade of selling natural curiosities, by dressing up small ray fish, so as to resemble the fabulous dragons.

GENUS VII. AGAMA. AGAMAS.

AGAMA Genus.

The species now ranked under this name had generally been regarded as guanas, or stellios, from which Daudin distinguishes them by the following characters. Body oblong, more or less thick, entirely covered with small rhomboidal scales, that are almost always carinated and reticulated together; tail in most instances cylindrical, but in a few compressed; throat capable of being inflated; tongue short, thick, a little cleft at its tip; head thick, callous, generally set with spines at the back part, and covered with numerous small rhomboidal scales; feet long and thin, having each five slender toes furnished with claws. There are twenty-five species, arranged under five Sections.

Species.

SECT. I. *Agamas having a compressed Tail.*

Superciliosa.

Species 1. *Agama superciliosa.* Supercilious Agama. Body of a pitchy black; back and tail crested above; occiput callous and spinous; scales of the body rhomboid and carinated.

L'Agame sourcilleux, Daud. iii. p. 336.
Lacerta superciliosa, Linn. a Gmel. p. 1063.

Le Sourcilleux, Lacepede, vol. i. part ii. art. 7.
Fringed lizard, Shaw.

Scutata. 2. *A. scutata*. Fork-headed A. Tail a little compressed, of the length of the body; a serrated crest on the back and tail; occiput callous and two forked.

L'A. occiput fourchu, Daud. iii. p. 345.
Lacerta scutata, Linn. a Gmel. p. 1063.
Shielded lizard, Shaw.
La tete fourchue, Lacepede, vol. i. part ii. art. 8.

Atra. 3. *A. atra*. Black A. Occiput very spinous; body of a blackish squalid brown above, with a longitudinal yellowish band along the back; belly and throat bluish; tail a little compressed.

L'Agame sombre, Daud. iii. p. 349.

Fasciata. 4. *A. fasciata*. Banded A. Tail compressed, thrice as long as the body; colour blue, paler below, with pale spots on the neck, and four transverse pale blue bands, of which the second is the shortest, on the back.

L'A. à bandes de l'Inde, Daud iii. p. 352.

SECTION II. *Agamas properly so called.*

Body slender, without tubercles; tail cylindrical.

Colonorum. 5. *A. colonorum*. Common Agama. Tail long; upper part of the neck and back part of the head spinous, with the scales of the occiput reversed; a small dorsal pectinated crest; colour a pale greenish blue.

L'A. des cotons, Daud. iii. p. 356.
Lacerta agama, Linn. a Gmel. p. 1064.
L'Agame, Lacep. i. part ii. art. 17.

Calotes. 6. *A. calotes*. Galeot A. Blue; tail long; fore part of the back and back part of the head furnished with a small crest. See Plate CCXCVII. Fig. 9.

PLATE CCXCVII. Fig. 9.

L'A. galeote, Daud. iii. p. 361. pl. xliii.
Lacerta calotes, Linn. a Gmelin, p. 1063.
Galeot lizard, Shaw.
L'A. galeote, Lacepede, i. part ii. art. 16.

Umbra. 7. *A. umbra*. Clouded A. Tail long; occiput callous and spinous; back five streaked; a black spot on the throat.

L'A. umbre, Daud. iii. p. 373.
Lacerta umbra, Linn. a Gmel. p. 1064.
Clouded lizard, Shaw.
L'Umbre, Lacepede, ii. part ii. art. 30.

Undulata. 8. *A. undulata*. Undulated A. Ash brown above, irregularly marked with transverse bands or waves; bluish below, with a large whitish cross.

L'A. ondulé, Daud. iii. p. 384.

Angulata. 9. *A. angulata*. Angled A. Head wrinkled above, and almost naked; scales of the back rhomboidal and carinated, those of the belly smooth; two large round scales below the throat; tail long and hexagonal.

L'A. hexagone, Daud. iii p. 389.
Lacerta angulata, Linn. a Gmel. 1061.
Angulated lizard, Shaw.
L'Hexagone, Lacepede, i. part ii. art. 22.

Muricata. 10. *A. muricata*. Muricated A. Body longitudinally streaked with pointed carinated scales; tail striated, barred, twice as long as the body; occiput callous and spinous.

L'A. hérissé de la Nouvelle Hollande, Daud. iii. p. 391.
Muricated lizard. White's *Voyage to New South Wales*, p. 244.

Versicolor. 11. *A. versicolor*. Harlequin A. Back marked on each side with a longitudinal white line; body of a clear blue, with transverse brown bands upon the back; tail twice as long as the body.

L'A. Arlequiné, Daud iii. p. 395, plate xliv.

Flavigularis. 12. *A. flavigularis*. Yellow-throated A. Grey, reddish above, with a yellow throat; tail once and a half as long as the body, a short longitudinal white line upon each flank.

L'A. a gorge safranée, Daud. iii. p. 398.

Rosacauda. 13. *A. rosacauda*. Rose-tailed A. Grey, pale below; tail of a rose colour, 1½ the length of the body.

L'A. rose-queue, Daud. iii. p. 400.

Aspera. 14. *A. aspera*. Rough A. Head smooth and reddish above; body and tail beset with pointed scales, marbled with transverse shades of reddish-brown and white.

L'A. rude, Daud. iii. p. 402.

Stellaris. 15. *A. stellaris*. Starred A. Body and tail furnished above with a toothed crest, with numerous white starry points on the back and on each side.

L'A. etoilé, Daud. iii. p. 404.

SECTION III. *Orbicular Agamas or Tapays.*

Body a little depressed, and beset here and there with small rounded or pointed tubercles.

Orbicularis. 16. *A. orbicularis*. Orbicular A. Body orbicular and rough, variegated above with brown; head like that of a toad; feet yellow below; tail of moderate length.

L'A. orbiculaire, Daud. iii. p. 406. plate xlv. fig. 1.
Lacerta orbicularis, Linn. a Gmel. p. 1061.
Le Tapaye, Lacepede, vol. ii. part ii. art. 37.
Orbicular lizard, Shaw.

Gemmata. 17. *A. Gemmata*. Gemmed A. Body marked with six longitudinal rows of four-sided pointed scales, with brownish transverse angular bands upon the back.

L'A. á pierreries, Daud. iii. p. 410.

Plica. 18. *A. plica*. Plated A. Tail long; occiput callous, palpebræ excoriated above; neck tuberculated at the sides, and plated below.

L'A. plissé, Daud. iii. p. 412.
Lacerta plica, Linn. a Gmel. p. 1074.
Le plissé, Lacepede, ii. part ii. art. 31.

Paraguensis. 19. *A. paraguensis*. Paraguay A. Tongue round and thick; head obtuse; a longitudinal brown band upon the back, with a triangular brown spot on each side of the tail.

L'A. du paraguay, Daud. iii. p. 414.

Helioscopa. 20. *A. helioscopa*. Stargazing A. Tail imbricated, thick at the base, and sharp at the tip; head thick and callous, spinous at the back part; neck contracted, marked with a transverse fold below; tail scarlet below.

L'A. helioscopa, Daud. iii. p. 419.
Lacerta helioscopa, Linn. a Gmel. p. 1074.

Uralensis. 21. *A. uralensis*. Uralian A. Head roundish, neck plated below; back of a livid ash-colour, wrinkled, and a little rough; tail the length of the body, black at the tip, and six-banded.

L'A. raboteux de l'oural, Daud. iii. p. 422.
Lacerta uralensis, Linn. a Gmel. p. 1073.

Guttata. 22. *A. guttata*. Dotted A. Head roundish; body smooth, blue above, with round white dots; belly whitish; tail longer than the body, black at its tip, with four black opposite spots towards its base.

L'A. a gouttelettes, Daud. iii. p. 426.
Lacerta guttata, Linn. a Gmel. p. 1078.

Aurita. 23. *A. aurita*. Eared A. Angles of the mouth dilated on each side into a semi-orbicular dentated crest.

L'A. a oreilles, Daud. iii. p. 429. plate xlv. fig. 2.
Lacerta aurita, Linn. a Gmel. p. 1073.

SECT. IV. *Lizard Agamas.*

Plates on the head, and a row of granular pores under each thigh.

Marmorata. 24. *A. marmorata*. Marbled A. Throat inflated;

head covered with numerous plates, colour brownish-bay, with transverse dark bands and green shades; tail very long.

L'A. marbré de Surinam, Daud. iii. p. 433.
Lacerta marmorata, Linn. a Gmel. p. 1065.
Marbled lizard, Shaw.
Le marbré, Lacepede, ii. part ii. art. 39. plate ii.

SECT. V. *Agamas with prehensile Tails.*

Prehensilis. 25. *A. prehensilis.* Prehensile A. Four transverse black bands on each flank; belly brown, with black and white shades; three black bands upon the cheeks; tail prehensile, scarcely longer than the body.

L'A. a queue prenante, Daud. iii. p. 440.

GENUS VIII. STELLIO. STELLIOS.

STELLIO Genus. Body oblong, thick, entirely covered with small scales, regularly disposed transversely; tongue thick, short, and a little cleft at the tip; head broad, rather short, covered above with numerous scales or plates; throat capable of slight inflation; tail compressed, surrounded with transverse rows of large carinated pointed scales; feet strong, furnished each with five separate toes, tipt with claws.

This singular tribe of reptiles, which, in the form of their bodies and the tubercles with which they are often covered, bear some resemblance to the toads, are found only in the hottest parts of Africa and America. They hide themselves during the day below stones, and in the crevices of old buildings, and leave these retreats at the approach of night. They prefer dry situations, and live chiefly on insects.

Species. Daudin has characterised nine species, which he arranges under three Sections, as follows.

SECT. I. *Cordyli.*

Plates upon the head, body, and tail versicillated and spinous.

Cordylus. *Species* 1. *Stellio cordylus.* Cordyle S. Head plated above, body and tail covered with pointed carinated scales, disposed in whirls.

Le Stellion Cordyle, Daud. iv. p. 8.
Lacerta Cordylus, Linn. a Gmel. p. 1060.
Le Cordyle, Lacepede, i. part ii. art. 21.

SECT. II. *True Stellios.*

Head covered above with small scales, with some scattered transverse bands of large scales upon the body.

Vulgaris. 2. *S. Vulgaris.* Common S. Body covered with small scales, with a few transverse bands of larger scales upon the back; scales of the tail a little elongated.

Le S. proprement dit, Daud. iv. p. 16.
Lacerta stellio, Linn. a Gmel. p. 1060.
Le stellion, Lacepede, ii. part ii. art. 33.
Rough lizard, Shaw.

Platurus. 3. *S. Platurus.* Broad tailed S. Tail flat, broadest in the middle, spinous at its edges; occiput and back tuberculated and spinous; muzzle slender; colour brownish-grey.

Le S. a queue plate de la Nouv. Hollande, Daud. iv. p. 24.
Broad tailed lizard. White's *Voy. to N. S. Wales*, p. 246.

SECT. III. *Bastard Stellios.*

Numerous very small scales on the upper part of the head and body.

Quetz-paleo. 4. *S. quetz-paleo.* Quetz-paleo S. Pale grey; body a little scaly and granulated; tail the length of the body, with elongated scales, each thigh furnished below with a row of fifteen pores.

Le S. quetz-paleo. Daud. iv. p. 26.

Spinipes. 5. *S. spinipes.* Spinefooted S. Body of a bright green, covered with minute scales, spinous at the sides; upper part of the feet covered with round sharp scales; pores below the thighs; tail a little elongated.

Le S. spinipède, Daud. iv. p. 31.

Azureus. 6. *S. azureus.* Azure S. Body of a light azure colour, without spots and slender; tail elongated, and surrounded with 35 or 36 spinous whirls.

Le S. azuré de l'Amérique meridionale, Daud. iv. p. 36. pl. xlvi.

Brevicauda. PLATE CCXCVII. Fig. 10. 7. *S. brevicauda.* Short tailed S. Colour light blue, with transverse bands of a darker blue, and a star-like spot upon the fore-head; tail a little depressed and short.

Le S. courte queue, Daud. iv. p. 40. pl. xlvii.

Pelluma. 8. *S. pelluma.* Pelluma S. Upper part of the body variegated with green, yellow, blue and black; lower part with green and yellow; tail the length of the body.

Le S. pelluma du Chili, Daud. iv. p. 46.
Lacerta pelluma, Linn. a Gmel. p. 1060.
Pelluma lizard. Shaw.

Niger. 9. *S. niger.* Black S. Colour black, with a double broad white spot on each side of the neck.

Le S. négre, Daud. iv. p. 48.

GENUS IX. CHAMELEO. CHAMELEONS.

CHAMELEO Genus. The head short and pretty thick, covered on its surface with smooth five-sided or six-sided scales; nose generally obtuse; eyes covered with a granular membrane, perforated in the middle; tongue long and cylindrical, terminating in a glutinous tubercle, and very extensile; tympanum of the ear very apparent; throat capable of inflation into a compressed pouch; body elongated, compressed, capable of considerable inflation, covered with small scaly tubercles, irregularly disposed at a distance from each other; back sharp, and often furnished with a crest formed by small prominent or pointed scales; tail at least as long as the body, covered with a granular scaly skin, capable of being rolled in a spiral form round an object; feet furnished each with five toes, terminating in claws, and united two together and three together.

Vulgaris. PLATE CCXCVII. Fig. 11. *Species* 1. *Chameleo vulgaris.* Common chameleon. brownish-grey, with a spiny crest upon the back and throat; occiput pyramidal, four-sided, with prominent tubercles under the skin of the back. See Plate CCXCVII. Fig. 11.

Le Caméléon ordinaire, Daud. iv. p. 181.
Lacerta chamæleon. Linn. a Gmel. p. 1069. See Shaw's *Gen. Zool.* iii. pl. lxxvi.
Le Caméléon, Lacepede, ii. part ii. art. 26.

Senegalensis. 2. *C. Senegalensis.* Senegal C. Yellowish ash colour, shaded above with blackish; an acute slender crest upon the back, and a serrated crest upon the belly; occiput furnished with a triangular eminence.

Le C. à ventre dentelée en scie du Senegal, Daud. iv. p. 203.

Pumilus. 3. *C. pumilus.* Dwarf C. Light blue, with two yellowish longitudinal lines on each side of the body; throat fringed below.

Le C. nain du Cap de bonne Esperance, Daud. iv. p. 212. pl. liii.
Lacerta pumila. Linn. a Gmel. p. 1069.

Bifidus. 4. *C. bifidus.* Two-forked C. Fore part of the muzzle prominent and two forked, with each division long and compressed.

Le C. nez fourchu de l' inde, Daud. iv. p. 217. pl. liv. See *Phil. Trans.* vol. lviii.

The chameleons are remarkable both for peculiarity of structure and singularity of manners; and the first and best known species has long been celebrated, both in ancient and modern times, for the variety of colours which it assumes on different occasions. Their skin is remarkably thin and delicate, and is so loose and dilatable, especially about the belly, as to admit of considerable inflation when the animals expand their ample lungs by a long and deep inspiration. Their eyes are remarkable, both for the membrane that covers them, and for the ease with which they are directed at the same time towards different objects. The peculiar structure of their feet, and their prehensile tails, serve to give them a surer hold of the branches of trees in which they generally live, and thus secure them against the attacks of serpents, by whom they are eagerly sought after, while their long extensile and glutinous tongue enables them more easily to catch the insects which form their natural food. From the smallness of these insects, and the long abstinence which the chameleons are able to sustain, it was long believed that these animals lived upon air: a vulgar error, which has given birth to many a pretty expression among our poets. It has also been supposed, that chameleons assume the colour of any object on which they are laid. This is so far true, that if the object be green of any shade, as green is the prevailing colour of the chameleon, and as it passes through various shades of this colour when pleased or angry, hungry or satiated, it acquires, in the course of the experiment, a shade very near that of the grass or cloth on which it is laid. It never becomes quite blue or quite white, though it often verges upon these colours; and sometimes the shade of green is so dark, that a hasty observer might call it black.

Attempts have been made to account for the changes of colour in the chameleon, by the remark, that the blood of this animal is of a violet blue, while the natural colour of the skin is yellow; hence, when the skin is most transparent, and the animal in greatest vigour, the shade of green is darkest, or assumes most of the blue tinge, while, when the skin is least stretched, and the circulation languid, the colour becomes paler, and verges towards yellow-white, or even brown.

Chameleons are found chiefly in the tropical climates of the old continent, especially in Egypt and other parts of Africa. They are generally of diminutive size, the largest not exceeding two feet, from the muzzle to the tip of the tail; of which the tail occupies one-half.

GENUS X. GECKO. GECKOS.

GECKO Genus.

The animals of this tribe are not so unsightly in their external appearance as they are disgusting in their manners, and the noxious fluid which they secrete. Their head is pretty thick, especially at the articulation of the jaws, where it is bordered with small plates, while the surface of the head is covered with small rounded prominent scales; the muzzle is taper; the tongue thick, flat, slightly cleft at its tip, and glutinous, but not extensile; the eyes resemble those of the chameleons, but the external opening of the ears is less apparent, and the throat is susceptible of slight inflation. The body is long and thin, a little depressed, and covered with very small prominent scales; the tail is generally cylindrical, but in a few species flattened; the feet have each five broad toes, flattened along their margins, covered on their inferior surface with small transverse imbricated scales, concealing glandular pores, from which exudes a very corrosive fluid. Each toe is tipped with a small crooked claw.

The geckos are found in South America, in Africa, and the East Indies. They live about walls and in trees, feed chiefly on insects, and have so little dread of mankind, as familiarly to enter their houses.

There are 15 species, arranged under three Sections.

SECTION I. *Geckos.*

Geckos, properly so called, having the five toes distinct, or a little palmated at their base, the tail cylindrical, and the body smooth.

Ægyptiacus.

Species 1. *Gecko Ægyptiacus.* Egyptian or common gecko. Light ash-grey; tail for the most part having six broad rings at its base; body rather swollen, and a little flattened. See Plate CCXCVII. Fig. 12.

PLATE CCXCVII. Fig. 12.

Le Gecko ordinaire, Daud. iv. p. 107.
Lacerta gecko, Linn. a Gmel. p. 1068.
Common gecko lizard, Shaw.
Le Gecko, Lacepede, ii. part ii. art. 48.

A very curious structure has lately been detected in the foot of this animal by Sir Everard Home, Bart. Sir Joseph Banks had often observed at Batavia, that the Gecko comes out in the evening from the roofs of the houses, and walks down the smooth hard polished chunam walls in search of flies; and it occurred to Sir Everard Home, that this must be done by a contrivance like that of the *Echineis remora*, or sucking fish. Having procured from Sir Joseph a large specimen, weighing 5¾ oz. he was enabled to ascertain the peculiar mechanism by which the feet of the animal can keep hold of a smooth surface. The Gecko has five toes, and at the end of each, except the thumb, is a very sharp curved claw. On the under surface of each toe are 16 transverse slits leading to as many cavities, or pockets, whose depth is nearly equal to the length of the slit which forms the orifice: they all open forwards, and the external edge of each opening is serrated like a small-toothed comb. The cavities, pockets, and serrated edges are covered with a cuticle. A large oval muscle moves the claw of each toe, and from the tendons of these large muscles, two sets of smaller muscles originate, one pair of which is lost upon the posterior surface of each of the cavities that lie immediately over them. The large muscles draw down the claws, and necessarily stretch the small muscles. When the small muscles contract, they open the orifices of the cavities, and turn down their serrated edge upon the surface on which the animal stands. By this means vacua are formed, and the animal adheres to the surface by the pressure of the atmosphere. See *Phil. Trans.* 1816, p. 149. and page 41, col. 2. of this article.

PLATE CCXCV. Fig. 18, 19.

Lævis.

2. *G. lævis.* Smooth G. Ash grey, all the scales very minute, inside of the thighs not porous; tail of moderate length, simple at the base; tips of the toes triangular.

Le G. lisse d'Amérique, Daud. iv. p. 112.

Spinicauda.

3. *G. spinicauda.* Spine-tailed G. Body smooth; tail nearly the same length as the body, thick, and ringed at the base; rings beset with spines on each side.

Le G. a queue épineuse, Daud. iv. p. 115.

Guttatus.

4. *G. guttatus.* Dotted G. Pale red above, with small round whitish spots disposed in rows; numerous square scales upon the tail.

Le G. a gouttelettes blanches, Daud. iv. p. 122. pl. xlix.

Surinamensis.

5. *G. Surinamensis.* Surinam G. Tail as long as the body, with brown bands, a yellowish band bordered with brown running from the eyes to the thighs; back marbled with little brown spots.

Le G. de Surinam, Daud. iv. p. 126.

Porphyreus.

6. *G. porphyreus.* Porphyry G. Pale red-brownish above, with numerous small round spots of a paler hue.

Le G. porphyré, Daud. iv. p. 130.

Squalidus. 7. *G. squalidus.* Squalid G. Tail short; toes carinated above, lamellated below; scales very minute, unequal, and dotted.

Le G. chagriné, Daud. iv. p. 134.

Vittatus. 8. *G. vittatus.* Banded G. Reddish, with a longitudinal white band running from the occiput, where it is forked, along the back; tail long, marked with white bands.

Le G. a bandeblanche de l'Inde, Daud. iv. p. 136. plate l.

Lacerta vittata, Linn. a Gmel. p. 1067.

Forked lizard, Shaw.

Rapicauda. 9. *G. rapicauda.* Turnip-tailed G. Dirty brown, with a whitish band, bordered with brown, behind the eyes; tail short, thick, and turbinated at the base, constricted at the anus, pointed at the tip.

Le G. a queue turbinée, Daud. iv. p. 141. plate li.

Lacerta rapicauda, Linn. a Gmel. p. 1068.

Turnip-tailed lizard, Shaw.

Sect. II. *Geckots.*

Tail cylindrical; body covered with pointed scales.

Fascicularis. 10. *G. fascicularis.* Common geckot. Twelve longitudinal rows of acute fasciculated scales on the body; tail short, with two broad rings at its base.

Le G. fasciculaire, Daud. iv. p. 144.

Lacerta mauritanica, Linn. a Gmel. p. 160.

Moorish lizard, Shaw.

Le Geskotte, Lacepede, ii. part ii. art. 49.

Triedrus. 11. *G. triedrus.* Triangular G. Body covered above with eighteen longitudinal rows of triangular pointed scales; lower part of the tail covered with small transverse plates.

Le G. a ecailles triédres, Daud. iv. p. 155.

Tuberculosus. 12. *G. tuberculosus.* Tuberculated G. Brownish, covered above with scattered, sharp, tuberculated scales, with brown spots upon the back, disposed in pairs.

Le G. tuberculeux, Daud. iv. p. 158.

Sect. III. *Flat-tailed Geckots.*

Fimbriatus. 13. *G. fimbriatus.* Fimbriated G. Head, body, and legs flattened at the sides, and bordered with a membranous fringe; tail broad and compressed, with a simple membrane on each side.

Le G. a tete plâte, Daud. iv. p. 160. pl. lii.

La tete plâte, Lacepede, ii. part ii. art. 50.

Cristatus. 14. *G. cristatus.* Crested G. Tail furnished with a pinnatifid membranous crest; feet palmated.

Le G a queue cretée, Daud. iv. p 167.

Lacerta caudiverbera, Linn. a Gmel. p. 1058.

Flat-tailed lizard, Shaw.

Le fouette-queue, Lacepede, i. part ii. art. 4.

Sarroubea. 15. *G. sarroubea.* Sarroube G. Yellow, spotted with green; four feet four-toed.

Le G. sarroubé de Madagascar, Daud. iv. p. 176.

La salamandre sarroubé, Lacep. ii. part ii. art. 58.

Genus XI. Anolis. ANOLES.

Anolis Genus. The animals of this genus are nearly allied to those of the last, in the form of their bodies and the structure of their feet, except that, in the latter, only the first joint of the toes are scaly below. The body is covered with fine granular scales; the tongue is not cleft, and is attached to the floor of the mouth; the tail is cylindrical in some species, and compressed in others.

The anoles are inhabitants of America, where they live in dry places much exposed to the sun. Daudin reckons eight species, arranged under two Sections.

Sect. I. *Anoles having the Tail compressed, carinated, and serrated.*

Species.

Bimaculatus. Plate CCXCVII. Fig. 13. *Species* 1. *Anolis bimaculatus.* Two-spotted A. Bluish green, with a black spot upon each shoulder; back flattened and serrated. See Plate CCXCVII. Fig. 13.

L'Anolis bimaculé, Daud. iv. p. 55.

Lacerta bimaculata, Linn. a Gmel. p. 1059.

Le Bimaculé, Lacepede, i. part ii. art. 10.

Pennsylvanian lizard, Shaw.

Carbonarius. 2. *A. carbonarius.* Charcoal coloured A. Deep black, with shades of blue; throat yellow; toes broadest at their tips.

L'A. charbonnier, Daud. iv. p. 64.

Lineatus. 3. *A. lineatus.* Striped A. Body marked on each side with two longitudinal rows of oblong black linear spots.

L'A. rayé, Daud. iv. p. 66. pl. xlviii. fig. 1.

Sect. II. *Anoles having a cylindrical Tail articulated, but not carinated.*

Bullaris. 4. *A. bullaris.* Red-throated A. Greenish or reddish, with a black spot on the temple.

L'A. roquet, Daud. iv. p. 69.

Lacerta bullaris, Linn. a Gmel. p. 1075.

Le roquet, Lacepede, ii. part ii. art. 40. pl. iv. fig. 1.

Punctatus. 5. *A. punctatus.* Dotted A. Blue above, with white dots, and a black longitudinal line upon the back; sides dotted with black.

L'A. a points blancs de l'Amerique meridionale, Daud. iv. p. 84. pl. xlviii. fig. 2.

Lacerta punctata, Linn. a Gmel. p. 1076.

Dotted lizard, Shaw, *Gen. Zool.* vol. iii.

Podagricus. 6. *A. podagricus.* Gouty A. Greenish above, yellowish below, with marginated nostrils, and the joints of the toes flattened.

L'A. goutteux, Daud. iv. p. 87.

Auratus. 7. *A. auratus.* Gilded A. A longitudinal white line edged with brown, running from the eyes along each side of the body; toes slender.

L'A. doré, Daud. iv. p. 89.

Sputator. 8. *A. sputator.* Spitting A. Tail round, and of moderate length, covered below with a longitudinal row of plates; toes truncated; body ash colour, with transverse white bands bordered with liver colour.

L'A. sputateur, Daud. iv. p. 99.

Lacerta sputator, Linn. a Gmel. p. 1076.

Spitting lizard, Shaw, *Gen. Zool.* vol. iii.

Genus XII. Lacerta. LIZARDS.

Lacerta Genus. In the numerous tribe of lizards, properly so called, the body is covered on its upper part with very small hexagonal or rounded scales, disposed in numerous transverse bands, and below with small smooth square plates, disposed in longitudinal rows. The head resembles an oblong pyramid with four sides, covered above and on the sides with smooth plates. The tongue is forked, and capable of being thrust far out of the mouth. The opening to the ear is oval or oblong, and very apparent. The tail is at least as long as the body, quite cylindrical, composed of jointed rings, and has no upper crest. All the feet are nearly of equal length, and under each thigh there is a row of small, rough, porous, scaly tubercles. Each foot has five toes, completely separate, thin, and terminated by small crooked claws. Many of the species inhabit woody situations, and seek their food among the foliage, or in the underwood. This food consists chiefly of insects. Others live about ruinous buildings, or even approach the dwellings of mankind, and feed partly on insects, and partly on fruits and vegetables. A few have their natural habitation in marshes, ponds, or lakes, and prey upon the small animals which inhabit them.

The lizards are in general lively and active, and, on the whole, form the most pleasing of all the Saurian tribes. They are innocent in their manners: cheerful in their movements; and many of them, from their agreeable form and variety of colour, constitute very pleasing features in a group of natural objects.

Species.

Most of them are natives of the warmer climates; but more of this tribe than of any other of the Saurian order, are indigenous in the temperate countries of Europe. There are about 32 species, which Daudin distributes under seven Sections.

Sect. I. *Ameiva Lizards.*

No scaly collar on the neck; tail entirely cylindrical and verticillated.

Ameiva.

Species 1. *Lacerta ameiva.* Ameiva lizard. Of a bright blue colour, with four longitudinal rows of round whitish spots on each side; neck transversely plaited below.

Le lezard ameiva, Daud iii. p. 96.

L'Ameiva, Lacepede, vol. i. part ii. art. 23.

Lacerta ameiva, Linn. a Gmelin, p. 1070.

Blue lizard, Shaw, *Gen. Zool.* vol. iii.

Litterata.

2. *L. litterata.* Lettered L. Bluish green, variegated above with oblong black spots, and transverse black bands, dotted with white on each side; neck transversely plaited below.

Le L. verda traites noiresd'allemagne, Daud. iii. p. 106.

Graphica.

3. *L. graphica.* Graphic L. Bluish-green marked with black points and characters, with a longitudinal fold on each side of the body, without white eye-like spots; neck transversely plaited below.

Le L. graphique, Daud. iii. p. 112.

Argus.

4. *L. argus.* Argus L. Blue; back marked with blue eyes disposed in transverse rows, with a longitudinal fold on each side of the body; tail transversely plaited below.

Le L. argus d'Amerique. Daud. iii. p. 117.

Gutturosa.

5. *L. gutturosa.* Swollen throated L. Sea-green, throat and neck swollen; red spots scattered over the body, especially on each side.

Le L. verd a points rouges, Daud. iii. p 119.

Erythrocephala.

6. *L. erythrocephala.* Red-headed L. Back dark green, with transverse undulated brown bands; throat white; breast black; sides marked with brown bands; belly striped longitudinally with black, blue, and white; head red; tail short.

Le L. á tête rouge, Dand. iii. p. 122.

La tete rouge, Lacepede, vol. I. part ii. art. 20.

Sect. II. *Green Lizards.*

Green lizards, having a scaly collar round the neck, and a verticillated tail.

Ocellata.

7. *L. ocellata.* Eyed L. Black above, with lines and eye-like spots of a light green; light yellow below without spots.

Le grand L. verd ocellé du midi de l'Europe, Daud. iii. p. 125. pl. xxxiii.

Le L. verd. Lacepede, i. part ii. art. 19. pl. xv. fig. 1.

Viridis.

8. *L. viridis.* Green L. Bright green, marked above with very numerous black or brown points; light green below without spots.

Le L. piqueté, d'Europe, Daud. iii p. 144. pl. xxxix.

Jamaicensis.

9. *L. jamaicensis.* Jamaica L. Back reticulated with pale brown, with yellow dots; a double longitudinal row of ovate blue spots along each side; tail long.

Le L. verd de la Jamaique, Daud. iii. p. 149.

Bilineata.

10. *L. bilineata.* Two-lined L. Back marked with two longitudinal white lines, edged above with brown; a longitudinal row of brown spots, and white points on each side of the body, and a long tail.

Le L. verd a deux raies, Daud. iii. p. 151. pl. xxxv. fig. 1.

Stirpium.

11. *L stirpium.* Copse L. Bright green, spotted with black; back and tail grey, with a brown interrupted line along the back; a double row of black eye-like spots along each side, and a dotted belly.

Le L de souches, Daud. iii. p. 155. pl. xxiv. fig. 2.

Viridula.

12. *L. viridula.* Greenish L. Bright green above; yellow below; tail three times the length of the body, and black at the tip, with an orange coloured spot on the occiput and neck.

Le L. verdelet de Panama, Daud. iii. p. 165.

Tiliguerta.

13. *L. tiliguerta.* Tiligurta L. Tail double the length of the body; belly marked with eighty plates.

Le L. tiligurta, Daud. iii. p 167.

Lacerta tiliguerta, Linn. a Gmelin. p. 1070.

Dumetorum.

14. *L. dumetorum.* Wood L. Bright green, with the neck and belly of a bright steel colour; feet black, and the collar of the neck serrated, and of a violet colour.

Le L. des boissons de Surinam, Daud. iii. p. 172.

Sect. III. *Ribbon Lizards,*

Having a collar on the neck, and several longitudinal white parallel lines along the upper part of the body.

Lemniscata. Plate CCXCVII. Fig. 14.

15. *L. lemniscata.* Laced L. Nine white longitudinal lines upon the back and sides; long tail, blue on the upper part; thighs spotted with white, and the middle dorsal line two-forked next the head.

Le L. Galonné, Daud. iii. p. 175. pl. xxxvi. fig. 1. Lacepede, i. part ii. art. 25.

Lacerta lemniscata Linn. a Gmelin, p. 1075.

Sexlineata.

16. *L. sexlineata.* Six-striped L. Blackish brown above, with six longitudinal white lines upon the back, with another short white line extending from the eyes over the shoulders; tail twice as long as the body, and thighs without spots.

Le L. a six rais, Daud. iii. p. 183.

Lacerta sexlineata, Linn. a Gmelin, p. 1074.

Le lion, Lacepede, i. part ii. art. 24.

Bosquiana.

17. *L. bosquiana.* Bosquian L. Bright blue above, with nine white longitudinal lines, with intermediate dots upon the back and sides, the middle line being short and undivided; tail twice as long as the body; thighs spotted with white.

Le L. bosquien, Daud. iii. p. 188. pl. xxxvi. fig. 2.

Cæruleocephala.

18. *L. cæruleocephala.* Blue headed L. Head blue with a white longitudinal line along the middle of the back; two yellow parallel lines on each side; white dots upon the thighs, and tail twice the length of the body.

Le L a tête bleue, Daud. iii. p. 19

Teyou.

19. *La teyou.* Teyou L. Upper part of the head green; back violet colour, with one green line and six white ones; throat and belly of a silvery white.

Le L. teyou verd, Daud. iii. p. 195.

Deserti.

20. *L. deserti.* Desert L. Tail the length of the body; back black, with six white interrupted longitudinal lines; belly white without spots.

Le L. du désert, Daud. iii. p. 199.

Lacerta deserti, Linn. a Gmelin, p. 1076.

Velox.

21. *L. velox.* Swift L. Body ash-coloured above, variegated with brown dots, and five longitudinal streaks of a lighter colour; sides spotted with black and blue.

Le L. veloce, Daud. iii. p. 202.
Lacerta velox, Linn. a Gmelin. p. 1072.

Sect. IV. *Spotted Lizards.*

Lepida. 22. *L. lepida.* Languedoc L. Body greenish blue above, with nine or ten transverse black bands, spotted with small round white eyes; belly whitish; tail scarcely longer than the body.

Le L. gentil du Languedoc, Daud. iii. p. 204. pl. xxxvii. fig. 1.

Maculata. 23. *L. maculata.* Spotted L. Blackish blue above, with a few round spots of a pale violet; belly whitish; tail once and a half as long again as the body.

Le L. tacheté d'Espagne, Daud. iii. p. 208. pl. xxxvii. fig. 2.

Sect. V. *Grey Lizards.*

Agilis. 24. *L. agilis.* Agile L. Ash coloured above, whitish below; back marked with a longitudinal dotted brown line, and a subreticulated brown longitudinal stroke, edged with paler colour on each side of the body.

Le L. gris des murailles, Daud. iii. p. 211. pl. xxxviii. fig. 1.

Brongniardi. 25. *L. brongniardi.* Brongniardian L. Bluish grey, irregularly marbled on the back with black spots, and with three longitudinal lines of black spots and dots on each side.

Le L. brongniardien, Daud. iii. p. 221.

Sericea. 26. *L. Sericea.* Silky L. Brownish above, shaded with glossy green and blue; pale green below; tail twice as long as the body, and a little streaked.

Le L. soyeux, Daud. iii. p. 224.

Laurentii. 27. *L. laurentii.* Laurentian L. Ash brown above, everywhere spotted, with the spots upon the back obscure, those on the sides disposed in a triple longitudinal row.

Le L. de Laurenti, Daud. iii. p. 227.

Arenicola. 28. *L. arenicola.* Sand L. Brownish grey, paler without spots below, with a row of brown spots upon the back, and a double series of brown eyes dotted with white, and another single row of white dots on each side.

Le L. arénicole, Daud. iii. p. 230. pl. xxxviii. fig. 2.

Fusca. 29. *L. fusca.* Brown L. Dark brown, with a longitudinal row of obscure spots on each side; belly paler.

Le L. brun, Daud. iii. p. 237.

Arguta. 30. *L. arguta.* Sharp snouted L. Tail short and verticillated, thick at the base, and very sharp at the tip; a remarkable double plate under the neck; general colour sea green, with numerous transverse black bands; belly white.

Le L. a museau pointue, Daud. iii. p. 240.
Lacerta arguta, Linn. a Gmel. p. 1072.

Sect. VI. *Dracenoid Lizards.*

Having two scaly folds under the neck, and a cylindrical tail verticillated at its proximal, and reticulated at its distal, half.

Quinquelineata. 31. *L. quinquelineata.* Five-streaked L. Bluish, with five longitudinal black lines upon the back, and white spots on each side.

Le L. a cinq raies, Daud. iii. p. 243.

Sect. VI. *Striated Lizards.*

Striata. 32. *L. striata.* Striated L. Grey, bluish at the sides, with two longitudinal brown lines; scales of the back and belly carinated, and forming longitudinal streaks.

Le L. strié, Daud. iii. p. 247.

A considerable degree of uncertainty and ambiguity prevails among writers, respecting the animals called *Lizards*. If, with Linnæus and his followers, we comprehend under this name not only the species just enumerated, but the Tupinambes, the Stellios, the Basilisks, the Guanas, the Geckos, the Chameleons, the Scinks, and the other tribes of the Saurian order, we shall find it comprehend above 150 species; and even curtailed as it is by the modern French naturalists, we see that it is pretty numerous. As it is impossible for us, within the circumscribed limits of an article like the present, to describe even all the most important species, we shall here confine ourselves entirely to a general account of those which are found in the British islands.

Mr Pennant, in the 3d vol. of his *British Zoology*, has described only three species of lizard as belonging to Britain, viz. the *Scaly lizard*, (a variety of *Lacerta agilis*, Linn.) the *Warty lizard*, (*Lacerta palustris*, Linn.) and the *Brown lizard*, (*Lacerta vulgaris*, Linn.) He indeed mentions two more, the *Little brown lizard*, and the *Snake-shaped lizard*, from Ray, but gives nothing on these species from his own observation.

Mr Revett Sheppard, in a paper published in the 7th vol. of the *Linnean Transactions*, has particularised six species as being indigenous in this country, viz. *Lacerta agilis*, scaly or swift lizard; *L. ædura*, swelled-tailed L.; *L. anguiformis*, viperine L.; *L. vulgaris*, brown L.; *L. palustris*, warty lizard; and *L. maculata*, spotted L. Of these he seems to consider the 2d, 6th, and perhaps the 3d, as new species. His descriptions of these species are sufficiently minute, but he adds nothing respecting their habitats or manner of life.

The species most common in this country are the *Warty lizard*, or water newt, and the *Brown lizard*, or common land newt; and of these the former has been most minutely examined. The warty lizard is extremely common in ponds and other stagnant waters. The young lizards continue for some time in an imperfect or larva state, and the perfect animals annually change their skin. *

Genus XIII. Takydromus. TAKYDROME.

Takydrome Genus. This genus has been formed by Daudin for the purpose of including two species, which differ from the lizards, properly so called, in having a very slender body, which, as well as the extremely long tail, is verticillated, or formed of scaly carinated rings. They have also two small vesicles at the base of each thigh, a long extensile forked tongue, and a remarkable contraction between the head and body. There are two species, viz.

Quadrilineatus. *Species* 1. *Takydromus quadrilineatus.* Four-streaked Takydrome. Brown above, whitish below, with two longitudinal white lines on each side.

Le Takydrome brun a quatre raies, Daud. iii. p. 252.

Sexlineatus. 2. *T. sexlineatus.* Six-streaked T. Bright shining blue, with three longitudinal black lines on each side of the body. See Plate CCXCVII. Fig. 15. Plate CCXCVII. Fig. 15.

Le T. nacre a six raies, Daud. iii. p. 256. pl. xxxix.

These animals inhabit dry places, and, as their generic name imports, run with great swiftness.

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* We have said (p. 31.) that the lizards are innocent reptiles, a position now generally maintained by modern naturalists. We are, however, assured, by an intelligent friend, a clergyman, that when a boy, he had one of his fingers so much affected, in consequence of handling a brown lizard, as to be very nearly in a state of gangrene.

GENUS XIV. SCINCUS. SCINKS.

Scincus Genus.

Body long and rather thick, entirely covered with elliptical or rounded imbricated scales. Head oblong, covered above with a few plates; tongue rather thick, short, and slightly cleft at its tip. Tail longer or shorter in the different species, covered with scales similar to those of the body. Feet strong, rather short and thin, furnished each with five long, thin, separate toes, terminating in claws.

This is a numerous tribe, comprehending 21 species, which are all natives of warm climates. They are brisk in their motions, and fond of basking in the sunshine. They live in dry stony places, and feed on insects. The species are arranged by Daudin in four sections, as follows.

SECT. I. *Common Scinks.*

Species. Tail short and conical; colour grey, having generally transverse bands of a deeper colour.

Officinalis. *Species* 1. *Scincus officinalis.* Officinal Scink. Grey, begirt with transverse blackish zones; back a little angular; muzzle short and acute; tail compressed at the tip; margin of the toes serrated.

Le scinque ordinaire d'Egypt, Daud. iv. p. 130.
Lacerta scincus, Linn. a Gmel. p. 1077.
Official scink, Shaw, iii. pl. lxxix.
Le scinque, Lacep. ii. part ii. art. 34. pl. i. fig. 2.

Galliwasp. Plate CCXCVII. Fig. 16. 2. *S. galliwasp.* Galley-wasp S. Thick, brown above, with large rounded imbricated scales; muzzle taper, with plates on its upper part; tail thick and short. See Plate CCXCVII. Fig. 16.

Le gros S. gally-wasp de la Jamaique, Daud. iv. p. 239.

Gigas. 3. *S. gigas.* Giant S. White, with nineteen transverse bands; tail of moderate length.

Le S. géant, Daud. iv. p. 244.

Mabouya. 4. *S. mabouya.* Mabouya S. Shining ash-brown, with numerous small black spots above each side; sides and belly pale; tail elongated; muzzle prominent.

Le S. mabouya, Daud. iv. p. 246. Lacepede, ii. part ii. art. 24. pl. ii. fig. 1.

Tiliguga. 5. *S. tiliguga.* Tiliguga S. Tail of moderate length, round, and conical; body thick, brown above, thickly set with black dots, whitish below.

Le S. teliguga, Daud. iv. p. 251.
Lacerta tiliguga, Linn. a Gmel. p. 1073.
Sardinian lizard, Shaw.

SECT. II. *White-streaked Scinks.*

Æneus. 6. *S. Æneus.* Bronze S. Body slender, of a bronze colour, with a broad longitudinal pale streak upon the back; tail once and a half the length of the body.

Le S. bronze, Daud. iv. p. 254.

Bilineatus. 7. *S. bilineatus.* Two-streaked S. Brownish, with two white longitudinal lines upon the back, with brown spots disposed in rows.

Le S. a deux raies, Daud. iv. p. 256.
Lacerta interpunctata, Linn. a Gmel. p. 1075.

Trilineatus. 8. *S. trilineatus.* Three-streaked S. Brown above, with three longitudinal white lines; tail a little longer than the body, with the scales on its back part hexagonal.

Le S. a trois raies, Daud. iv. p. 263.

Quadrilineatus. 9. *S. quadrilineatus.* Four-streaked S. Tail long and round; fore feet four-toed; hind feet five-toed, with two longitudinal white lines on each side of the body.

Le S. a quatre raies, Daud. iv. p. 266.
Lacerta quadrilineata, Linn. a Gmel. p. 1076.
Le quatre raies, Lacepede, ii. part ii. art 57.

Algira. 10. *S. Algira.* Algerine S. Scales of the back carinated; two yellow longitudinal lines on each side of the body; tail long and round.

Le S. Algire, Daud. iv. p. 269.
Lacerta Algira, Linn. a Gmel. p. 1073.
L'Algire, Lacep. ii. part ii. art. 32.

Quinquelineatus. 11. *S. quinquelineatus.* Five-streaked S. Blackish above, with five longitudinal yellow or white lines upon the back; whitish below; tail of moderate length.

Le S. a cinq raies, Daud. iv. p. 272. pl. lv. fig. 1.
Lacerta quinquelineata, Linn. a Gmel. p. 1075.
Le S. strié, Lacepede, ii. part ii. art. 38.

Cruentatus. 12. *S. cruentatus.* Bloody S. Tail a little verticillated; ash colour above, scarlet below, with a whitish tip; seven white streaks upon the neck, four of which reach to the tail.

Le S. ensanglanté de la Siberie, Daud. iv. p. 278.
Lacerta cruenta, Linn. a Gmel. p. 1072.
Red-tailed lizard, Shaw.

Melanurus. 13. *S. melanurus.* Black-tailed S. Pale ash colour above, marked with seven longitudinal yellowish lines; yellowish below; tail round and black, twice as long as the body.

Le S. a sept raies et a queue noire de l'Inde, Daud. iv. p. 280.

Octolineatus. 14. *S. octolineatus.* Eight-streaked S. Black above, with eight longitudinal whitish lines; whitish below; tail ferruginous, and twice as long as the body.

Le S. a huit raies de la Nouvelle Hollande, Daud. iv. p. 285.
The ribboned lizard, White's *Voyage to New South Wales,* p. 245.

SECT. III. *Black-streaked Scinks.*

Sloanii. 15. *S. sloanii.* Sloanian S. Brown above, with four black longitudinal lines, of which the intermediate are shortest; tail a little longer than the body, with rounded imbricated scales on its proximal, and hexagonal verticillated scales on its distal half.

Le S. sloanien, Daud. iv. p. 287. pl. lv. fig. 2.

Schneiderii. 16. *S. schneiderii.* Schneiderian S. Bright brownish above, with a pale longitudinal line on each side, whitish below; tail twice as long as the body.

Le S. schneidérien, Daud. iv. p. 291.
Le Dore, Lacepede, ii. part ii. art. 36.

Tristatus. 17. *S. tristatus.* Sallow S. Back pale brown; sides of a deeper colour, marked with a double pale longitudinal band; tail long and cylindrical.

Le S. rembruni, Daud. iv. p. 296.

Laticeps. 18. *S. laticeps.* Broad headed S. Head behind the eyes, broad, colour brownish, spotted with black; tail as long as the body, having its distal part covered both above and below with transverse plates.

Le S. a large tête, Daud. iv. p. 301.

Carinatus. 19. *S. carinatus.* Ridged S. Scales carinated; tail twice as long as the body, covered with scales as in the last species.

Le S. Caréné, Daud. iv. p. 304.

SECT. IV. *Ocellated Scinks.*

Ocellatus. 20. *S. ocellatus.* Eye-spotted S. Ash coloured above, with numerous transverse lines of black scales; yellow in the middle; tail about the length of the body.

Le S. Ocelle de Chypre et d'Egypt, Daud. iv. p. 308. pl. lvi.

Lacerta ocellata. Linn. a Gmel. 1077.

Lateralis.

21. *S. lateralis.* Variegated S. Ash-coloured above, with transverse rows of black spots, with oblong white dots in the middle; black longitudinal lines, dotted below with white upon the sides; tail shorter than the body, and ending suddenly in a point.

Le S. a bandes laterales, Daud. iv. p. 314.

Of all these species, the first or Egyptian scink is the most celebrated, both from the high estimation in which it is held by the natives, and for its having been once employed in Europe as a medicine. It is a small animal, seldom exceeding six or seven inches in length, and is of a pale yellowish brown colour. In its manners it is perfectly harmless; and so active in its motions, that it hides itself in the sand in an instant. This species is so numerous in some parts of the East, that several thousands of them have been seen at once in the great court of the temple of the Sun at Balbec. The ground, the walls, and scattered stones of these ruinous buildings, were covered with them, exhibiting a beautiful appearance from their glittering colours, as they lay basking in the sun. See Bruce's *Travels.*

GENUS XV. SEPS. EFTS.

Seps Genus.

Body, neck, and tail very long, thin, cylindrical, and covered with imbricated scales of a roundish or elliptical form. Head thin, oblong, covered above with few scales; tongue rather thick, short, and slightly cleft at its tip. Either four or two feet extremely short, simple, very slender, scaly, furnished with one, two, three, four, or five toes, indistinct, sometimes with claws, sometimes without.

The animals which compose this genus so nearly resemble some of the serpents, as scarcely to be distinguished from them by a casual observer. Indeed, if we except the short and often indistinct feet, and the marks of an external auditory orifice, they possess almost all the other characters of serpents; and accordingly several of them have been ranked among the Ophidian reptiles. In their habitudes and manners, they nearly resemble the scinks, though, from the shortness of their feet, their motions are rather those of snakes than lizards. Daudin enumerates six species, arranged under the two following sections.

Species.

SECT. I. *Four-footed Efts.*

Pentadactylus.

Species 1. *Seps pentadactylus.* Five-toed Eft. Five toes on each foot, furnished with claws; bay or ash coloured above, with numerous longitudinal brown streaks; whitish below. See Plate CCXCVIII. Fig. 17.

PLATE CCXCVIII. Fig. 17.

Le Seps quadrupède pentadactyle, Daud. iv. p. 325.

Lacerta serpens, Linn. a Gmel. p. 1078.

Tridactylus.

2. *S. tridactylus.* Three-toed E. Feet furnished with three extremely short toes without nails; bay or ash colour above, with four longitudinal brown streaks; paler below.

Le S. quadrupède tridactyle, Daud. iv. p. 333, pl. lvii.

Monodactylus.

3. *S. monodactylus.* One-toed E. Feet extremely thin and short, composed of one toe without claw; tail three times as long as the body; scales subimbricate, and slightly carinated.

Le S. quadrupède monodactyle, Daud. iv. p. 342, plate lviii. fig. 1.

Lacerta anguina, Linn. a Gmel. p. 1079.

SECT. II. *Two-footed Efts.*

Schneiderii.

4. *S. schneiderii.* Schneiderian S. Whitish above, with a brown line; brown below; feet remote from the *anus,* extremely short, either two or three-toed; toes without claws, and as if arising from a common pedicle.

Le S. schneiderien, Daud. iv. p. 348.

Sheltopusik.

5. *S. sheltopusik.* Sheltopusik S. Head and body without distinct separation; tail long and round, as well as the body, covered with pale imbricated scales; rudiments of hinder feet only, two-toed, and without claws, at the *anus.*

Le S. bipède sheltopusik, Daud. iv. p. 351.

Lacerta apoda, Linn. a Gmel. p. 1079.

Gronovii.

6. *S. gronovii.* Gronovian E. Dorsal scales dotted with brown; tail smooth at the tip; hinder feet only, very short, with one toe and no claw.

Le S. gronovien, Daud. iv. p. 354, pl. lviii. fig. 2.

Lacerta bipes, Linn. a Gmel. p. 1079.

GENUS XVI. CHALCIDES. CHALCIDES.

Chalcides Genus.

These reptiles differ from those of the last genus only in the disposition of the scales that cover the body and tail, which, instead of being imbricated as in the seps, are arranged in rings, or verticillated. They inhabit similar situations, and have similar manners. There are four species, of which three are four-footed, and one two-footed.

SECT. I. *Four-footed Chalcides.*

Tetradactylus.

Species 1. *Chalcides tetradactylus.* Four-toed Chalcides. Scales of the belly hexagonal, with a longitudinal furrow on each side of the body; feet four-toed.

Le chalcide quadrupède tetradactyle, Daud. iv. p. 362.

Tridactylus.

2. *C. tridactylus.* Three-toed C. Feet three-toed, very short, and without claws; tail a little longer than the body. See Plate CCXCVIII. Fig. 18.

PLATE CCXCVIII. Fig. 18.

Le Chalcide quadrupède tridactyle, Daud. iv. p. 367, pl. lviii. fig. 3.

Le Chalcide, Lacepede, ii. part ii. art. 52.

Monodactylus.

3. *C. monodactylus.* One-toed C. Feet short and very slender, with one toe without claw; tail once and a half the length of the body, and cylindrical.

Le C. quadrupède monodactyle, Daud. iv. p. 370.

SECT. II. *Two-footed Chalcides.*

Propus.

4. *C. propus.* Grooved C. Fore feet only with five toes, of which four are clawed and one naked; each side of the body longitudinally furrowed.

Le C. bipède cannelé, Daud. iv. p. 372. pl. lviii. fig. 4.

Bipède cannelé, Lacepede, ii. p. 325.

Fossil Saurians.

Several remains of Saurian reptiles, in a fossil state, have been discovered in the bowels of the earth, particularly the bones of two species or varieties of crocodile, nearly allied to the gavial, but considered by Cuvier as distinct from that species. These remains of crocodiles have been found near Honfleur, Mons, Angers, and Havre in France; at Altorf in Bavaria; at Elston near Newark, in the English county of Nottingham; and on the coast of Whitby in Yorkshire. See *Annales de Museum,* tom. xii. p. 73, and *Phil. Trans.* vol. xxx. p. 963, and vol. l. p. 688, and 786. There have besides been found in the mountains of St Pierre, near Maestricht, some enormous bones of a Saurian reptile, which have occasioned some dispute between MM. St Fond and Cuvier; the former alleging them to be the remains of a gavial crocodile, and the latter arguing, with much plausibility, that although so large, they resemble parts of a Tupinambis rather than of a crocodile.

Parts of a winged reptile, resembling the flying dragon, have also been found in a rock near Manheim. See Daud. in *Hist. Nat. des Reptiles*, tom viii. p. 294.

ORDER III. BATRACIAN REPTILES.

BATRACIAN Order.

The animals of this order resemble those of the two preceding in several respects. Like them, they have all feet, and jaws not formed, of two branches, moveable on each other; and in one part at least of their progress towards maturity, they have all tails. Like the Saurians, their jaws are furnished with teeth, and their larynx is capable of producing sound. On the other hand, they differ from the Chelonians and Saurians, in having a naked body in many instances covered with warts or tubercles; in having the bones soft; in having no external copulative organ in the male, nor any real internal one in the female. Some of them have a sternum, but no ribs; others ribs, but no sternum. Most of the species have four feet in their perfect state. All of them swim, some crawl, and others leap; and the species of one genus attach themselves to objects, by round tubercles terminating their toes. The other characteristic marks have been already mentioned in the first part of this article.

Modern naturalists reckon six genera as belonging to this order, which Dumeril arranges under two subdivisions, as follows:

FAMILY I. *Batracians without Tails.*

GENUS I. HYLA. HYLÆ, or TREE FROGS.

HYLA Genus.

Body slightly compressed, elongated, and smooth. Tongue short and thick; the two fore feet furnished with four toes, the hinder with five; all of them without claws, but terminated by lenticular tubercles.

The tree-frogs, as their name imports, have their habitation in trees, to the leaves of which they adhere by the tubercles on their toes, and where they are often seen leaping from branch to branch, or from leaf to leaf, in search of worms and insects. During winter and early spring they seek the bottom of lakes and rivulets, where, after their hybernation is over, they pair, and where the female lays her eggs. Most of the species are natives of America; but some are common in France, Italy, and other warm European countries.

At the pairing season the male makes a loud shrill croaking noise, and inflates his throat in a remarkable manner. The croaking is said to be particularly loud in the evenings on the approach of rain. It has also been remarked of these animals, that their skin has the power of absorbing water.

There are twenty-eight species distinguished by the following names and characters.

Viridis.

Species 1. *Hyla viridis.* Green H. Bright green above, with a yellow line on each side, bordered with a blackish shade extending from the nostrils to each flank, and forming a sinuosity above each loin; whitish below.

La rainette verte, Daud. viii. p. 23. Lacepede, ii. part iii. art. 14.

Rana arborea, Linn. a Gmel. p. 1054.

Tree-frog, Shaw.

Lateralis.

2. *H. lateralis.* Flank-striped H. Bright green, lighter below, with a straight yellow line upon the sides of the upper lip, body, and limbs.

La R. flanc-rayée, Daud. viii. p. 27.

Bilineata.

3. *H. bilineata.* Two striped H. Obscure green, with two parallel longitudinal white lines a little arched upon the back.

La R. bi-rayée, Daud. viii. p. 30.

Femoralis.

4. *H. femoralis.* Thigh-spotted H. Green, with seven or more yellow spots on the upper part of the thighs.

La R. fémorale, Daud. viii. p. 32. pl. xciii. fig. 1.

Squirella.

5. *H. squirella.* Yellow-rumped H. Obscure green, with brown spots upon the back, and yellow rump.

La R. squirelle, Daud. viii. p. 34. pl. xciii. fig. 2.

Variegata.

6. *H. variegata.* Variegated H. Brown above, with green denticulated spots; limbs marked with transverse green bands; toes flattened.

La R. bigarré, Daud. viii. p. 36.

Intermixta.

7. *H. intermixta.* Mixed coloured H. Greenish grey above, interspersed with red spots and dots; pale red below.

La R. mélangée, Daud. viii. p. 38.

Bicolor. PLATE CCXCVIII. Fig. 19.

8. *H. bicolor.* Two coloured H. Blue above, yellowish below, with white spots surrounded with violet. See Plate CCXCVIII. Fig. 19.

La R. bicolore, Daud. viii. p. 40.

Rana bicolor, Linn. a Gmel. 1052.

Cyanea.

9. *H. cyanea.* Blue H. Blue above, reddish clouded ash-colour below; hinder feet palmated.

La R. bleue de la Nouvelle Hollande, Daud. viii. p. 43.

Blue frog, White's *Voyage to New South Wales*, p. 248, pl. iv.

Frontalis.

10. *H. frontalis.* Banded H. Body and legs reddish brown above, with ovate oblong white spots.

La R. a bandeau, Daud. viii. p. 45.

Rana leucophylla, Linn. a Gmel. p. 1055.

Tinctoria.

11. *H. tinctoria.* Stained H. Body smooth, with two longitudinal and one transverse yellowish lines upon the back.

La R. a tapirer, Daud. viii. p. 48.

Fusca.

12. *H. fusca.* Brown H. Brown above; whitish ash-coloured below; entirely without spots.

La R. brune, Daud. viii. p. 51.

La brune, Lacepede, ii. part iii. art. 16.

Rubra.

13. *H. rubrà.* Red H. Brownish red above, with a double pale line on each side, and rounded spots above the thighs.

La R. rouge, Daud. viii. p. 53.

La rouge, Lacepede, ii. part iii. art. 20.

Quadrilineata.

14. *H. qudrilineata.* Four-streaked H. Blue or sulphur-yellow above, with a double yellow or whitish line on each side.

La R. a quatre raies, Daud. viii. p. 55.

Aurantiaca.

15. *H. aurantiaca.* Orange H. Orange-yellow, with a stain of reddish upon the back.

La R. orangée, Daud. viii. p. 57.

L'Orange squelette, Lacep. ii. part iii. art. 19.

Hypochondrialis.

16. *H. hypochondrialis.* Hypochondrial H. Bluish-grey above, with the sides of the body and limbs yellowish, marked with transverse brown bands; toes cleft.

La R. hypochondriale, Daud. viii. p. 60.

Lactea.

17. *H. lactea.* Milky H. Milky white, with a brownish line extending from the nostrils to the eyes; fore-feet semipalmated, hinder palmated.

La R. lactée, Daud. viii. p. 62.

Boans.

18. *H. boans.* Croaking H. Whitish ash-coloured, with broad transverse red and brown streaks; head and mouth broad; hinder-feet semipalmated.

La R. beuglante, Daud. viii. p. 64.

Rana boans, Linn. a Gmel. p. 1055.

Croaking frog, Shaw.

La Couleur-de-lait, Lacepede, ii. part iii. art. 17.

Ocularis.

19. *H. ocularis.* Eye-streaked H. Silvery-grey, with a lateral brown band extending from each eye to the side; limbs marked with transverse brown bands.

La R. oculaire, Daud. viii. p. 68.

Verrucosa.

20. *H. verrucosa.* Warty H. Uniformly brownish, with a warty back.

La R. a verrues, Daud. viii. p. 70.

Marmorata.

21. *H. marmorata.* Marbled H. Yellow-ash, marbled with reddish above, dotted with black below; all the feet flat and palmated.

L. R. marbre, Daud. viii. p. 71. pl. xciv.

Le Marbre, Lacepede, ii. part. iii. art. 33.

Venulosa.

22. *H. venulosa.* Veined H. Pale reddish, marbled with irregular red streaks or spots, dotted with brown; hinder feet semipalmated.

La R. réticulaire, Daud. viii. p. 74.

Rana venulosa, Linn. a Gmel. p. 1053.

La réticulaire, Lacepede, ii. part iii. art. 6.

Tibiatrix.

23. *H. tibiatrix.* Flute H. Yellowish white, interspersed above with reddish dots; hinder feet semipalmated.

La R. fluteuse, Daud. viii. p. 76.

Palmata.

24. *H. palmata.* Palmated H. Pale reddish, marbled with reddish brown, with two streaks above the limbs; all the feet palmated.

La R. patte d'oie, Daud. viii. p. 80; Lacepede, ii. part iii. art. 7.

Punctata.

25. *H. punctata.* Dotted H. Whitish grey or brownish above, with scattered white dots, and a white line on each side; belly white.

La R. ponctuée, Daud. viii. p. 81.

Blochiana.

26. *H. blochiana.* Blochian H. Ash-coloured above; whitish below, with an obscure line extending from the nostrils to the ear, and obscure transverse bands upon the thighs.

La R. blochienne. Daud. viii. p. 83.

Melanorabdota.

27. *H. melanorabdota.* Black spotted H. Green above, with transverse black spots.

La R. a taches noires, Daud. viii. p. 85.

Surinamensis.

28. *H. surinamensis.* Surinam H. Ash-coloured; marked with ovate red spots above, dotted with black below; all the toes separate.

La R. de Surinam, Daud. viii. p. 86.

GENUS II. RANA. COMMON FROGS.

RANA Genus.

Body thick, a little compressed, elongated, moist, covered with a few small tubercles; generally granulated below, except at the thorax, which is smooth; on each side of the back, above the loins, there is in some species a longitudinal angular fold; tongue short and thick; the fore feet have four separate toes, with the thumb a little larger than the rest in the male; the hinder feet are almost always palmated, and are much longer than the body; the toes are pointed, and have usually a small tubercle under each articulation.

Common frogs cannot climb like the tree-frogs, nor can they be said to walk, their proper motion being that of leaping. They inhabit marshy and boggy places, and the borders of lakes and ponds, into which they frequently leap and swim about, either in search of insects, worms, and the fry of fishes, or for amusement. Here too they pair and lay their eggs.

About the time when the young frogs are come to maturity, it often happens that migrations take place among them from a crowded pond or stream, to one where they are less numerous. On these occasions, it is astonishing what numbers have been seen at once crossing a field or road in their way to their new habitation. According to Mr Rae, two or three acres of ground have been seen nearly covered with them. Frogs arrive at full maturity in about five years, and are supposed to live about twelve or fifteen. The croaking of some species, especially of that called the bull-frog, is remarkably loud, and in some parts of America, where this species abounds, the noise made by their united croaking is heard at a very considerable distance.

Frogs are capable of being rendered familiar, and have become so tame as to eat out of the hand. Some of the species serve for food to man, and most of them become the prey of the larger animals that inhabit marshy situations.

Species.

Daudin enumerates sixteen species of Rana, viz.

Esculenta.

Sp. 1. *Rana esculenta.* Esculent Frog. Green with black spots, and three longitudinal yellow lines upon the back; belly whitish.

La Grenouille verte, Daud. viii. p. 90.

Rana esculenta, Linn. a Gmel. p. 1053.

La Grenouille commune, Lacepede, ii. part. iii. art. 1.

Gibbous frog, Pennant, *Brit. Zool.* iii. p. 7.

Esculent, or *green frog,* Shaw, iii. pl. xxxi.

Temporaria.

2. *R. temporaria.* Common F. Red or brown above, or greenish, with a blackish spot extending from the eye through the opening of the ear.

La G. rousse a tempes noires, Daud. viii. p. 94.

Rana temporaria, Linn. a Gmel. p. 1053.

La Rousse, Lacepede, ii. part iii. art. 2.

Common frog, Brit. Zool. iii. p. 3. Shaw, iii. pl. xxxix.

Punctata.

3. *R. punctata.* Dotted F. Ash-coloured, dotted with green above; feet marked with transverse bands; toes separate.

La G. ponctuée, Daud. viii. p. 100.

Plicata.

4. *R. plicata.* Plaited F. Brown, with the sides double plaited; breast and arms marked with four brown spots; feet separate.

La G. plissée, Daud. viii. p. 102.

Clamata.

5. *R. clamata.* Noisy F. Dull ash-coloured, interspersed with black dots; upper lip green; hind feet palmated.

La G. criarde, Daud. viii. p. 104.

Typhonia.

6. *R. typhonia.* Typhon F. Ash-coloured or reddish, with a few brown spots, and either five or three longitudinal yellow lines upon the back; belly whitish.

La G. galonnée, Daud. viii. p. 106, pl. xcv. Lacepede, ii. part iii. art. xii.

Rana marginata, Linn. a Gmel. p. 1053.

Hurricane frog, Shaw.

Rubella.

7. *R. rubella.* Reddish F. Rusty colour above, with three longitudinal black lines upon the back, and a triangular white spot upon the forehead.

La G. rougette, Daud. viii. p. 109.

Maculata.

8. *R. maculata.* Spotted F. Grey, with a square green spot upon the head, and another round one on each shoulder; whitish below, marbled with black.

La G. tachetée, Daud. viii. p. 111.

Pipiens.

9. *R. pipiens.* Bull F. Very large; dark green above, whitish grey below, interspersed everywhere with blackish spots.

La G. mugissante, Daud. viii. p. 113. Lacepede, ii. part iii. art. 9.

Rana ocellata, Linn. a Gmel. p. 1052.

Bull frog, Catesby's *Carolina.*

Rana catesbiana, Shaw, iii. pl. xxxiii.

Ocellata.

10. *R. ocellata.* Eye-spotted F. Very large; reddish brown above, with round brown spots, eyed with yellow on the sides and buttocks.

La G. ocellée, Daud. viii. p. 118.

Halecina.

11. *R. halecina.* Pitpit F. Green above, with brown spots eyed with yellow; three longitudinal lines shaded with yellow upon the back; white below.

La G. hallécine, Daud. viii. p. 122.

Tigurina.

12. *R. tigurina*. Tigrine F. Large; greyish-brown, with a longitudinal yellow line extending from the nose to the rump; dark brown spots edged with yellow above the limbs, and yellow buttocks.

La G. tigrée, Daud. viii. p. 125.

Grunniens.

13. *R. grunniens*. Grunting F. Brown or reddish, with oblong yellow spots behind the eyes.

La G. grognante, Daud. viii. p. 127.

Paradoxa.

Plate CCXCVIII. Fig. 20.

14. *R. paradoxa*. Paradoxical F. Greenish-ash or reddish above, marbled with reddish brown; thighs marked below with oblique reddish lines. See Plate CCXCVIII. Fig. 20.

La G. Jackie, Daud. viii. p. 130; Lacep. ii. part iii. art. 11.

Rana paradoxa, Linn. a Gmell. p. 1055.

Paradoxical frog, Shaw.

Surinam frog or *Jackie*.

Surinam frog.

The natural history of this extraordinary animal is but imperfectly understood. It has long been supposed, that it is first a frog, and afterwards changes into a fish; in which latter state it is eaten by the natives of Surinam, under the names of Jackie and Frog-fish.

Considerable light has been lately thrown on the economy of the Surinam frog by Mr W. M. Ireland and Sir E. Home, in a paper just published in *The Journal of Science and the Arts*, 1816, vol. i. p. 55. edited at the Royal Institution by Mr Brande. Mr Ireland has had the good fortune to witness the changes which the animal undergoes from the tadpole to the perfect state; and the following is an abstract of his observations, with those of Sir E. Home, on the internal structure of the tadpole in two of its stages.

When first seen by Mr Ireland, the tadpole was about four inches and a half long by about an inch broad, had a large head and small mouth, very much resembling those of a fish, though the rudiments of two legs were evident just behind the head. In about a fortnight, the length of the animal had increased to eight inches, and its breadth to about two and a half; and the rudiments of the legs were developed into nearly perfect members, with five clawed toes, united by a membrane, evidently the future hind legs of the animal.

On examining its internal structure during this fortnight, the intestinal canal appears very long, and coiled up, and the rudiments of the lungs are seen in the posterior part of the belly.

In about three weeks the fore-legs make their appearance, the head and mouth assume their ordinary figure, the former being considerably smaller, and the latter larger than before; and the animal, which till now had lain at the bottom of the vessel in a torpid state, becomes more active and lively, and usually remains suspended in the water, with its mouth above the surface. By this time the intestinal canal is wonderfully altered in extent and appearance, being contracted apparently to less than half its length, and having but very few short convolutions, and nearly the whole of the cavity of the belly is filled with fat.

In about six weeks, the animal is greatly contracted in size, being little more than three inches long by about an inch in breadth, and has become a perfect frog, except some small remains of the tail, which has been gradually sloughing off or absorbed, and the disappearance of which has so greatly contracted the animal's length.

The appearance of the tadpole, in the state usually called the Frog-fish, is shewn in Plate CCXCV. Fig. 17. which is reduced to one-fourth of its natural length, and the animal nearly in its perfect state, and one-half its natural size, is represented in Plate CCXCVIII. Fig. 20.

Arunco.

15. *R. arunco*. Arunco F. Body warty; feet palmated.

La G. arunco, Daud. viii. p. 134.

Thaul.

16. *R. thaul*. Yellow F. Body warty; yellow feet, semipalmated.

La. G. thaul, Daud. viii. p. 136.

Rana lutea, Linn. a Gmel. p. 1050.

Genus III. Bufo. TOADS.

Bufo Genus.

Body thick, short, and broad, more or less warty on the upper surface; head thick and short; eyes large and protuberant, with a vertical pupil; tongue short and thick; skin dilatable by inflation; belly often granulated; fore-feet with four separate toes, the thumb larger in the male; hinder feet comparatively short, and generally palmated with five toes; all the toes pointed, but without claws.

From the construction of their legs and feet, toads do not leap so well as frogs, but they walk better, and swim with facility. In their other habits and modes of life they resemble frogs, except that, when irritated or terrified, they emit from the pores of their warty skin a sort of frothy fluid, which, though not venomous, as was formerly supposed, is sufficiently irritating to affect delicate parts of the skin of an animal that touches it. It is scarcely now necessary to remark, that the stone in the toad's head, which has given rise to Shakespeare's beautiful simile, is only a poetical fiction, those substances which have received that name appearing only to be the fossil teeth of a species of fish.

Toads feed on worms and insects, and in their turn become the prey of the larger birds and snakes; and it is said, that their flesh, so far from being venomous, affords as wholesome nutriment as that of the frog. Some of these animals are also capable of being domesticated. We are informed by Mr Pennant, that an individual of the common toad was known to frequent the steps of a gentleman's house in Devonshire for thirty-six years, where it was accustomed to be fed every evening by the family and their visitors.

The accounts that have been published in various works, respecting living toads found in hollow trees and blocks of stone, however extraordinary, seem so well authenticated, that we can scarcely doubt the reality of such occurrences, though we cannot satisfactorily account for them.

Species.

There are about thirty-two species of toad which are thus distinguished.

Vulgaris.

Species 1. *Bufo vulgaris*. Common Toad. Pale reddish-ash coloured, with red pustules above, reddish-white below.

Le crapaud cendre a pustules rouses, Daud. viii. p. 139.

Cinereus.

2. *B. cinereus*. Cinereous T. Uniformly ash coloured, pustular.

Le C. cendré, Daud. viii. p. 141.

Flaviventris.

3. *B. flaviventris*. Yellow bellied T. Ash coloured and pustular above, sulphur-yellow below.

Le C. a ventre jaune, Daud. viii. p. 143.

Panamensis.

4. *B. panamensis*. Panama T. Ash coloured; pustules tipt with violet, yellowish below; feet semipalmated.

Le C. de panama, Daud. viii. p. 145.

Bombinus.

5. *B. bombinus*. Natter-jack T. Olive-brown above,

orange-yellow below, with bluish spots and a fold below the throat.

Le C. sonnant ou pluviale, Daud. viii. p. 146.

Among other synonymes under this species, Daudin refers to

Rana bombina, Linn. a Gmel. p. 1048; *Rana rubita*, ibid. p. 1047; *Rana salsa*, ibid. p. 1049.

La sonnante, Lacepede, ii. part iii. art. 4; *La pluviale*, ibid. art. 3.

Natterjack, Pennant, *Brit. Zool.* iii. p. 12.

Roeselli.

6. *B. roeselli.* Roesellian T. Greenish above, with elevated dark brown spots; greenish-ash coloured below; feet palmated.

Le C. de roesel, Daud. viii. p. 150. plate xcvi.

Rana bufo, Linn. a Gmel. p. 1047.

Toad, Pennant, *Brit. Zool.* iii. p. 7; Shaw's *Gen. Zool.* iii. plate xl.

Le Crapaud commun, Lacepede, ii. part iii. art. 21.

Calamita.

7. *B. calamita.* Calamite T. Olive above, with dark spots, reddish pustules, and a longitudinal yellow line along the middle of the back.

Le C. calamite, Daud. viii. p. 153; Lacep. ii. part ii. art. 25.

Viridis.

8. *B. viridis.* Green T. Marked above with contiguous green spots, and irregular whitish-livid lines dotted with red; feet semipalmated.

Le C. verd, Daud. viii. p. 156; Lacep. ii. part iii. art. 22.

Gibbosus.

9. *B. gibbosus.* Gibbous T. The body ovate, smooth, convex, brownish above, with a longitudinal yellow indented band along the middle of the back; toes separate.

Le C. bossu, Daud. viii. p. 158; Lacep. ii. part iii. art. 29.

Rana gibbosa, Linn. a Gmel. p. 1047.

Gibbous toad, Shaw.

Fuscus.

10. *B. fuscus.* Brown T. Marked above with broad brown spots, interspersed with livid ash-coloured lines, and one pale longitudinal line; hind feet palmated.

L. C. brun, Daud. viii. p. 161; Lacep. ii. part. iii. art. 24.

Cursor.

11. *B. cursor.* Courier T. Smoothish above, spotted with reddish and black, with warty sides, yellowish below, with three black spots upon the breast; toes separate.

Le C. courier, Daud. viii. p. 164.

Gutterrosus.

12. *B. gutterrosus.* Swelled throated T. Grey, spotted with brown, warts sharp, and reddish at the tip; throat swoln.

Le C. goitreux, Daud. viii. p. 166; Lacep. ii. part iii. art. 28.

Ventricosus.

13. *B. ventricosus.* Inflated T. Mouth narrow, arms and thighs surrounded with a lax skin, capable of inflation.

Le C. ventru, Daud. viii. p. 168.

Rana ventricosa, Linn. a Gmel. p. 1049.

Humid toad, Shaw.

Lævis.

14. *B. lævis.* Smooth T. Pale yellow, with a smooth, rather flattened body, and a longitudinal row of small pointed tubercles above each side.

Le C. lisse, Daud. viii. p. 171.

Dorsiger.

15. *B. dorsiger.* Surinam T. Dark brown, head flat and triangular; eyes minute, situated at the top of the head; toes of the fore feet separate, and three or four forked at their tips; hind feet palmated; cells on the back in the female.

Le C. pipa, Daud. viii. p. 172; Lacep. ii. part iii. art. 30.

Rana pipa, Linn. a Gmel. p. 1046.

Surinam toad, Shaw, iii. plate xxxi.

Obstetricans.

16. *B. obstetricans.* Accoucheur T. Dirty green, with small irregular brown spots above; whitish below.

Le C. accoucheur, Daud. viii. p. 176.

Margaritifer.

17. *B. Margaritifer.* Pearly T. A coriaceous auricular lobe above each side of the head; numerous warts upon the body, bearing some resemblance to pearls; hinder feet semipalmated.

Le C. perlé, Daud. viii. p. 179.

Rana margaritifera, Linn. a Gmel. p. 1050.

Pearled toad, Shaw.

La perle, Lacep. ii. part iii. art. 10.

Surinamensis.

18. *B. Surinamensis.* Dwarf Surinam toad. Bright brown above; belly dotted with grey, with a white line on the hips; all the toes separate.

Le C. de surinam. Daud. viii. p. 184.

Albonotatus.

19. *B. albonotatus.* White spotted T. Brown; slight-warted, with a white line extending from each nostril to each thigh; upper part of the limbs spotted with white.

Le C. a taches blanches, Daud. viii. p. 185.

Ovalis.

20. *B. ovalis.* Oval T. Head short; muzzle long; body ovate, nearly globular; brownish or bluish above, yellowish below; feet palmated.

Le C. ovale, Daud. viii. p. 187.

Lineatus.

21. *B. lineatus.* Striped T. Warty, brownish red, with a white line drawn from each nostril through the eyelids to the hind feet, another on each arm; white bands upon the limbs, and all the toes separate.

La C. rayé, Daud. viii. p. 188.

Musicus.

22. *B. musicus.* Musical T. Brown above, with blackish spots; head furrowed above; limbs marked with blackish bands.

Le C. criard, Daud. viii. p. 190.

Rana musica, Linn. a Gmel. p. 1046.

Musical toad, Shaw.

Scaber.

23. *B. Scaber.* Rough T. Yellowish, with black lips; body a little spinous, especially about the legs; head furrowed above; hind feet slightly palmated.

Le C. rude, Daud. viii. p. 194.

Le pustuleux, Lacepede, ii. part iii. art. 27.

Bengalensis.

24. *B. bengalensis.* Bengal T. Body thickly covered with warts; yellowish grey; head slightly furrowed above; black sharpish pointed warts below the feet; hind feet semipalmated.

Le C. du bengale, Daud. viii. p. 197.

Spinosus.

25. *B. spinosus.* Spinous T. Dark brown above, with broad spots of a paler hue; pale grey below, with tubercles tipt with a black spine.

Le C. epineux, Daud. viii. p. 199.

Horridus.

26. *B. horridus.* Horrid T. Dark green above; warty, with numerous small black spines on each tubercle, marbled below with green and paler shades; all the toes separate.

Le C. hérissé, Daud. viii. p. 201.

Australian frog, Shaw.

Spinipes.

27. *B. spinipes.* Spine-footed T. Brown above, bluish below; sides marked with ochry colour; fore feet spinous above.

Le C. spinépede. Daud. viii. p. 203.

Humeralis.

28. *B. humeralis.* Shoulder-knot T. Very large; ash-grey, irregularly spotted with brownish; parotid glands large and gibbous.

Le C. epaule armée, Daud. viii. p. 205.

Rana marina, Linn. a Gmel. p. 1049.

La grenouille epaule armée, Lacep. ii. part iii. art. 8.

Marine toad, Shaw.

Semilunatus.

29. *B. semilunatus.* Semilunated T. Blackish, with

a white spot behind each ear; head slightly furrowed above; hinder feet semipalmated.

Le C. demi-lune, Daud. viii. p. 208.

Agua. 30. *B. agua.* Brazilian T. Very large; beautifully marbled with yellow, brown, and grey, and rough with tubercles; large parotid glands; hinder feet very slightly palmated.

Le C. ague, Daud. viii. p. 209.—Lacep. ii. part iii. art. 32.

Rana braziliensis, Linn. a Gmel. p. 1049.

Cyanophlytis. 31. *B. cyanophlytis.* Blue-warted T. Bluish brown above, with blue pustules on each side, extending from the eyes to the lower part of the breast and sides, and thence to the rump.

Le C. a pustules bleues. Daud. viii. p. 212.

Cornutus. 32. *B. cornutus.* Horned T. Head large, with a long conical protuberance, or horn, upon each upper eyelid.

Le C. cornu, Daud. viii. p. 214.—Lacepede, ii. part iii. art. 31.

Rana cornuta, Linn. a Gmel. p. 1050.

Horned frog, Shaw.

FAMILY II. *Tailed Batracians.*

GENUS IV. SALAMANDRA. SALAMANDERS.

Salamandra Genus. Body elongated, cylindrical, naked, sometimes warty, and terminated by a tail that is either cylindrical or flattened, so as to form a fin, and persistent. No external ears; tongue short, thick, and entirely fixed within the lower jaw. Fore feet having either three or four toes; hinder furnished with five toes, all blunt, and without claws.

Till within these few years, the salamanders had been ranked among the lizards, to which they are allied only from their having a tail, and from the similar position and structure of their legs. In their internal organization and their general habits, they are entirely distinct from all the Saurian order, and more nearly resemble the frogs and toads. They have no true ribs; they respire in the same manner as the Batracians already described, and in most of them the fecundation of the ova takes place in a similar manner. In a few of them, indeed, the young are extruded from the ova while still within the oviduct of the female; and the species in which this takes place are called *ovoviviparous.* In their metamorphosis, the young salamanders pass through the early stages of existence with much the same appearances as we have described in the tadpole of the frog, except that the number of stages is rather less. The tadpole of the salamander bursts the ovum within ten days after it is dropt from the mother, and takes about four months to arrive at its perfect state, during which time it subsists entirely on vegetables; while in their perfect state, they feed on snails, worms, and insects. The number of young produced by one female salamander sometimes amounts to thirty or forty.

These animals are found in most warm climates; and at least six of them are natives of the south of Europe. They inhabit the banks of unfrequented streams, moist shady woods, and high grounds; but are seldom seen except during wet weather. They appear to live equally well in the water and on land, and they swim with great facility. During winter they lie concealed about the roots of old trees, in the cavities of old walls, or in subterranean recesses, where they are sometimes found twisted together. In their general habits, they are very sluggish, and their pace is slow.

It was believed by the ancients, and is still a popular superstition among the vulgar in most countries, that salamanders are not only capable of existing with impunity in fire, but have the power of putting a stop to a considerable conflagration when thrown among the flames. This absurd idea has perhaps arisen from the fact which has been observed by Maupertuis, that when one of these animals is placed upon a fire, its whole body soon becomes covered with drops of a milky fluid, which oozes through the pores of the skin, and quickly dries upon its surface.

Species. There are about fourteen species, which are thus distinguished.

Terrestris. *Species* 1. *Salamandra terrestris.* Common salamander. Blackish, variegated with irregular blackish spot; tail cylindrical, and a little obtuse.

La Salamandrie terrestre. Daud. viii. p. 221. pl. xcvii. fig. 1.—Lacepede, ii. part ii. art. 54. pl. viii. fig. 1.

Lacerta salamandra, Linn. a Gmel. p. 1066.

Salamander, Shaw, iii. pl. lxxxii.

Atra. 2. *S. atra.* Black S. Uniformly black without spots; tail cylindrical and a little obtuse.

La S. noire, Daud. viii. p. 225.

Rubra. 3. *S. rubra.* Red S. Red interspersed with numerous black points, with a blackish streak upon the belly: hinder feet semipalmated.

La S. rouge, Daud. viii. p. 227.

Venenosa. 4. *S. venenosa.* Venomous S. Ground black, with round yellow spots, arranged in a double row along the back.

La S. venimeuse, Daud. p. 229.

Lacerta punctata, Linn. a Gmel. p. 1076.

La pontuée, Lacepede, ii. part ii. art. 56.

Alleganiensis. 5. *S. alleganiensis.* Alleghany S. Large, brown, paler below, with a shortish compressed tail, slightly crested.

La S. des monts alleganis, Daud. viii. p. 231.

Cristata. 6. *S. cristata.* Crested S. Blackish above, marked below with large rounded orange-coloured dots; sides granulated with white, and dotted with black; tail compressed; back of the male furnished with a fimbriated crest.

La S. crêtée, Daud. viii. p. 233.

Rubriventris. 7. *S. rubriventris.* Orange bellied S. Black above, with brownish spots; orange below without spots, except a few black dots under the neck.

La S. a ventre orangé, Daud. viii. p. 239. pl. xcviii. fig. 1.

Marmorata. 8. *S. marmorata.* Marbled S. Olive green above, marbled with brown; brownish below, with white granular dots; tail compressed.

La S. marbrée, Daud. viii. p. 241.

Abdominalis. 9. *S. abdominalis.* Abdominal S. Olive green above, dotted with yellow below, with a longitudinal yellowish line on each side of the back; all the toes separate.

La S. abdominale. Daud. viii. p. 250.

Palmipes. 10. *S. palmipes.* Webfooted S. Head and arms yellow, slightly dotted with black; back olive brown; belly yellowish; hind feet palmated.

La S. palmipéde, Daud. viii. p. 253. pl. xcviii. fig. 2.

Elegans. 11. *S. elegans.* Elegant S. Head and feet yellow, slightly dotted with black; back olive; belly yellowish; all the toes separate, but those of the hind feet lobated.

La S. elegante, Daud. viii. p. 255.

Punctata. 12. *S. punctata.* Dotted S. Olive ash above, yellow below, every where interspersed with black dots; tail very much compressed; all the toes separate.

La S. ponctuée, Daud. viii. p. 257.

Cincta. 13. *S. cincta.* Girded S. Yellowish olive above, dotted yellow below with a white streak; edged below with black dots; all the toes separate.

L. S. ceinturée, Daud. viii. p. 259.

Tridactyla. 14. *S. tridactyla.* Three-toed S. Fore feet three-toed; hind feet four-toed.

La S. tridactyle, Daud. viii. p. 261.—Lacep.

Le Lizard tridactyle, Lacep. ii. part ii. art. 59.

Genus V. Proteus. PROTEUS.

Proteus Genus. Body elongated cylindrical, terminated by a compressed tail forming a fin; tongue short, thick, adhering within the lower jaw; fore feet furnished with three toes, and the hinder with two; all without claws; branchiæ persistent.

Anguinus. *Species. Proteus anguinus.* Serpentine Proteus. Fore feet three-toed; hind feet two-toed.

Le proté anguillard, Daud. viii. p. 266. pl. xcix. fig. 1.

Proteus anguinus, Laurenti, *Synops. Reptil.* p. 37. pl. li. fig. 3.—Scopoli, *Annales Hist. Nat.* vol. v. p. 70.—Linn. a Gmel. p. 1056, note.—Hermann, *Tab. Affinitat. Animal.*—Schneider, *Hist. Amphib. fascic.* i. p. 45.—Schreiber, *Phil. Trans.* 1801.

The curious animal for which the present genus has been constituted, was first observed at the bottom of a lake in Carniola in Germany, and described in 1768, by Laurenti, in the work referred to above. It was afterwards described by Scopoli, and was briefly noticed by Linnæus in his *Systema Naturæ*, who, however, considered it as the tadpole of a salamander; but the most complete account of the animal has been given by Schreiber, a German naturalist, in a memoir of his published in the Transactions of the Royal Society of London for 1801. From this account it is now generally allowed, that the Proteus is to be considered as a perfect animal, differing from all the other reptiles with which we are acquainted.

Its general length is about thirteen inches by about one inch of medium breadth, and the head is nearly two inches long. It has no external nostrils; and its eyes, which are black, and situated towards the base of the muzzle, are so small as with difficulty to be distinguished. The colour of the living animal is a flesh red, and the gills are scarlet; but when immersed in spirits after death, it becomes white. It appears to walk with difficulty, but swims with great ease. One that was kept by Baron Zois, lived for about ten days, and during that time refused all nourishment, and appeared in a torpid state.

The Proteus undergoes three degrees of metamorphosis before arriving at its perfect state. In the two former, it is blind and without feet.

It is said on certain occasions to utter a sound resembling that made by forcing down the piston of a syringe.

Two reptiles have lately been noticed by the French naturalists, bearing a near relation to the Proteus above described. One has been described by Cuvier under the name of *Axolote Mexicaine,* and has four toes on each fore foot, and five on each hinder. This we might call *Proteus mexicanus.* The other is described and figured by Lacepede, in the tenth volume of the *Annales de Museum,* p. 230. pl. xvii. by the name of *Protée tetradactyle,* (*Proteus tetradactylus,*) with four short pointed toes on each of the four feet. It differs from the Proteus auguinus in having a thicker and shorter body, a much broader tail, and the legs larger and shorter.

Genus VI. Siren. SIREN.

Siren Genus. Body elongated, cylindrical, and terminated by a compressed tail, forming a fin; tongue short, thick, and adherent; fore feet digitated; no hind feet; branchiæ persistent.

Lacertina. *Species. Siren lacertina.* Lacertine Siren. Feet four-toed.

La Siren lacertine, Daud. viii. p. 272. pl. xcix. fig. 2.

Siren lacertina, Linn. *Amœnit. Academ.* vii. p. 311.

Muræna siren, Linn. a Gmel. p. 1136.

Siren lacertina, Shaw's *Naturalist's Miscellany,* N°20, pl. lxi.—Schneider, *Hist. Amphib.* fascic. i. pl. 48.

The extraordinary reptile which constitutes this last genus of Batracians was first observed in 1765, by Dr Alexander Garden, in a fresh water lake near Charlestown in Carolina, and was described by Linnæus in the Memoirs of the Academy of Upsal for that year. He considered it either as the tadpole of a species of lizard or salamander, or as a new genus of his order Nantes, to which he gave the name of Siren. Soon after, Linneæus placed the Siren in the order of Amphibia, which he denominated Meantes, from which Gmelin, in his edition of the *Systema Naturæ,* injudiciously removed it to the class of Fishes, and considered it as a species of *murœna.*

The Siren very much resembles an eel in the general form of the body and tail. Its mouth is small, and furnished with small sharp teeth, set partly in the palate, and partly in the lower jaw. Its eyes are very small, but more evident than those of the Proteus. Its skin is of a blackish colour, slightly grained and porous, with a longitudinal white line, extending on each side from the feet to the tail, and a shorter one along the middle of the back. The whole length of the animal sometimes exceeds three feet; and the feet, which are small, and composed of a *humerus,* a fore arm, and four small pointed toes, furnished with claws, are about an inch long.

Its tongue is bony, and formed like that of fishes; the gills are composed of three fimbriated plates on each side, are very apparent, and are above half an inch long. It has a real larynx, and its lungs resemble those of salamanders. In its metamorphosis from the ovum to the perfect state, it seems to follow the same degrees with the *Proteus,* except that its eyes are sooner open.

This animal appears to reside entirely in the water, where it must swim with great facility. It was supposed by Linnæus, from the form of its feet, that it can also move with tolerable ease upon the land; but we believe it has never yet been seen in that situation.

EXPLANATION OF PLATES.

PLATE CCXCV.

Fig. 1. Skeleton of a species of Tupinambis.

Fig. 2. The head of the same animal. *a,* the intermaxillary bone; *b, b,* the two superior, or coronal maxillary bones; *c,* the nasal bone; *d,* one of the zygomatic arches; *e,* a supernumerary bone; *f, f,* the two sides of the frontal bone; *g,* the parietal; *h, h,* two bony arches forming the interior border of the temporal fossa; *i,* a small portion of the left basilar jaw; *k,* the bone with which this is articulated; *l, l,* the occipital bone; *m,* its condyle.

PLATE CCXCV.

Fig. 3. The jaws of the Nilotic crocodile extended, shewing the mode of their articulation.

Fig. 4. Stomach of the common land tortoise.

Fig. 5. Stomach of the Gavial crocodile, with a portion of the intestinal canal commencing at *a*, the pylorus.

Fig. 6. Stomach of the Nilotic crocodile partly laid open; *a*, a pouch into which the aliments pass before proceeding out at *b*, the pylorus.

Fig. 7. Stomach and intestines of the Chameleon; *a*, the *pylorus*; from *a* to *b*, the small intestine; *b*, the commencement of the large intestine.

Fig. 8. Part of the intestines of the land tortoise; *a b*, a part of the small intestine; *b*, the commencement of the large intestine.

Fig. 9. The *rectum* of the Nilotic crocodile insensibly commencing from the small intestine; *a a*, a valve between the two.

Fig. 10. *Rectum* of the Gavial; *a*, the termination of the small intestine; *b*, the rectum; *c*, a projection from the small intestine into the large for acting as a valve.

Fig. 11. Stomach and intestines of the Siren; *a* the *pylorus*; *b*, the termination of the hepatic duct.

Fig. 12. The heart of the crocodile seen on its lower surface; *a a*, the right auricle; *c*, the common trunk of the right carotid and right brachial arteries; *d*, the common trunk of the same arteries on the left side; *e e*, the continuation of the right posterior *aorta*; *f f*, the left posterior aorta: *g h*, the left and right pulmonary arteries; *i k*, the pulmonary veins; *o*, the opening by which the right auricle communicates with the inferior compartment of the ventricle; *p*, an orifice by which this compartment communicates with the pulmonary cavity of the ventricle; *q*, *r*, two valves at the commencement of the left aorta; *s*, *t*, the trunks of the two arteries *c* and *d* laid open; *v*, the trachea; *x x*, its subdivisions into bronchi; *y y*, situation of the lungs.

Fig. 13. The heart of the crocodile viewed on its inferior surface, but a little more to the left side.

Here the letters *a*, *c*, *d*, *e*, *f*, *g*, *h*, refer to the same parts as in the preceding figure. *b*, the left or pulmonary auricle; *m*, a row of tubercles behind; *x*, *y*, the valves guarding the entrance of the left pulmonary artery; *z*, the communication between the inferior and pulmonary compartments of the ventricle.

Fig. 14. The crocodiles heart seen on its upper surface; where the letters *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *k*, refer to the same parts as in the former figures. *l*, the upper compartment of the ventricle laid open.

Fig. 15. The general appearance of the ova of frogs, as extruded from the oviduct.

Fig. 16. The tadpole of the frog, when only a few days old.

Fig. 17. The tadpole of the Surinam frog in that stage called *frog-fish*.

Fig. 18. Is the under surface of one of the toes of the *Gecko Egyptiacus*, of the natural size. See p. 29.

Fig 19. Is a toe dissected to shew the appearance of the pockets on its under surface, their serrated cuticular edge, the depth of the pockets, and the small muscles by which they are drawn open, the parts being highly magnified: *a a* are the two muscles which lie on the sides of the bones of the toe, with their tendons inserted into the last bone, close to the root of the claw. The muscles belonging to the pocket go off from these tendons.

PLATE CCXCVI.

Fig. 1. *Chelonia mydas*. Green turtle.
Fig. 2. *Testudo Græca*. Common land tortoise.
Fig. 3. *Crocodilus Niloticus*. Crocodile of the Nile.
Fig. 4. *Dracæna*. Dragon lizard.
Fig. 5. *Tupinambis ornatus*. Ornamented tupinambis.
Fig 6. *Basiliscus mitratus*. Mitred basilisk.
Fig. 7. *Iguana delicatissima*. Common guana.
Fig. 8. *Draco volans*. Flying dragon.

PLATE CCXCVII.

Fig. 9. *Agama calotes*. Galeot Agama.
Fig. 10. *Stellio brevicaudatus*. Short-tailed stellio.
Fig. 11. *Chameleo vulgaris*. Common chameleon.
Fig. 12. *Gecko Egyptiacus*. Egyptian gecko.
Fig. 13. *Anolis bimaculatus*. Two-spotted anolis.
Fig. 14. *Lacerta lemniscata*. Laced lizard.
Fig. 15. *Takydromus sexlineatus*. Six-striped takydrome.
Fig. 16. *Scincus officinalis*. Common scink.

PLATE CCXCVIII.

Fig. 17. *Seps pentadactylus*. Five-toed eft.
Fig. 18. *Chalcides tridactylus*. Three-toed chalcides.
Fig. 19. *Hyla bicolor*. Two-coloured tree-frog.
Fig. 20. *Rana paradoxa*. Surinam frog.
Fig. 21. *Bufo dorsiger*. Surinam toad.
Fig. 22. *Salamandra terrestris*. Common salamander.
Fig. 23. *Proteus anguinus*. Common proteus.
Fig. 24. *Siren lacertina*. Lacertine siren.

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INDEX OF GENERA, AND REMARKABLE CIRCUMSTANCES.

HERRING. See Ichthyology.

HERRING Fishery. See Fisheries.

HERTFORD Town, in the hundred of Hertford, in Hertfordshire, is pleasantly situated 21 miles north from London, on the river Lea, which is navigable for barges to the town. The streets are chiefly neat and clean, and the houses well built. It contains two parish churches; a handsome sessions house, in which the assizes for the county are held; a market house and town hall, in which are kept the quarter sessions and county courts; and a county gaol and penitentiary house, built on Mr Howard's plan. The most important public seminaries for education consist of the East India College, for the education of youth destined to fill the various offices in the civil departments in India; and a large school belonging to Christ's Hospital in London, where about 500 of the younger children are kept prior to their being sent to the metropolis. Hertford returns two members to Parliament. The right of election is vested in the inhabitants who do not receive alms; and in such freemen only as, at the time of their being made free, were inhabitants of the borough. Their number is about 700. The only article of consequence manufactured here is malt, by which, and the large quantities of corn and wool sent down the river to London, the inhabitants are principally supported.

In 673, a synod was held at Hertford, and King Alfred here built a castle, by means of which the Danes, who had come up the Lea from the Thames, were destroyed. On the site of the ancient castle the present one, now the East India College, was erected in the time of Charles I. The manor of Hertford belonged to the Crown from 1345 till the sixth year of Charles I., when it was granted to William Earl of Salisbury, whose descendant, the present marquis, is now owner of it. In the 25th year of the reign of Elizabeth, and afterwards in the 34th and 35th of the same reign, the Michaelmas term was adjourned from London to this town, on account of the plague then raging in the metropolis.

At Haileybury, in the parish of Amwell, in the vicinity of the town of Hertford, and about 19 miles from London, is situated the East India College. This site was chosen by the directors of the East India Company, when they formed the determination of abandoning the grand and extensive plan of a college at Calcutta, sketched out and partly begun by the Marquis of Wellesley during his administration of India. The object of both institutions is to give a suitable education to those persons who are meant to occupy civil employments under the company in India.

The college near Hertford was instituted in April 1805, and the foundation stone of the building was laid on the 12th of May 1806. The beauty of the building, the fineness of the situation, the salubrity of the air, and the object of the institution, render it an object of considerable interest. The college is capable of accommodating above 100 students, and rather more than thirty, on an average, are annually sent from it to India. According to the plan of the institution, young men are received when they have completed their 15th year, and they continue at the college till they are 18, or till the court of directors shall deem it proper to send them to their respective destinations. A nomination to the college, on the part of the court, is equivalent to an immediate appointment. The students are instructed by courses of lectures, nearly on the plan pursued at the universities of Oxford and Cambridge. The college council, under whose direction and authority the institution is more immediately placed, consists of a principal and several professors. Besides the general superintendance of the college, it is the duty and office of the principal more especially to watch over the moral and religious conduct of the students, to instruct them in the principles of ethics and natural theology, and in the evidences, doctrines, Hertford, Hertfordshire.

and duties of revealed religion. Besides, he, as well as such of the professors as are in holy orders, preach in the college chapel. The principal is assisted in the superintendance of the college by the dean, who is annually chosen from among the clerical members of the college council.

The lectures of the professors are arranged under four heads, viz. oriental literature: 1st, Practical instruction in the rudiments of the oriental languages, especially the Arabic, Persian, Hindostanee, Sanscrit, and Bengalee. 2d, A course of lectures to illustrate the history, customs, and manners of the people of India. In these two departments there is a professor for the languages, a professor of Hindoo literature, and of the history of Asia, two assistants who are natives of the East, and a Persian writing master. There is also a visitor and councillor in the oriental department. Under the second head are included mathematics and natural philosophy, for which there are two professors. The third head comprises classical and general literature, for which there are two professors. The fourth head comprises a course of lectures on general polity, and on the laws of England, and the principles of the British constitution; a course of lectures on general history, and on the history and statistics of the nations of modern Europe; and a course of lectures on political economy. For these subjects there are two professors. There are also attached to the college, masters for French, drawing, and fencing.

The college year is divided into two terms of twenty weeks each, with a summer vacation of eight weeks, and a winter vacation of four weeks. The principal examination takes place previous to the winter vacation, and continues three weeks. It is terminated by a visitation of the court of directors, when the result of the examination is presented by the principal, in separate lists for each department, of the respective merits of each student. These lists are inserted in the public records of the company. Other lists are also given in, exhibiting a relative view of the conduct and proficiency of each student. Prizes of books, medals, &c. and certificates of superior merit, are publicly given by the chairman. Every student going to India, carries with him a certificate under the college seal, attesting what his attainments have been during his academical course.

In 1801, Hertford contained 515 houses, and 3360 inhabitants. In 1811, the population abstract gave as follows:

Houses inhabited	598
Families inhabiting them . . .	735
Males	2038
Females	1862
Total	3900

See Arthur Young's *Agriculture of Hertfordshire*; *Beauties of England and Wales*, vol. v.; Lyson's *Environs of London*. (W. S.)

Situation and boundaries.

HERTFORDSHIRE is an inland county of England, bounded by Bedfordshire and Cambridgeshire towards the north and west, Buckinghamshire towards the west, Essex towards the east, and Middlesex towards the south. Its limits are principally artificial, except on the south east, where it is separated from Essex by the rivers Lea and Stoot. From Bailey to Royston, the Ikenild Street, one of the four Roman highways running through the island, divides the counties of Cambridge and Hertford. It is intermixed with Buckinghamshire in a singular manner, so that its shape on the western side is rendered extremely irregular by projections and indentures. It is situated between the parallels of 51° 37', and 52° 5' North Latitude. Its greatest length may be reckoned at 25 miles, and its breadth from north to south at 35 miles. According to Halley, it contains 451,000 acres; but according to the poors rate returns, only 385,000. It is among the smallest counties in England.

Face of the country.

The general aspect of this county is pleasant. The northern part is the most hilly, forming a scattered part of the chalky ridge, which extends across the kingdom in this direction. A range of high ground stretches out from the neighbourhood of Kings Langley, towards Berkhampstead and Tring. Another elevated ridge commences at St Albans, and proceeds in a northern direction towards Market Street. A number of streams take their rise from this side of the county.

Towns, &c.

Hertfordshire contains 1 county town, Hertford; 8 hundreds; 19 market towns; 120 parishes; returns 6 members to parliament, viz. 2 for the shire, 2 for Hertford, and 2 for St Albans; and is in the province of Canterbury, and diocese of London. There are no places of any consequence in it besides Hertford, St Albans, Royston, and Ware.

Hedge-rows.

Most of the county is enclosed; and in consequence of its being very ill situated for coals, the old hedges are every where filled with oak, ash, sallow, &c. Independent of the wood thus distributed in hedge-rows, very fine timber, in considerable quantity, is spread over every part of the county.

Soil.

The prevailing soils are loam and clay, in general not of a very fertile quality. The vales, however, through which the rivers and brooks flow, are composed of a rich sandy loam. The most productive soil of this nature is on the west side of the river Lea. The principal clay district is on the north-east on Essex side. In the parishes of North Mimy, &c. the general description of soil is extremely barren. The chalky soil prevails on the north side of the county. The basis, indeed, of the whole of Hertfordshire is chalk intermixed with a great quantity of flints. The landed property is greatly divided, in consequence of the vicinity of the metropolis.

Rivers.

The principal rivers are the Lea, the Rib, the Quin, and the Colne. The Lea enters this county near Bower-heath, and traverses it in a direction nearly from north-west to south-east, to its confluence with the Stort, after which it runs nearly south, washing the towns of Hertford and Ware, from the last of which it is navigable to the Thames. It collects, in its course, all the streams of the northern and eastern parts of the county. The Rib, which rises in this county, joins the Lea between Hertford and Ware: the Quin also rises in this county, and falls into the Rib. The Colne rises near Kits-end, in Middlesex; and, after uniting various streams on the south-western side, conveys them out of the county near Rickmansworth. In one part of its course, near Colney Park, it has a short underground passage, though not particularly observable, except in dry weather. The nine sister-springs of the Cam, and the springs which constitute the source of the New River, are in Hertfordshire.

Canals.

The grand junction canal enters this county above Berkhampstead, and leaves it following the course of the Colne. The Watford canal commences near the town of Watford, where it unites with the grand junction, and goes to St Albany.

Agriculture.

Farms are in general small. Perhaps the size most common is from 160 to 400 acres. The principal part of the land is under tillage, and the produce in wheat, barley, and oats, is very considerable. Wheat and barley in particular are grown here of as good a quality as in any other part of the kingdom. In the neighbourhood of Wheathampstead, great quantities of wheat have been grown for a very considerable length of time, whence this place takes its distinctive appellation. Indeed, in the opinion of many, Hertfordshire was distinguished for the excellence of its tillage husbandry, even before Norfolk. Turnips and clover are supposed to have been introduced in the time of Cromwell, who, it is said, gave £100 a year, on that account, to a farmer of the name of Howe. Even the judicious culture and application of tares were practised in this county upwards of 80 years ago—at a period when they were scarcely known in any other part of England. It does not seem, however, that the arable husbandry of Hertfordshire has improved much latterly; and the kind of plough still in general use, will, with many, be deemed a proof of this remark. This plough, known by the name of the great Hertfordshire wheel plough, though of great merit and utility in breaking up strong flinty fallows in a dry season, ought certainly to be dispensed with in all the other operations of husbandry; and, even for that purpose, it might be constructed in such a manner as to do its work with more ease to the horses. It is excessively heavy, and so ill formed that it will not move in its work one yard without the ploughman. The plough-shares alone weigh from 50 to 70 lbs.

Hertfordshire plough.

Grass lands.

The grass-lands of Hertfordshire, compared with those under tillage, are very trifling: in fact, it may be said that there is no grass district in it, except a very narrow margin in the south line, in the vicinity of Barnet, which, being near London, is made artificially productive, by means of manure brought by the hay carts. There are, however, some tolerably good meadows, especially those on the Stort, extending from Hackerell to Hertford, and those in the vicinity of the Lea, and about Rickmansworth. The many streams that flow through the county are extremely favourable to irrigation, though that system is not carried to any great extent. In the south-west corner of the county are many orchards. Apples and cherries are their principal produce.

Cattle and sheep.

As the land in this county is chiefly arable, and the artificial grasses are cultivated almost entirely for hay for the London market, live stock is an object of very inferior consideration. The Suffolk breed of cattle is regarded as the best. The sheep are mostly ewes of the Southdown and Wiltshire breeds. The horses are of various kinds, but the Suffolk punch appears to be preferred.

Roads.

The principal roads in Hertfordshire, in consequence of its vicinity to the metropolis, are very good. Six great leading turnpikes pass through this small district. Many of the cross roads are nearly as good as the turnpikes.

Trade and manufactures.

The great business of the county is the traffic of corn, and the malting trade. The latter is carried on to a very great extent in the towns of Hitchin, Baldock, Royston, and Ware. Ware alone sends a greater supply of malt to London than any other place; and it always obtains the highest price, not only on account of the excellence of the barley from which it is made, but also from the excellence of the mode in which it is manufactured. The Hertfordshire malt, however, is not all made from barley grown in the county; large quantities being purchased in all the surrounding districts, which, after being malted in the towns above mentioned, is sent to London chiefly by the navigation of the Lea. There are very few manufactures in Hertfordshire of any consequence: at St Albans there is a small cotton manufactory, and two silk-mills. The machinery of the latter is particularly well contrived. At Berkhampstead fringe lace is made; and also a considerable quantity of wooden shovels, bowls, spoons, &c. In this, and some other parts of the county, plaiting straw is a resource for poor women and children. At Watford there are some silk mills, one of which is worked by the waters of the Colne; the rest by horses. In 1803 the poor rates amounted to £71,291: in 1815, they had increased to £98,380.

Malt.

Poors-rates.

Antiquities.

There are several antiquities of great interest in this county. The British City of Verulam, on the site of which St Albans stands, is of greater antiquity than even London itself; and, under the dominion of the Romans, acquired the dignity and privileges of a municipium. In the vicinity of this place Cæsar defeated Cassivellaunus; Boadicea conquered and massacred 70,000 Romans and Britons; and two bloody battles were fought between the rival houses of York and Lancaster in 1455 and 1461. The field of Barnet, between St Albans and London, was also the scene of a bloody battle in the destructive wars of the two houses, which proved decisive in favour of Edward IV., his great foe, the Earl of Warwick, surnamed the king-maker, being there slain in 1471. During the Saxon heptarchy, this county was partly in the kingdom of the East Saxons, and partly in Mercia. The king of the latter resided in a castle at Berkhampstead. At this place a parliament was held in 697, and the laws of Ina were published. William the Conqueror here swore to preserve the laws made by his predecessors. King Henry II. kept his court here, and granted it all the liberties and privileges which it had engaged under Edward the Confessor; and so lately as the reign of James I. the royal nursery was established here. Upon a hill in Harborough field, near Ashwell, are evident marks of a Roman fortification, (now called Ardbury Banks), a large square work enclosed with a trench or rampart. Here the Romans had a standing camp, so advantageously situated, that they could discover the approach even of a small body of men at a great distance. Several Roman coins and earthen vessels have been dug up here at different times.

Population.

In 1801 there were 18,172 houses in this county, and 97,577 inhabitants. In 1811, it appears, from the population abstract, that there were—

Houses inhabited	20,345
Families inhabiting them	22,744
Houses building	131
——— uninhabited	436
Families employed in agriculture	11,998
——————— trade	7,192
——————— other lines	3,554
Males	55,023
Females	56,631
Total inhabitants	111,654

The following is the statistical state of the county in 1811:

Area in square statute miles	528
English statute acres	337,920
Rental of land	£342,350
Amount of tithe	45,292
Annual value of a square mile	735

Number of persons in a square mile	211
Agricultural population in centesimal parts .	52
Net product per family	32

(W. S.)

HESIOD, one of the earliest Greek poets. Little is known of his life, and the few facts that have reached us have occasioned much controversy among the learned. It appears that his father Dius had originally resided at Cuma, a town of Æolia in Asia Minor, whence he afterwards removed to Ascra, now Zagara, situated in a valley of Mount Helicon. (See Helicon and Clarke's *Travels*, part ii. sect. iii. p. 112.) It is uncertain whether Hesiod accompanied his father from Cuma, or was born at Ascra. The latter is perhaps the more probable conclusion. In one of his poems he mentions a short voyage to the isle of Eubœa, as the only occasion on which he had ever been on shipboard; but if he had come from Cuma, he must have crossed by sea into Greece. It is true, in the passage alluded to, he speaks of his nautical experience, but the affirmation is unlimited; and it may be supposed, had there been any exception, that exception would either have been noticed, or the expression modified. There is another presumption in favour of Ascra, given by Plutarch on the authority of Ephorus, the historian of Cuma, who relates that Dius had been compelled to emigrate to Ascra, on account of debt, and there married Pycimede the mother of Hesiod. What was Hesiod's occupation is uncertain. La Harpe, in his *Cours de Literature*, supposes him to have been a priest of the Temple of the Muses. Others have maintained, that, according to the Proem to his Theogony, he tended sheep in the vallies of Helicon; a mode of life, it has been thought, better suited and more congenial to the bard of husbandry; though it is evident, as the writer of the Theogony, the same reason applies with equal force in favour of his sacerdotal profession. From the picture of the Muses presenting him with a laurel branch, Mr Elton infers, with Pausanias, that he was not a minstrel or harper, but a rhapsodist, and sang or recited to the branch instead of the lyre." He is reported to have carried off the prize from Homer at a poetical contest. That he won a contested prize in Eubœa, as noticed in his poem of the *Works and Days*, cannot reasonably be doubted; but that he vanquished Homer has been justly regarded as a fiction of later times. Hesiod is noted for longevity, but it is uncertain whether he was permitted to die a natural death. There is a tradition that he was murdered at Ænoe, on a pilgrimage to the Delphic oracle, by the son of his host Ganyctor. Ganyctor having entertained Hesiod, and a Milesian, his fellow-traveller, and his daughter having been violated in the night, suspicion fell upon the aged bard, who, without farther ceremony, was put to death by the brothers, and thrown into the sea. The body being cast on shore, or, as fiction will have it, conveyed to land by a dolphin, was recognised by his dog, and the murderers, upon confession, were drowned in the waves.

The era of Hesiod is still more doubtful than his birth-place. Some authors, as Quintilian, Heinsius, and Justus Lipsius, give him a greater antiquity than Homer; Cicero, Pliny, and Paterculus place him a century later; while a third party, among whom are Plutarch and Varro, supported by the venerable authority of Herodotus, concur in making him a contemporary. The attempts to decide the question of priority, from philological criticism and astronomical calculations, are equally vague and ineffectual. The inference in favour of Homer, which has been drawn from his use of the word θεμιστας for law, when Hesiod employs νομους, alleged to be of more recent origin, is of no force, as Mr Elton justly remarks, "unless we suppose that Homer's poems contained every word in the language." The ingenious argument of Dr Samuel Clarke, on the same side, with regard to the quantity of καλος, of which in Homer the first syllable is long, while Hesiod varies it at pleasure, and of οπωρινος, the penult of which in Homer is long, and short in Hesiod, is scarcely more successful. The difference of locality, of dialect, and more particularly the very considerable alterations which the original poems have manifestly undergone since their collection and arrangement, do not admit of any conclusive argument being founded on such minute diversities. Paterculus places Hesiod 800 years before Christ, and Homer 920; and Herodotus, making them contemporaries, fixes their common era at 884 years before Christ. According to the Parian marbles, Hesiod flourished before Christ 944 years, and Homer 907.

Few of the poems* ascribed to Hesiod are now extant, and there is much difference of opinion respecting the small number that have reached us; these are the Theogony, the Works and Days, and the Shield of Hercules. These remains have manifestly suffered greatly from corruption and mutilation. The many spurious additions and alterations with which modern interpolators have loaded and disfigured them, have so changed their original simple character, as to raise serious doubts of their antiquity.

Joseph Scaliger denies that the Shield of Hercules is the production of Hesiod, while Tanaquil Faber as confidently affirms it to be genuine. This contrariety of decision, in persons so competent to decide, can be accounted for only by the unauthentic and adulterated state of the poem. With regard to his rank as a poet, Quintilian has given him the slender praise of mediocrity. "If the Battle of the Titans," says Mr Elton, "be Hesiod's genuine composition, and if the Shield, as there is reason to believe, contain authentic extracts from his heroical genealogies, we shall decide that Hesiod, as compared with Homer, is less rapid, less fervent in action, less teeming with allusions and comparisons; but grand, energetic, occasionally vehement and daring; but more commonly proceeding with a slow and stately pace. In mental or moral sublime, I consider Hesiod as superior to Homer."

We subjoin a list of the lost poems of Hesiod.—The Catalogue of Women or Heroines, in five parts, of which the fifth appears to have been entitled "the Heroogony." The Melampodia, a poem on divination. The great Astronomy, or Stellar Book. Descent of Theseus into Hades. Admonitions of Chiron to Achilles. Soothsaying and Explications of Signs. Divine Speeches. Great Actions. Of the Dactyli of Cretan Ida; discoverers of iron. Epithalamium of Peleus and Thetis. Ægemius. Elegy on Batrachus, a beloved youth. Circuit of the Earth. The Marriage of Ceyx. On Herbs.

See an ingenious dissertation on the *Life of Hesiod*, prefixed to a new translation of his *Remains*, by Charles Abraham Elton. Lond. 1815. (r)

HERSCHEL, is the name given by some astrono-

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* "The Bœotians," says Pausanias, "have a tradition that Hesiod only wrote the poem of the Works and Days."

mers to the Georgium Sidus. See ASTRONOMY, vol. ii. p. 649, and URANUS.

HESSE, a principality of Germany, is bounded on the south by the bishopric of Fulda, the principalities and the counties of Irenburg, Nidda, and Solms; on the east, by Brunswick Eichsfeld and Thuringia; on the west, by Solms, Nassau, Westphalia, and Waldeck; and on the north, by Waldeck, Padenborn, and Brunswick. Its figure is irregularly oval, and it extends about 60 miles from north to south, and from 50 to 70 from west to east. It occupies 2760 square miles, and contains 750,000 inhabitants.

The greater part of this principality was annexed by Bonaparte to the new kingdom of Westphalia; and the grand duchy of Hesse, which was one of the states of the Confederation of the Rhine, was formed out of new territories. Before the peace of Presburg it contained 154 square German miles, and had a population of 319,000; after the peace of Presburg, its extent was 202 square miles, its population 478,800, its military contingent 4000, and its revenue in rixdollars 1,660,000. An account of this principality will be found in our article on the circle of the RHINE, of which it forms a part. See CASSEL and DARMSTADT.

HEVELIUS, or **HOEVELKE, JOHN**, a celebrated Polish astronomer, was born at Dantzic on the 28th January 1611, and was the son of a brewer of that city. After studying mathematics under Peter Cruger, he travelled through Holland, Germany, England, and France, between the years 1630 and 1634; and upon his return to his native place, he was principally employed in the affairs of the republic of Dantzic, of which he was made consul in 1651. About the year 1660, by the advice of his former master, he devoted himself wholly to the study of astronomy. In the year 1641, he built an observatory at his own expence, and furnished it with excellent telescopes and graduated instruments, which he constructed with his own hands. With these instruments, which consisted of a sextant, a quadrant 6¾ feet radius, and very large telescopes, he made numerous observations, the result of which appeared at Dantzic in the year 1647, in his work entitled "Selenographia, sive Lunæ descriptio, atque accurata, tam maculorum ejus, quam motuum diversorum, aliarumque omnium vicissitudinum phasiumque telescopii ope deprehensarum, delineatio: in qua simul cæterorum omnium planetarum nativa facies, variæque observationes, presertim autem macularum solarium et jovialium tubo specillo acquisitæ, figuris sub aspectum ponuntur; necnon quam plurimæ astronomicæ, opticæ, physicæque quæstiones resolvuntur. Addita est nova ratio lentes expoliendi, telescopia construendi, et horum adminiculo varias observationes exquisite instituendi."

In 1650, he published an epistle to his friend Eichstad, on the eclipse of the sun, on Nov. 4th 1649; and in 1652, appeared another epistle on the solar eclipse, addressed to Gassendi and Bullialdus.

About this time, Hevelius made the important discovery of the moon's libration, of which he gave an account in a letter to Riccioli, which was published in 1654, and entitled *De motu Lunæ libratorio in certas tabulas redacto*. In 1656 he published his *Dissertatio de Nativa Saturni facie, ejusque variis phasibus, certa periodo redeuntibus cui addita est Eclipsis Solis anni* 1656, *observatio et diametri solis apparentis accurata dimensio.*

In 1661, Hevelius had the good fortune to observe the transit of Mercury on the sun's disc; and in 1662, he published his observations, entitled, "Mercurius in sole visus anno 1661, cum aliis quibusdam rerum cœlestium observationibus, rarisque phenomenis; cui annexa est Venus in sole pariter visa 1639, Liverpolisæ a Jeremia Horroxio, nunc primum edita, notisque illustrata. Accedit succincta historiola novæ ac miræ stellæ in collo Ceti certis anni temporibus clare admodum effulgentis, rarsus omnine evanescentis; necnon genuina delineatio paraselenarum et parheliorum * quorundam rarissimorum."

The reputation of Hevelius was now so great, that the illustrious Colbert recommended him to the notice of Louis XIV. who granted him a pension. A copy of the letter, in which Colbert announced this act of liberality to Hevelius, is preserved in the Royal Library at Paris. Hevelius shewed his gratitude by dedicating to Colbert his "Prodromus Cometicus, quo Historia Cometæ anno 1664 exorti cursum, faciesque diversas capitis ac caudæ accurate delineatas complectens, necnon dissertatio de cometarum omnium motu, generatione variisque phenomenis exhibetur," *Dantz.* 1665. A supplement to this work appeared in 1666, entitled, "Descriptio Cometæ anno 1665, exorti cum genuinis observationibus tam nudis quam enodatis mense Aprili habitis; cui addita est mantissa *Prodromi Cometici*, observationes omnes prioris Cometæ 1664, ex iisque genuinum motum accurate deductum, cum notis et animadversionibus, exhibens."

In the year 1668, he published in folio, his great work on comets, under the title of "Cometographia, totam naturam Cometarum, utpote sedem, parallaxes, distantias, ortum et interitum, capitum caudarumque diversas facies, affectionesque, necnon motum eorum summe admirandum, beneficio unius, ejusque fixæ et convenientis hypotheseos, exhibens; in qua universa insuper phenomena, questionesque de cometis omnes rationibus evidentibus deducuntur, demonstrantur, ac iconibus æri incisis plurimis illustrantur; cumprimis vero Cometæ annorum 1652, 1661, 1664, 1665, ab ipso auctore summo studio observati.—Accessit omnium Cometarum, a mundo condito huc usque, ab historicis philosophis et astronomis annotatorum, historia, notis et annotationibus locupletata, cum peculiari tabula Cometarum Universali."

When this work was completed, Hevelius sent a copy of it to Dr Hooke, and to other distinguished members of the Royal Society. In return for this work, Dr Hooke presented Hevelius with a Description of the Dioptric Telescope, and the method of using it; and recommended it as preferable to the use of plain sights in astronomical instruments. In this way commenced the celebrated controversy respecting the use of plain and telescopic sights. Hooke maintained, that with an instrument of a span radius, the distances and altitudes of celestial objects could be measured to a second by telescopic sights; and Hevelius insisted in his reply, that with a good eye, and great experience, he had obtained the same accuracy in the use of his instruments; and he sent eight distances between stars, for the purpose of being examined by Dr Hooke. Here the controversy was for the present terminated.

In the year 1673, Hevelius published in folio, the first part of his "Machina Celestis, organographiam,

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* These Paraselenæ and Parhelia are described in our article HALO, Vol. X. p. 614, and represented in Plate CCLXXXVII. Figs. 4, 5, 6.

sive instrumentorum astronomicorum omnium quibus auctor sidera hactenus rimatus et dimensus est, accurata delineatio et descriptio pluribus iconibus æri incisis illustrata et exornata; cum aliis quibusdam tam jucundis quam scitu dignis. quæ ad mechanicam opticamque pertinent, animadversionibus, imprimis de maximorum tuborum constructione et commodissima directione, necnon nova facillima lentes quasvis ex sectionibus coni expoliendi ratione." Hevelius sent copies of this work to all his friends in England except Dr Hooke; who, in revenge of the affront, published in 1674 his "Animadversions on the First Part of the *Machina Celestis*, of the honourable, learned, and famous Joannes Hevelius, together with an explication of some instruments made by R. H." Lond. 4to. This work was characterised by the irritability of its author. It was written with that tone of arrogant superiority, which injured his own cause and excited the highest resentment on the part of Hevelius. In the same year, Hevelius sent a letter to the Royal Society, containing a reply to the objections of Hooke and Flamstead, and appealing to observation for the correctness of his opinions. He complained of the "bitterness and boasting" with which he had been attacked, and requested that the Royal Society would send some eminent astronomer to examine his instruments and method of using them. This reasonable demand was acceded to; and Dr Halley, who held nearly the same opinions as Hooke, was requested to repair to Dantzic. He arrived in that city on the 26th May 1679, and continued with Hevelius till the 18th of July. By means of a good instrument, furnished with telescopic sights, Halley compared his own observations with those of Hevelius; and he particularly attended to the successive observations made upon the same stars by Hevelius, with his large brass sextant. The result of this examination was highly favourable to our author. Halley left an attestation, dated July 8-18th, 1679, declaring himself "abundantly satisfied of the use and certainty of these his instruments and observations. And whereas he had before been always doubtful, that his observations by naked sights might as to some minutes be uncertain, and had therefore wondered why he declined the use of telescopic sights; he had, partly to gratulate the author's publishing of his observations, and partly to satisfy his own scruples, undertaken that journey, which he now considers as no small happiness, and declares himself abundantly pleased with it: and offers himself a voluntary witness of the almost incredible certainty of these instruments, as having seen with his own eyes not one or two, but a multitude of observations of the fixed stars performed with his great sextant, even by divers observers, and by himself sometimes, though less expert therein, being often repeated, most accurately and almost incredibly to agree, and never to differ more than by an inconsiderable part of a minute."

In the year 1679, Hevelius published his "Machinæ Celestis Pars Posterior; rerum Uranicarum observationes, tam eclipsium luminarium quam occultationum planetarum et fixarum, necnon altitudinum meridianarum, polarium, solstitiorum et æquinoctiorum, una cum reliquorum planetarum fixarumque omnium hactenus cognitarum globisque adscriptarum, æque ac plurimarum huc usque ignotarum, observatis, pariter quoad distantias, altitudines meridianas et declinationes, additis innumeris aliis notatu dignissimis atque ad astronomiam excolendam maxime spectantibus rebus, plurimorum annorum summis vigiliis indefessoque labore ex ipso æthere haustas, permultisque iconibus, auctoris manu æri incisis, illustratas et exornatas, tribus libris exhibens."

Hevelius had fortunately presented about 30 copies of this work to his friends; for before it was published, his property of every description was consumed by a dreadful fire, on the 26th September 1679. No fewer than seven houses, containing his money, plate, gold, silver, household goods, printing houses, great part of his library, the remaining copies of all his printed works, published at his own expence, from the year 1647 to 1679, and particularly his observatory, with all his optical and astronomical instruments, were completely reduced to ashes. Among the articles preserved were the latter part of his *Machina Celestis*, containing the observations of nearly 50 years, and his *New Catalogue of the Fixed Stars*.

A full account of this calamity, and of his dispute with Dr Hooke, were published in 1685, in his "Annus Climactericus, sive rerum Uranicarum et observationum annus quadragesimus nonus, exhibens diversas occultationes tam planetarum quam fixarum, post editam Machinam Celestem observatas, necnon plurimas altitudines meridianas solis, et distantias planetarum fixarumque, eo anno impetratas cum amicorum nonullorum epistolis ad rem istam spectantibus et continuatione historiæ novæ stellæ in Collo Ceti, ut et annotationum rerum celestium."

This work was the last which Hevelius published. Worn out with the infirmities of age, and with the labours of science, he died on the 28th January 1687, in the 76th year of his age. Hevelius left behind him the reputation of having been one of the most industrious and ingenious practical astronomers of the age in which he lived. The surprise which Halley expressed at the wonderful accuracy of his observations, must be felt by every person who examines them, and who considers that they are well made by unassisted vision, and that the instruments were constructed and graduated with his own hands.

Hevelius left behind him two complete works, and many other manuscripts. The first of these made its appearance in 1690, in folio, entitled, "Prodromus astronomiæ, exhibens fundamenta quæ tam ad novum plane et correctiorem stellarum fixarum catalogum construendum quam ad omnium planetarum tabulas corrigendas omnimode spectant, necnon novas et correctiores tabulas solares, aliasque plurimas ad astronomiam pertinentes, utpote refractionum solarium, parallaxium, declinationum, angulorum eclipticæ et meridiani, ascensionum rectarum et obliquarum horizonti Gedanensi inservientium, differentiarum ascensionalium, motus item et refractionum stellarum fixarum, quibus additus est uterque catalogus stellarum fixarum, tam major ad ann. 1660, quam minor ad ann. completum 1700. Accessit Corollarii loco tabula motus lunæ libratorii, ad bina sæcula proxime ventura prolongata, brevi cum descriptione ejusque usu."

This work, which was published by his widow, contains the catalogue of 1888 stars. It was afterwards reprinted in the 3d vol. of Flamstead's *Historia Celestis*, and is incorporated in the catalogue of stars given in our article ASTRONOMY.

In the same year appeared his other posthumous work, entitled, "Firmamentum Sobiescianum sive Uranographia, totum cœlum stellatum, utpote tam quodlibet sidus quam omnes et singulas stellas, secundum genuinas earum magnitudines nudo oculo et olim jam cognitas, et nuper primum detectas, accuratissimisque organis rite observatas, exhibens; et quidem quodvis sidus in peculiari tabella, in plano descriptum, sic ut omnia conjunctim totum globum celestem exactissime referant: prout ex binis hemispheriis majoribus, boreali scilicet et australi, adhuc clarius cuique patet." This work contains 54 charts, representing the whole heavens.

Hevelius was elected a Fellow of the Royal Society of London in 1664, and contributed several papers to the *Philosophical Transactions.*

When M. Delisle passed through Dantzic on his way to Russia in 1626, he purchased all the manuscript observations of Hevelius, along with his extensive correspondence, forming seventeen folio volumes, four of which were occupied with his observations. These manuscripts contain much curious information respecting the history of astronomy. They were lodged by Delisle in the depot of the marine at Paris. Those who wish for farther and more minute details respecting the life and writings of Hevelius, will find much information in a life of him, published at Dantzic in 1780 by Benjamin Leugnich, and entitled, *Hevelius, oder Anekdoten und Nachrichten von diesem beruehmten Manne.* Many particulars respecting our author will also be found in Bernoulli's *Travels in Prussia, Poland, and Warsovia,* 1782, p. 183. A figure of his mausoleum is given in Bernoulli's *Collection of Voyages,* tom. ii. 1781. See also the *Journal de Savans, Aout.* 1782, and Murr's *Journal Literaire, Nuremb.*

HEXACHORD *Major* of Galileo, is an interval of music, whose ratio is $\frac{16}{27}$, $= 462\,\Sigma + 9\,f + 40\,m$, or the *Comma-redundant major* SIXTH. See that article.

HEXACHORD *Major* of the Greeks, or hexachordon major of Holder, &c. has the ratio $\frac{3}{5}$, $= 451\,\Sigma + 9\,f + 39\,m$, or the *Major* SIXTH, which see.

HEXACHORD *Minor* of Didymus, has the ratio $\frac{81}{128}$, $= 404\,\Sigma + 8\,f + 35\,m$, or the *Comma-deficient minor* SIXTH, which see.

HEXACHORD *Minor* of Galileo, has the ratio $\frac{50}{81}$, $= 426\,\Sigma + 8\,f + 37\,m$, or the *Comma-redundant minor* SIXTH, which see.

HEXACHORD *Minor* of the Greeks, or hexachordon minor of Holder, &c. has the ratio $\frac{5}{8}$, $= 415\,\Sigma + 8\,\Sigma + 36\,m$, or the *Minor* SIXTH, which see. (ϱ)

HEXAEDRON. See CRYSTALLOGRAPHY.

HEXAGON. See GEOMETRY, vol. x. p. 221.

HEXHAM, is a market-town of England, in the county of Northumberland, finely situated on the south side of the river Tyne, at the confluence of the north and south Tyne. The two long streets, of which the town consists, are narrow, and not well built; but the town contains some good houses. The road from Newcastle to Hallwhistle passes through one of the streets, and the other principal street runs at right angles to this. At the intersection of these streets, stands the spacious market-place in a large square, with a convenient piazza for the butchers market, which has moveable stalls, and which is well supplied with water from a fountain. The church of Hexham, which forms a part of its ancient monastery, founded in 1112, is highly ornamented in the inside, and contains many fine sepulchral monuments. This church was dedicated to St Andrew, and was much celebrated for its beauty and extent by ancient historians. It is in the form of a Greek cross. The tower, which is in the centre, appears low and broad, though it has a height of 102 feet. The architecture is Gothic and Saxon. A double gallery runs round the whole structure, opening with Saxon arches, each opening being composed of three arches, the middle circular, and the others pointed, with very light pillars. The nave was burnt down by the Scots in 1296, and nothing remains of it but part of its western door. The choir now forms the parish church, and is crowded with inelegant pews and galleries. The priory stood at the west end of the church; and not many years ago, its cloister and chapels were to be seen. There are two ancient stone towers at Hexham, one of which is used as a sessions-house, and formerly belonged to the priors of Hexham. The other is situated on the top of a hill near the Tyne.

It appears from two Roman inscriptions, found in a crypt of the church, that the Romans had a station, or town, at this place; for it is obvious, that this was not the *Epiacum* of the ancients, as Horsley supposed. The crypt, where they were found, is a place fifteen feet by nine, and contains a number of carved stones, which seem to have once formed part of a Roman fortress.

The town is governed by a bailie chosen annually. The principal employment of the inhabitants consists in tanning leather, and in making shoes, hats, and gloves.

The following is a statistical abstract of the parish for 1811:

Inhabited houses,	729
No. of families,	1171
Do. employed in trade and manufactures,	639
Males,	2136
Females,	2719
Total Population,	4855

See Pennant's *Tour in Scotland,* vol. iii.; Hutchinson's *History of Northumberland*; and the *Beauties of England and Wales,* vol. xii. p. 158—168.

HEXHAM, BATTLE OF. See ENGLAND, vol. viii. p. 638. col. 2.

HEYWOOD, JASPER, D.D. a writer of the age of Queen Elizabeth, and son of the epigrammatist Heywood, whom we shall immediately have occasion to mention. He was born in London 1535, and studied at Merton College, Oxford; from whence, according to Wood, he was on the point of being expelled for his irregular life, when he resigned his fellowship. Soon after he repaired to St Omers, and entered into the Society of Jesus at that place. From thence he went to Diling in Switzerland, where he distinguished himself by his learning and zeal for disputing with heretics; so as to obtain the rank of doctor of divinity. In the year 1581, Pope Gregory the XIII. sent him at the head of the first mission of Jesuits to England, but her majesty shipped him off, with 70 of his associates, out of the kingdom; and, returning to Italy, he died at Naples, where the zealous catholic Joannes Pittseus contracted an intimacy with him, and speaks of him with great respect. He translated three of the tragedies ascribed to Seneca, viz. the *Thyestes, Hercules Furens,* and *Troas,* in the measure of the syllables, and from that circumstance has obtained a name in poetical biography. (η)

HEYWOOD, JOHN, father of the preceding writer, was one of the earliest dramatic writers that England produced. Warton says of him, that he drew the Bible from the stage, and introduced representations of popular life, and familiar manners. He was born at North Mims, near St Albans, in Hertfordshire, and in his youth contracted an intimacy with Sir Thomas More, who introduced him to the patronage of the princess (afterwards queen) Mary. His jests, and musical talents, made him a favourite with Henry VIII. who frequently made him handsome presents. When Mary came to the throne, he was admitted to her most intimate conversation, and is said to have amused her with his diverting stories even in her last illness. On the accession of Elizabeth, being a bigotted catholic, he naturally anticipated the loss of his court favour; and, going into voluntary exile, he settled at Mechlin in Brabant, where he died in 1565.

As a poet, he was famous in his time, and his plays are still curious relics. One of them, *The Four P's*, is in Dodsley's *Collection*. His longest work is the *Spider and Fly*, of which honest Holingshed says, "that the author dealeth so profoundlie and beyond all measure of skill, that neither he himself that made it, nor any one that readeth it, can reach unto the meaning thereof." His *Dialogue of Proverbs*, and *Six Hundred Epigrams*, give us but a humble idea of the wit and conversation of our ancestors. (x)

HEYWOOD, Thomas. This author was an actor as well as a writer, and flourished in the reigns of Queen Elizabeth, James I. and Charles I. The date of his birth and death, (we might almost add, the whole history of his life,) is unknown, except his profession and character as a writer. In the latter capacity he is distinguished as one of the most prolific that ever existed; for, besides his prose compositions of *The English Traveller*, *Apology for Actors*, &c. &c. he tells us, that the plays in which he had either a principal share, or wrote entirely, amounted to two hundred and twenty. Of this number, it is true, that but a few comparatively remain. Different reasons have been assigned for the loss of so many of them. It has been alleged, that they were lost from the desultory manner in which he wrote them, on the backs of play-bills and tavern-bills, as he was a great frequenter of taverns; but the true reason seems to have been, that the managers, in those days, purchased the sole property of the copies of plays, and it was not their interest to let them be published till the public had been completely satiated with them; of course when plays ceased to be attractive, the memory of them would perish, and the actors would not much trouble themselves about compositions, which, if they had been printed, might not have repaid the cost.

Of 25 of his plays that remain to us, there is one that ought especially to redeem his name from oblivion. This is, *The Woman killed with Kindness*. The interest of it is founded, like that of Kotzebue's *Stranger*, on a story of domestic infidelity, and the repentance that ensues; but it terminates more tragically, and with a severer moral lesson. Mrs Frankland, the penitent, though forgiven by her husband, cannot forgive herself, and dies broken-hearted. In this, and in several other pieces, Heywood, though not highly fanciful nor poetical, and though he seems to have hardly possessed the common ambition of a poet—to be thought such,—is nevertheless exceedingly natural and touching. The last scene between Frankland and his wife is very touching. It concludes thus:

> *Acton, (the brother of Mrs Frankland,)* How do you feel yourself?
> *Mrs Frank.* Not of this world.
> *Frank.* I see you are not, and I weep to see it.
> My wife, the mother to my pretty babes,
> Both those lost names I do restore thee back,
> And, with this kiss, I wed thee once again;
> Though thou art wounded in thy honoured name,
> And with that grief upon thy death-bed liest,
> Honest in heart, upon my soul, thou diest.
> *Mrs Frank.* Pardoned on earth, soul, thou in heaven art free
> Once more. Thy wife dies thus, embracing thee! (x)

HIBERNATION. See Hybernation.

HIERA. See Kammeni.

HIERES, is a town of France, in the department of the Var, about nine miles east of Toulon. It is situated in a delightful valley, about four leagues long and one broad, open on the south to the sea, and bounded on the north, east, and west, by lofty mountains. Between the northern and western chain is a narrow pass, which is the road to Toulon. At the sloping entrance of this pass, on the declivity of a mountain that defends the whole plain, is situated the town, which is built in the form of an amphitheatre. The summit of the mountain is bare, and is cleft in several places, to give it the appearance of a fortification from a distance. Towards the base of the mountain, stands the modern part of the town, which contains the principal street, the square, and the inns; but it has a gloomy and dirty appearance. The old town, which stands on the highest part of the mountain, presents a heap of uninhabited ruins; but the suburbs, which skirt the mountains, are chearful and clean, and have a neat and rural appearance.

Near the mouth of the small river Gapeau, which intersects the plain of Hieres, are the salt-pits, consisting of a number of small basins separated by canals. The houses of the superintendants, excisemen, and workmen, have the appearance of a little sea-port. The salt is sent to Toulon, Marseilles, and Genoa, and the annual revenue amounts to about 500 000 francs.

About four English miles from the town is the Etang, situated in the centre of an isthmus, running from the southern coast. It is about a league long, and half a league broad, and the three little islands in the middle of it contain a great number of aquatic birds. The eastern part of the isthmus joins the road of Hieres, and is called La Plage de la Munasse. The lower part of it is the peninsula Giens, which contains many interesting objects.

Hieres is celebrated for the mild temperature of its winters; but it is reckoned unhealthy from May to October

At the chapel of Notre Dame, on a hill situated near the sea-shore, and about a league from the town, is a good painting of the Twelve Apostles, and a bas-relief, by Puget.

The garden of M. Fille is well worthy of being visited. Its annual revenue is about 24,000 francs. In the garden of M. Beauregard, which is excellent, a crop of artichokes sold, in 1793, for 1800 francs. The chief exports from Hieres are oil, wine, fruit, vegetables, flowers, and salt, which are sent almost exclusively to Toulon and Marseilles. A thousand oranges are sold for 45 livres. Vessels are loaded in summer at the beach near the salt-works; but in winter, all the merchandize must be conveyed to Toulon by land. East Long. 6° 7′ 55″, and North Lat. 43° 7′ 2″. Population about 7000. See Christ. August. Fischer *Reise nach Hyeres, im Winter von* 1803 *and* 1804. Leipzic, 1806; and Millin's *Voyages dans les Departemens du Midi de la France*, tom. ii. chap. 61.

HIERES, Isles of, (the *Insulæ Arearum*,) are a cluster of three small islands in the Mediterranean, situated about four leagues from the town of Hieres. They are called Porquerolles, Porticros, and the isle of Titan. They were called Stoechades by the Marseillois, who first inhabited them. The most western of these is Porquerolles, which is the largest and best wooded, and contains 85 inhabitants. Porticros is three leagues farther to the east, and is more elevated and fertile. It

Hiero, Hieroglyphics.

has a haven, and contains about 50 inhabitants. The other island is about three quarters of a league to the east of Porticros. It has fewer inhabitants, and is less fertile than the rest. All these islands may be seen from the town of Hieres. They are defended by small forts, and are covered with lavender and strawberries. They are frequently visited by parties of pleasure from the town. See Fischer's *Reise nach Hyeres.*

HIERO. See SYRACUSE.

HIERO'S CROWN. See HYDRODYNAMICS.

HIEROGLYPHICS, (from ἱερος, *sacred*, and γλυφειν, *to carve*,) properly sculptures or carvings, (and hence, by an easy and obvious transition, *paintings* also,) symbolically denoting, by particular figures and collocations of external or corporeal objects, sacred, moral, and religious truths.

Hieroglyphics may be considered as a *species*, of which *symbol* is the *genus*; for hieroglyphics are a particular class of symbols, differing however from other symbols, as well by the nature of the truths of which they are the signs, as by the mysterious and recondite mode in which these truths are exhibited. The truths denoted by hieroglyphics properly relate not to common or trivial objects, but to things sacred or divine; and the mode of exhibiting these is designedly obscure and enigmatical, requiring sagacity and acuteness, as well as patient attention, to develope their meaning.

The origin of hieroglyphical writing has generally been derived from Egypt; and undoubtedly it appears to have been there that hieroglyphics first assumed the form of a regular system. But, in fact, the first steps in the formation and employment of hieroglyphic emblems, may be traced as nearly coeval with the earliest attempts of mankind to communicate their thoughts by visible marks, in addition to articulate sounds. In such attempts, it seems plain, that the first, as being the most natural, way of accomplishing the end, would be by presenting a picture or delineation of the object to be denoted. To express a *man*, an *animal*, or a *tree*, the figure of the object would be drawn and exhibited. To intimate that a man had been slain by a wild beast, the figure of a man stretched on the earth, and the animal standing over him, would be formed; to indicate that a hunter had caught his prey, the picture of the man with the prey in his hands would be given. Such was probably the earliest mode of writing. It is the opinion of the best informed writers, that it prevailed among the Phœnicians, Egyptians, and other early communities; and we know with certainty, that it was in use among the Mexicans when invaded by the Spaniards,—intelligence of their arrival having been transmitted to the emperor in a picture, and even the history of the empire having been delineated by paintings upon skins, afterwards found in one of the temples.

This way of communicating thoughts, however, was, of necessity, liable to much inconvenience. It was often difficult, and generally bulky. To lessen the toil, and abridge the size of the picture, different modes of abbreviation were resorted to. The principal part of the object might first be made to stand for the whole; as the head for the man, a hand holding a weapon for a warrior. Next, the principal circumstance in a complicated action might denote the entire action; two or more hands, with weapons opposed, might denote a battle; a scaling-ladder, set against a wall, a siege. In a short time, a farther improvement would occur; to put the instrument of an action for the thing itself, as, we are informed by Hori Apollo, two feet standing in water represented the fulling of cloth.

Hieroglyphics.

Nearly connected with this, was the practice of denoting the efficient cause by the effect produced; as harvest, by a sheaf of corn—winter, by a leafless tree—hostile incursion, by ruined buildings and dead bodies.

From these different kinds of contracted characters, the transition was easy to the third stage in the progress of writing; to make one thing represent another, where any resemblance sufficiently striking between the two objects could be perceived. To this mode of communication it became frequently necessary to have recourse. Intellectual objects of every kind; the passions and feelings of men; the moral qualities of actions, admit of no direct delineation by picture, they must therefore be represented, if represented at all, by sensible objects, to which they either bear, or are supposed to bear, some resemblance. Under the view of such analogies, wisdom was signified by an eye; ingratitude, by a viper biting the hand that offered it food; courage, by a lion; cunning, by a serpent. This constitutes what may properly be termed the *symbolic* mode of writing. It is in some measure analogous to that stage in the progress of speech observed among all rude tribes, where figures, tropes, and metaphors, fill up a great portion of every harangue.

This mode of writing is founded on resemblances perceived or supposed; and as it is difficult to set limits to the power of imagination in discovering or figuring resemblances, it might be supposed that the symbolic mode of writing could be carried to an indeterminate extent. But in fact it has its limits; it must be understood if it is to be useful at all; the resemblance, therefore, must be either obvious and discerned by mere intuition, or so generally perceived and recognised, that the persons to whom it is addresed may easily pass from the sign to the thing signified. If the resemblance be very recondite and remote, if the analogy is traced from qualities not generally observed, the symbolic writing becomes proportionally obscure, and to the uninstructed not even intelligible.

It is thus, by a natural progress, that we can trace the origin of hieroglyphics. Mere picture writing was an obvious invention; contraction of picture writing was probably taught by necessity: symbols required the exercise of imagination; at first, probably, plain and perspicuous, they soon became more complicated and obscure.

Among a people who had no mode of representing their thoughts but by means of figures or characters of this description, the very progress of knowledge, or the extension of enquiry beyond the mere objects of sense or immediate observation, could not fail both to add to the number, and augment the obscurity of the symbolic signs made use of. New discoveries, new truths, new subjects of thought, required appropriate and expressive symbols; these might either be drawn from objects not hitherto delineated, or figures previously in use might be employed, arranged in forms and collocations remote from their former delineations. In either way it would follow, that to persons unacquainted with the very subjects to which the signs related, the symbols, until explained, would present confused and unintelligible groups. It was in this manner that the universe, or universal nature, came to be denoted by a winged globe, with a serpent issuing from it; and a serpent itself was made to represent the divine nature, on account of its supposed vigour and spirit, its great age, and the reverescence ascribed to it.

Hieroglyphics then are only an extension of picture writing, adapted to remote or mysterious objects. The first use, even of the simple hieroglyphic writing, was to record the history, the laws, and civil polity of the community; not, as Bishop Warburton justly observes, to conceal knowledge, but in fact to preserve and communicate it. But afterwards hieroglyphics came to be employed for a very different use. From the very nature of such a mode of writing, it is easy to see how conveniently, in the hands of a set of men aiming at pre-eminence by the reputation of superior wisdom, it might be used, either to conceal their knowledge, or veil their ignorance from the people. Enigmatic figures, explained only to the initiated, were admirably fitted for such an end; and where the situation and circumstances of the people permitted this mode of concealment, we might expect to find it introduced and carried on. The extent, however, to which it could be carried, must be determined by the character or by the peculiar institutions of a people. Where superiority in knowledge in any class of the community was small, and the separation of professions not very rigid, the opportunities of concealing knowledge would be few, and the use of enigmatic figures less frequent; but where distinctions were strongly marked, particularly where a separate class of men were set apart to the conducting of religious rites and ceremonies, there, if no counteracting circumstance occurred, the occasions and means would be numerous and readily embraced.

Upon these principles it is not difficult to discover in the situation and character of the Egyptian priesthood, the circumstances which, though they did not indeed produce the invention of hieroglyphics, certainly occasioned a more extensive use of them than prevailed elsewhere. The Egyptian priests were a separate class of men, closely united among themselves, but sacredly distinct from the people, at a time when the only mode of writing in Egypt was by pictures or symbolic signs. Their retired life, joined with the objects about which they were chiefly employed, gave them the means and inclination of carrying their researches into abstract truths farther than the rest of their countrymen; the fruits of these researches were denoted by peculiar, often by the most grotesque and capricious symbols, conveying a secret meaning only to the initiated. In no other community, probably, did the same opportunities occur. Among some communities the separation of the different classes was neither wide nor permanent, and even where they were, yet as soon as alphabetic or even character writing was introduced, the use of symbolic writing would be in a great measure superseded. Hieroglyphics from that period, cultivated only for sacred purposes by the priests from the love of mystery and concealment, would soon lose their meaning, and in time become wholly unintelligible to all but the priests and their disciples.

Such appears to have been the history of hieroglyphic writing. The nature of it has been already explained. The symbols made use of in it were formed by assemblages of various objects, plants, animals, parts of the human body, heavenly objects, terrestrial appearances; all these combined in groups, which being first probably put together upon fancied resemblances, could hardly be deciphered, after the secret of their composition was lost. Some learned men have supposed that the Egyptian hieroglyphics contained much secret knowledge; probably they contained but little, and to employ pains in deciphering them, would only be a waste of labour.

Hieroglyphics abound on the ancient monuments of Egypt; the great obelisk brought from Egypt to Rome, is full of such figures; and on almost all the obelisks now existing they are met with. Many curious hieroglyphic figures were engraved on what was termed the Isiack Table, a large black table, long preserved at Rome, and at the sacking of that city, in 1525, found by a poor tradesman, and afterwards removed to Mantua, where it disappeared at the capture of the place. It had been previously engraved, and a plate of it is given in Montfaucon's *Antiquities*. Many Egyptian hieroglyphics were also engraved on gems, and small figures, which are still to be met with in cabinets. Hieroglyphics, properly so called, seem to be almost peculiar to Egyptian antiquities; the uncouth and distorted figures of some of the Hindoo gods, have been conjectured to constitute significant emblems, somewhat of the nature of hieroglyphics; but it appears to have been in Egypt alone that they were extensively employed; a circumstance that may easily be accounted for upon the principles already explained.

Sir John Marsham supposes hieroglyphics to have been the origin of the worship of animals; the figure and the thing signified, being as he supposes, so connected, that both began to be held equally sacred. This is by no means improbable, though no direct proof of it is to be had. It seems certain, however, that hieroglyphics were often engraved on gems, as a kind of magical spell; these gems were termed Abraxas; they were exhibited by certain corrupted Christians, natives of Egypt, who had mixed a great deal of Paganism with their Christianity: many of them are still to be met with in the cabinets of the curious. These abraxas were superseded among the superstitious orientals by talismans.

The subject of hieroglyphics has been frequently treated of. Among the ancients, *Horus Apollo* or *Horapollo*, wrote a treatise expressly on the subject. In modern times, one of the most laborious writers on hieroglyphics was the learned Jesuit Kircher. His *Œdipus Ægyptiacus* contains a great collection of curious particulars; but his explanations are fanciful, and indicate little judgment. In the second book of Montfaucon's *Antiquities* is given a general account of hieroglyphics, illustrated with accurate engravings. By far the most ingenious and philosophical account, both of the history and nature of hieroglyphics, is given by Warburton in the 4th book of the *Divine Legation*. The Bishop has not, however, been careful to distinguish between emblems in general, and hieroglyphics properly so called. Dr E. D. Clarke, in his *Travels* lately published, maintains, but by no means upon certain grounds, that the hieroglyphic characters were the letters of an ancient alphabet, and the more compound forms probably a series of monograms. (∂)

HIEROGRAMMATIST, (from *ιερος, holy*, and *γραμματευς, a writer*,) an order of priests among the ancient Egyptians. To them was committed the care of the hieroglyphics, the exposition of religious doctrines, and the superintendance of the Egyptian learning in general. They were regarded as a kind of prophets; and to establish their reputation for this, they made use of their knowledge of the heavenly bodies, or meteoric phenomena, to impose upon the people. They were always near the person of the king, to whom they were next in dignity, and were exempted from all civil employments. When Egypt became a Roman province they fell into total neglect. (∂)

HIEROMANCY, the art of divining futurity from observing the sacrifices when in the act of being offered up. See Divination and Sacrifice. (∂)

HIGHGATE is a village in Middlesex, about four miles north of London, delightfully situated on the top and sides of one of the highest hills in the county, commanding the most beautiful and extensive prospects over Essex, Surry, and Kent, in one direction, and Hertfordshire, Bedfordshire, and Buckinghamshire, in another. It consists principally of the villas of the opulent merchants, &c. of London, and its buildings are equal, if not superior, to any in the neighbourhood of the metropolis. In order to avoid the steep hill, it was proposed to cut a tunnel through it, which was begun in 1808. The roof of it, however, fell in after the work had made some progress, and it was found necessary to make an open cut through the hill. This great improvement is now completed; and the London road passes below an arch, which it became necessary to build for the purpose of carrying a cross road over the cut.

HIGHLANDS. See SCOTLAND.

HILDESHEIM, is the name of a German bishopric, founded in 822 by Charlemagne. It extends about 50 or 60 miles from east to west, and about 35 from north to south, and contains about 54 square German miles. The soil of the greater part of the district is good, and produces abundance of corn, flax, hops, and vegetables. The southern districts are hilly, and covered with forests; some of the hills containing excellent quarries and iron mines. The wood is principally oak, beech, ash, and birch. The diocese contains 16 bailiwicks, 75 manors, 13 towns, 234 villages, and 85,000 inhabitants, with an annual revenue of 250,000 rix-dollars. The principal towns are Hildesheim, Peina, Rosenthal, and Marienburg. After the secularization of the diocese in 1803, it was given among the indemnities to the King of Prussia. After the peace of Tilsit, it formed part of the kingdom of Westphalia.

HILDESHEIM, or HILLESHEIM, the *Bennopolis* of the ancients, is a town of Germany, and the capital of the diocese, of the same name. It is situated on a rugged declivity, watered by the river Innerste; about 6 leagues S. E. of Hanover, and 10 W. S. W. of Brunswick. The town is tolerably large, but is irregularly built, and old fashioned. It is divided into the Old and New Town, which were united in 1583. The principal public buildings are the cathedral, Holy Cross Abbey, the Gymnasium Andreanum, about eight Protestant churches, and several monasteries. The cathedral belongs to the Roman Catholics, and its bishop was the only catholic one in all Saxony. It is a richly ornamented Gothic building, and contains among its antiquities the celebrated Pagan monument of Irminsal, which fronts the great choir. It is a column which serves to support a chandelier of several branches. Population 12,600.

HIMALEH, or HIMALAYA mountains, the *Emodus, Himaus*, or *Imaus* of the ancients, is a stupendous range of mountains, which bound Hindostan on the north, and separate it from the country of Great and Little Thibet. In East Long. 76°, and North Lat. 34° 30′, the Himaleh range joins the mountains of Cashmere on the west, the northern range of the latter being as it were a continuation of the former. The Himaleh mountains being supposed to commence at this point, take a S. E. direction to Bootan, and form the boundary between that country and Thibet, in about 90° E. Long. and 28° N. Lat. stretching still farther to the east they terminate to the north of Assam. The river Burram-pooter is supposed to wind round the eastern extremity of the range about 95° of East Long. It appears from Col. Crawford's observations, that one of the peaks of Himaleh, seen from Patna, is more than 20,000 feet above Nepaul, or about 25,000 feet above the level of the sea. The country declines in height from the summit of these mountains to the south, the surface being irregularly mountainous to the borders of Bengal, Oude, and Delhi, where the plains begin, which stretch to the sea. Several of the tributary streams of the Indus, and probably the Indus itself, have their origin from the western side of these mountains. It is supposed that the sources of the Sanpoo, or Burram-pooter, and its tributary streams, are separated only by a narrow range of snow clad peaks, from the sources of the streams which form the Ganges. See Rennel's *Memoir*, and *Asiatic Researches*; Hamilton's *Gazetteer*; and our articles INDIA and THIBET.

HINCKLEY is a town of England, in Leicestershire, situated near the borders of Warwickshire. The town is divided into the *Borough*, and the *Bond* without the liberties. The limits of the borough were formerly those of the town, which has been extended by the successive addition of four streets, the Bond End, the Castle End, the Stocken Head, and the Duck Puddle. The parish church is a neat large structure, with a modern built spire, erected in 1788, on the old tower. The body of the church seems to have been built about the 13th century. Its length, from the chancel to the west door, is 66 feet, and its width near the chancel about 80 feet. There are three other places of worship, and a Roman Catholic chapel. The town-hall, school-house, and ball-house, are very curious, but in a ruinous state.

Hinckley was once of much greater extent, and was encircled with a wall and deep ditch, traces of which are still to be seen. The part called the Jewry-wall is said to have been part of the temple of Janus. There is near the river a mount, supposed to have been a Roman fortification; and near the church are the ruins of a bath, with three mineral springs. Tesselated pavements, and other Roman antiquities, have been discovered here. This town is said to form the middle of the highest ground of England, and commands a view of no fewer than 50 churches. Its principal manufacture is that of coarse stockings of cotton, thread, and worsted. A larger quantity of stockings is supposed to be made here than in any town in England. The number of frames in the town and neighbourhood is computed at 1200, which give employment to nearly 3000 persons. The town is likewise noted for the goodness of its ale.

In 1811, the parish of Hinckley, including Dadlington and Stoke Golding, contained

Inhabited houses	1097
Families	1224
Do. employed in trade and manufactures	1010
Males	2872
Females	3186
Total population	6058

See Nichol's *History of Hinckley*; and the *Beauties of England and Wales*, vol. ix. p. 473.

HINDOSTAN. See INDIA.

HINZUAN. See JOHANNA.

HIPPARCHUS. See ASTRONOMY, vol. ii. p. 590, 591.

HIPPIAS. See ATHENS.

HIPPOCRATES, commonly called the Father of Physic, was the most renowned physician of ancient Greece, and the oldest medical writer of whom there are any authentic works now extant. He was a native of the island of Cos, which had been long celebrated in the annals of medicine, being the seat of one of the schools founded by the Asclepiades or descendants of Æsculapius. Hippocrates himself belonged to that family, and is reckoned by his biographers the 18th in a direct line from that personage. Among the number of his ancestors was Podalirius, the son of Æsculapius, who, along with his brother Machaon, followed the Grecian army in the Trojan war. His genealogy by the mother's side was equally honourable; as, in this line, he was the 20th descendant of Hercules. These genealogies may be fabulous, but they were credited among the ancients, and tended to increase the veneration in which the character of this great physician was held. Very few details of the life of Hippocrates have been transmitted to us; but the singular eminence of his character makes the biographer dwell with pleasure on circumstances, which, in the life of another man, would appear unworthy of attention. Hence a variety of unimportant rumours are stated, and the arguments for and against their probability are studiously discussed.

He was born in the first year of the 80th Olympiad, or 458 years before Christ, in the reign of Artaxerxes Longimanus of Persia, and was the contemporary of Socrates, Herodotus, and Thucydides. His father Heraclides, and his grandfather Hippocrates the elder, who were both eminent physicians, bestowed much pains on his education in literature and general science, as well as in medicine. He studied polite literature and eloquence under Gorgias of Leontium, a celebrated rhetorician. He is said to have studied the physical sciences under Democritus; but it rather appears that he was not acquainted with that philosopher till he was more advanced in life, and already celebrated as a medical practitioner. He enjoyed, from the circumstances of his ancestors, and the spirit of the place of his nativity, great incitements to medical studies, and great advantages for the prosecution of them. Under these favourable auspices, he acquired an early relish for the medical profession, and devoted himself to it ever after with ardour and assiduity. Besides studying in the school belonging to his native island, he studied the gymnastic medicine under Herodicus, by whom it was invented, and he travelled much in Greece, Thessaly, and Thrace, where he made many observations on the history of epidemic diseases. The greater part of his professional life seems to have been spent at Larissa, in Thessaly. One Andreas, who wrote on the history of medicine, assigns a less honourable motive for his peregrinations. He says that he absented himself in order to escape from the punishment due to some larcenies which he had committed in the library of the medical school of Cnidos, where he was said to have transcribed some of the books, and then burned the originals. This account, however, entirely originated in the jealousy of the Cnidian school, to which Andreas belonged, and the precepts of which were controverted by Hippocrates. It is inconsistent with the sentiments of high honour which were conspicuous in all the conduct of Hippocrates. Others said, that he fled because he had copied some inscriptions in the temple of Æsculapius, detailing the cures of sick persons, who thus recorded their acknowledgments to that deity. This report is equally groundless with the other, and does not correspond with any thing that we know of the tendencies of ancient prejudice. He seems to have also travelled in Africa and Asia; but the chief scenes of his travels were on the European continent, where he frequently visited different cities and countries for the purpose of relieving epidemic distempers, with which they were occasionally afflicted. While a dreadful pestilence prevailed among the Illyrians, he was earnestly invited by that people to favour them with the advantages of his medical skill; but, on inquiring into various circumstances attending that epidemic, he concluded that his services would be ineffectual. He declined the journey; and finding reason of apprehension that the same disease would extend to Thessaly and Greece, he sent his sons to these countries, for the purpose of preparing them to meet the visitation with proper precautions. In a plague at Athens, he is said to have contributed much to the health of the city, by ordering large fires to be lighted for purifying the air, and by burning various perfumes in private houses, in the manner of the Egyptians. His sons, also, gave material assistance. These accounts, however, do not well correspond with historical dates. The great plague of Athens, described by Thucydides, happened when Hippocrates was only thirty years of age, and could not have sons capable of giving medical directions. The inhabitants of Abdera, observing that their fellow-citizen Democritus had contracted much singularity of manners, that he had become addicted to immoderate and ill-timed laughter, and secluded himself from society, conceived him to be insane, and invited Hippocrates to go and pronounce a judgment on his case, and take him under his medical care. Hippocrates went, and finding Democritus a man of deep research, who engaged himself with unwearied assiduity in philosophical pursuits, pronounced him the wisest man in Abdera. Ten talents were offered to him on this occasion, but he declined accepting of any recompense.

Kings and princes are said to have made different attempts to engage him in their service. We are told, that Perdicas, king of Macedon, invited him to his court to cure his son of a consumption; and that Hippocrates discovered the whole complaint to consist in the workings of a secret passion which the young man cherished for Phyla, the mistress of his father. This story, however, coincides so exactly with the accounts of the cure performed by Erasistratus on Antigonus, the son of Seleucus Nicanor, that we are forced to conclude it to be fabulous; and it must be confessed, that the other anecdotes of his life do not rest on the most satisfactory evidence. They are all derived from the same source, a collection of letters and other pieces, called τα [illegible], sometimes published with the works of Hippocrates.

Artaxerxes offered him large sums, and a splendid establishment, to induce him to enter his service during a destructive epidemic which desolated some of the provinces, and also the armies of Persia. Hippocrates refused the offer in a haughty stile, expressing his contempt of barbarians, and the indignity to which he would find himself subjected by leaving the Greeks to devote his services to that people. This unnecessary affront, arising from an excess of national pride, highly offended Artaxerxes, who then demanded of the inhabitants of Cos, that Hippocrates should be delivered into his hands, threatening them with the extremity of his vengeance in case of refusal. The people of Cos, however, were too honourable, and too much attached to their illustrious countryman, to yield to these intimidating threats; and Hippocrates remained unmolested.

The high character of this physician gave him, on one occasion, an opportunity of performing an important political service for his native country, which he tenderly loved. The Athenians threatened the island of Cos with a formidable invasion. Hippocrates solicited the assistance of the people of Thessaly and the adjoining countries, and at the same time sent Thessalus his son to Athens, to avert the storm by negotiation, and sage remonstrances on the baneful tendency of ambition. The exertions both of the father and the son were successful. The Thessalians, the Messenians, and the states of the Peloponnesus, engaged to espouse the interests of the island of Cos; and the Athenians, partly out of regard for Hippocrates, and partly from the apprehensions which so much resistance created, abandoned their hostile designs.

Hippocrates entertained a deep sense of the importance of the duties of the professional character. He spared no pains which were necessary for his own improvement, and the successful practice of his art. He was aware that medicine requires more assiduous attention than other employments; he exacted of all his pupils an oath, binding them to certain rigid principles of duty, and, among other things, to engage, that they would enter no house whatever except for the purpose of relieving those who needed their assistance. This rule, if taken according to the strict meaning of the words, appears somewhat fantastic, as it supposes that the number of patients and of practitioners should always be nicely accommodated to one another. It shews, however, the abhorrence which Hippocrates had of any degree of negligence and frivolity in the medical character. He was ready at all hours to attend on a call; and submitted with as much willingness to all those minute attentions which were necessary for the welfare of his patients, as to professional offices which were apparently the most dignified. It also redounded to his honour, that his attention was not less directed to the gratuitous object of preventing, than to the lucrative employment of curing disease. Of this he has left a testimony in his writings, by treating on the subject of diet and of water. These features of disinterestedness would not merit great praise in modern times, in which they are so common, and are requisite to establish a character, and are therefore often either mimicked for this express purpose, or avoided if they interfere with false and fashionable notions of dignity. They acquire greater lustre from the consideration of the different sort of manners which prevailed in the days of Hippocrates, as well as the complete superiority to intrigue by which, in his conduct, they were accompanied.

His zeal for science and humanity was rendered efficient by his excellent talents, and the weight of his personal character. His sagacity in observing nature was a resource to him on every emergency; and the accuracy of his judgment led him to resist the useless frivolities which superstition had introduced into medical practice. Inviolable secrecy, justice, and good faith, marked the whole of his conduct. Uniting dignity with humanity in his deportment, he employed firmness or complacency on such occasions as called for the exercise of either quality. He spoke but little; and his language was masculine and concise. His actions were never conducted with agitation; no prescription was given with precipitance; no circumstances were neglected; nor was the result ever left in any degree to accident. If at any time he failed of success from want of previous experience adapted minutely to any individual case, he acknowledged his failure in the most ingenuous manner. In his writings, he sometimes warns his readers against mistakes and errors which he himself had committed, and which were attended with fatal consequences. He exhibited in all respects a bright example of the qualities which he himself enumerates, with so much eloquence and good sense, as contributing to the perfection of the medical character. Hence his precepts on that subject acquire a double authority.

Hippocrates lived to a great age; some say 109, others, however, make it much less. He died at Larissa, and was buried between that city and Gyrtona. He left among numerous other disciples, his two sons, Thessalus and Draco, both eminent physicians, and his son-in-law Polybus, who had been a favourite pupil, and afterwards became a celebrated teacher, and arranged and published the works of his friend and master. In statues and paintings Hippocrates is represented with his head covered, which is different from the usual manner of the Greeks, and was probably done on account of his having been so great a traveller, as that was the only description of individuals who were uniformly thus distinguished.

Hippocrates has always been regarded as the father of his art. The honour in which he was held, both during his life and after his death, was very high. The inhabitants of Argos erected a statue of gold to him. The Athenians more than once voted him a crown of gold, and initiated him in their great religious mysteries. This last was a favour very seldom conceded to strangers. Although he did not cultivate general philosophy except as subservient to medicine, he exemplified so ably its spirit, that Plato, Aristotle, and others, looked up to him as a master, and sometimes commented on his opinions. Aristotle even followed him as a model of stile. His works have been held in high esteem in all subsequent ages; they have been translated or commented on by Galen, Celsus, and numerous other physicians of the most eminent genius, both in ancient and modern times.

The treatises which have gone under his name are 72 in number; but they are not all of equal authenticity. Doctrines so contradictory are sometimes contained in them, as shew them plainly to have been the works of distinct authors. Some are probably of much more ancient origin than Hippocrates himself. Some are thought to have been written by his grandfather, who bore the same name: and several have been either much altered and interpolated, or entirely written by subsequent authors. Those which are universally allowed to be genuine are, "the Aphorisms," "the Prognostics," the first and third book "on Epidemics;" and the book "on the influence of air, water, and local situation." Some are regarded as supposititious, because they deviate from the character of Hippocrates, as shown in the works now enumerated, both in solidity, method, and correctness of language; while others bear only in part the character of this master, and incline the critical reader to suspend his judgment of their authenticity. These last seem to have been such as Hippocrates left in an unfinished state, or the substance of notes or copies taken from his prelections by his pupils. Such are "The Four Prognostics;" "the Predictions;" the 2d, 5th, 6th, and 7th books "on Popular Diseases;" that "on Diet in acute Diseases;" the books "on the Parts of the Human Body;" "on Aliment;" "on the Recoveries that happen on critical Days;" and "on the Humours." There is considerable difficulty, however, in deciding in the negative respecting the works said to belong to a particular author. We may give a judgment on the positive authenticity of certain performances, which bear the stamp of the genius and manner of a masterly writer. But such writers often produce works which are not equal to their genius, works which have been written under inauspicious circumstances, which have diminished their attachment to their subject, impaired their confidence in themselves, and obstructed the full exercise of their talent. Great differences may also depend on the period of life. Juvenile performances may be comparatively lame or volatile, and old age brings along with it a decay of the mental powers, which may appear in the literary performances to which it gives origin. Differences of the time of life will sometimes also account for inconsistencies of doctrine produced by changes of opinion which have taken place between the times at which different works have been composed.

The principal editions of the works of Hippocrates in the original are, those of Aldus at Venice in 1526; and of Frobenius at Basle in 1538, both in folio.

The editions of Greek accompanied by Latin translations are, those of Hieronymus Mercurialis, at Venice, in 1578; of Zwinger, at Basle, in 1579; of Anutius Föesius, at Francfort, in 1595; of J. A. Vander Linden, at Leyden, in 1665; of Renatus Chartrier, with the works of Galen, at Paris; and of Stephen Mack at Vienna, in 1743, 1749, and 1759.

The editions of Latin translations, without the original, are that of Cratander at Basle, by several translators, in 1526; of M. F. Calous, at Rome, in 1525, from MSS. in the Vatican; of J. Cornarius, at Venice, in 1545; and that of Anutius Föesius, at Francfort, in 1596, in 8vo, by Wechel.

As Hippocrates was the first author who applied philosophical reasoning to medicine, the sect of the Dogmatists looked up to him as their head. But he did not cultivate theory to the exclusion of observation and experience: he was one of the most accurate observers that any age has produced, and his reasoning has much less mixture of error than might have been expected, from his deficient knowledge of anatomy, and the want of good logical methods at the time at which he wrote.

He gave a general theory of the formation and conservation of the universe, in conformity to the doctrine of the four elements; and he applied the same doctrine to account for the formation of the human body. In explaining the doctrines of health and disease, he acknowledged a general active principle, which he called *nature*, to which he ascribed the attribute of justice. This agent he considered as the cause of nutrition in the animal economy, by attracting what is good, retaining and preparing it, and rejecting what is superfluous and hurtful. The manner in which he accounts for the formation of the brain, the bones, the membranes, and all the various parts, has that air of absurdity which is universal in the physical philosophy of the ancients. His anatomy and physiology are not very fully contained in the works which have reached our times, and are evidently imperfect and fanciful. He divides the constituent parts of the animal economy into the solids, the fluids, and the spirits. The solids are the containing parts, the fluids the parts contained, and the spirits those which give motion to the whole. On this division, followed up with various subdivisions, he establishes his doctrine of the causes of disease. He divides the humours, for example, into the blood, the phlegm, the yellow bile, and the black bile, and distinguishes these by the possession or the want of heat or of moisture. The blood is warm and moist; the phlegm cold and moist; the yellow bile warm and dry, and the black bile cold and dry. The most valuable parts of the writings of Hippocrates are his histories of diseases. In delineating these, we find him a faithful and laborious observer of facts; hence he was deeply skilled in the diagnosis and prognosis of diseases. By far the greater part of his descriptions are still recognised as accurate by all who follow him in the path of careful observation. The article in which his observations are most deficient, is the pulse, which he so much overlooked, that some have supposed him altogether unacquainted with the changes to which it is liable. It was chiefly from the degree of heat, and the difficulty of respiration, that he judged of the state of a fever.

In the treatment of diseases, he inculcated a profound respect for the progress of nature, whom he regarded as the arbiter and judge of diseases, and as having certain salutary objects in view in the greater part of those successive changes in the constitution which they implied. This doctrine is in fact the same which has been maintained by various later theorists, under a different set of terms, and with slight modifications, such as the *archæus* of Van Helmont, and the *vis medicatrix naturæ* of Dr Cullen. The opinions of Hippocrates on this general point made him unwilling to use any means for interrupting the course of nature as exhibited in the phenomena of disease: hence his practice is culpably feeble; and those whom an admiration of his genius has led to follow him closely, have been too prone to satisfy themselves with the exercise of tracing the course of diseases rather than to resist their progress. These have been most numerous in France, where the study of the Greek medicine is treated as a separate branch of education. The Hippocratic method is denominated the method of expectation, and is extolled as rational and sure. But it deserves, in some measure, the sarcasm of the Roman physician Asclepiades, who called it a mere meditation on death, a solicitude to observe how a disease would terminate, and what length of time it would require to destroy the patient. Hippocrates indeed recommends some practical remedies for the purpose of aiding the good intentions of nature, and gently correcting some slight deviations incident to it. His precepts in this department are delivered with some formality, in conformity to the style of the early philosophy; but they are not characterised by that emptiness and unmeaning mystery which often prevailed, and they exhibit a justness of remark which was entirely his own. His general principle was, to cure contraries by contraries, cold by heat, heat by cold, evacuation by repletion, and repletion by evacuation. In idiopathic fevers, he began with the regulation of diet, which consisted in prescribing abstinence, with a very sparing allowance even of liquids, for three or four days, that no morbid matter might be added to the system, while nature threw off that which was already present. This was succeeded by the exhibition of various liquids till the fourteenth day, and it was not till a late period that any solid food was allowed. Medicinal preparations were also long deferred, and consisted of gentle laxatives and emetics. In inflammatory complaints his practice was more active; he used fomentations, bloodletting, and purging. He also gave some weak wine and aromatics, which are, it must be confessed, less correct prescriptions in diseases requiring the strictest antiphlogistic treatment. In empyema (a collection of pus in the cavity of the thorax) he first drew out the patient's tongue, then poured a little irritating liquid, prepared from the root of arum, from hellebore or copper, into the trachea, for the purpose of exciting a violent cough, and thus discharging the purulent matter.

He was also in the practice of shaking violently the patient's body, with a view to detach the matter from the parts to which it adhered. In diseases of the head he first applied fomentations, and then excited sneezing for bringing off the phlegm.

In pharmacy he made extensive improvements. His preparations are diversified in their composition and consistence, so as to answer minutely the various purposes of external medicine. He paid great attention to the diversities of state, and the shades of morbid sensation in diseased parts, and nicely adapted to them the forms of his remedies. In this respect he may often serve for a model to correct the gross ideas of those who exclusively venerate the agency of powerful simples. As a surgical author, Hippocrates had great merit; though the vigour of his practice in this department sometimes exceeded the bounds of moderation. He placed great reliance on the revulsion produced by powerful discharges by means of blood-letting, and which was assisted by the use of cupping instruments; and when this failed, he formed extensive and deep ulcers, by the actual cautery. A full account of the opinions, theoretical and practical, of this ancient author, would fill a large volume. In this country, an acquaintance with them is, even among medical men, reckoned an object of curiosity rather than an attainment necessary to the physician; but the perusal of the works of Hippocrates himself has an excellent tendency to cherish in the mind of a professional man, that zeal for the objects of his art, and that keen and persevering attention to his duties, which renders his life most satisfactory to himself, and most useful to society. See Le Clerc's *Histoire de la Medicine*; Fabricius; also the *Life of Hippocrates*, by Soranus; and the introduction to Pinel's *Nosographie Philosophique*. (*H. D.*)

HIPPOCRENE. See HELICON, vol. x. p. 703.

HIPPOPOTAMUS. See MAMMALIA.

HIRE, PHILIP DE LA, an eminent and industrious French astronomer, was born at Paris on the 18th March 1740. His father was painter to the king, and instructed his son in the same art, particularly in drawing, and such branches of the mathematics as related to his profession. In the year 1761, three years after he had lost his father, De la Hire went into Italy to reestablish his health, and to study those fine models of painting and sculpture which every artist was ambitious to imitate; but, during the three years which he spent in that country, he discovered that he was more fitted to excel in astronomy and geography than in the fine arts, and he henceforth devoted his whole time to these interesting studies.

Upon his return to Paris, he was nominated one of the members of the Academy of Sciences; and in 1699, he was named *Pensionnaire Geometre*. Between the years 1678 and 1718, he published no fewer than *two hundred and forty-four* memoirs on almost every branch of mathematics and natural philosophy.

When the great Colbert had resolved to make a correct map of France, De la Hire was associated with M. Picard in this important duty, which occupied him for several years. In 1683, he was employed in continuing to the north of Paris the meridian which Picard had begun in 1669, while Cassini was employed in extending it to the south. The death of Colbert having put an end to this great undertaking, De la Hire was next employed in the formation of the great waterworks with which Louis XIV. embellished his palaces. De la Hire filled also the situation of royal professor of mathematics and architecture, and was much esteemed among his countrymen. His name, however, is not associated with any great invention or discovery; and we are called upon only to admire the extent of his knowledge, and the persevering industry which he exhibited both in acquiring it for himself and in communicating it to others. The works which he published separately were,

1. Nouveaux Elemens des Sections Coniques. Paris, 1678, 1 vol. 12mo.
2. La Gnomonique. 1682.
3. Traité du Nivellement de M. Picard, avec des additions. Paris, 1684.
4. Sectiones Conicæ in novem Libris distributæ. Paris, 1685, folio.
5. Traité du mouvement des eaux et des autres corps fluides; ouvrage Posthume de M. Mariotte. 1686.
6. Ecole des Arpenteurs. 1689.
7. Traité de Mecanique. 1695, 1 vol. 12mo.
8. Tabulæ Astronomiæ Ludovici Magni jussu et munificentia exaratæ. 1702.

De la Hire died on the 28th April 1718, and left behind him a son, Gabriel Philip de la Hire, who was much esteemed as a physician, and who published several papers on medicine and natural philosophy in the Memoirs of the Academy from 1699 to 1720.

HIRUDO. See INTESTINA.

HIRUNDO. See ORNITHOLOGY.

HISPANIA. See SPAIN.

HISPANIOLA. See ST DOMINGO.

HISTORY.

Division of the subject.

IN this article it is proposed, in the first place, to point out and explain the various advantages of the study of history; secondly, to enumerate those branches of study which ought to be entered upon, previous to, or contemporary with the study of history; thirdly, to give a brief and rapid sketch of the order in which ancient and modern general histories may most conveniently and advantageously be read; fourthly, to point out the order in which the history of particular countries may be read, so that they may be illustrative of one another; fifthly, to notice the different species of history besides what is emphatically called History.

Advantages of the study of history.

I. With respect to the advantages which may be derived from the study of history, they are various and important: if the value of that department of science is to be rated highest, which combines advantages of the most obvious and beneficial nature, history possesses a very strong claim to our attention and study. It is equally attractive to the unreflecting and philosophical mind: the former it interests by the excitation of novelty; the latter by the usefulness and importance of the general principles which may be deduced from the facts which it records. But perhaps the utility and value of this branch of study cannot be placed in a more obvious and conspicuous point of view, than by stating that it combines amusement of the deepest interest; the exercise and improvement of the best faculties of man; and the acquisition of the most important species of knowledge.

A source of amusement

History, considered merely as a source of amusement, is infinitely preferable to novels and romances, the perusal of which too frequently debilitates the intellect by inflaming the imagination, and corrupts the heart by the infusion of what may justly be regarded as moral poison. Whatever valuable impressions are made upon the mind by fictitious adventures, the same in kind, though, perhaps, generally not equal in degree, are made by the perusal of history; and while works of fiction are not in their nature capable, in general, of any other uses than the authors had in view, which must necessarily be very limited; true history, being an exhibition of the conduct of Providence, has infinite relations and uses, and may be regarded as an inexhaustible mine of the most valuable knowledge. It has been very justly remarked, that "works of fiction resemble those machines which we contrive to illustrate the principles of philosophy, such as globes and orreries, the uses of which extend no farther than the views of human ingenuity; whereas real history resembles the experiments made by the air-pump, the condensing engine, or electrical machine, which exhibit the operations of nature, and the God of nature himself, whose works are the noblest subject of contemplation to the human mind, and are the ground-work and materials of the most extensive and useful knowledge."

Its effects on the mental powers.

But a higher use of history is to improve the understanding and strengthen the judgment: by studying history, and examining into the causes and consequences of the events which it unfolds, the penetration is sharpened, the attention of the mind is fixed, and the comprehension enlarged: hence are acquired the faculty of discovering quicker, and that flexibility and steadiness so necessary to be found in the conduct of all affairs, that depend on the concurrence or opposition of other men. It is a great but a prevalent mistake to imagine, that history is calculated to enlighten the judgment only on those subjects which are connected with the welfare of the community at large; it is nearly in an equal degree calculated to enlighten the judgment on those that bear on individual utility and comfort. In this respect the advantages of history are more important than those we derive from our own individual observation and experience; for though the impressions made by the latter will be more vivid, and probably more permanent, yet the knowledge we derive from history is more correct, and consequently a better guide to us, in our intercourse with the world; for the examples which it presents are generally complete; the whole is before us; whereas in real life, every scene opens very slowly, and we consequently see but a small part of a thing at a time;—hence we are liable to be deceived in our judgment of it.

The history of Great Britain will sufficiently illustrate the truth of the preceding remarks; if entered upon merely as a source of amusement and interest, it is rich and valuable in this point of view. The rude and barbarous state in which this country and its inhabitants existed at the period of the Roman conquest, contrasted with its present situation, when it has attained an infinitely higher rank in the scale of intellect and power than Rome ever reached, cannot fail to act as a stimulus to the curiosity, to learn the various events which occurred between these two states so diametrically opposite. Besides this general source of interest and amusement, which the history of Britain holds out, there are many particular periods in it which are almost equally calculated to excite and gratify these feelings. This is considering the history of Great Britain in its lowest character; it further illustrates our preceding remarks, by the constant exercise which it affords for our judgment and penetration; so that it may be justly affirmed, that the faculties of the human mind will derive from its perusal a great accession to their strength.

Makes us acquainted with the mechanism of society.

But the great advantage to be derived from history,—and this advantage flows in the most direct manner, of the highest character, and in the utmost abundance from the history of Britain,—consists in this, that by means of it we gain our knowledge of the mechanism of society; of the reciprocal influence of national character, laws, and government; of those causes and circumstances, that have operated towards the production and advancement, or the destruction and retardation of civil and religious liberty, and the various branches of science and literature. It leads to a knowledge of man in his social relations: it exhibits the various operations of different systems of polity upon human happiness. In a country which enjoys so great a portion of civil liberty as happily falls to the lot of the inhabitants of the British empire, almost every order of the community has its influence upon the measures of the legislative and the executive powers; consequently a knowledge of history should be diffused to as wide an extent as possible among them. A familiar acquaintance with the history of their country was, in the best times of the Roman republic, held to be essentially requisite to qualify youth for stations of dignity, power, and profit, in the administration of public affairs. Hence the bitterness of the sarcasm, uttered by Marius, when he asserted, that in his degenerate days, men of illustrious birth did not begin to read the history of their country till they were elevated to the highest offices of the state, that is, as he said, "they first obtained the employment, and then bethought themselves of the qualifications necessary for the proper discharge of it."

In this brief enumeration of the principal uses to be derived from the study of history, it is presupposed that historical facts are made the subjects of mature reflection. He who is satisfied with merely storing his mind with a multiplicity of events, even though those events may be of the highest class in point of importance, and calculated to establish or illustrate the most useful principles, will derive little profit from a great expence of time and labour.

Preparatory studies.

Geography and chronology.

II. The sciences which are of the most constant and general use in the study of history, so as to have deserved to be called its two eyes, are geography and chronology. Without the former, no reader of history can have any clear and distinct idea of what he reads. Moreover, by a knowledge of this science, we are able to verify many past transactions, which, if they ever happened, must have left indelible traces on the face of the earth. Many curious examples of this nature may be seen in Addison's Maundrels, and Shaw's Travels. With respect to chronology, it is absolutely impossible to form clear and distinct notions of the intervals of time, of the rise and fall of empires, and of the successive establishment of states, without some such general comprehension of the whole current of time, as may enable us to trace out distinctly the dependence of events, and distribute them into such periods and divisions, as shall place the whole train of past transactions in a just and orderly manner before us. For a further illustration of the uses of Geography and Chronology as applicable to history, we refer our readers to those two articles in this work.

Statistics.

Another branch of study, which ought to be pursued

Statistics.

along with the study of history, is what is called Statistics; or that branch which comprehends an account of the sources of the wealth and power of different states, such as their population, habits of industry, agriculture, manufactures, trade, commerce, and finances. Unless we possess information on this head, it is obvious that we shall be much perplexed, and frequently led astray, in our endeavours to account for the comparative influence and exertions of different nations. Thus, for example, a person ignorant of the advances which Britain has made in agriculture, manufactures, commerce, and what may be called the economics of the state, cannot possibly satisfactorily account for the high rank which she holds in the scale of European nations,—a rank to which, from the mere inspection of the map of Europe, she does not seem by any means to be entitled.

The science of government.

Another collateral branch of study ought to be that of the governments of nations; not a minute investigation of the various parts of their government, but such a knowledge of their general and leading principles as would enable us to ascertain, how far, and in what respects, the influence and advances of each state might justly be attributable to their respective constitutions. In this point of view also, Great Britain may be cited as an instance peculiarly illustrative of the justice and truth of our observations. A person who had made himself acquainted with the progress of this country in agriculture, manufactures, and commerce, and who beheld in them the sources of her wealth and power, would still be desirous of learning the causes which had enabled her to make this progress so far beyond that of other nations; and of these causes, on investigation, he would find her free constitution to be the most prominent and operative. The observations which we have now offered respecting the connection between the history and the statistics and government of a country, will be most fully and satisfactorily confirmed and illustrated by reading the articles Britain, *History of*; England, *History and Statistics of*; and Scotland, *History and Statistics of*, in this work. It is only within these few years that the study of statistics has been much attended to; and we think we may, without the charge of vanity, or partiality, refer to this *Encyclopædia*, as connecting the history and statistics of the various civilized countries of the world, more intimately and fully together than they had been previously done in any work of the same nature.

The laws, &c. of each state.

Whatever illustrates the manners, customs, feelings, circumstances, and condition of the inhabitants of a country in the various periods of its history, ought also to be studied by him who wishes to derive from history its highest gratification and its full advantage. The popular ballads of a nation, in this respect, ought to be perused; collections of the laws, ordinances, and internal regulations enacted in a state, during any particular period of its history, are well calculated for the same object; they give information respecting the condition of the great mass of the community, whether they were free or slaves; and also respecting the prevalent crimes and vices of the age, and what measure of punishment was necessary to expiate or repress them.

State trials.

Official dispatches.

All these are collateral branches of study, which are connected with the proper and advantageous perusal of history in general; but those who wish to enter more minutely into the history of any country, and to gain access to as many sources of evidence respecting it as possible, may derive great advantage and assistance from the records of the courts of law. These furnish a vast variety of historical facts, most minutely investigated. To refer again to the particular instance of our own country: It may with truth be affirmed, that no one can form an adequate and correct idea of the gradual amendment effected in our institutions, and of the value of those constitutional principles and efforts, from which those amendments have been derived, who has not read with attention the state trials. Treaties with foreign powers should also be perused; and the despatches of ambassadors, especially the confidential communications made by diplomatic agents. In the official letters of Barillon, published by Sir John Dalrymple and Mr Fox, the impolicy of Charles II. and of his unfortunate successor, is clearly traced; and in the papers of Sir Robert Walpole, as published by Mr Cox, a striking picture is exhibited of the difficulties incident to the administration of a free government. How much history may be illustrated by the publication of such official papers, or rather how inexplicable the facts it records may often be, if not illustrated by such papers, is proved in a most striking and interesting manner in the following instance. In the years 1775 and 1776, General Washington lay encamped before the town of Boston, at the head of a force far superior to that of the British, for the period of nine months, without striking a blow. The General's official correspondence with Congress, published in the year 1795, accounts for this dilatoriness, which, till this publication, was inexplicable. From it, it appears, that, during a great part of this time, he was so scantily provided with powder, that, had the British been aware of his situation, and marched to attack him, he would have been under the necessity of abandoning his position.

Biography.

Biography also may be brought to the elucidation and assistance of history. In the lives of sovereigns, eminent statesmen, generals, and lawyers, peculiarities of character, prejudices, motives, and reasons for conduct, which history cannot detect, and other circumstances, are often brought to light, which serve to elucidate what is obscure, to connect what is disjointed and abrupt, and to account for what before seemed without an adequate and appropriate cause.

Monuments, &c.

The history of many nations may also be elucidated by visible monuments, such as pillars, edifices, or mere heaps of stone; and by the names given to counties, towns, &c. Of the same nature with public monuments are national customs, in commemoration of remarkable historical events; such as the Athenians sending annually a ship to Delos; the paschal supper among the Jews; the Lord's Supper among the Christians; our making bonefires on the 5th of November, and carrying oak boughs on the 29th of May.

Medals.

Coins and medals are also of great use, in the illustration of history. On ancient medals, a number of events have been recorded, so that they serve to confirm such passages as are true in old authors, to ascertain what was before doubtful, and to record such as were omitted. By means of them, Vaillant has been enabled to ascertain, in a very great degree, the chronology of three important kingdoms of the ancient world, viz. Egypt, Syria, and Parthia. Of Balbec and Palmyra, whose ruins are so famous, history scarcely makes any mention, and we have little knowledge of them, but what is supplied by medals and inscriptions. In modern times, coats-of-arms have been made use of for the purpose of distinguishing families. They must, therefore, be of great use in tracing pedigrees, and consequently in ascertaining persons and events in history. See MEDALS.

Plan for studying history.

III. One of the most important directions for facilitating the study of history, is to begin with authors who present a general view of the whole subject. This is like sketching an entire outline, before any part of the picture is finished; and learning the grand divisions of the earth, before the geography of particular countries is studied. The principal advantage of this method is, that it gives a clear idea of the comparative importance, as well as of the connection which the history of any particular country bears to the history of the world. The same advice is applicable to a person who proposes to study any particular period of the history of any particular country. He ought, in the first place, to make himself acquainted with the history of the country in general, and then study the history of the particular period. The history of the civil wars, during the reign of Charles I. will excite comparative little interest, and afford comparatively little instruction, unless an acquaintance with the previous history of England enables us to trace the causes of those wars, and the condition, feelings, opinions, influence and views, not merely of the different parties, but also of the different classes of the community.

General history.

A general acquaintance with the whole course of history, will render it less necessary to attend to the order in which particular histories are read; for if the reader is thus previously prepared, by a general acquaintance with history, he will be able to refer any particular history he engages in to its proper place in universal history. Indeed, after a thorough introduction to a whole course of history, it is comparatively a matter of little moment, in what order and connexion particular histories are read; for they will easily, and without confusion, range themselves in the mind in their proper place, and appropriate rank in point of importance.

Epitomes of universal history.

Tursellius.

Le Clerc.

Sleidan.

There are several epitomes of universal history. While the custom of giving lectures prevailed in the foreign universities, the most celebrated were Tursellius and Le Clerc's; but the use and popularity of these Latin epitomes has very considerably diminished, since the lectures have been given in the vernacular tongues of the respective countries of Europe. Tursellius's is a judicious and elegant performance; but by no means impartial or candid, where the interests of the Catholic church interfere. That of Le Clerc's is not liable to the same objection; but at the same time, it must be remarked, that it is not entitled to the same praise. With these epitomes may be mentioned, as also written in Latin, Sleidan's *Introductio ad Historiam*, or a brief account of the Babylonian, Persian, Macedonian, and the Roman monarchies.

Of ancient history.

Bossuet.

Baron Holberg.

Lord Woodhouselee.

Logan.

Rollin.

Millot.

Bossuet's *Discours sur l'Histoire Universelle*, which may be regarded as an epitome of ancient history, as it comes down only to the period of Charlemagne, acquired a reputation at its first appearance hardly warranted by its merits, and which it has by no means supported. It is an elegant, and in some parts even an eloquent performance; but these are recommendations to history of very small comparative importance, when contrasted with credulity, bigotry, and partiality, with which this performance is justly chargeable. One of the most useful epitomes, upon the whole, is that written by Baron Holberg, in Latin, and translated, with improvements and additions, into English, by Gregory Sharpe. Its most prominent and serious defect is, that too little notice is taken of the history of Greece. None of these epitomes direct the attention of the reader to any other subject than the political part of history; they seldom or ever enter into the consideration of the causes or consequences of events; and never digress, if digression it may be properly called, into the consideration of the state of the arts and sciences, religion, laws, manners, government, and literature, during the different epochs of which they treat. In fact, they will by no means satisfy the mind that wishes to attain a proper introduction to history, as it is now generally written. For this purpose, the *Elements of General History, Ancient and Modern*, by the late Alexander Fraser Tytler, Lord Woodhouselee, ought to be read: In point of arrangement, due proportion and connection of parts, perspicuity and interest of style, a philosophical spirit, and the elucidation of the state of the arts and sciences, literature, &c. this work may be justly commended in the highest terms. *The Philosophy of History*, by Logan, and a larger work said to be written by the same author, but published under the name of *Rutherford*, should also be perused, preparatory to entering upon a regular course of history. Of the larger epitomes of ancient history, that of Rollin is the most interesting and complete: it is compiled with scrupulous fidelity from the best Greek and Latin historians: its style is fluent, and even elegant: its great fault is credulity, which prevents the author from discriminating in his recital of events between the marvellous and the true. The ancient history of the Abbe Millot, which constitutes the first part of his *Histoire Generale*, is more brief than that of Rollin; but, at the same time, more full than the epitomes we have mentioned above. The arrangement of this work is judicious; the style precise and compact. In his preface he informs his readers, that his plan is to seize those topics of historical narrative, which present the greatest portion of utility. He gives a bold, and in general a faithful and impartial sketch of events and characters; but the observations with which he relieves and intermixes his narrative, are frequently more distinguished for their obvious truth, than their originality or profoundness.

Sketch of a course of ancient history.

The reader having been thus prepared for a regular progress in ancient history, by the perusal of such parts of the above epitomes as confine themselves to that period, (for some of these epitomes, it may be observed, embrace modern as well as ancient history,) we shall now lay down a method by which the principal authors of antiquity may be read, so as to collect from them a pretty regular series of facts, which will comprise the history of Asia, Africa, Greece, and Rome, till the dissolution of the empire of Constantinople.

Herodotus.

Herodotus is the earliest historian extant, next to the authors of the historical books of the Old Testament. His history comprises every thing he had an opportunity of learning respecting the Lydians, Ionians, Lycians, Egyptians, Persians, Greeks, and Macedonians, from the year 713 to the year 479 before the birth of Christ. Perhaps no author of history, ancient or modern, might be appealed to, as more fully illustrating the truth of the remark made at the beginning of this article, that, even in respect to amusement, history presents claims to attention not inferior to works of fiction. The great merits of this author are his diligence, accuracy, fidelity, and impartiality. The accuracy of the geographical knowledge which he displays, is continually receiving confirmation from the discoveries of the moderns. His style is simple and elegant. His faults and defects are his digressive method, and his intermixture of fable. A more particular account of several events in the period of Herodotus' History may be extracted from the following authors: Justin, books i. ii. iii. and vii.; the 7th book of Xenophon's *Cyropædia*; the lives of Aristides, Themistocles, Cimon, Miltiades, and Pausanius, by Plutarch and Cornelius Nepos; and those of Anaximander, Zeno, Euripides, Heraclitus, and Democritus, by Diogenes Laertius, will illustrate not only the history of Herodotus, but also the state of manners and philosophy at that period.

Thucydides.

Thucydides must be read after Herodotus. In his introduction he connects his history with that of Herodotus, by giving a summary view of the history of Greece, from the departure of Xerxes to the commencement of the Peloponnesian war. He proposed to write the entire history of that war, but his work reaches only to the 21st year of it. The method he pursues is directly the reverse of that followed by Herodotus; for his exact and scrupulous observance of chronological order, obliges him to interrupt his narrative, in a manner that is very painful and disagreeable to his reader. His style is uncommonly compact and dense; so that his meaning is frequently not brought out with sufficient fulness and perspicuity. His reflections are acute and profound, but more interesting to the politician than the philosopher. After the first book of this author, the 11th and 12th of Diodorus Siculus ought to be read; and, after the whole of his work, the 4th and 5th books of Justin, and the lives of Alcibiades, Chabrias, Thrasybulus, and Lysias, by Plutarch.

Xenophon.

The 1st and 2d books of Xenophon's History of Greece, complete the account of the Peloponnesian war, with the contemporary affairs of the Medes and Persians. After this the expedition of Cyrus, by the same author, should be read; and, lastly, the remainder of his History of Greece, which contains an account of the affairs of the Greeks and Persians till the battle of Mantinea, in the year 363 before Christ. All the historical books of Xenophon comprise a period of about 48 years. The style of Xenophon is remarkable for its elegance; his impartiality is undoubted; and his manner and plan form a happy medium between the loose and slightly connected excursions of Herodotus, and the extreme rigour of Thucydides. His account of the retreat of the Ten Thousand, in which he bore a principal part, is perhaps as interesting a portion of history as ancient or modern times can present, and is told in the most interesting manner. To complete the history of all that period of which Xenophon treats, the lives of Lysander, Agesilaus, Artaxerxes, Conon, and Datames, by Plutarch or Cornelius Nepos, and the 13th, 14th, and 15th books of Diodorus Siculus, ought to be read. The continuation of the work of Diodorus Siculus brings the history of Greece and Persia down to the commencement of the reign of Alexander the Great, in the year 336 before Christ. The history of Alexander has been written by Arrian, Plutarch and Quintus Curtius. After these authors, may be read the 18th, 19th, and 20th books of Diodorus Siculus, together with the 13th, 14th, and 15th books of Justin;—these contain the history of Greece from the 323 before Christ to the year 301. At this period, the course of historical narrative may be traced from the 16th to the 30th books of Justin, and all that follow till the two last, which complete the history of Greece till it mingles with that of Rome.

Diodorus Siculus.

The object of Diodorus Siculus was, by reading and travelling, to collect materials for an universal history, from the earliest account of things to the time of Augustus when he flourished. But only a small portion of it has come down to us. Of 40 books, of which the entire work consisted, the first five, which bring the history of the world to the Trojan war, are entire; the next five are wanting; but from the 11th to the 20th inclusive the work is complete. The work of Justin is an abridgment of an universal history, written by Tropes Pompeius, who lived in the age of Augustus. It is written in a style of considerable perspicuity and force, and a due proportion and connection is observed among its several parts. Plutarch's lives of Pyrrhus, Aratus, Agis, Cleomenes, and Philopæmon, should be read to complete this portion of history.

As these authors contain not only the history of Greece, but that of all the nations of the world that were known to the historians; so the following course of Roman history must also be regarded as comprehending all that is now to be learned of the subsequent ancient history of all other nations.

Dionysius of Halicarnassus.

The early part of the Roman history is treated in the most full and satisfactory manner by Dionysius of Halicarnassus. His entire work consisted of 20 books, and brought down the history to the commencement of the first Punic war; but of these, only the 11 first are now extant, and they terminate in the year 341 before Christ, after the dissolution of the decemvirate, and the resumption of the chief authority by the consuls. This author pays much more particular attention to manners, customs, and laws, than the ancient historians usually did; and, on this account, is peculiarly interesting and instructive. He is, however, very credulous; and his style, though pure, is harsh. To complete the history of the period of which Dionysius treats, the 1st, 2d, and 3d books of Livy, and the lives of Romulus, Numa Pompilius, Valerius Poplicola, Coriolanus, and Camillus, by Plutarch, should be read.

Livy.

After Dionysius, by reading from the 4th to the 10th books inclusive of Livy, the history of Rome will be brought down to the year 292 before Christ. The entire work of Livy consisted of 142 books; but it has come down to us in a very mutilated and imperfect state, only 35 being left. This author is entitled to the highest praise for fidelity, impartiality, and the rich and eloquent grandeur of his style. A chasm occurs between the 10th and 20th books of Livy, which may be, however, in some measure, filled up, by the perusal of the 1st and 2d books of Polybius; the 17th, 18th, 22d, and 23d books of Justin; and Appian's Punic and Illyrian wars. From Polybius we may learn many curious and important particulars respecting the art of war among the ancients. His topographical descriptions of the places which have been the site of the remarkable events he records are uncommonly accurate. His style is harsh and involved; his reflections bear evidence of a strong and reflecting mind. After Appian should be read the remainder of Livy from the 21st book to the end, which brings the history of Rome to the year 166 before Christ. The lives of Hannibal, Scipio Africanus, Quintus Flaminius, Paulus Æmilius, Cato major, the Gracchi, Marius, Sylla, Cato minor, Sertorius, Lucullus, Pompey, and Brutus, by Plutarch, will not only serve to complete the history of Livy, but will also afford some striking particulars respecting the manners and state of society of Rome during the most interesting period of its history.

Polybius.

Sallust.

The war of Jugurtha, and the conspiracy of Cataline, which happened respectively 100, and 62 years before Christ, have been narrated by Sallust. The great merit of this writer is his impartiality at a time when prejudice and party spirit must have been very common and very powerful in Rome. His style is remarkable for its conciseness; and this quality is particularly conspicuous in the characters which he draws.

Cæsar.

Most of the transactions in which Julius Cæsar was engaged, are best illustrated by his celebrated Commentaries, and the supplement to it compiled by Hirtius and others. In the Commentaries we may gain some very authentic and interesting information respecting the early state, manners, laws, and customs of those nations which now hold the most distinguished place in modern Europe. The merit of this work of Cæsar's is very high in respect both to matter and style; the advantage which he derived, in respect to accuracy of information, from narrating his own exploits, is not, in a single instance, counterbalanced by vanity, partiality, or the concealment of his faults: his style is remarkable for its simplicity and ease. The sesecret history of this important period will be most clearly understood from a perusal of Cicero's Epistles, which may also be consulted for information respecting the state of society, manners, customs, &c. The fragments of the history of Dio Cassius contain a detail of the events which took place between the period when Lucullus flourished and the death of the Emperor Claudian. In combination with this author may be read the elegant compendium of Velleius Paterculus, from the foundation of Rome to the reign of Tiberius, at which period he lived.

The Lives of the Twelve Cæsars, written by Suetonius, will prepare the way for the study of the works of Tacitus; and, together with the Epistles of Pliny, will afford a pretty clear insight into the state of society, and manners of the Roman empire at this period.

Tacitus.

Tacitus wrote annals of the public affairs from the death of Augustus nearly to the end of the reign of Nero; but only a small portion of them have come down to us, viz. the four first books; a small part of the 5th; all the 6th from the 11th to the 15th; and part of the 16th. There is also a history, by the same author, which extends from the beginning of the reign of Galba to the end of that of Domitian. His work on the manners of the Germans is particularly interesting and instructive, as a preparatory study to the modern history of the northern and middle states of Europe. His life of Agricola is perhaps the finest specimen of biographical writing extant. Tacitus justly deserves the name of a philosophical historian: his insight into human nature, especially into the sources and workings of the worst passions, is deep and penetrating: his style is uncommonly dense.

Herodian.

On the times of servility that succeeded the period in which Tacitus lived, a dim light is shed by the works of Aurelius Victor, Herodian, the six compilers who are commonly known by the name of *Scriptores Romani*, Eutropius, Zosimus, Zonaras, Jornandes, Ammianus Marcellinus, Procopius, Agathias Nicetas, Nicephorus Gregoras, and Joannes Cantacuzenus. Procopius, &c. are distinguished by the appellation of the Byzantine historians. Their works relate to the history of the Greek or Eastern Empire to the period of its destruction by the Turks. Of all these authors, the only two that possess much merit are Herodian and Ammianus Marcellinus. The former wrote the history of his own times from the death of Antonine to the reign of Balbinus and Pupienus, A. D. 238. His manner of narrating events is uncommonly engaging and happy. Every scene, with its causes and effects, is presented in the clearest and best point of view. Simplicity and elegance characterise his style. Ammianus Marcellinus wrote 31 books from the beginning of the reign of Nerva to the death of Valens, in whose court he lived; but of those, the first thirteen, a superficial epitome of 257 years are now lost. In those which are extant, he begins with Gallus Cæsar, about the year of Christ 353, and largely describes the actions of Constantius, Cæsar, Julian, Jovian, Valentinian, and Valens—a period of 25 years, bringing down the history of Rome to the year of Christ 378. He was the last subject of Rome who composed a profane history in the Latin language. He well deserves the character and the praise which Gibbon gives him: "It is not without the most sincere regret (says that author) that I must now take leave of an accurate and faithful guide, who has composed the history of his own times without indulging the prejudices and the passions which usually affect the mind of a contemporary." (Gibbon's *Roman Empire*, Vol. IV. chap. xxvi. p. 426, 8vo. edition.)

Ammianus Marcellinus.

Gibbon's work connects ancient and modern history.

A most important series of events, connecting ancient and modern history, is supplied by Gibbon's *History of the Decline and Fall of the Roman Empire*. This work commences with a view of the policy which swayed the Roman cabinet in the time of Augustus. Rapidly passing on to the age of the Antonines, A. D. 180, it exhibits the extent and military force, the union and internal prosperity, and the constitution of the empire at that period. It then begins to assume the form of a history in detail, which is brought down to the total extinction of the Roman Empire in the west; is afterwards continued to the taking of Constantinople by the Turks, A. D. 1453; and concludes at the establishment of the Papal power in the city of Rome, and the adjacent territory. The minute and extensive learning displayed in this important work not only supports the authenticity of the facts which it records, but also enables the author to discuss many correlative or incidental subjects, which elucidate either the manners, customs, laws, and state of society at the different periods of which he treats, or those institutions that even at present characterize and distinguish the principal nations of Europe. His style is by no means chaste; the unremitting pomp of his periods fatigues his readers; and he deserves unqualified and severe censure for the disingenuous manner in which he has insinuated his animadversions on the Christian religion. But, after all these deductions from the merit and value of this work, it is highly useful; and indeed the only work for the reader who wishes to obtain a clear, full, and interesting view of history, and the state of society between the period of the declension of the Roman empire and the infancy of the principal European states.

Epitomes of modern history.

Those epitomes of modern history, which are connected with ancient history, have already been mentioned. We shall now notice such epitomes as are confined to modern history. A good general epitome was a work long wanting to the republic of letters. We have omitted to notice the Ancient Universal History in the former part of this article, because it is much too voluminous to serve as an introduction to a general knowledge of ancient history. The same remark applies to the Modern Universal History. Both of them are much more useful as books of reference, or for consultation, after a tolerably accurate and extensive knowledge of history has been acquired, than as introductory works; besides, the various portions of both are executed with very unequal degrees of merit.

Voltaire.

Voltaire's *Essai sur les Mœurs et l'Esprit des Nations*, is rather a commentary on facts, an acquaintance with

Russel.

which is presupposed, than a detail of the facts themselves. The *Histoire Moderne* of the Abbe Millot is a judicious abridgment. It deserves the character of accuracy and impartiality; but, besides being liable to the objections that have been offered to the ancient history of the same author, it is too much compressed for the extent and importance of the topics which it embraces. Russel's History of Modern Europe is a work of a much higher character, and much more valuable and useful to the student in every respect. Its merits appear to us not sufficiently known and prized. Probably by those who have never read it, it is supposed that no great talents could be required or exercised in drawing up a mere abridgment of history. But the contrary is the fact: to judge from this work of Russel's, he must have been a man of considerable penetration, sound judgment, a philosophical spirit, and correct taste. His work is divided into two parts; the first embracing the period from the rise of modern kingdoms to the peace of Westphalia in 1648, and the second comprehending the events of history from the peace of Westphalia to the peace of Paris in 1763. A third part, bringing the history down from the peace of Paris to the treaty of Amiens in 1802, has been added by Dr Coote, who, though he has strictly adhered to the plan, has by no means attained to the merits of the original work. The subdivision of the plan is effected with considerable skill and ingenuity in a series of letters, in which the principal transactions of the leading European states are concatenated with as rigid adherence to chronological order, as was consistent with the mixed and fluctuating interests of those states. By passing over events which derived their importance and interest merely from the period in which they occurred, or the personages who were concerned in them, he has been enabled to give more room for those of a more permanent nature. As a repository of facts, therefore, judiciously selected, methodically arranged, and authenticated with sufficient learning and diligence, this modern history of Europe may justly be regarded as a work of very great utility; but it deserves higher praise. The causes and consequences of the most important events are traced with great ingenuity and penetration, at the same time that fanciful speculations regarding them are carefully avoided. The observations on the characters of the principal personages are distinguished by the vivid and faithful pictures which they exhibit. The progress of society from the rise of modern kingdoms down to the peace of Paris in 1763, exhibiting the manners of the people in their rudest state, and in their highest polish, is given at stated periods with much ability and research. The advances made in taste and science, and the usurpations of the ecclesiastical at the expence of the civil power, are clearly developed; and, being connected with the progress of war, politics, and legislation, exhibit, in a clear and conspicuous manner, the intellectual and moral improvement of European society. The style of this work is pure, elegant, and concise; and the reflections that are interspersed, always illustrate and confirm the sacred principles of public and private justice.

General views of the history of Europe.

This work will serve to exhibit the great and leading outlines of the events of modern history; and from Gibbon's Decline and Fall may be traced the origin of those barbarous tribes, whose chiefs, at different periods, making themselves masters of the various subdivisions of the Roman empire, laid the foundations of the modern kingdoms of Europe. The student having thus gained a general knowledge of modern history, as well as a more particular insight into the origin of the European states, ought, in the next place, to peruse those works which exhibit a general view of the history of modern Europe at various periods.

Gaillard.

History of Abelard and Eloise.

History of Petrarch.

Froissart.

Shepherd's Life of Poggio,

Roscoe's Life of Lorenzo,

and of Leo X.

Much valuable information relative to one of the most important of the early periods of modern history is to be derived from the *Histoire de Charlemagne*, published by M. Gaillard in the year 1782, in four vols. 12mo. The general state of Europe in the 11th century is described by Mr Berrington in the second edition of the Lives of Abelard and Eloise. In the Abbe Sade's *Memoires Sur la Vie du Francois Petrarque*, the author, by regularly indulging in details of circumstances with which Petrarch has little or no connection, has contrived to interweave into these memoirs a minute and elaborate account of the events which took place in Italy, France, and other parts of Europe, during the greater part of the 14th century. The history of this period may still be further illustrated by the Chronicles of Froissart, which, besides a minute detail of the transactions which occurred from 1326 to 1400, give a most interesting and amusing insight into the manners, customs, habits, and feelings of that period. A succinct narrative of general history is also to be found in Shepherd's Life of Poggio, which, relating to the origin of the famous ecclesiastical feud, the schism of the West, almost touches the period of Petrarch, and traces the principal occurrences which took place in Italy and Europe in general, beyond the middle of the 15th century. The Life of Lorenzo de Medici, by Mr Roscoe, may be next perused: as Lorenzo's political connections were very extensive, his history embraces the principal occurrences which happened in the more civilised portions of Europe, during his life from 1448 to 1492. The succeeding period of general history is illustrated by the same author in his Life of Leo X. In this work, Mr Roscoe enters fully into the state of Italy and Europe, which had so much influence on the fortune of that people, and which was also in no small degree modified by his actions. In both these works, Mr Roscoe has given a copious history of the progress of literature and the fine arts.

Robertson's Charles V.

Philip II. and III.

The History of Charles V. next becomes the most prominent in the general history of Europe; and, with this view of it, it has been most ably written by Dr Robertson. The first volume of his work contains a view of the progress of society in Europe, from the subversion of the Roman Empire to the beginning of the 16th century, embracing the several heads of government, laws, manners, military establishments, and the political constitution of the principal states of Europe. The History itself comprehends the eventful period between the years 1500 and 1559, during which events took place which materially affected the state of society, and the advancement of literature, knowledge, and liberty in Europe. The Histories of Philip II. and III., by Drs Watson and Thompson, may also be read with reference to a general acquaintance with the history of Europe during the period of their reigns, and to a knowledge of several events, which tended materially to change the relative situation and importance of the various states of Europe. Indeed, the political alliances and wars of these monarchs involve the interests of so many kingdoms, that their history displays the general topics of the history of Europe till the year 1621, the period of the death of Philip III.

Soon afterwards the French monarchy began to assume such a rank, and to connect itself with so many states, that its history ought to be perused, as throw-

Gustavus Adolphus.
Louis XIV.
Voltaire.

ing more light on the general history of Europe than that of any other kingdom at this time. Harte's Life of Gustavus Adolphus, and Scheller's History of the Thirty Years' War, also illustrate, in some degree, the history and state of the north of Europe about the same period; and bring down the narrative of events nearly to the age of Louis XIV. Voltaire's life of this monarch will conduct the reader to the period when, in consequence of the alliances formed by the English nation with various continental powers, the history of the world is strictly connected with that of our native land.

Histories of particular countries.
Britain.
Ireland.
India.

IV. Under the 4th division of this article, we proposed to point out the order in which the history of particular countries may be read, so that they may be illustrative of one another. "Nature," as Mr Gibbon justly observes, "has implanted in our breasts a lively impulse to extend the narrow span of our existence, by the knowledge of the events that have happened on the soil which we inhabit, of the characters and actions of those men from whom our descent as individuals or as a people is probably derived. The same laudable emulation will prompt us to review and to enrich our common treasure of national glory; and those who are best entitled to the esteem of posterity, are the most inclined to celebrate the merits of their ancestors. The history of Britain, therefore, naturally will and ought to claim our highest interest. Under the article Britain, in this *Encyclopædia*, will be found a history of the Island from its first population by the Celts, until the arrival of the Saxons in the year 449. As our constitution, our national character, the tone of our manners and feelings, and our language, are, in a great measure, derived from our northern ancestors, the articles Germany and Scandinavia ought to be read in connection with the early part of the history of Britain. From the arrival of the Saxons till the union of the crowns of England and Scotland in the year 1603, the histories of these two countries are treated distinctly under the respective articles; but the connection between them during the greater part of this period, was so close, though generally of a hostile nature, that their histories are necessarily mutually illustrative of each other. The history of France, also, given under that article, ought to be read, for the purpose of illustrating the histories both of England and Scotland; while an attentive consideration of the language, the manners, and the state of society in France, will afford elucidation, and give additional interest to the English and Scotch history during the same period. Under the article Britain is given the history of the island from the union of the crowns of England and Scotland to the commencement of the year 1812; and the most interesting portion of the foreign history of Britain from 1812 to the last peace of Paris in 1815, will be found under the article France. A more full account of the war between Great Britain and her colonies, than is to be found under the former article, is given under the article America, (*American United States.*) After the perusal of the histories of England, Scotland, and Britain, read in this order, and thus elucidated, the reader should peruse the history of Ireland, given under that article: and as India forms now such an extensive and valuable portion of the British empire, the history of it, under that article, ought to be read in connection with the history of the united kingdom.

Rapin.
Hume.
Henry.
Andrews.

If the student is desirous of entering more fully and deeply into the history of this country than the articles in this *Encyclopædia*, necessarily succinct, will enable him to do, Rapin will afford him a very elaborate, and in general a very faithful, history of England till the close of the 17th century; while, in Hume's History, he will find infinitely more philosophy, but far less impartiality and accuracy. The history of England, from the period of the Revolution, cannot boast any writer of standard excellence. In Henry's History of England, and Andrews' History of Great Britain, connected with the chronology of Europe, the literature, arts and manners, religion and government of the several periods, which these works respectively comprise, are elucidated.

Pinkerton.
Hales.
Robertson.
Laing.
Leland.
Warrington.

The very early history of Scotland has been most elaborately elucidated by Pinkerton; the same author, and Lord Hales, have also treated, in a masterly and satisfactory manner, the history of this country during a less remote period. After the second work of Pinkerton, should be read Robertson's History of Scotland, during the reigns of Queen Mary, and James VI. till his accession to the crown of England; and Laing's History of Scotland from the union of the crowns to the union of the kingdoms. Leland's History of Ireland traces, in a masterly manner, the transactions which took place in that country, from the invasion of Henry II. to the treaty of Limerick in the reign of William III. Those portions of the history of this ill-fated and ill-used country since that period, which are particularly full of incidents, cannot yet be treated in an impartial manner. In the History of Wales, by the Rev. W. Warrington, all the facts are collected which can throw light upon the government, manners, and final subjugation of a people, still strongly marked by a peculiar character, manners, and customs.

History of France.
History of Italy.

Next to the history of the United Kingdom, the history of France claims the attention and investigation of the student, both on account of its connection with the history of these islands, and on account of the relative importance of that state in Europe. Under the article France will be found a sketch of its history, as full as the limits and nature of this work will allow, accompanied by a statistical account of that country, which, as we have already remarked, ought always to be read in conjunction with history. The early portion of the history of France admits of and requires elucidation, from a knowledge of the manners, laws, &c. of the ancient German tribes, nearly as much as the early history of Britain; the article Germany, therefore, may be profitably consulted for that purpose. After the affairs of France cease for a time to be intimately interwoven with the affairs of England, its history becomes connected with, and therefore may be elucidated by, the history of Austria under the Emperor Charles V. and by the history of Italy. During the 17th and the early part of the 18th centuries, the history of France requires a reference to the histories of the Netherlands and of Spain. From the commencement of the war between Britain and France in 1744 to the present time, the histories of the two countries are mutually illustrative of each other.

Spain and Portugal.

The history of Spain, perhaps, both on account of its relation to the histories of Britain and France, and on account of the importance of that kingdom in the scale of Europe, at least during a certain period, next claims the investigation of the student. Besides the article Spain, the article Arabia may advantageously be consulted, in elucidation of the manners, customs, &c. and the early history of the peninsula. After the expulsion of the Moors, the histories of France, Spain, and Italy, from the end of the 15th to the beginning of the 16th centuries, are intimately connected. As the discovery of the new world happened at that period, the articles AMERICA, MEXICO, and PERU, ought to be consulted for an account of the transactions of the Spaniards there. Soon afterwards the history of this country becomes connected with that of the Netherlands. After the separation of the United Provinces from Spain, its history may be chiefly elucidated by the histories of Portugal, Italy, France, and Britain. The history of Portugal admits of little elucidation from the history of any other country except Spain; the articles AFRICA and ASIA, however, may be consulted for a brief account of their discoveries and settlements in these quarters of the globe.

German kingdoms. As an introduction to the history of the German kingdoms and states, the article GERMANY ought to be perused: this will prepare the way for the history of Austria, illustrated in its progress by the histories of Switzerland, Italy, France, Spain, Russia, Turkey, Sweden, and the Netherlands: the history of Prussia, illustrated by the history of Brandenburgh, Russia, Austria and France; the history of Bavaria, Saxony, &c. The account of the Reformation, given in the article ECCLESIASTICAL *History*, ought to be consulted, with reference not only to the history of Germany, but also to those of Britain, France, and the Netherlands, during the 16th and part of the 17th centuries. **Russia.** The history of Russia will receive elucidation from the histories of Austria, Prussia, Sweden, Poland, Turkey, and Persia. **Denmark, &c.** The article SCANDINAVIA ought to be consulted for a general view of the manners, customs, laws, &c. and early history of Denmark, Sweden, and Norway. These countries, besides mutually illustrating the history of one another, will receive elucidation principally from the history of Russia and Germany. **Netherlands.** Under the article NETHERLANDS, will be found the history of that country, not only while it remained undivided, but also of the United Provinces, and of the new kingdom, which has reunited the whole seventeen provinces. That portion of the history of this country, which properly relates to the United Provinces, will receive elucidation from the history of Spain, France, and England, during nearly the whole of the period, from the establishment of their independence till they were merged in the kingdom of the Netherlands. **Switzerland.** The comparatively pacific history of SWITZERLAND admits of illustration, in no important degree, except from the history of Austria, during the very early period of the establishment of its independence, till, like nearly all the other states of continental Europe, its history becomes involved in the revolutionary history of France.

Italy. The general account of ITALY ought to be consulted previous to the histories of Naples, Sicily, Venice, Tuscany, the Popedom, &c.; and these will be elucidated by the histories of France, Spain, Austria, and Turkey. The history of the Popedom indeed, both in its ecclesiastical and civil character, is so intimately connected with the history of all the European kingdoms, (except Russia and Poland,) till the Reformation, that it ought to be studied carefully; for this purpose the article ECCLESIASTICAL *History* may be consulted. The history of Poland will be elucidated principally by that of Turkey, Austria, and Russia.

History of the kingdoms of Asia. Respecting the histories of the kingdoms of Asia, Africa, and America, our notices must be very short. Of course before the history of any particular country in any of these divisions of the globe is studied, the description of that particular division, under its proper head in this work, ought to be consulted. Turkey, from its connection with the histories of Austria, Poland, and Russia, claims perhaps the first notice. **Arabia.** The history of Arabia, illustrated by the life of Mahomet, is an interesting object of study, not only on account of the conquests and literature of the Arabs, but also from the connection of their history with that of the Peninsula. **China.** Though the history of CHINA has little or no connection with the history of any European state, yet the peculiarities of its inhabitants must render its history interesting: Under that article will be found not only an accurate and well-proportioned abridgment of the history, but also a very faithful and detailed description of the manners, language, institutions, &c. of that singular country. **India.** Since the middle of the last century, the history of INDIA has become so intimately connected with the histories of France and Britain, and that country at present forms so large and valuable a portion of the British empire, that its modern history ought to excite considerable interest, even though its ancient history, and the character of its inhabitants, and their laws, institutions, &c. did not put forth strong claims to our attention. For an account of the histories of the other kingdoms of Asia, we must barely refer our readers to the articles of PERSIA, BIRMAN EMPIRE, JAPAN, THIBET, TARTARY, MALACCA, CEYLON, SIAM, &c. **Africa.** The history of the principal states of Africa will be found under the articles EGYPT, ABYSSINIA, CAPE OF GOOD HOPE, ALGIERS, MOROCCO, TRIPOLI, TUNIS, &c. **America.** The history of the united states of America, as already mentioned, should be sought for under the articles AMERICA and BRITAIN; of the British colonies there, under the articles CANADA, NOVA SCOTIA, &c. and also under BRITAIN; of the Spanish colonies, under the articles BUENOS AYRES, CHILI, MEXICO, PERU, &c. and also under SPAIN; of the Portuguese settlements under the head of BRAZIL, and also under PORTUGAL.

Other species of history. V. We shall now conclude this article with a brief notice of the different species of history, besides that which is emphatically so styled. **Ecclesiastical history.** History, strictly speaking, relates to the narration of the wars and political events of kingdoms; but besides this species of history, that which relates to the support which Christianity has received from the secular power; together with the benefits or disadvantages resulting from this support; and also to the internal administration of the church, its constitution and discipline, its doctrine and its worship; or, in other words, the history of Christianity, of its corruptions and reformation, and of the influence which its principles, or the conduct of its professors, have had on the political condition and affairs of mankind, may justly be regarded, as very intimately connected with the species of history, which we have been so fully considering. **Its connection with political history.** Ecclesiastical history, therefore, ought to be studied, not merely in its religious, but also in its political point of view. Whoever reflects on the power of the Pope for several centuries,—on the friendly relations or wars between the different states of Europe, which they brought about,—on the wars arising from the Reformation, and on the great and decided change in the political character and power of the mass of the people which that event produced, must be convinced that ecclesiastical history cannot safely be neglected even by the mere statesman. This article, therefore, ought to be carefully perused, both by itself, and in connection with the history of the different states of Europe.

The histories of the different arts and sciences are quite of a distinct class from political and ecclesiastical

Histories of the arts and sciences;—illustrative of the political character, power, and resources of nations.

history; though, to the student of both of these, as well as to the man of science, they must be interesting and useful. The resources and the wealth of states depend mainly on their advances in the arts and sciences; and with respect to the connection of some of the latter with the state of religious knowledge, the history of astronomy is sufficiently explanatory. As one of the principal objects and advantages of history, strictly so called, is to gain an insight into the progress of man in political and individual happiness, surely an acquaintance with the advances which he has made in every species of knowledge, which secures his liberty, or multiplies his means of defence or enjoyment, must be interesting and important. Besides, whoever is desirous of satisfactorily accounting for the difference between ancient and modern nations, as displayed in their respective histories, and for the great and decided superiority of the latter, must look beyond mere political history, to the history of those arts and sciences, which were comparatively unknown to the ancients, and in which the moderns have made such wonderful advances,—advances that will be found, in a great measure, and nearly in every instance, accompanied by, if not really productive of similar advances in national resources, and political power The copious histories of the arts and sciences, therefore, given in this work, under the respective heads of each art or science, ought by no means to be neglected by such as wish to read political history to advantage; and if they are perused in connection with the statistical account of each country, given along with its history, the causes of the comparative progress of nations in political liberty and power will be very clearly and satisfactorily traced. (w. s.)

HIVE. See Bee, vol. iii. p. 415, &c.

HOBBES, Thomas, celebrated as a literary and philosophical character, but chiefly for the peculiarities of his moral and political doctrines, was the son of a plain unlettered clergyman of Malmesbury, Wiltshire. He was born on the 5th of April 1588, at the crisis when this country was menaced by the formidable armada sent by Philip II. of Spain. His mother, powerfully affected by the consternation then so general over the kingdom, was delivered before the full time, in consequence of which Hobbes was remarkably delicate in his childhood But he evinced a singular aptitude for learning, and attracted much notice by his proficiency at school. Before the age of 14, he translated the Medea of Euripedes into Latin iambics. At this age, he went to Magdalene Hall, Oxford, where he distinguished himself by his application and genius. The Earl of Devonshire, wishing to profit by his talents, employed him as a companion and instructor to his eldest son, who was nearly of the age of Hobbes, and that family continued to patronise him as long as he lived. At an early period he was known to the celebrated Lord Bacon, with whom he was a great favourite, and to whom he acted as an amanuensis in translating some of his treatises into Latin. He travelled with his noble pupil in France and Italy, where he cultivated the society of Galileo and other celebrated characters, and studied the customs, institutions, manners, and learning of these two nations.

He now resolved to devote his life to the cultivation of polite literature, and his first publication was an English translation of Thucydides, which appeared in 1628. But his plans were disconcerted by the death of his pupil and friend. He soon after formed an engagement to travel with the son of Sir Gervase Clifton, with whom he remained for some time in France. In 1631, the Countess Dowager of Devonshire renewed his connection with her family, by putting the young earl, then 13 years old, under his care. He went with his pupil to Paris, where he studied mechanics and the laws of animal motion. On these subjects he had frequent conversations with Father Mersenne and with Gassendi, who was then engaged in an attempt to revive the physical doctrines of the Epicurean school. It was at the age of 40 that his attention was first turned to mathematical studies, in consequence of having accidentally looked into a copy of Euclid, where the enunciation of the 47th proposition of the first book arrested his curiosity. "This," he exclaimed, "is impossible!" He then rapidly went over the demonstration, and traced in a retrograde direction the preceding theorems on which the steps of the process were founded. The lovers of the mathematical sciences much regretted that he began these studies so late in life; as he evinced a happy talent for them, yet laboured under the disadvantage of an obstinacy of opinion which might have been corrected by the more varied views unfolded during the pliant period of youth.

The ardour of his mathematical studies was in a great measure repressed, in consequence of the profound interest which he took in political affairs, in which he did not intermeddle as a busy politician, intriguing with individuals for the establishment of one party on the ruins of another, but conceived the design of producing a general impression by an open exposition of his opinions, which, though new and peculiar, he hoped to render popular, by the force of thought which he could display, and the strong evidences by which they were supported. When the political differences of the age were so strongly marked, it was a fair general conclusion that both parties were as likely to be wrong as any one was to be exclusively right, and that a man of vigorous thinking powers, who devoted much laborious meditation to his subject, might form a more accurate system than any maintained by his cotemporaries. Nor was it unnatural for a young author to presume too much on the readiness of mankind to lay themselves open to conviction. These ideas he had cherished for a considerable time, and some represent him as having cultivated mathematics chiefly with a view to habituate himself to a close and steady mode of thinking.

His first political essay was a small tract, which was not printed, but circulated in manuscript in the year 1640, during the sitting of the parliament in April, which was dissolved the following May, when the parliament and Charles I. differed so widely on the subject of the royal prerogative. This tract strongly asserted the pretensions of royalty, and condemned those of the parliament and the people as unjust encroachments. It occasioned a considerable sensation, and would have involved Hobbes in imminent danger, if that parliament had not been dissolved. This was the harbinger of the noted political works which he subsequently published, his book *De Cive*, and his *Leviathan*. Mainwaring, bishop of St David's, was sent to the Tower for preaching the doctrine of Hobbes; and the latter made a timely retreat to Paris, to prosecute his studies in the enjoyment of personal security. Here he returned to the society of Mersenne and Gassendi, to which was added that of Des Cartes. Afterwards, however, Hobbes controverted the doctrines of the latter on the subject of innate ideas, which terminated all their friendly intercourse.

In 1642, he published, while at Paris, a few copies of his book *De Cive.* He became acquainted with Sir Charles Cavendish, brother to the Duke of Newcastle, who admired his mathematical talents, and attached himself warmly to him as a friend and patron. In 1647, his fame in mathematics procured for him a recommendation to instruct the Prince of Wales, afterwards Charles II., in this branch of science. His fidelity and care in the execution of his trust secured to him the esteem of that prince, which continued ever after, though on some occasions prevented from being manifested by the obnoxiousness of his principles. In this year, a more complete edition of his work *De Cive* was published in Holland under the care of Dr Sorbiere, to which two recommendatory letters were prefixed, one by Father Mersenne, and another by Gassendi.

In 1650, his book *De Homine* was published in London, containing a developement of his doctrines of sensation, particularly as illustrated by the mechanism of vision, with a dissertation on human speech, intellect, appetite, passion, action, and character: also another work, entitled, *De Corpore Politico,* or "Elements of Law." In this and the year 1651, he published in London his *Leviathan,* a work in which his opinions on moral and political subjects were more completely embodied. After the publication of this work, he returned to England, though Cromwell was now at the head of the government, and lived at the Earl of Devonshire's country seat in Derbyshire. It is remarked that he lived in communion with a congregation belonging to the church of England, and regularly resorted to their place of worship. His assertion of the royal prerogative was not now construed to his disadvantage, as he had prudently intimated that his doctrine was applicable to any individual possessed of supreme power.

In 1654, he published his letter on "Liberty and Necessity," which occasioned a long controversy with Dr Bramhall, afterwards lord primate of Ireland. He advocated the doctrine of necessity. He sometimes says he could not help being astonished that those who argue that men can act without constraint, forget that the determination of their actions depends on their will, and that it is not to the actions as separated from the will, but to the laws of the will itself that our inquiries must be directed. He must be allowed to have added some precision to the nature of the arguments embraced in this controversy. He now began a dispute on his part not creditable, with Dr Wallis of Oxford, which involved the greater part of mathematical science. Not content with attacking the doctrines of his adversary, he exposes with grovelling minuteness the inaccuracies of his language; and, though afterwards repeatedly refuted to the satisfaction of all the mathematicians of the age, he persevered with unaccountable obstinacy in asserting his first opinions.

At the restoration of Charles II. in 1660, Hobbes removed to London, where he now reckoned himself safe. In the country, he was possessed of every advantage that books could supply, by the ample library of his patron, which was always enriched with every additional work that he chose to recommend; but he wished to enjoy the advantages of the conversation of the learned, which he found necessary to his habits of enjoyment, and to the full activity of his talents. Soon after he came to London, the king observed him from his carriage, and renewed his acquaintance with him: He fondly cherished his conversation, and settled on him an annual pension of £100. But the personal favour of Charles was not sufficient to screen Hobbes from the censure of the parliament, which, in 1666, was publicly pronounced against his book *De Cive* and the *Leviathan.* This prince, though fond of absolute power, was a tool of the high church party, to which that controul on the part of the sovereign over ecclesiastical affairs which Hobbes recommended was extremely obnoxious. They professed the strictest attachment to hereditary monarchy, but certainly exacted it as a condition, that the king should maintain their hierarchy and forms as the established religion of the state; and, if we may judge from subsequent events, would have entertained but feeble objections to any prince capable of being seated firmly on the throne, who would shew himself most cheerful in assenting to this indispensible condition. Hobbes maintained, that the natural ferocity of man renders it necessary to vest the absolute power in one person, to whom the church and the consciences of the people ought to be subjected. Thus, he made the radical truth of any religious system a matter of little importance. To admit this, would be to acknowledge the church to be wholly a plastic mutable engine of government, and to compromise the dignity which she always asserts of having her principles founded in immutable truth. A bill was also brought into Parliament to punish atheism and profaneness, which he considered as aimed at him; for, though neither atheism nor the denial of Christianity were tenets maintained by him, he knew himself to be accused of them by the general voice, and therefore was somewhat uneasy. On this occasion, apprehending that his house would be searched, and his papers seized, he burned some of them, and particularly one which was the most obnoxious of all, a Latin poem on the encroachments of the Romish and reformed clergy on the civil power. The king was now obliged to withdraw from him all public expressions of his personal regard. He continued, however, to live in London unmolested; was held in high esteem among the learned; and was honoured by the visits of ambassadors and other illustrious foreigners, among whom was Cosmo de Medicis, then prince, and afterwards Duke of Tuscany, who procured his picture for his cabinet, and a collection of his writings for his magnificent library at Florence. Hobbes had it in contemplation to publish an elegant edition of his Latin works; but finding it impracticable in London, he had an inferior one executed at Amsterdam in 1668. In 1675, he published his English translation of the Iliad and Odyssey.

About this time, he took a final leave of London to pass the remainder of his days at the Earl of Devonshire's seat in Derbyshire, where he continued to prosecute his studies. In 1676, his dispute with Dr Laney, Bishop of Ely, on liberty and necessity, made its appearance; and, in 1678, his *Decameron Physiologicum,* or ten dialogues on natural philosophy; also, his *Art of Rhetoric,* and his *History of the Civil Wars, from* 1640 *to* 1660, which he entitled *Behemoth,* of the publication of which, however, his friend Charles the II. who saw it in manuscript, did not approve.

His mental powers continued vigorous till his last illness, and his great delight consisted in exercising them. In his 85th year, he wrote an account of his own life in Latin verse, which evinced considerable activity of mind, though the execution of his task afforded no bright display of literary taste. In the following quaint conceit, for example, he depicts the circumstances of his birth:

> "*Fama ferebat enim, sparsitque per oppida nostra,*
> *Extremum genti classe venire diem;*
> *Atque metum tantum concepit tunc mea mater,*
> *Ut pareret geminos meque metumque simul.*"

He continued even to study mathematics with great perseverance, and he died at the house of his noble patron in 1679.

The accounts given of his temper and private character are various, according to the channels through which they are communicated. Those whose doctrines he disputed, and whose writings and characters he reviled, drew along with them a number of partisans to stigmatise him as rude, acrimonious, and untractable. Of this temper we certainly perceive some traces in his writings; but we likewise find in them occasional proofs of a spirit of conciliation and candour, together with a sense of the bias which external circumstances gave to his writings. In the following terms he concludes his preface to his book *De Cive*: "If, in this treatise, you find any thing of questionable solidity, or any thing expressed with too great acrimony, remember that they are spoken not from party zeal, but a sincere wish for the peace of society; and by a man whose grief, so justly awaked by the distractions and calamities of his country, entitles him to a share of forgiving tenderness. He therefore craves, that you will, on such occasions, bear with his weakness, and not indulge towards him the extremity of your displeasure." He laid it down as a maxim, that it was unlawful to commence an abusive attack on any writer without provocation, but that, when first attacked in this way, he was entitled to make the severest retorts; and his practice shewed, that on such occasions he knew no bounds. He aspersed with the utmost scurrility the members of the Royal Society as a body, expressing his contempt for their attachment to experimental inquiry, and representing them as abandoning the use of their rational faculties.

At court, he was a common object of banter, which he bore with good temper, and was remarkable for the felicity and fecundity of his repartees. To serious questions, however, he never gave a ready reply. If his opinion was asked on any point of philosophy or of political science, he gave a winding, computing, and diffident sort of answer, which, in a less noted man, might have been mistaken by the superficial for a mark of indecision of character, but in reality proceeded from his being aware of the multiplicity of circumstances to be taken into account, and the risk which there always is of running into error. All who cultivated his society pronounced him a delightful companion. Mr Wood, in his *History of the Antiquities of Oxford*, inserted this character of Hobbes: "He was a man of whom (amidst the varieties of accounts, good and bad, that have been circulated) this may be most truly pronounced, that he had a most comprehensive and well replenished mind on universal science,—a mind which despised riches and secular honours, and was superior to the envy of the world. To his relations and others he was ever kind and beneficent. Among his companions, his conversation was cheerful, open, and free. By strangers he was held in veneration, as the first ornament of his country." This eulogium, however, was struck out of the work by Dr Fell, dean of Christ-Church, through whose hands all works printed at the university-press were required to pass. The transaction was communicated to Mr Hobbes, who had a pamphlet, containing a full exposure of it, ready for appearing in London and Oxford at the same time with the work of Mr Wood. Hobbes was remarkable for vigour of nerve, and steadiness of intellect. He used to say, that in his most complicated arithmetical calculations he never mistook a figure; and with the same undeviating steadiness he prosecuted all his learned undertakings. The high value which he put on this natural quality, had probably some influence in rendering him impatient of opposition, and gave origin to the harsh features which some parts of his works bear.

According to the account given of him by Dr White Kennet, he was considered in the house of the Earl of Devonshire as a humourist, or unaccountable being; a character very readily acquired by a man who dedicates to study the hours by which those around him have their manners moulded by their general intercourse with others. His amusements, exercises, and social interviews, being subservient considerations, were dictated by his own thoughts; and, though not resulting from an unaccommodating temper, appeared capricious, because they were singular. In this nobleman's house he was retained from gratitude and affection, rather than with a view to any sort of services, and he lived in ease and plenty without any official charge. His mornings were spent in violent exercise, such as running and climbing steep ascents, in which he exerted himself to fatigue. After breakfast, he went round the family, to wait on the countess, the children, and the visitors. Thus the time passed till twelve o'clock, when he had a little dinner prepared for him, after which he retired to his study, where he smoked, thought, and wrote for several hours.

Sensible that he was obnoxious to a powerful party, he was haunted with habitual apprehensions for his safety. The pension of the King was chiefly valued by him as a pledge of protection from persecution; and he had Lord Arlington and some other friends engaged to protect him at court whenever there was occasion. He disliked to be left in a house alone, some said for fear of being assassinated by his enemies, while others ascribed it to the workings of an involuntary superstition. When the Earl went from home, he always went along with him, even in his last illness, when he required to be conveyed on a feather bed to the carriage, and survived the journey only a few days. He avoided all conversation on the subject of death. If, as has been supposed, he scarcely believed in a future state, yet he seems not to have been capable of looking forward to his dissolution with that placid indifference with which men generally look back to the period preceding their birth. He reckoned on the continuance of life when his constitution was too much worn out to justify such expectations; and when, in reply to some anxious inquiries, he was forbid to hope for a recovery, he lay in a state of silence and apparent stupefaction, which was concluded to be in a great measure produced by the state of his mind. The last words which he uttered in the full possession of his senses were, "I shall be glad to find any hole to creep out of the world by," which probably expressed a wish that his last moments should be exempt from pain and disturbance. He conformed to the Episcopal Church of England, and declared that he preferred that religion to all others; yet he had no confidence in the utility of religious services on his death-bed. On one occasion, during his residence in France, when his life was seriously in danger, he resented the solicitations of the Romish priests and the Protestant clergy to submit to some rite which would proclaim him a believer in their respective systems, and told them, that if they did not desist, he would expose the impostures of their whole fraternity from Aaron downwards.

It is with the writings of Hobbes, and the opinions which he circulated, that the public is chiefly concerned. His writings were fitted to make a powerful impression at the time at which they appeared; but the character of society has subsequently so much changed, that they are now comparatively of little interest. His small treatise *De Homine* is regarded by the philosophical world as the best of his works. In this he, in some degree, advanced the science of optics, then in a rude state. His notions, though crude and inaccurate, are ingenious and interesting. His moral observations sometimes breathe the sage spirit of Aristotle. At one time he, like that author, condenses his meaning in a few words; at another he suddenly deviates into a style of extreme expansion. This chiefly happens when he applies his doctrines to the opinions and transactions of his own times. A celebrated living author (Professor Stewart) justly remarks, that Hobbes, whether right or wrong, never fails to set his reader a-thinking, which is the most indubitable proof of original genius.

To attempt to collect a system of moral, political and religious doctrine from his works, would now appear ludicrous. In some parts his inquiries are shallow and deficient, most especially in his investigations of our ideas of morality and justice. He considers a regard for personal advantage as the only law of man in a state of natural liberty, and represents all the obligations of justice and good conduct to our fellows as the consequence of civil contracts formed under the influence of individual prudence. The laws, he says, are the foundation of justice: before them justice and injustice are unmeaning words. If this view of things had been advanced only as a general description of the actual condition of man under a total want of laws, as well as the absence of generous or deliberate reflection, and if he had considered pactions and civil institutions as the means by which men agree to execute beneficial ends, he could not have been greatly blamed; but he regards even civil compacts as the sole effect of the regard of each man for his own safety; and such feelings of kindness and compassion as most loudly proclaim the social virtues to be a part of our original nature, are represented as arising solely from a reflection on the possibility that exists of experiencing in our own persons the evils which we deplore in others.

In forming this, and some other views, he appears to have been led astray by the desire of giving what appeared to him a palpable account of human affairs; but it partakes too much of those gross maxims which sometimes indecently obtrude on our notice both in conversation and books, which foster our worst passions by boldly representing them as the necessary springs of human conduct. No doctrines can have a more destructive influence on those finer feelings which are connected with just reflection and the encouragement of exalting sympathies, but which require to be delicately cherished if they are to be preserved from pollution and degradation. The same love of palpability seems to have been the origin of that system of materialism, or rather that preference of the language of materialists, which appeared in the explanations which Hobbes gave of the origin and laws of thought. By representing justice as founded on positive law, he overturns the principles of jurisprudence itself, which must precede law, and determine the propriety of institutions. If he acknowledged the preservation of the general welfare to be a valuable end, it was certainly paradoxical to deny that a man, on his first interview with a stranger on an unknown shore, previously to the establishment of any mutual understanding, is under obligations to cultivate personal kindness, and to abstain from violence and domination. The boundaries of these early feelings, and the modes in which they may be best expressed, are not indeed easily defined, especially if we encounter distraction from the circumstance of a numerous population. Therefore it appeared the easiest method to pronounce them arbitrary, and in no degree binding, compared to declared promises, compacts, and promulgated laws. But men may differ both about the formation and the execution of laws, and how are their differences to be decided? "They must," says Hobbes, "choose a sovereign power, and to this their whole interests are at once committed." Such is the origin of regal government; and from this simple fact he draws the monstrous conclusion, that kings can do no wrong; that they must never be resisted; and that to their hands the lives, properties, and consciences of the members of a state must be perpetually and unconditionally entrusted. That such will be the state of mankind, if they are barbarous in their character, jarring in their views, or bereft of spirit; that it will even be worse than this, if they are subjugated by the power of a brutal master, who feels no obligation to consult their welfare farther than as it is subservient to his imagined interest or the gratification of his caprice, is a fact too often exemplified in the history of the world: but to erect it into a principle that this *ought* to be the case, and that no efforts of mankind should be directed to the formation of any better state of society, is an idea which, in a reflecting mind like that of Hobbes, could only be generated by the miserable dissensions by which he was surrounded. In the days of Cromwell and the Charles's, the spirit of intolerance was active, extravagance contended with extravagance, and there seemed to be no possibility of terminating the scene of violence by a temperate discussion of principles, or a mutual adjustment of views; it was therefore necessary to still the passions by some powerful agent. The agent that occurred to Hobbes as the most suitable, was the exertion of absolute authority in the hands of the chief magistrate, and the perpetual establishment of this power seemed necessary for the prevention of future troubles. As a temporary expedient, he might have been pardoned for advancing such a position, even by those who dissented from him; but when he erects it into a universal principle, he must be regarded as an aggressor of the rights and interests of society, and a deliberate apologist of tyranny.

In theology Hobbes speculated with equal infelicity. Insensible both of the mysterious nature of his subject, and the reverence which it required, he examined it with a minute and daring curiosity, and pronounced his opinions in the same dogmatic spirit which characterises his other discussions. To retail his notions would be superfluous. Let it suffice to mention that, in conformity with his general theory of right and wrong, he asserts that the attribute of justice has no meaning as applied to the divine Being, who possesses uncontrolled power, and is not accountable to any superior. His comments on scripture cannot be read with interest by

Hobbes.

any class of men. The Christian must regard them as audacious and wild, and the infidel as tedious and unmeaning. Although, with his usual love of palpability, he explodes some mysteries, and attempts to reduce his subject to a few short and easy theorems, these are so repugnant to the conclusions which the slightest farther reflection would suggest, that their only tendency is to unhinge such religious views as his readers may have formerly entertained, without furnishing any thing satisfactory in their stead, or emancipating the mind from the wishes which it may have habitually cherished.

Hobbes will long be pointed to as an eloquent and remarkable writer, but rather fitted to excite wonder than to gain approbation. His intentions, however, are not deserving of that abhorrence which his name excites among many who have never looked into his writings. Hobbes was inconsistent, but he seems never to have seen this, and to have been thoroughly sincere in his doctrines. Though the tendency of his writings is objectionable, there is no appearance of the slightest design of impairing the credit of Christianity, and he evidently thought that the publication of his doctrines would promote the political interests of his country and the world. Notwithstanding his power in exciting philosophical reflection, we are not now in need of his aid, as we possess abundance of literature better adapted to every purpose of philosophy; and we can only turn our attention occasionally to his writings as objects of curiosity, forming a remarkable epoch in the history of human opinions. See Leland's *View of Deistical Writers*; Mosheim's *Ecclesiastical History*; Aubrey's *Letters and Anecdotes*; and Hobbes's *Works*. (*H. D.*)

Hodeida ‖ Hogarth.

HODEIDA is a sea-port town of Arabia, situated on the Red Sea. Although the harbour is larger than that of Loheia, yet it will admit only small vessels. The town is large, and is composed principally of huts built in the ordinary style. The mansion of the Dolah, or governor, the mosques, the custom-house, and the houses of the principal merchants, are built of stone. There is a small castle near the sea, but it is not capable of much defence. At the distance of a mile and a half from Hodeida is a well of excellent water, from which the town is supplied, the water nearer the town being very bad. Hodeida is the sea-port of Beetlefackie, a town in the interior, about 30 miles from the coast, and only about half a day's journey from the hills where the coffee grows.

The Dolah of Hodeida is accountable only to the Imam; but his jurisdiction is confined to the city. His revenues consist partly of the duties upon exported coffee. All the mercantile transactions at Hodeida are carried on in Spanish dollars and cavears; 40 cavears making one Spanish dollar. The cavear is an imaginary coin. All foreign coins pass current here. The coffee from Beetlefackie, which is intended for India, Muscat, or Europe, is sent by land to Mocha; but that which is intended for Jidda, is shipped at Hodeida. East Long. 42° 59′, and North Lat. 14° 49′, according to Lord Valentia's chart. See Niebuhr's *Travels through Arabia*, sect. ix. chap. 2.; and Milburne's *Oriental Commerce*, vol. i. p. 95, 96.

HOEING. See Agriculture, vol. i. p. 299.

HOGARTH, William, the celebrated painter, was the grandson of a yeoman, who possessed a small tenement in the vale of Bampton, near Kendal in Westmoreland. He had three sons. The eldest succeeded his father in his little freehold; the second settled at Troutbeck, near Kendal, and was remarkable for a talent at provincial poetry;* the third son, who was the father of the painter, after having kept a school in the country, going to London, and pursued the same occu-

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* We trust that it will not be indulging in diffuse or impertinent anecdote, to subjoin a few particulars respecting this poetical uncle of the great Hogarth, whom we find denominated the Mountain Theocritus of his native place by Mr Walker, the lecturer on natural philosophy, who came from the same part of the country. The songs and quibbles, he says, of old Hogarth, had often delighted him in his youthful years. "These simple strains," he adds, "were composed while he held the plough, or was leading his fuel from the hills."—Who does not recal Burns to his recollection in perusing this circumstance?—"He was," continues Mr Walker, "as critical an observer of nature as his nephew, for the narrow field he had to view her in. Not an incident or an absurdity in the neighbourhood escaped him. If any one was hardy enough to break through any decorum of old and established repute,—if any one attempted to overreach his neighbour, or cast a leering eye at his wife, he was sure to hear himself sung over the whole parish, nay to the very boundaries of the Westmoreland dialect; so that his songs were said to have had a greater effect on the manners of his neighbourhood, than even the sermons of the parson himself. But his poetical talents were not confined to the incidents of his village. I myself have had the honour to bear a part in one of his plays, (I say one, because many are extant in MS in the mountains of Westmoreland at this hour). This play was called *The Destruction of Troy*. It was written in metre, much in the manner of Lopez de Vega, or the ancient French drama. The unities were not too strictly observed, for the siege of ten years was all represented. Every hero was in the piece, so that the dramatis personæ consisted of every lad of genius in the whole parish. The wooden horse—Hector dragged by the heels—the fury of Diomede—the flight of Æneas—and the burning of the city—were all represented. I remember not what fairies had to do in all this; but, as I happened to be about three feet high at the time of this still-talked-of exhibition, I personated one of these tiny beings. The stage was a fabrication of boards placed about six feet high on strong posts; the green-room was partitioned off with the same materials; its ceiling was the azure canopy of heaven; and the boxes, pit, and galleries, were laid into one by the great Author of Nature, for they were the green slope of a fine hill. Despise not, reader, this humble state of the provincial drama. Let me tell you, there were more spectators for three days together than your three theatres in London would hold; and let me add, still more to your confusion, that you never saw an audience half so well pleased. The exhibition was begun with a grand procession from the village to a great stone, dropped by the devil, about a quarter of a mile off, when he tried in vain to erect a bridge across Windermere; so the people, unlike the rest of the world, have remained a very good sort of people ever since. I say the procession was begun by the minstrels of five parishes, and were followed by a yeoman on bull-back. This adept had so far civilized his bull, that he would suffer the yeoman to mount his back, and even to play his fiddle there."——After detailing an accident that befel the yeoman, from his bull running away with him, the narrator proceeds:—"This accident rather inflamed than depressed the good-humour arising from the procession; and the Clown, or Jack-pudding of the piece, availed himself so well of the incident, that the lungs and ribs of the spectators were in manifest danger. This character was the most important personage in the whole play. He was a compound of Harlequin and Merry-Andrew, or rather the arch fool of our ancient kings. . . . . . The play was opened by this character with a song, which answered the double purpose of a play-bill and a prologue; for his ditty gave the audience a foretaste of the rueful incidents they were about to behold, and it called out the actors one by one, to make the spectators acquainted with their names and characters, till the whole dramatis personæ made one great circle on the stage. The audience being thus become acquainted with the actors, the play opened with Paris running away with Helen, and Menelaus scampering after them. Then followed the death of Patroclus, the rage of Achilles, the persuasions of Ulysses, &c. &c. and the whole interlarded with apt songs, all the production of ald (old) Hogarth. The bard, however, had been dead some years; and, I believe, this Fête was a jubilee to his memory. But let it not detract from the merit of Mr Garrick to say, that his at Stratford was but a copy of one forty years ago on the banks of Windermere. Was it any improvement, think you, to introduce several bulls instead of one? But I love not comparisons; and so conclude, yours, &c. Adam Walker."—*From Anecdotes of Hogarth.*

pation in Ship Court, in the Old Bailey. William Hogarth was born in the parish of St Bartholomew in 1698, and seems to have received only the usual education of a mechanic. He was bound apprentice to Ellis Gamble, a silversmith in Cranbourn Court, Leicesterfields; and was to learn in that profession only the branch of engraving arms and ciphers on metal. Before his apprenticeship had expired, his genius for drawing began to point to the comic path which it afterwards pursued. Having one day rambled to Highgate with some companions, he witnessed a quarrel in a public-house, in which one of the disputants received a blow with a quart pot, that made the blood stream down his face. Such a subject, one would think, was little calculated for gay effect; but humour is not an over-delicate faculty, and the distorted features of the wounded sufferer, it seems, so much attracted the fancy of young Hogarth, that he sketched his portrait on the spot, with the surrounding figures, in ludicrous caricature. His apprenticeship was no sooner expired, than he entered into the academy of St Martin's Lane, and studied drawing from the life, in which he never attained to great excellence. It was character, the passions, the soul, that his genius was given him to copy. In colouring, he proved no great master; his forte lay in expression, not in tints and chiaro-scuro. It is not exactly known how long he continued in obscurity, but the first piece in which he distinguished himself as a painter is a representation of Wanstead Assembly. In this are introduced portraits of the first Earl Tylney, his lady, their children, tenants, &c. The colouring of this is said to be better than that of some of his later and more highly finished pieces.

From the date of the earliest plate that can be ascertained to be the work of Hogarth, it may be presumed, that he began business on his own account at least as early as the year 1720. His first employment seems to have been the engraving of arms and shop bills; the next to design and furnish plates for booksellers.* Among these, were designs for Hudibras, with Butler's head. His Hudibras (says Horace Walpole) was the first of his works that marked him as a man above the common; yet what made him then noticed now surprises us, to find so little humour in an undertaking so congenial to his talents.

The success of his plates was sufficient to bring him business as a portrait painter; but it was not permanent, or attended with much reputation. The author of the volume of anecdotes respecting him, affirms with confidence, that though not a portrait painter, who could gratify the self-love of his employers, he drew individual likenesses in his best pieces. One of his most striking scenes of this sort, was the examination of the committee of the House of Commons into the cruelties exercised on the prisoners of the Fleet to extort money from them. On the table of the committee are the instruments of torture. A prisoner in rags, half starved, appears before them, with a good countenance, that adds to the interest. On the other side is the confronted and atrocious gaolor, with villany, terror, and the eagerness to tell a lie, depicted in his features, and expressed in his gesture. This was Bambridge, the warden of the fleet, who, with Huggins his predecessor, were both declared guilty of extortion and cruelty. In 1730 Hogarth made a clandestine marriage with the daughter of Sir James Thornhill, sergeant painter, and history painter, to George I. Hogarth was at this time called in the Craftsman an ingenious designer and engraver; but his father-in-law regarded him as so unworthy of his daughter, and was so much offended by the match being a stolen one, that he was not easily reconciled to it. About the same period our painter began his celebrated Harlot's Progress, some scenes of which were purposely put in the way of Sir James Thornhill to bespeak his favour. Sir James remarked, that the man who could produce such works could maintain a wife without a portion; but he afterwards relented, and the young pair took up their abode in his house.

By the appearance of his Harlot's Progress, his fame was completely established, and his finances raised, by the rapid sale of the plates that were struck from the pictures. He might be said in this production to create a new species of painting,—the moral comic; and in the furniture, dresses, and details of the scenes, to give a history of the manners of the age. The Rake's Progress, which appeared in 1735, though, in the opinion of many, superior in merit, had not so much success from want of novelty. In the following year, ambitious of distinguishing himself as a painter of history, he finished the Scripture scene of the Pool of Bethesda, and of the Good Samaritan; but the burlesque turn of his mind mixed itself with all subjects, and here with disadvantage. Nor was he more successful in his picture of Danaë, where the old nurse tries the gold by ringing it with her teeth. His fame was however now so high, that Swift complimented him in the Legion Club, and Fielding in his preface to Joseph Andrews. Theophilus Cibber had also brought his Rake's Progress on the stage in the shape of a pantomime.

His printed proposals, dated January 25, ascertain his Company of Strolling Players, and his Marriage a la Mode, to have been then ready for sale. He had also projected a Happy Marriage, by way of a counterpart to his Marriage a la Mode. The time supposed was immediately after the return of the parties from church. The scene lay in the hall of an antiquated country mansion. On one side the married couple were represented sitting. Behind them was a group of their young friends of both sexes in the act of breaking bride-cake over their heads. In front appeared the father of the young lady grasping a bumper, and drinking, with a seeming roar of exultation, to the future happiness of her and her husband. By his side was a table covered with refreshments; jollity rather than politeness, was the designation of his character. Under the screen of the hall, several rustic musicians in grotesque attitudes, together with servants, tenants, &c. were arranged. Before the dripping-pan stood a well fed divine, with his gown and cassock, with his watch in his hand, giving directions to a cook dressed all in white, who was basting a haunch of venison. Among the faces of the principal figures, none but that of the young lady was completely finished. Hogarth had been often reproached for his inability to give grace and dignity to his heroines. The bride was meant to vindicate his pencil from this imputation. The effort, however, was unsuccessful. The girl was

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* Thirteen folio prints, with his name to each, appeared in Aubrey de la Mortraye's Travels, 1723. Seven smaller prints for Apuleius's Golden Ass, 1724. Fifteen head pieces to Beaver's Military Punishments of the Ancients; and five frontispieces for the translation of Cassandra, in five vols. 1725. Seventeen cuts for Hudibras, 1726, Two for Perseus and Andromeda, 1730, Two for Milton, the date uncertain; and a variety of others between 1726 and 1733.

pretty, but her features were uneducated. She might have attracted notice as a chambermaid, but would have failed to extort applause as a woman of fashion. The parson and his culinary associates were more laboured than any other parts of the picture. The painter sat down with a resolution to delineate beauty improved by art, but seems, as usual, to have deviated into meanness, or could not help neglecting his original purpose to luxuriate in more congenial ideas. He found himself, in short, out of his element in the parlour, and therefore hastened in quest of ease and amusement to the kitchen fire.

Soon after the peace of Aix-la-Chapelle, he went over to France, and was taken into custody while he was drawing the gate of that town; a circumstance which he has recorded in his picture, entitled, *O the Roast Beef of Old England*, published 1749. He was actually carried before the governor as a spy; and after a very strict examination, committed a prisoner to Grandsire his landlord, on his promising that Hogarth should not go out of the house till he was to embark for England. Previous to this commitment, he had behaved with a sturdiness and sauciness which he thought became an Englishman, but which betray the extreme grossness of his manners. In the streets he was often clamorously rude. A tattered bag, or a pair of silk stockings with holes in them, drew a torrent of imprudent language from him, and which there were Scotch and Irish emigrants on the spot who could interpret to the French. But his pleasantry was extinguished by what happened when he was drawing the gates of Calais; for though the innocence of his design was rendered perfectly apparent on the testimony of other sketches he had about him, which were by no means such as could serve the purpose of an engineer, he was told by the commandant, that had not the peace been actually signed, he should have been obliged to have hung him up immediately on the ramparts. Two guards were then provided to convey him on shipboard; nor did they quit him till he was three miles from the shore. They then spun him round like a top on the deck, and told him he was at liberty to proceed on his voyage without farther molestation or attendance. The slightest allusion to this ludicrous affair used to be offensive to our painter.

In 1753, he appeared in the character of an author, and published a quarto volume, entitled, *The Analysis of Beauty*, written with a view of fixing the fluctuating ideas of taste. His intention was to shew that a curve is the line of beauty, and that round swelling figures are most pleasing to the eye. He received assistance in this work from Dr Benjamin Hoadley the physician, and the Rev. Mr Townley corrected the preface. The family of Hogarth rejoiced when the last sheet of his Analysis was printed off, as the frequent disputes he had with his coadjutors in the course of the work, did not much harmonise his disposition. If beauty really did consist in any particular kind of lines, there were few painters less likely to discover them than Hogarth, and he was no metaphysician; but the refutation of an exploded theory would be now superfluous.

About 1757, his brother-in-law, Mr Thornhill, resigned the place of King's sergeant painter, in favour of Hogarth, who soon after made an experiment in painting that involved him in some confusion. The collection of pictures of Sir Luke Schaub, was sold in 1758, by public auction; and the celebrated painting of Sigismunda, said to be the work of Corregio, (Mr Walpole thought that it was by Furino,) excited his emulation. From a contempt of the ignorant virtuosi of the age, many of whom he had seen bubbled by vile copies, as well as from having never studied the great Italian masters, he persuaded himself that the praises bestowed on their glorious works were only the effects of prejudice. He went farther, he determined to rival the ancients, and unfortunately chose the subject we have mentioned. His Sigismunda is described by Walpole as the representation of a maudlin strumpet, just turned out of keeping, and with eyes red with rage and usquebaugh. Her fingers bloodred by her lover's heart, (the blood was afterwards expunged from her fingers,) that lay before her like that of a sheep for dinner. None of the sober grief; no dignity of suppressed anguish; no settled meditation of the fate she meant to meet; no amorous warmth turned holy by despair; in short, all was wanting that should have been there; all was there that such a story would have banished from a mind capable of conceiving such complicated woe,—woe so sternly felt, and yet so tenderly. Hogarth's performance was more ridiculous than any thing he had ever ridiculed. He set the price of £400 on it, and had it returned on his hands by the person for whom it was painted. This unfortunate picture, which was the source of so much vexation to Hogarth, at least made a versifier of him. He addressed an epistle to a friend, occasioned by Sir Richard Grosvenor (now Lord,) returning the picture on the artist's hands. The verses are splenetic and conceited, without a particle of wit or humour.

The last memorable event in his life, was his quarrel with Mr Wilkes. His connection with the Court probably induced him to quit the line of party neutrality which he had hitherto observed, and to engage against Mr Wilkes and his friends in a print, September 1762, entitled, *The Times*. He was attacked in return, in a number of the *North Briton*, which produced his caricature of Wilkes. At an early period of his career, Hogarth had ventured to assail Pope himself in the blaze of his poetical reputation,* and from his exasperation he escaped, either by his obscurity, or by the prudence of the poet. But he was now destined to feel the lash of a writer, inferior indeed in fame, but equal in the talents of vituperation. Churchill avenged the caricature of his patron Wilkes, by his *Epistle to Hogarth*, not, indeed, the brightest of his works, and in which the severest of his strokes fell upon his age. Hogarth retaliated by caricaturing Churchill under the form of a canonical bear, with a club and a pot of porter. Never, as Walpole truly remarks, did two angry men, of their abilities, throw mud with less dexterity.

It deserves to be noticed, that, amidst the bitterest invectives on Hogarth, his enemy, Churchill, conceded a degree of merit to him with which his warmest admirers may be contented, and a description of his genius to which they would find it difficult to add a material circumstance.

> In walks of humour, in that cast of style,
> Which, probing to the quick, yet makes us smile;
> In comedy, his natural road to fame,
> Nor let me call it by a meaner name,
> Where a beginning, middle, and an end,
> Are aptly join'd; where parts on parts depend,

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* In a plate, entitled, *The Man of Taste*, 1731, (for a poem of Welsted, we believe,) containing a view of the gate of Burlington-house, with Pope whitewashing it, and bespattering the Duke of Chandos's coach, as well as in a ludicrous picture on the subject of the South Sea bubble.

Each made for each, as bodies for their soul,
So as to form one true and perfect whole,
Where a plain story to the eye is told,
Which we conceive the moment we behold;
Hogarth unrivall'd stands, and shall engage
Unrivall'd praise to the most distant age.

Hogarth having been said to be in his dotage when he produced his print of the bear, it should seem was provoked to make the following additions to this print, in order to give a farther specimen of his still existing genius. In the form of a framed picture on the painter's pallet, he has represented an Egyptian pyramid, on the side of which is a Cheshire cheese, and round it £3000 per annum, and at the foot a Roman veteran in a reclining posture, designed as an allusion to Mr Pitt's resignation. The cheese is meant to allude to a former speech of Mr Pitt's, in which he said that he would rather subsist a week on a Cheshire cheese and a shoulder of mutton, than submit to the enemies of his country. But to ridicule this character still more, he is, as he lies down, firing a piece of ordnance at the standard of Britain, on which is a dove, with an olive branch, the emblem of peace. On one side of the pyramid is the city of London represented by the figure of one of the Guildhall giants going to crown the reclining hero. On the other side, is the King of Prussia, in the character of one of the Cæsars, but smoking his pipe. In the centre, stands Hogarth himself, whipping a dancing bear, (Churchill,) which he holds in a string. At the side of the bear is a monkey, designed by Mr Wilkes. Between the legs of the little animal is a mop-stick, on which he seems to ride like a child on a hobby-horse. At the top of the mop-stick is the cap of liberty. The monkey is undergoing the same discipline as the bear. Behind the monkey is the figure of a man, but with no lineaments of face, and playing on a fiddle. This was designed for Earl Temple, in allusion to the inexpressiveness of his countenance.

Amidst these disgraceful hostilities, Hogarth was visibly declining in his health. In 1762, he complained of an inward pain, which proved to be an aneurism, and became incurable. The last year of his life was employed in retouching his plates, with the assistance of several engravers, whom he took with him to Chiswick. On the 25th of October 1764, he was conveyed from thence to his house in Leicester Fields, in a very weak condition, yet remarkably cheerful; and receiving an agreeable letter from the celebrated Dr Franklin, he drew up a rough draught of an answer to it. In the night time, however, he was seized with a vomiting, probably owing to a circumstance of which he had boasted before going to bed, viz. that he had eat a pound of beef steakes to his dinner, and expired about two hours after, aged 67. His corpse was interred in the Church-yard of Chiswick, on a monument which bears a simple inscription on one side, and on the other emblematic ornaments, with some verses by Garrick.

In his private character this celebrated man is reputed to have been hospitable and liberal, as well as accurately just in his dealings, but his manners were coarse and vulgar, and his powers of delighting seem to have been restrained to his pencil. To be a member of clubs of illiterate men was the utmost of his social ambition, and even in those assemblies he was oftener sent to Coventry than any other member. The slightest contradiction is said to have transported him to rage. His genius as a comic painter is of that strong description which breaks down the partition between connoisseurship and the popular taste in the enjoyment of it. It is merit which his satyrist yet ablest panegyrist so well expressed, "which we conceive the moment we behold." The critic Du Bos often complained that no history painter of his time went through a series of actions. What Dubos wished to see done, Hogarth performed, though probably without knowing that he was so obligingly complying with a critic's request. In his Harlot's Progress he launches out his young adventurer, a simple girl upon the town, and conducts her through all the vicissitudes of wretchedness to a premature death. This was painting to the understanding and to the heart. None had before made the comic pencil subservient to instruction; nor was the success of this painter confined to his persons. One of his excellencies consisted in what may be termed the furniture of his pieces; for as in sublime historical representations, the fewer trivial circumstances are permitted to divide the spectators attention, the greater is the force of the principal figures; so in scenes of familiar life, a judicious variety of little incidents contributes an air of versimilitude to the whole. The rake's levee room, (Walpole observes) the nobleman's dining room, the apartments of the husband and wife in marriage *à la mode*, the alderman's parlour, the bed-chamber, and many others, are the history of the manners of the age.*

For a scientific view of the works of this great artist, we must refer the reader to Walpole's Anecdotes of Painters, which we have already quoted.—A complete list of his prints, at least the most complete that has been made out, will be found in the Biographical Anecdotes, by Nichols. Walpole has made one remark upon them in his eulogy of Hogarth, against the truth of which his works bear ocular demonstration, viz. that his delicacy is superior to that of the Dutch painters, or rather that his indelicacy is less. The illustration of this would be a task more easy than agreeable. Mr Gilpin, in his Essay on Prints, observes, that in design Hogarth was seldom at a loss. His invention was fertile, and his judgment accurate. An improper incident is rarely introduced. In composition, he continues, we see little in him to admire; in many of his prints, the deficiency is so great, as to imply a want of all principle, which makes us ready to believe that when we do meet with a beautiful group, it is the effect of chance. Of the distribution of light, according to the same writer, he had as little knowledge as of composition. Neither was Hogarth a master of drawing. But of his expression, in which the force of his genius lay, we cannot speak in too high terms; in every mode of it he was truly excellent. The passions he thoroughly understood, and all the effects which they produce in every part of the human frame; he had the happy art also of conveying his ideas with the same precision with which he conceived them. (*n*)

HOLBEIN, John, or Hans, an eminent painter, was born at Basle, in Switzerland, in the year 1498. He was instructed in the art by his father John Holbein, whom he very soon surpassed. Holbein was the particular friend of the celebrated Erasmus. At his re-

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* Among the small articles of furniture in the scenes of Hogarth, (says the compiler of the anecdotes of his life) a few objects may speedily become unintelligible, because their archetypes being out of use, and of perishable natures, can no longer be found. Such is the *dare for larks*, a circular board, with pieces of looking-glass inserted in it, hung up over the chimney-piece of the distressed poet; and the Jew's cake, (a dry tasteless biscuit, perforated with many holes, and formerly given away in great quantities at the feast of the passover) generally used only as a fly-trap, and hung up as such against the wall in the sixth plate of the Harlot's Progress.

Holbein.

quest he visited London, where he was patronised by Sir Thomas More, to whom Erasmus had introduced him. Sir Thomas employed him in painting the whole of his family, and several of his relations and friends, and he allowed him an apartment in his own house, where he continued for three years. When King Henry VIII. saw these performances, he was so much struck with the talent which they displayed, that he took Holbein into his service, and honoured him with his patronage and kindness during the rest of his life.

It is a singular circumstance, that Holbein always painted with his left hand. He succeeded equally in oil, water colours, and distemper. After he arrived in England, he learned the art of miniature painting from Lucas Cornelii, and carried it to a very high degree of perfection.

In the Florentine collection, are the portraits of Martin Luther, Sir Thomas More, Richard Southwell, and of Holbein, all painted by our author. The "Sacrifice of Abraham," which has been much admired, is in the cabinet of the King of France, along with several portraits executed by Holbein.

In the library of the university of Basle are several of Holbein's works in the highest preservation. A few are preserved, which he painted before he was 15 years old; one of which he drew upon a sign for a writing-master. The portraits of himself, his wife, and children, in the same group, are much esteemed. The other pictures of Holbein in this collection are, the Passion of our Saviour, in eight compartments; the Institution of the Supper; the Body of our Saviour after the Crucifixion; a Lucretia; a Venus; a Cupid; and portraits of Erasmus and Ammerbach. Erasmus is represented as writing his Commentary upon Matthew. In the same library are preserved a copy of Erasmus's *Eloge de la Folie*, which he had presented to Holbein who ornamented the margin of it with very interesting sketches, done with the pen. An edition of this work was published at Basle, in 1676, by Charles Patin, who got the original sketches copied by Stettler of Berne, and engraved by Merian. A new edition of this work, in Latin, French, and German, with fac-similes of the original designs engraven on wood, was published by M. Haas in 1780. The paintings of Holbein on the organ of the cathedral are still to be seen.

The Dance of Death on the walls of the cemetery of the Dominicans at Basle, was not painted, as has often been said, by Holbein, but by John Klauber, at the desire of the council, when the plague ravaged that city. These walls were pulled down in 1805. The paintings had been restored in 1558, 1616, 1658, and 1703. Since the year 1792, they have been almost entirely effaced. From these paintings it is probable that Holbein took the idea of composing the famous drawings of the Dance of Death; in which he has shewn so much judgment and imagination, that even Rubens condescended to study and copy them. It consisted of 44 designs, done with the pen, and slightly shaded with Indian ink. These designs were engraved by Haller, and more recently by M. de Mechel, a celebrated artist of Basle. The originals were sold, along with the famous collection of Crozat at Paris, to M. Fleichman of Strasburg. In the reign of the Emperor Joseph II. the Prince Gallitzin, the Russian ambassador at Vienna, purchased them, and carried them to St Petersburg. Holbein died in the year 1554, in the 56th year of his age. See Coxe's *Travels in Switzerland*, vol. i. p. 162.

Holden's Temperament.

HOLDEN'S TEMPERAMENT of the Musical Scale. In 1770, Mr John Holden, in a work on music, in long quarto, recommended a system of tuning, in which each of the fifths, except that on ♯G, should be flattened $\frac{1}{7}$th of a major comma; producing a perfect or untempered major seventh; and a major third and major fifth, alike tempered by the $\frac{2}{7}$th of a major comma, but in contrary directions, as Mr Farey has shewn in the *Philosophical Magazine*, vol. xxxvi. p. 46; and Mr Liston in his *Essay on Perfect Intonation*, p. 22.

The latter gentleman, in p. 23 describes this system as being "nearly what *is in common use*;" and in p. 142, gives it the preference over the scale which Mr HAWKES at last adopted, (viz. V—$\frac{1}{5}$ C, see his Temperament); on which account, we shall here present the musical student with a table of the beats of each of the 72 concords in Mr Holden's system, calculated on purpose for our work, viz.:

1	2			3	4	5	6	7	8	9
C	612.00000	12	53	480.0000	0	0	0	0	0	0
B	555.00000	11	48	450.0000	13.3830	42.5792	4.4778	3.3500	8.9330	11.2074
♭B	512.40315	10	44	428.7920	54.0190	5.3336	4.2664	3.1920	63.7110	10.6802
A	455.40315	9	39	401.9825	11.9550	4.9909	4.0002	2.9923	7.9800	10.0125
♯G	398.40315	8	34	376.8679	11.2074	35.6605	3.7602	♯15.6859	7.4802	40.4365
G	355.79843	7	31	359.1067	10.6802	4.4665	3.5732	2.6733	7.1296	8.9143
♯F	298.79843	6	26	336.0625	10.0125	31.8555	3.3500	2.5063	6.6830	36.1219
F	256.40315	5	22	320.7960	40.4865	3.9900	3.1920	2.3880	47.6650	7.9902
E	199.40315	4	17	300.7463	8.9143	3.7401	2.9923	2.2389	5.9704	7.4903
♭E	156.59685	3	14	286.5724	36.1219	3.5648	♭15.6859	2.1332	42.5792	7.1380
D	99.59685	2	9	268.6617	7.9902	3.3415	2.6733	2.0001	5.3336	6.6915
♯C	42.59685	1	4	251.8703	7.4903	23.8325	2.5063	1.8751	4.9999	27.0245
C	0	0	0	240.0000	7.1380	2.9852	2.3880	1.7866	35.6605	5.9775
Notes.	Σ Value of the Notes.	+f	+m	Vibrations in 1" of time	*Flat*, of 3d on	*Sharp*, of IIId on	*Sharp*, of 4th on	*Flat*, of Vth on	*Flat*, of 6th on	*Sharp*, of VIth on
					Beats in 1" of time.					

In column 2, the notes are set down in the nearest regular interval in Farey's notation: col. 3. is adapted to the octave above tenor-cliff C; and the beats are expressed in the six following columns, all of them beating *flat* or beating *sharp*, as expressed at the bottom of the several columns, except ♭E in col. 6, and ♯G in col. 7, which are the reverse of all the other fourths and fifths, in this system: in which only two of the notes differ from those since adopted by Mr William Hawkes. See HAWKES' *Temperament*.

Holden's Temperament.

In a subsequent edition of his work, in octavo, entitled, "An Essay towards a rational System of Music," Mr Holden, from having, unfortunately, adopted a defective rule for calculating the *Grave* HARMONICS of a consonance, (see that Article), conceived, that he had legitimately introduced the prime number 7 into musical ratios; and thereupon, in the 2d part of his book, grounds a great many unfounded and false rules and conclusions, regarding harmonics: in particular, he gives an ascending and a descending scale, which, when combined, contains 24 notes within the octave, eleven of which involve the number 7 in their numerical ratios. (ε)

HOLLAND.

Holland.

Situation, boundaries, and extent.

HOLLAND, one of the provinces of the kingdom of the Netherlands, and, before the formation of that kingdom, the most considerable of the united provinces of the Netherlands, is bounded on the west by the German Ocean, or North Sea; on the north by the Zuyder Zee, which separates it from the province of Friesland; on the east, by the same sea, which separates it from the province of Overyssel, and by the province of Utrecht, and part of Guelderland; and on the south by the province of Zealand, and part of Brabant. It is situated between the latitude of 51° 40′ and 53° 10′ north, and the longitude of 3° 56′ and 5° 30′ east of London. Its greatest extent, from south to north, including the isle of Texel, is about 90 miles, and from east to west not above 25 miles in some places, and above 40 in others, it being of a very irregular figure, and extremely narrow towards its northern extremity. According to the calculation taken in the year 1554, there were upwards of 300,000 morgens of land in this province, each morgen being about two English acres. The states of Holland and Zealand, in a remonstrance made soon after this year to the Earl of Leicester, contended, that these two provinces, with all their heath, downs, and grounds delved out, could make in all but about 500,000 morgens; and De Witt, in his work on the true interests of Holland, calculates that there cannot possibly be more than 400,000 morgens of land in this province, down and heath not included.

Divisions.

South Holland.

Rhineland.

Islands.

This province is divided into South Holland, commonly called Ug Holland; and North Holland, generally called West Friesland, and sometimes Waterland; there are also subdivisions, the principal of which will be afterwards noticed. Both South Holland and North Holland contain a great many considerable cities, besides a vast number of large and beautiful villages. In South Holland the principal places are Amsterdam, Rotterdam, the Hague, Leyden, Haerlem, Dordrecht or Dort, Delft, the Briel, Gorcum, Gouda, &c. Rhineland is a subdivision or district in South Holland, the capital of which is Leyden: it contains within its jurisdiction 45 large boroughs and villages. This subdivision is bounded on the west by the coast of Holland; on the east by part of the province of Utrecht, and by Amstelland; on the north by part of the river Y, along the course of the dyke that goes from Haerlem to Amsterdam, and by the shallows and washes as far as Beverwic; and on the south, by a line drawn from Montfort through Oudewater and Gouda to the Hague: it has its name of Rhineland from the middle branch of the Rhine running through it. All the inhabitants of this district are obliged by law, agreed to among themselves, to provide for the maintenance and reparation of the dykes, sluices, and canals within the district; and they have a council which meets every Saturday at the Rhineland House, in Leyden. This council is composed of the Dyke-graaf, and seven assistants, called Heemraden. There are several islands belonging to South Holland: The island of Voornlees, between the mouths of the river Maese; Briel is the capital: This island, along with the small adjoining islands of Goree, and Overslackee, form the territory called Voornland, which was anciently part of Zealand. The isle of Ruggonhill, to the east of that of Voorn, of which Williamstadt is the principal town, together with the isle of Finard, formerly belonged to Brabant.

North Holland.

Texel.

North Holland is divided from South Holland by the river Y. The principal towns in it are Saardam, Edam, Monikendam, Alcmaer, and Hoorn. Across the mouth of the Zuyder Zee lies a row of islands, belonging to North Holland. The Texel island is separated from the North Cape of North Holland by a very narrow channel; it is about eight miles long and five broad; it is defended from the sea by sand hills and strong banks; there are several villages in it, and a large town on the east side, called Burgh, which enjoys the privileges of a city. As this island lies at the mouth of the Zuyder Zee, and commands the only passage to Amsterdam, the States have built a strong fortress on it, in which a considerable garrison is always kept. The island of Vlieland lies towards the north-east of the Texel; it is about nine miles long, and two broad; it has only two small villages; and is chiefly remarkable for the great quantity of muscles found on it. The island of Schelling lies to the north-east of Vlieland; and is about 10 miles long, and three broad; there are five villages on it. These islands, together with several large sand-banks, break the rage of the ocean, and form two good harbours, or rather roadsteds, at the Texel and the Vlie; the first being a noted station for ships bound to the south, and the other for those bound to the north. The Wierengen, thus called from the great quantity of sea-weed, named in Dutch, as in Scotch, *Wier*, is a number of little islands, which lie more to the south, on the coast of North Holland; the principal of them is five miles long, and two broad, and contains several villages.

Face of the country.

Coast and dykes.

The name of Holland, (the hollow land,) sufficiently indicates the nature of the country. The level of a great part of it is, indeed, below the level of the sea, which is kept out only by means of dykes, or natural sand banks. In many parts, the dyke, or mound, is 30 feet above the adjoining land; the width at top is enough to permit the passage of two carriages; and there is a sort of imperfect road along it. In its descent, the breadth increases so much, that it is not very difficult to walk down either side. On the land side, it is strengthened by stone and timber, and covered by earth and grass; towards the sea, somewhat above, and considerably below water-mark, a strong matting of

Dykes.

flags prevents the surge from carrying away the surface of the mound. This kind of defence appears to have been discovered in the 17th century; for Sir William Temple, in his observations on the Netherlands, expressly says, it was lately found out. This matting is held to the shore by bandages of twisted flags running horizontally, at the distance of three or four yards from each other, and staked to the ground by strong wooden pins. As this matting is worn by every tide, a survey of it is frequently made. Farther in the sea, it is held down by stones. Above, there are posts at every 40 yards, which are numbered, that the spot may be exactly described where repairs are necessary. The impost, for the maintenance of these banks, amounts to nearly as much as the land-tax. Sir William Temple asserts, that these dykes employ annually more men than all the corn of the province of Holland could maintain. In the time of De Witt, the making of one rood's length of sea-dyke sometimes cost 600 guilders. Besides these sea-dykes, there are other dykes to keep out the waters of the rivers. In the time of De Witt, the annual charges of the district of Rhineland, which contains about 8000 morgens, and has not much communication with the sea, nor with running but only with standing waters, paid as acredge money and inland charges, at least two guilders for every acre; besides for drawing out of the rain water by mills each acre 30 stivers, and towards foot-paths, highways, and ditches, at least 20 stivers more. The banks or dykes near Medenblick, in North Holland, near the Zuyder Zee, are stronger, broader, and higher, than any others in the country; for there being nothing to break the violence of the sea from the islands of Schelling and Vlieland to this shore, the water beats most furiously upon it when the northerly winds blow, and at spring-tides the sea rises sometimes as high as the dykes, and would even overflow and break them down, did not the inhabitants stop its fury by laying sails over the dykes, which preserve them in a tempest. Whenever the water of the sea, or the rivers, breaks over upon the lands, they are drained by means of wind-mills, of which there are immense numbers for this purpose. From what has been already said, it may well be imagined, that the general face of the country is that of a large marsh that has been drained, the canals, and even the sea, looking pale and even discoloured by mud; yet the eye is not unfrequently relieved and delighted by the groves, gardens, and meadows, while the great rivers, and the immense number of canals in this province, leading not only to every great town, but to every village, and almost to every farm-house, present an infinite number of vessels everywhere coursing up and down upon them.

Rivers.

The principal rivers in Holland are, the Rhine. When we come to treat of the progressive geography of this province, the changes in the course of the Rhine, so far as they are connected with it, will be mentioned; at present, we shall confine ourselves to its present state in Holland. According to some geographers, the northern mouth of this river must be sought in the Leck, which joins the estuary of the Meuse, between Dort and Rotterdam; according to others, it runs through Leyden, where it divides itself into two canals, one of which runs into the lake of Haerlem, and the other loses itself, four miles beyond Leyden, in the sand hills between Catwyk on the Rhine, and Catwyk on the sea, where was anciently the mouth by which it emptied itself into the ocean. The Leck, if it be not the ancient Rhine, must be regarded as another river in Holland; its course has been already mentioned. There is another small branch of the Rhine called the Vaert, or Vecht, which falls into the Zuyder Zee at Muyden, about eight miles to the east of Amsterdam. The little Yssel falls into the Maes, a short way to the east of Rotterdam. The Maes, passing before Gorcum, runs to Dort, where it divides itself into two large branches, forming an island called Ysselmonde. The most northern branch runs to Rotterdam; it is called the New Maes, to distinguish it from the southern branch, which is called the Old Maes. They reunite a little before they reach Vlardingen, and enter the ocean, by a wide mouth, a little below Briel. The Amstel is not properly a river, but rather a collection of waters from the Drecht, the Miert, and other rivulets, the waters of which are swelled by their communication with lakes and rivers, by means of canals. The Y, called by some a river, is more properly a branch of the Zuyder Zee, from which it begins, at a sand bank called the Pampus. Its channel here is half a mile broad, which breadth it continues to Amsterdam, but grows soon afterwards twice as broad. It receives the waters from the lake of Haerlem by a large canal, called the Sparen, and from several lakes in North Holland. It afterwards passes northwards to Beverwyk, without discharging itself again into the sea.

Haerlem Meer.

From the town of Haerlem, the great lake called the Haerlem Meer, or Sea of Haerlem, derives its name. It is situated between Haerlem, Amsterdam, and Leyden; and is formed by the waters of several rivulets, and of the sea, with which, as has just been noticed, it has a communication by means of the Y, which enters it by a sluice, strongly built with brick-work. From its communication with the sea, the waters of the Meer are brackish. There are canals from its several gulfs to the cities of Amsterdam, Leyden, and Haerlem. On the east side, there is a gulf or branch called the New Meer, from which a canal leads to the suburbs of Amsterdam. Here there is a dyke, over which loaded boats are carried, by means of a wheel and rollers, into another canal. On the north of the lake there is another gulf, where there is a sluice, which opens and shuts itself by the weight of the water. This is the sluice by which the lake communicates with the Y. In one place, the neck of land which separates the Haerlem Meer and the Y is so narrow, that a canal cannot be drawn through it. Both these waters have gained considerably on their respective shores, and if united would be irresistible. At the narrowest part, the neck of land consists of pile-work and masonry to the thickness of about 40 feet. On the south and south-west, Haerlem Meer communicates with several small branches of the Rhine, one of which comes from Leyden. The Haerlem lake is about 12 miles long, and nine broad; and as ground is very dear and valuable in Holland, it has often been proposed to drain it: but the draining of it would probably be productive of great mischief, for it receives the waters when the violent north winds drive them from the German Ocean into the Zuyder Zee and the Y; whereas if, by the draining of the lake, they were confined within the banks of the Y, the city of Amsterdam would be in great danger of being overflowed. Besides this, the lake of Haerlem affords a vast quantity of fish, and the conveniency of navigation not only to the adjoining villages, but also to Leyden, Haerlem, and Amsterdam. There are some small lakes in North Holland, but none deserving of particular notice.

Climate.

The climate of Holland is humid, cold, and generally unwholesome; the winters are sharp and very long, the rivers being generally rendered unnavigable by the ice for a considerable length of time. In the spring, which is very short, and by no means agreeable, the sharp cold winds frequently blast the blossoms of the fruit trees. The summers are not unfrequently very hot. The climate is also disagreeable and unwholesome, from sudden and extreme changes of temperature. The east wind generally blows nearly the whole of the winter, and is extremely fierce; but it serves to drive away the fogs, with which this country is dreadfully plagued. The moisture of the air is such, especially about Leyden, that all metals are apt to rust, and even the wood to mould. The climate about Williamstadt is particularly unwholesome, from the extreme flatness and marshiness of the ground; whereas, about Naerden, where the country is high and sandy, the air is by no means bad.

Soil.

The soil of Holland is in general uncommonly rich, being in fact alluvial, and consisting of deep fat loam; in some parts, however, it consists of a barren sand. The soil of North Holland, especially in the drained land called the Bemster, is particularly rich. The country near the village of Schagen is reckoned to possess the richest soil in Europe. Land is sold here at double the rate of any other in Holland, there having been trees upon it, one of which, upwards of a century ago, yielded the owner as much fruit in one year as brought him £10 sterling; and a sheep, bred here, was sold, about the same time, for the same sum.

Progressive geography of the Zuyder Zee.

The progressive geography of Holland is so interesting and important, that we have no doubt our readers will pardon us for dwelling on it pretty fully and minutely. It naturally divides itself into what respects the formation or extension of the Zuyder Zee, the alteration in the course, and the diminution of the size of the Rhine, so far as it is connected with Holland, and the changes which the breaking in, or draining off, of the sea has produced in different parts of this province.

From the name of West Friesland, which is given to North Holland, it is highly probable that part, at least of this division of the province of Holland, was formerly united to East Friesland. How much of it belonged to the Frisia Occidentalis of the ancients is not accurately known: some geographers are of opinion, that only that part to the north-east, in which Hoorn, Enchuyzen, and Medenblic are situated, was the ancient Frisia Occidentalis. From the description of Tacitus, it is evident that, in his time, no other distinction was known but that of greater or lesser Frisons; and that distinction arose entirely from the number of the forces which each could respectively bring into the field. He informs us, that among the Frisons were great lakes, evidently implying that they were of fresh water; and this is made yet plainer by the expression *ambiuntque immensos lacus*, which proves that these lakes were inhabited round by these nations. Hence it is probable that the more inland part of what is now the Zuyder Zee, was one of the lakes mentioned by Tacitus, between which and the Texel and Vlie islands, there lay anciently a large tract of land. This opinion is strengthened by several circumstances. These islands lie still in a contiguous line, and like the broken remains of a continued coast. The sea here, too, is remarkably shallow, and the sands through the whole extent very flat. From the inspection of the accurate maps of the ancient and middle geography of Gaul, by D'Anville, it will be seen that part of the present site of the Zuyder Zee was occupied by a considerable inland lake called Flevo. This lay towards the southern part of the present Zuyder Zee. The question then is, By what means, and at what period, were the northern part of the Zuyder Zee formed, and the communication between this Sea and the ocean opened, or at least rendered so wide as it is at present? From the lake of Flevo ran a river of the same name into the ocean. Formerly the Rhine divided itself into two grand branches at Burginasium, the present Schenck, about 5 miles north-west of the Colonia Trajana, now an inconsiderable hamlet, called Coln, near Cleves. The southern branch joined the Meuse at the town of Meusa, while the northern passed by Leyden into the ocean. From this branch Drusus formed a canal, bearing his name, which originally joined the Rhine to the Yssel, a river which flowed into the lake Flevo. This canal being neglected, the Rhine joined the Yssel with such force that their waters increased the lake of Flevo to a great extent, by which means it was carried forward to the ocean by a wide gulf, instead of having a communication with it only by means of the river Flevo. It is probable, also, that the entrance of this river into the ocean was much widened by the force of the waves; for, at present, the violent rage of the waves breaking in towards the mouth of the Zuyder Zee, threatens the parts of North Holland about Medenblick and Enchuysen, braving it over the highest and strongest dykes of the province upon every high tide and storm at north-west. The exact period when the lake Flevo was extended into the Zuyder Zee is not positively known; indeed it is probable that the increase took place at different periods. We are informed by an old Dutch chronicle, published by Vossius, that the increase on the south side, by the breaking in of the inlet to the Texel, took place about the year 1170; others say it was so late as the year 1400. The increase of the lake on its northern side was probably at an earlier period, and also gradual. It certainly was about the year 1400 that the river Y became navigable to Amsterdam by large vessels.

Of the Rhine.

In our account of the progressive geography of the Zuyder Zee, we have partly noticed the changes which have taken place in the course of the Rhine. At the same time that the lake Flevo gained its increase, the northern branch of this river was weakened by the division of its waters; and even the canal of Drusus was afterwards almost obliterated by the deposition of mud in a low country. The Rhine seems to have been farther divided and weakened by a canal cut by Civilis, which, according to Cluverius, is the present Leck; though Pinkerton thinks the deviation of the Rhine into the Leck was the work of natural causes. The same author regards the Leck, which joins the estuary of the Meuse between Dort and Rotterdam as the northern mouth of the Rhine; which, according to him, the Waal continues to be the southern, both being lost in a comparatively small stream, the Meuse. According to other geographers, what falls into the sea near Catwyk is not the Rhine, but a canal bearing the name of that river. In the sea at low tides, are to be seen, near this village, the foundations of an ancient Roman castle, that commanded the mouths of the Rhine.

Of the Maese.

The Maese, running by Dort and Rotterdam, fell, as it now does, into the sea, at Briel, with a powerful flow of water; but the sands, which are gathered for three or four leagues upon this coast, having obstructed the exit of the river, have caused or increased those inundations, out of which so many islands have been recovered, and of which that part of South Holland is so much composed. Towards the formation of these islands, the Scheldt seems also to have contributed. This river anciently formed a mere Delta, with four or five small islands. At what time the irruptions of this river took place, by which the islands of Zealand, and the most southern of those of Holland, were formed, is not accurately known. Pinkerton is of opinion that they happened at the time that the Godwin sands arose: other authors assign them to violent tempests in the years 860 and 1170. A Zealandic chronicler, quoted by Cluverius, says, that the islands of Zealand were formed by violent tempests in the year 938. It is more probable, however, that these great changes made a slow and gradual progress: none of them being so ancient as the time of Charlemagne, and some of them as recent as the fifteenth century.

Inundation near Dort.

Of the most recent changes in the geography of Holland, besides the enlargement of the Zuyder Zee already mentioned, that which took place in the year 1421, to the south-east of Dort, is the most remarkable. Dort is the capital of a bailiwick of the same name. In 1421, this bailiwick was made an island, by a violent tempest, which drove the waters up the Maese and the Mereune with such violence, that they overflowed their banks, and swallowed up a large tract of land, with 70 villages and 100,000 people; a vast lake between Dort and Brabant was also formed. The name of Dordrecht signifies a ferry on the river Dort, but that river is now swallowed up by the channel of the Maese. The isle of Rugenhil, on which Willenstedt stands, was covered by the sea for some time; it was recovered so late as the year 1634. Naerden is the capital of a district called Goyland: it lies upon the Zuyder Zee, 13 miles to the east of Amsterdam, and 14 to the north of Utrecht. The old town, which stood more to the north, was swallowed up by the sea. The ruins are still to be seen at low water, 200 perches from the present town.

Drained lands in North Holland.

Zype.

The drained lands in North Holland deserve particular notice under the head of Progressive Geography; they consist of the Zype, the Beenister, and Purmer, the Wormeer, and Schermeer. The Zype was first drained and encompassed by banks, by William Lord of Schagen, and secured by stronger fences in 1552; but the sea broke them down in 1570. After this it was drained again, and secured by a mole of prodigious height and bulk, proof against all attacks of the sea; and it is now, like all the other drained lands, very fruitful soil. The noise made by the waves which break upon it, sounds like the barking of a pack of hounds, from which circumstance it is called the *Houndswood*. It is supported by large beams of timber, firmly placed in the ground, and strongly fastened together, the distances between them being filled with very large stones; and the mole is strengthened by a vast bank cast up against it.

Purmer.

Beenister.

Purmer, or Purmeren, and the Beenister, are both drained lakes: the latter is encompassed by a channel from 4 to 8 rods broad, and is joined to the former by a bridge at the south end. Purmer is about 5 miles long, and above 2 broad. The Beenister contains 7000 acres, besides the high ways, dikes, and canals which surround and cross it in several places. It lies between Purmer and Edam, and was a lake till the year 1610, when, after four years labour, and vast expence, (the banks, by which the water thrown out by the mills was confined, having been broken, after the work was half done,) it was made dry land; and is now so planted with gardens, orchards, rows of trees, and fertile inclosures, that Sir William Temple says it is the pleasantest summer landscape he ever saw. There were no fewer than thirty mills employed to drain the Beenister.

We come now to the consideration of the agriculture, fisheries, manufactures, and commerce of the province of Holland. The agriculture of such a country, where the soil and climate are so very moist, cannot be expected to be considerable, or to present many instructive or interesting topics: in some respects, however, it deserves notice, particularly in what regards the pasturage of North Holland, and most especially of the drained lands.

Agriculture.

Fields.

Roads.

In this province, few lands are held in fief, or by homage, and the women being very fruitful of children, and the men generally dividing their landed property among them, estates are for the most part small. The farms are also small: the farm houses are neat, sheltered and concealed by small clusters of trees, and included together with their gardens and orchards, in a perfect green fence. The fields are separated from each other, and from the road, neither by hedges or walls, but by deep ditches filled with water, over which are laid small bridges, that may be opened in the middle by a sort of trap door, raised and locked to a post, to prevent the intrusion of strangers. The roads in many places are made on the dike of the canal, the fields being frequently between five and six feet below the level of the road; but the communication between most of the farm houses and the villages and towns, and also between the several parts of the same farm, is often entirely by means of small canals. The most magnificent public roads in Holland are those in the vicinity of the Hague. The road from this place to Scheveling is pointed out by the Dutch as an object of admiration to strangers: the length of this avenue, for it can hardly be called a road, is nearly two miles, and its breadth rather more than 20 paces: it is a perfectly straight line, so that the entrance of the road commands a view of the whole; and the church of Scheveling, a picturesque object, terminates the prospect. It is shaded on each side by beeches, limes, and oaks, of an astonishing growth, which are so closely and skilfully planted, that they form to appearance an impervious forest. From Delft to the Hague, the road is magnificently grand. It is of sufficient breadth to admit four or five carriages abreast, shaded on both sides by lofty rows of trees, kept in excellent repair, and so level, that not the least inequality of ground is to be perceived.

Tillage.

Wheat.

Madder.

Hemp.

Flax.

There is very little land under tillage in the province of Holland, as may be easily imagined from the nature of the soil and climate; and what is under tillage is almost exclusively confined to South Holland. The crops principally cultivated are wheat, madder, tobacco, hemp, flax, clover, &c. The country adjacent to Gravesande, not far from the mouth of the Maese, is reckoned to produce the best wheat, as well as the sweetest grass in South Holland. Madder of most excellent quality, naturally as well as prepared, in a most superior manner, has long been a productive and famous crop in Holland. Tobacco is not so extensively or carefully cultivated as formerly. Hemp flourishes remarkably well, the depth and moisture of the soil being admirably adapted to the luxuriant growth of this plant. Oudewater, about seven miles to the south of Woerden, upon the lesser Yssel, in South Holland, is noted for good hemp produced on its soil. Flax is grown not only for the purpose of manufacture, but also for its seed, though some of the other provinces in the Netherlands are more remarkable for this crop than Holland. The same remark applies to clover.

Pastures. The pastures of Holland, especially, as has been already remarked, of North Holland, are perhaps unrivalled for the abundance and luxuriance of the grass they produce. **Milk.** From it they obtain milk, cheese, and butter, all of excellent quality. Mrs Radcliffe remarks, that on her way from Helvoetsluys to Rotterdam, she passed now and then a waggon filled with large brass jugs, bright as new gold; in these vessels, which have short narrow necks, covered with a wooden stopper, milk is brought from the field, throughout Holland. It is always carried to the towns in light waggons or carts, drawn frequently by horses as sleek and well-conditioned as those in our best coaches. **Butter.** The butter of Holland is of a very superior quality: the greater part of it is salted and barrelled for exportation; Beenister is noted for the excellence of this article. **Cheese.** There are several kinds of cheese made in Holland, some of which are rich and highly esteemed, and some, made from milk, which has previously supplied the butter, of course very inferior in quality. Leyden, Gouda, Edam, Gravesande, and Hoorn, are famous for their cheese: from the last place, vast quantities both of cheese and butter are exported to Spain, Portugal, and other countries, especially during their annual fair in the month of May. The cheese made in Holland is of two sorts, red and white; the red is much esteemed, and somewhat resembles the Parmasan; it is made into large and small shapes; the former weighs from 18 to 20, and the latter from 6 to 8 libs: the white cheeses weigh from 6 to 7, and the richest kinds are excellent as toasting cheeses. Besides the common Dutch cheeses, there are some called *Kanterkaas*; these are of various sorts, the principal of which are the green cheeses, the white of Leyden, the cummin cheese of Leyden, and the round cheese. In North Holland, about 18 millions of pounds of cheese were sold in the year 1801: and at Gouda, in 1803, about two millions were sold. **Cattle.** The cattle which produce such large quantities of excellent butter and cheese, are not indigenous, but for the most part are of the Holstein or Danish breed. In the vicinity of Hoorn they have a considerable trade in Danish cattle, which are imported lean, and fattened in the rich pastures round this place, and then driven to the other parts of Holland. The utmost attention is every where paid to the warmth and cleanliness of the milch cows, so that even in summer the animals appear in the meadows clothed with ludicrous care. The horses are principally from England or Flanders. The number of horned cattle in Holland, in the year 1804, amounted to 902,526, of which 252,394 were under two years of age. At that time, it was generally believed that there had been a great decrease in the number of horses, sheep, and swine. **Horses and sheep.** The ancient race of sheep indigenous to the country, have long been improved by the introduction of foreign breeds; but the soil and climate of Holland are not favourable to this animal: very little wool is exported, what is obtained from the sheep being chiefly consumed in the manufactures of the country. **Bees.** In some parts of Holland, bees are an object of much attention to the farmer, chiefly on account of the wax which they afford. **Wax.** A vast quantity of this article is annually gathered; and the bleaching of it forms a considerable branch of industry among the poorer classes: a great deal of white wax was formerly exported to Spain. In connection with the agriculture of Holland, its horticulture must not be passed over: **Gardens.** the mode of laying out the gardens is still very ungraceful and artificial; the trees are bent and cut into a thousand fantastic shapes, and the flower-beds are of every form that can displease and disgust the eye of taste. There are generally abundance of stagnated canals, with puerile bridges thrown over them. But setting aside these points of inferiority, the people of Holland in several respects are excellent horticulturists, especially in what regards the culture and improvement of the most beautiful flowers. **Tulips.** The rage for flowers, especially tulips, is not nearly so great or general at present as it was formerly. There is to be seen in the registers of Alcmaer, the record of a circumstance which deserves to be mentioned: In the year 1637, there were sold publicly in this city, one hundred and twenty tulips, for 90,000 guilders: one of these flowers, called the Admiral of Enchuysen, with its root and offsets, was sold for 5200 guilders; two others, called Brabanters, for 3800 guilders; and one named the Viceroy sold for 4203 guilders. Not only the name and price of these flowers, but also their weight, are particularly set down in the registers of this city. The passion of paying exorbitant prices for flowers at length came to such a height in Holland, that the States were obliged to put a stop to it by severe penalties; many gentlemen having been ruined by that passion. The fruit of Holland, though abundant, is seldom of good quality: the humidity of the climate, as well as its rapid growth, from the richness of the soil, rendering it insipid.

Fisheries. The fisheries of Holland consist of those which are carried on near the coasts, and those which are carried on at a distance. The shores abound with excellent fish, particularly turbot and soals; but for other fish, in consequence of the shallowness of the sea near the coast, the fishermen are generally obliged to go to the distance of more than five miles. The village of Scheveling is particularly remarkable for the number of fishermen whom it contains; they are distinguished by their ruddy countenances and athletic limbs. The principal foreign fishery of Holland, formerly was that of herrings: it was carried on from the ports of Dort, Rotterdam, Delft, Schiedam, Briel, Enchuysen, &c. The time of departure for the fishery was about the 24th of June. The cod fishery, which is still carried on to a considerable extent, commences in October, and ends in April. It is carried on upon the Dogger Bank; what is caught serves not only for the consumption of Holland, but forms one of its chief exports. The city of London consumes immense quantities of cod, caught by the Dutch. The whale-fishery was formerly vested in a company, called the Northern Company: it afterwards became open and free; but, like all the other branches of the fisheries and commerce of Holland, was destroyed by the revolutionary wars, and has not yet revived. It was chiefly carried on upon the coasts of Nova Zembla, as far as Davis Straits, and upon those of Spitzbergen, Greenland, &c. The vessels engaged in this fishery, during its flourishing state, were about 300 in number.

Manufactures. The chief manufactures of Holland are linens, (many of which, however, are made in Silesia) pottery and painted tiles, woollen cloth, leather, wax, snuff, sugar, starch, paper, &c. **Linen.** At Haerlem, there are considerable manufactures for the fabrication of fine linen cloths, dimity, satins, &c. which, though they have fallen off considerably, in consequence of the war, and the measures of Bonaparte, still give employment to a number of workmen, and carry on a profitable trade with

Bleacheries. **Woollen manufactures.**

Brabant and Germany. The bleacheries of Haerlem have long been famous for the delicate whiteness which they give to linen cloths, large quantities of which are annually brought hither from all parts of the Netherlands and Germany to undergo this operation; and before the war between Holland and Britain, and the improvements made in the process of bleaching, by means of the oxymuriatic acid, much was sent from Ireland and Scotland. The principal inhabitants of Amsterdam and other neighbouring places, also send their linen to be washed and bleached at Haerlem. The superior whiteness of the bleacheries of this town is attributed to some peculiar quality in the water of the lake of Haerlem. Some woollen cloth is manufactured at Delft, and other places, but Leyden is the principal seat of this branch of manufacture: here is a large building for examining and sealing the cloth. This manufacture is at present in a very decayed state; half a century ago, there were annually made upwards of 100,000 pieces; and many thousand industrious workmen were employed. The woollen manufactures, in all Holland, at the beginning of the 18th century, amounted to about 200,000 pieces of broad cloth, serges, baize, stuffs, &c. whereas in the year 1802, they did not exceed 20,000 pieces; and in 1804, the whole manufacture did not amount to 400,000 ells of cloth. The effects of this decay were strikingly evinced at Leyden, the population of which fell from 80,000 to 30,000. The manufactures of this city do not appear, even in their most flourishing condition, to have rivalled in the fineness of their articles, the looms of England; but their coarse cloths found a ready sale on the continent, and the East and West India companies procured them ready markets in the other quarters of the globe. As the commerce of Holland declined, that of Britain increased, and the manufacturers of Yorkshire deprived the manufacturers of Leyden of the foreign markets to such an extent, that the Dutch merchants discovered it was for their interest to export English cloths in preference to the manufactures of their own country. The woollen trade of Leyden also received much injury on the continent, from the establishment of extensive looms in various parts of Germany and the Netherlands, which then ceased to draw any considerable supplies from Leyden. In the year 1808, the minister for the interior made a report to the king of Holland, on the state of the woollen manufactures, from which it appears that attempts were then making to improve the Dutch wool, by the introduction of Merino sheep, and to revive the woollen manufactures of Leyden. The manufacturers of this city are extolled for the durability, beauty, and excellent quality of their cloths and kerseymeres; and, from a passage in the report, it appears that Louis had conferred the golden prize of honour on the Leyden cloth. This report also gives some information respecting other branches of woollen manufacture in Holland. Bocking frize, formerly imported from England, seems to have been made at Amsterdam; the blankets of Leyden are mentioned as of excellent quality; and the silver prize of honour seems to have been conferred on the camlet hall of that city.

Earthen ware. **Glass.** **Pipes.**

Delft was formerly famous for its manufacture of earthen ware, which rivalled the porcelain of China, and was generally sought after and esteemed throughout Europe, for its elegance and beauty. In the year 1800, there were scarcely 300 persons employed in the potteries of this place; whereas, in their most flourishing days, they gave subsistence to upwards of 10,000. The principal causes of this astonishing decay, independently of those which have produced a general decay of manufactures and commerce in Holland, are the immense quantities of porcelain which, for a century and a half, have been imported in Europe from China; and the rival manufactures which, during that time, have been established in Germany and England. The earthen ware of Staffordshire was some years ago so much approved of in Holland, that the states general, in order to protect the manufacturers of Delft from absolute ruin, were obliged to lay duties on its importation into the republic, which were so severe as to amount almost to an entire prohibition. Glass, especially glass toys, are made in several parts of Holland. The glass-house in Rotterdam was formerly deemed the best in the Seven Provinces. It made a number of glass toys and enamelled bowls, which were exported to India, and exchanged for china ware, and other oriental commodities. From the universal practice of smoking among the Dutch, it may naturally be supposed that manufactures of pipes are by no means uncommon. There is a noted manufacture of them at Gouda; they are remarkably neat, and a very extensive trade of them is carried on. They make also in the neighbourhood of this city a vast quantity of bricks and tiles, the latter principally what are called Dutch tiles. At Enchuysen, salt brought from Brittany is refined.

Breweries and distilleries.

The breweries and distilleries in Holland are numerous and extensive. Delft, Gouda, and Muyden are particularly celebrated for their beer. The beer made in Delft is chiefly consumed in that place and the adjacent country. In the 15th century, the town of Gouda had 350 breweries, from which Zealand and a great part of Flanders were furnished with beer. In 1518, they had decreased to 159; in the year 1522, there were 153; in 1588, there were 126; and in the year 1803, there were only two. These, however, make beer of excellent quality; imitating London porter with tolerable success. If, however, it is drank out of the cask, it is very inferior; but after it has been in bottles for some time, its taste is nearly as agreeable as London bottled porter, from which it is difficult to distinguish it. Muyden is noted for good beer called Flemish physic. The distillation of ardent spirits is the sole manufacture which has increased in Holland. In 1775, there were at Scheidam, particularly noted for its Geneva, 120 distilleries. In the year 1792, 220, and in the whole province of Holland 400; each of these distilleries yielded annually 4492 ankers of gin. The whole distilleries of the seven provinces would produce annually 2,152,672 ankers; but the want of grain renders it necessary to reduce this quantity one-third, which leaves 1,400,000 ankers, of which 456,000 are consumed in the country, and the remainder exported.

Sawing mills.

There are a great number of sawing mills in Holland, particularly in the vicinity of Rotterdam. They are lofty and rather pleasing objects, the mill generally rising from the top of a substantial building two or three stories high. Some of them are painted in a whimsical taste, and others adorned with grotesque figures. During the flourishing state of Holland, Saardam, where Peter the Great acquired a practical knowledge of the art of ship-building, derived great wealth from that trade; but it is now almost annihilated.

Miscellaneous manufactures.

The miscellaneous manufactures of Holland, not yet enumerated, most of which, however, are confined to Amsterdam, are stuffs embroidered with gold and silver, damasks, brocades, mohair, silk, &c. and particularly the preparation of drugs for dyeing, painting, and medicine, such as camphor, vermilion, sulphur, borax, lapis lazuli; likewise pitch, tar, rosin, spermaceti, &c. The oil mills are numerous. The cordage made in Holland is very good; and Dutch paper, particularly cartridge paper, is still exported in very great quantities, even to England, though we now rival or excel them in the manufacture of fine writing paper. The preparation of diamonds, that is, the cutting, polishing, and grinding of them, is confined to Amsterdam, where many artists are employed for that purpose. The manufacture of skaits is also of some consequence in Holland.

Commerce.

The United Provinces were formerly pre-eminent in commerce; and the province of Holland, from its greater extent, population, and riches, as well as from its possessing near all the sea-ports, enjoyed nearly the whole of this commerce. Long before the French Revolution, however the trade of the United Provinces had begun to decline; and the circumstances of that tremendous event may be said to have utterly annihilated the commerce of Holland. While it lasted, it was carried on principally with France, England, Spain, and Portugal, the Levant and Mediterranean states, Russia, Sweden, and Denmark; and with Germany by means of the Elbe, the Ems, the Weser, the Rhine, and the Meuse. The inland trade with Germany, by the canals and the Rhine, is almost the only branch which has escaped the ravages of war. Of this, the most remarkable feature consists in the vast floats of timber which arrive at Dort from Andernach and other places on the Rhine. The length of these rafts is from 700 to 1000 feet; the breadth from 50 to 90; and 500 labourers direct them, living in a village of timber huts erected on the rafts for their reception. The navigation is conducted with the strictest regularity. On their arrival at Dort, the sale of one raft occupies several months, and frequently produces upwards of £30,000 sterling. The commerce of Holland was either transit or direct. The articles of direct commerce were supplied either by her agriculture, such as butter, cheese, &c. or by her manufactures, as prepared drugs for medicine, dyeing, &c linen, woollen cloth, paper, &c.; or they were supplied by her East India possessions and her fisheries. In return, Holland received either what was necessary for her own consumption, particularly corn, or those articles which she again distributed over the rest of Europe. In the year 1807, nearly one million pounds of silk were imported into England from Italy through the medium of Holland.

Population.

The province of Holland is extremely populous; perhaps more so than any other part of Europe. In the year 1515, it contained only 45,000 houses. In the year 1732, the number of houses was increased to 163.462. De Witt, in his work on the true interests of Holland, informs us, that, in the year 1622, the States laid a poll tax upon all inhabitants, none excepted but strangers, prisoners, and vagrants, and those that were on the other side of the line; yet were there found in all South Holland no more than 481,934, although the instructions of the commissioners appointed for that purpose were very strict. The following are the particulars, as registered in the Chamber of Accounts:

In 1622.

Dort, with its villages	40,523
Haerlem, with its villages . . .	69,648
Delft, with its villages	41,744
Leyden and Rhineland	94,285
Amsterdam, and its villages . . .	115,022
Rotterdam, and its villages . . .	28,339
Gouda, and its villages	24,622
Gornichem, and its villages . . .	7 585
Schiedam, and its villages	10,393
Schoonhoven and its villages . . .	10,703
Brill, with its villages	20,156
The Hague	17,430
Heusden	1,444
	481,934

De Witt supposes that West Friesland, or North Holland, might have the fourth part of the inhabitants of South Holland, or 120,483, which, added to 481,934, would give 602,417 as the total population of the province of Holland in the year 1622. This, however, in the opinion of De Witt, was far below the truth, and he raises the number to 2,400,000. This must be an exaggeration; and it is given here, only for the purpose of adding De Witt's calculation of the proportions of this number, engaged in different employments: according to him, 450,000 were employed, directly or indirectly, in the fisheries: 200,000 were supported by agriculture, inland-fishing, herding, hay-making, turf making, and by furnishing materials for these operations: 650,000 in manufactures: 250,000 in navigation and trade: 650,000 in miscellaneous employments; and 200,000 gentry, magistrates, soldiers, &c. In the year 1732, the population of Holland certainly did not exceed 980,000. In the year 1796, an estimate of the population of the Seven United Provinces was made by order of the National Assembly, which we shall give entire, for the purpose of comparing the population of Holland with that of the other provinces.

In 1796.

Guelderland, in the towns, ...	64,994	
in the flat country	152,834	
		217,828
Holland, in towns	495,017	
in the flat country	333,525	
		828,542
Zealand, in towns	39,978	
in the flat country	42,234	
		82,212
Utrecht, in towns	45,204	
in the flat country	47,600	
		92,904
Friesland, in towns	44,824	
in the flat country	116,689	
		161,513
Overyssel, in towns	41,805	
in the flat country	93,255	
		135,060
Groningen, in towns, ...	23,770	
in the flat country	90,785	
		114,555

The country of Drent, in towns . . .	5,789
in the flat country	33,883
	39,672
Dutch Brabant, in the towns	48,711
in the flat country . .	159,466
	208,177

Total population.

The total is 810,192 in towns, and 1,070,274 in the flat countries, making the entire population of the United Provinces, in the year 1796, to be 1,830,463. The population of the province of Holland as stated above, in the year 1732, was 980,000, and in the year 1796 it was 828,542, which shews a decrease of 151,458 inhabitants, equal to one-thirteenth of the whole population.

Classes of the inhabitants.

The people of Holland may be divided into the following classes;—the clowns, or boors, who cultivate the land; the mariners, or skippers, who navigate the ships and inland boats; the merchants and traders, who fill the towns; the *rentecners*, or men that that also live in towns, upon the rents of their estates; and the gentlemen, officers of the army and navy, magistrates, &c. The boors feed chiefly on herbs, roots, and milk. The other classes drink enormous quantities of tea and coffee, or, more properly speaking, of lukewarm water, scarcely coloured. A great quantity of spirituous liquors are also drank; 456,000 ankers of geneva being annually consumed in the province of Holland. The class of gentlemen, or nobles, is very limited; most of the families having been extinguished in the long wars with Spain.

Manners and customs.

Of the characteristic manners and customs of the people of Holland we can only mention a few. To every house throughout North Holland there are two doors; one of which is never opened but when a corpse or a christening is carried from the house, while the other serves for the ordinary purposes of the family: this custom is peculiar to North Holland.

Houses.

The houses in almost every part of the province have a gay appearance, the windows and doors in general being painted green. The most scrupulous cleanliness is practised respecting them; not only the windows, but the whole front of the houses in most of the towns, is generally washed two or three times a-week, by engines for that purpose, which are abundantly supplied with water from the canals; and the same care is extended to the pavement of the streets in which the more opulent inhabitants reside. A Dutch house, in the old style of building, such as they are seen in Leyden more particularly, is generally six stories high, the three first of which are of an equal breadth, but of unequal heights; from the third story the roof rises to a point, and the rooms in this part of the house necessarily diminish in size as they approach to the top of the building. The front wall of the upper apartments projects so much from the roof as nearly to hide it, unless viewed in profile; and the exterior of each room diminishes, till that of the attic story is two-thirds less than the basement. To the aperture of the uppermost room is commonly fixed a small crane, for the convenience of hoisting up wood and turf, and these cranes sometimes have grotesque figures carved upon them. In the large and commercial towns, it frequently happens, that apartments that would grace the mansion of a prince, have no other views from their windows than the dead walls of a warehouse, used as a magazine for stock-fish, skins, tobacco, &c. so that the eye may turn from the works of Rubens and Titian to these disagreeable and disgusting objects.

Smoking.

The custom of smoking is so prevalent in Holland, that a genuine Dutch boor, instead of describing the distances of places by miles or hours, says, they are so many pipes asunder. Thus, a man may reach Delft from Rotterdam in four pipes; but, if he goes on to the Hague, he will smoke seven during the journey. Adjoining to their theatres is a room where refreshments are to be sold, and here the lovers of tobacco resort, to smoke their pipes between the acts. Their rigid attention to cleanliness, and bigotted attachment to smoking, jointly give rise to a most inconvenient and disgusting custom. After dinner, there is placed on the table, along with the wine and glasses, a spitting-pot, which is handed round as regularly as the bottle. All Dutchmen of the lower classes of society, and not a few in the higher walks of life, carry in their pocket the whole apparatus that is necessary for smoking: a box of enormous size, which frequently contains half a pound of tobacco; a pipe of clay, or ivory, according to the fancy or wealth of the possessor; if the latter, he carries also instruments to clean it; a pricker to remove obstructions from the tube of the pipe; a cover of brass wire for the bowl, to prevent the ashes, or sparks, of the tobacco from flying out; and sometimes a tinder-box, or bottle of phosphorus, to procure fire in case none is at hand.

Health bulletins.

When a woman is brought to bed, a bulletin is daily fixed to her house, for the space of a fortnight or longer if she recovers slowly, which contains a statement of the health of the mother and child. This bulletin is fastened to a board, ornamented with lace, according to the circumstances of the person lying in; and serves to answer the inquiries of friends, and to prevent unnecessary noise near the house. When a person of consequence is dangerously ill, a bulletin of health is generally affixed to their house; but, unless it is a child-bed case, the board is not ornamented with lace.

Women.

The women in Holland, in general, are lovely rather than beautiful; in their persons they are well formed; their complexions are fair, and their features regular, but their countenances are inanimate. Women are shorter-lived in Holland than men; and after twenty-five generally lose all their beauty. The management of children is very absurd and injudicious. The air of the country is regarded as so prejudicial to them, that for the first two or three months they are never taken abroad; and, during this period, the windows of their apartments are kept invariably shut.

Dress of children.

Their dress consists in flannel rollers, girt very tightly about their bodies, and these rollers are farther covered with a large flannel wrapper, bound three or four times round the body of the infant, and fastened with pins at its feet. The use of water is rigorously denied them. Thus managed, they are sickly, squalid objects. Children, particularly females, are frequently indulged in the pernicious use of *chauffepieds*, or stoves, without which a Dutchwoman could not exist, and this adds to their unwholesome appearance. We may remark, by the bye, that the advances of Britain in civilisation and useful knowledge, are perhaps in no instance more decidedly conspicuous, than in the improved management of children. Many of our readers must remember the period, when British children were almost universally clothed and treated as Dutch children still are.

The female dress, such as it was generally worn in

Ancient female dress.

Holland nearly two centuries since, is not unfrequently still seen on the daughters of the ancient stock of burghers. The hair is bound close to the head, and covered with a small unornamented cap, with large plates of thin gold projecting from each side of the forehead, and a plate in the middle; ponderous earrings, and necklaces of the same metal; gowns of thick silk, heavily embroidered, and waists of unnatural length and rotundity; hats of the size of a small Chinese umbrella, gaudily lined within; sometimes these hats are set up in the air like a spread fan; yellow slippers, without quarters at the heel. Children and women of seventy are frequently seen in this preposterous dress. The women of rank or fortune are very fond of ornamenting their dress with rare and valuable jewels. These, as well as the gold plates worn by the lower orders, are of great antiquity, and are most carefully handed down from generation to generation.

Dutch language.

Literature.

The Dutch language is evidently of Gothic origin, but it is little known out of the United Provinces. Dutch literature will be more properly considered in the article NETHERLANDS; where, indeed, every thing relating generally to the history and statistics of the Low Countries must be sought for; as, in the present article, we confine ourselves, as much as possible, to the province of Holland. With respect to the encouragement given to literature, this province was formerly very remarkable. Leyden, Amsterdam, and the Hague, may be seen on the title-pages of the most valuable works, in Latin and French, which were printed during the 17th, and the beginning of the 18th centuries. The Elzivers, justly celebrated for the correct and beautiful editions which they have given to the world of the best writers of antiquity, resided in Leyden, and ennobled its press by the elegant specimens of typography, which, for the space of a century, appeared from their press. During the bright period of French literature, when the writings of Voltaire, Rousseau, D'Alembert, &c. were eagerly sought after by the learned and curious of Europe, the booksellers at the Hague and Amsterdam multiplied the editions of these authors, and carried on a lucrative trade with their works. Haerlem is one of the places which lays claim to the honour of the invention of the art of printing; but at present, the literary character, as well as the bookselling and printing trade of Holland, are at a very low ebb. There is one university in the province of Holland at Leyden, and an inferior college at Amsterdam.

Government and laws.

Though the province of Holland is now only a part of the kingdom of the Netherlands, and of course has lost many of its peculiar privileges and institutions, yet some particulars respecting its government require to be noticed, as they still remain under the constitution of the Netherlands. Deputies of the nobles, and those of the towns and country, are elected for the parliament of the kingdom. There are also provincial councils of state for South and North Holland. For the administration of justice, there are two courts held at the Hague; namely, the court of Holland, and the high council. The nobles of Holland are subject to the jurisdiction of this court; an appeal lies to it from the sentences of the inferior courts. The high council of Holland judge peremptorily and definitively of all cases brought before them by an appeal from the court of Holland. Among the laws of this province the following deserve notice. No person can be arrested for debt who has not been summoned regularly three times, with the interval of 14 days between each summons; and six weeks further must elapse from the last official notification and demand of the debt, before the creditor is permitted to arrest or seize the effects of the insolvent person. By this mode of procedure, debtors are generally enabled either fully to settle their affairs, or to compromise with their creditors, so that few are sent to prison. No person can be arrested in his own house in Holland, or even standing at the door of it, though all the previous citations should have been made; and should his wife be lying in, he is privileged, during her illness, to go abroad without molestation.

Religion.

The religion of Holland is Calvinism. In it there are two provincial synods; one for South Holland, and the other for North Holland. The whole province being divided into a great many classes, composed of the deputies of five or six neighbouring churches; each class sends four deputies to the respective synods, two ministers, and two elders. The synods meet twice a year, and a political commissary attends their meetings. The ministers are paid by the magistrates. Their salaries are small; few, even in the cities, having £200 a year, while in the country they have generally £60 or £70.

Taxes.

The taxes of the province of Holland are very heavy. They amounted in 1795 to 24,000,000 of guilders, or 2,000.000 sterling, which, on the supposition that the population was 800,000, formed an average of £2, 10s. each person; but a large portion of this taxation is, in fact, paid by foreigners, who consume the articles taxed. Among the taxes really paid by the inhabitants themselves are the following: A land-tax of about 4s. 9d. per acre; a sale-tax of 8 per cent. upon horses, $1\frac{1}{4}$ per cent. upon other moveables, and $2\frac{1}{2}$ per cent. upon land and buildings; a tax upon inheritances out of the direct line, varying from $2\frac{1}{2}$ to 11 per cent.; 2 per cent. upon every man's income; an excise of £3 per hogshead on wine, and a charge of 2 per cent. on all public offices. The excise upon coffee, tea, and salt is paid annually by each family, according to their number.

History.

The province of Holland, as well as all the countries watered by the Meuse and the Rhine, were for a long time divided into small earldoms; but in the year 923, Theodoric was appointed Count of Holland by Charles the Simple, King of France, and the title became hereditary. The most frequent wars of the counts of Holland were with the Frisons, a part of the old Saxons. There were also frequent contests between the counts of Holland and Flanders, concerning the possession of the islands of Zealand. The counts of Holland, likewise, were frequently opposed by their own nobility. In order to break their power, they not only demolished many of their castles and strong-holds, but also, about the year 1200, built several cities, and gave freedom to the inhabitants of the adjacent country, or even to foreigners, who would come and dwell in those cities. They were thus freed, not only from all taxes due to the counts themselves, but also, when they had dwelt in the cities a year and a day, from the vassalage they were under to their own lords. The counts, besides, gave especial privileges to those cities; but the inhabitants were not permitted, though at their own charge, to set up gates or walls to defend their cities, unless they purchased the privilege from the counts. Hence proceeded the difference between walled and unwalled cities in Holland; and also, that the counts being afterwards jealous of the former, destroyed many of them entirely, and pulled down the walls of others. Philippina, daughter of William III. Earl of Holland, was mar-

History.

ried to the Prince of Wales, afterwards Edward III. of England. This king afterwards contested the earldom of Holland with Margaret, his sister-in-law. In the year 1417, Jacquelin, heiress of Holland, married John IV. Duke of Brabant; but her uncle John of Bavaria, who had resigned the bishopric of Liege, in the hopes of espousing her, contested the succession. A kind of anarchy followed. Jacquelin went to England, where, in 1423, she married Humphrey, Duke of Gloucester; but this marriage having been annulled by the Pope, she married, in 1432, Borselen, stadtholder of Holland. But having no children by any of her husbands, Philip the Good, Duke of Burgundy, who was her first cousin, obliged her to give up the administration and government of her states, and at her death inherited them. Soon afterwards, Holland, with the other large possessions of the House of Burgundy, fell by marriage to the House of Austria. Its history, from this period, must be sought for under the article NETHERLANDS. See *Statistical Account of Holland*, by R. Meterlecamp, 1804; De Witt's *True Interest of Holland*; Sir William Temple's *Observations on the Netherlands*; Mrs Radcliffe's *Journey through Holland in* 1794; *A Tour through the Batavian Republic in* 1800, by R. Fell. (W. S.)

HOLLAND, NEW, an island in the South Pacific Ocean, which some geographers have called a continent from its immense extent. Its general outline somewhat approaches to that of a spherical triangle. It stretches from east to west above 2600 miles between Sandy Cape and the entrance of Sharks Bay; and its length surpasses 2000 miles from Cape York on the north, to Wilson's Promontory in 39° 10′ south latitude. New Holland was originally called the Great Southern Land; its present name was imposed by the Dutch, who navigated the coasts at an early period; but it has lately been proposed to alter its appellation to Notasia by Mr Pinkerton, and to Terra Australis by Captain Flinders, neither of which will probably be adopted. Nothing whatever being known of the interior, and very little with certainty of the skirts of the island, it is only divided into portions called by the names of their supposed discoverers, and the vessels which they commanded; as, Arnheim's, Van Diemen's, De Witt's, Endracht's or Concord's, Edel's, and Leuwin's land, on the north and west, and Nuytz's land on the south. The east coast was surveyed generally by Captain Cook, and called New South Wales; and the portion from Cape Howe, the south-east extremity, to Nuytz's Archipelago, where the recognition of that navigator is supposed to have terminated, occupying between 700 and 800 miles, was examined by D'Entrecasteaux, Captain Flinders, and M. Baudin, and also some other officers.

Coasts and bays.

New Holland is begirt with small and sterile islands. A large portion of the coast is inaccessible either from rocks or shoals, or the precipitous formation of the shores; but the greater part is low and sandy, exhibiting a barren aspect. A few lofty headlands project into the sea; bays and harbours are rarely to be seen, and navigable rivers are scarcely yet discovered. The northern coast is indented by the immense gulf of Carpentaria, stretching 400 miles in width at the entrance, and penetrating 500 miles into the land; which, although it is rudely laid down in the Dutch charts of the 17th century, was first completely explored by Captain Flinders in 1802. Sharks Bay, where Dampier anchored in 1699, was lately ascertained by the French to be 50 leagues deep. And besides these, there are several less capacious on the south coast, as King George's Sound, Port Philip, and Western-port, at the second of which a British settlement was attempted in 1804. On the east coast, Botany Bay is the most important, from the flourishing establishment connected with it; and two other inlets of a different description on the south coast merit notice, from being supposed the entrance to some great river dividing New Holland asunder. One of these, called Bonaparte's Gulf by the French, and Spencer's Gulf by the English, 48 miles wide at the mouth, penetrates the land 185 miles, terminating in a point exactly opposite to the bottom of the Gulf of Carpentaria. The other, separated from it by York's Peninsula, of which the extreme point lies in 136° 52′ East Longitude, is of smaller dimensions. The tide flows 40 miles up Hawkesbury river falling into Broken Bay, near Port Jackson, whither it is navigable by the largest vessels, and still farther by those drawing nine feet water. It is the most important river hitherto seen in New Holland; and from the floodings above, sometimes overflows those parts of the banks 40 or 60 feet above its ordinary level, thereby committing great devastation. King William's River, on the west coast, is now conjectured to be little more than a creek, whose narrow entrance is obstructed by rocks.

Nothing can be more repulsive than the bleak and dreary appearance of thousands of miles occupied by the shores of New Holland. The earth is parched, vegetation stunted, and animal life seems incapable of being supported, from the universal scarcity of subsistence. Its low, uniform and sterile aspect is such, that many conceive the whole has only been recently reclaimed from the sea. Nor is it so with the continental part of New Holland alone; for, amidst the numerous islands on the south, "nothing smiles to the imagination; the soil is naked; the heavens burning pure and cloudless; the waves agitated, but by nocturnal gales. Man seems to have fled these ungrateful regions; and the navigator, terrified by dangers incessantly renewed, turns aside his weary eyes from the miserable shores." Yet, admitting that the exterior is of later origin, we must reflect on the vast extent of the interior yet unknown; where lofty mountains, wide rivers, and thick forests, may all be frequent. A greater portion is unexplored than equal to the course of the longest river in the world; and possibly its streams may be received in lakes, discharged by subterraneous channels, or absorbed in sandy desarts. We are aware, indeed, that, in the warmer climates, islands, which are the work of an inconsiderable insect, arise in the seas; that they become a resting place for birds; decomposition and fertilization follow; the seeds of plants are conveyed thither, and the deciduous parts of vegetables are not slow in forming a new soil. Neither is it improbable that volcanic eruptions may form a nucleus or substratum for future accessions. Still these accessions are so gradual, that many ages would be required for the formation of so great a country as New Holland. Besides, the appearance of the coast cannot be rigorously applied to the interior; and those minerals supposed to enter the constitution of primitive mountains, are discovered here.

Mineralogy.

We are not enabled to give any specific account of the mineralogy of this country. Wilson's Promontory consists of granite; there are several small islands, some of which are granitic, and some volcanic; and coal is discovered near the surface. Coloured precious stones are also said to have been found in different parts, but we do not know whether their precise quality has been ascertained.

Botany.

In so far as the country is yet explored, the vegetable creation is diffused more rarely than under corresponding latitudes, and fewer products are convertible to the use of mankind. It is disclosed only in scanty patches, where the soil has undergone amelioration; and there it appears in all possible variety, from the coarsest grass creeping on the ground to forests consisting of trees of immense girth and altitude. It is said of the eastern parts, that "all the plants of this country are evergreens, and numbers of them are to be seen covered with blossoms at all seasons of the year." M. Leschenault remarks, "that in the districts hitherto visited, and especially the western coast, there have never been found in great masses, either the majesty of the virgin forests of the New World, the variety and elegance of those of Asia, or the delicacy and freshness of the woods in the temperate countries of Europe. Vegetation is in general dark and sombre; it resembles the shade of our evergreens or copses. Fruits are for the most part ligneous; the leaves of almost all the plants are linear, lanceolated, small, coriaceous, and spiny. This peculiar texture springs from the aridity of soil and climate; and it is doubtless owing to the same causes that cryptogamous plants are so rare." Most of the plants of New Holland constitute new genera, and those belonging to genera already established are almost as many new species. Their numbers and variety are amply described in the works of M. Labillardiere and Mr Robert Brown, to which we shall refer for illustrations. A plant approaching the qualities of coffee has been found, two species of tobacco, and a kind of indigo. Odoriferous gum exudes copiously from a tree abundantly disseminated, which is used for different purposes by the natives, and has gained some credit among the settlers for curing dysentery. Wood of beautiful colours, fit for the finest cabinet work and inlaying, is common; and other kinds have been employed in building vessels. But amidst the great diversity of plants, only some small berries, a few roots, and leaves, have yet been found which are suitable food. The climate of New Holland is particularly noxious to European fruits, as most of those introduced have speedily perished. Grain, however, succeeds admirably, producing a certain and luxuriant harvest, though the soil for the most part is soon exhausted, and some of what was once brought under culture is now completely abandoned.

Animals.

A field equally new is presented in the animal world, where an infinity of beings are beheld on this continent, its shores, and islands, that never were seen before. Mollusca are so numerous, that, on one of the latter, the French voyagers collected 180 species. Great shoals of whales and dolphins fill the seas, but in many parts they are rare. The phocæ are so multiplied, that profitable fisheries have been instituted for their skins and oil, though it is so indiscriminately followed in destroying the young as to threaten the extirpation of the genera. Among birds, the black swan, cassowary or emu, mountain eagle, and menura, are the most remarkable. The first, which is black as jet, except two or three white feathers of the wings, covers the lakes and rivers in flocks during the greater part of the year. The emu is seen both on the continent and the islands; and there is sometimes found an enormous nest, two or three feet in diameter, belonging to an unknown bird, perhaps of the flamingo kind. Quadrupeds are exceedingly rare, both in species and numbers, compared with the extent of the country. Besides the dog, which is akin to the shepherds' dog of Europe, and never barks, it is supposed that another carnivorous animal of somewhat larger size approaches the coast, which has not been seen. The members of the last French expedition having prepared to pass a night on Edel's land, inform us, that "suddenly a terrible roaring froze us with terror; it resembled the bellowing of an ox, but was much louder, and seemed to come from the neighbouring reeds." Most probably this was an alligator, both from the sound and situation. The greater proportion of the quadrupeds of New Holland, though absolutely new and unknown in other parts of the world, belong to the opossum tribes. Those attracting most attention are the kangaroo of various species; the wombat, and a singularly formed creature, the paradox or duck-billed ant-eater. The first is hunted for the sake of its flesh; the second has been domesticated by the settlers; the third, an amphibious animal, is now found more abundant in the late excursions which have advanced furthest into the interior. Perhaps we should add to the brute creation those introduced into New Holland since the year 1788. Three cows and a bull having strayed into the forests, propagated there, and many thousands of wild cattle are seen in great herds, which it is dangerous to approach. Sheep and swine have succeeded well, but the country proves unfavourable to goats. So little of New Holland has yet been explored, as to admit a strong presumption of many interesting accessions to zoology in addition to what it has already received.

Inhabitants.

The most striking peculiarities are beheld in that portion of the human race who inhabit these regions. In stature, the New Hollander is of the middle size; with a large misshapen head, slender extremities, and the belly projecting as if tumefied. The colour of the skin is reddish at birth, and then deepens almost to African blackness; but this is not uniformly so, and some are only of the copper or Malay cast: the hair is long and black, not woolly; the nose flat, nostrils wide, and the mouth immoderately large, with thick lips. These, added to bushy eyebrows, and other characteristics, give the natives a remarkable appearance: Dampier, who says "they are of a very unpleasing aspect, having no one graceful feature in their faces," seems inclined to doubt whether they should be ranked with the human race; and Mr Collins instances "one man, who, but for the gift of speech, might very well have passed for an oran-outang: he was remarkably hairy; his arms appeared of an uncommon length: in his gait he was not perfectly upright, and in his whole manner seemed to have more of the brute and less of the human species about him than any of his countrymen." Yet the physiognomy of the New Hollanders is not disagreeable; nay, it is said, that the delicacy which is to be found among white people, may be traced on the sable cheeks of their females. Sustenance being so scanty, and clothing never employed, a decided effect is seen in the want of physical strength, and the consequences of perpetual exposure. In their persons all are filthy; the regular ablutions of many eastern nations are not performed, and the disgust of strangers is heightened by the custom of both sexes rubbing fish oil into their skins as a protection against the legions of insects swarming around them. Tattooing, so general in the South Seas, is not practised by the New Hollanders; but they have a mode of raising tubercles on the skin, and both sexes ornament themselves with scars on the breast, back, and arms. The

Inhabitants. incisions, sometimes resembling the feet of animals, being made by the sharp edge of a shell, and kept open, the skin forms a large seam in healing which is very distinguishable in youth, but is almost totally effaced by age. Men have the septum of the nose perforated to receive a bone, and are subjected to the extraction of some of the front teeth when they attain the age of puberty; and the women are deprived of the first two joints of the little finger of the left hand. Their personal ornaments are not numerous, consisting of the teeth of beasts or mankind glued to their hair, feathers and the tail of the dog: and certain tribes divide their hair into parcels, matted together with gum into portions like the thrums of a mop. The men also ornament themselves previous to a dance or combat, with broad stripes of white paint, used entirely according to taste, without any definite fashion. "Some," Mr Collins observes, "when decorated in their best manner, looked perfectly horrible: nothing could appear more terrible than a black and dismal face, with a large white circle drawn round each eye."

All are absolutely naked: Some of both sexes wear the skin of the kangaroo around their shoulders as a defence against the weather, but for no other purpose. A few of the men also go with a girdle about the loins, but the natural state of the whole is absolute nudity, and along with it, neither male nor female entertains any sense of shame. Nevertheless, violations of chastity seem infinitely more uncommon than where a full proportion of clothing is used. Their habitations are of the most miserable description, the best being only very long pieces of bark bent in such a manner, and the ends stuck into the ground, as to resemble the roof of a barn. Many have no other shelter than rocks, or trees, or even holes in the earth. The subsistence of those hitherto seen on the shores, is chiefly fish: they also feed on a kind of larva, or worm, lurking under the bark of trees, which is extremely disgusting to the view, but reputed a great delicacy; and they endeavour to ensnare wild animals. Captain Flinders found a race at King George's Sound, who seemed to live more by hunting than fishing; and there are inhabitants of the woods north-west of Botany Bay, who make a paste of the fern root and ants bruised together.

Arts. The arts are here in the lowest stage: clothing and dwellings being unknown, all the ingenuity of these savages is concentrated in the means of obtaining subsistence and personal defence against their enemies. They construct canoes consisting of pieces of bark glued, or sewed together; and those seen at the bottom of the Gulf of Carpentaria, the largest of all, are thirteen feet and a half long, by two and a half broad. But many of the tribes seem quite unacquainted with them. Some tribes have also scoop nets and common nets for fishing: one of the latter no less than 80 feet long and three broad, consisting of larger meshes and stronger twine than any English twine, was discovered at Glass-house bay on the east coast. Their arms are wooden lances, wooden swords, and wooden shields. One of their fishing implements is a four-pointed lance.

Manners and customs. In regard to social order among these people, there is none: all we can affirm is, that they are divided into families, the oldest member of which claims a superiority over those immediately dependent upon him. There is no acknowledgment of chiefs; nor are any laws, except those of personal strength, recognised. It is by this means that even their marriages are accomplished. Instead of the courtship, suit, and persuasion employed in other countries, the object of desire, generally of another tribe, is felled to the earth with a club, in some remote situation, and dragged in a state of insensibility to the dwelling, if such it may be called, of the husband. She becomes his wife, and frequently remains attached to him ever after. Sometimes, however, a more favoured lover is found, for whom the husband is deserted; and many of the men do not confine themselves to a single wife. Their offspring is named after some visible object, a quadruped, a bird, or a fish; and females are in the earliest infancy subjected to that mutilation of the little finger above referred to. Women are held in great subservience. They are the victims of all the barbarity which the superior power of savages can inflict, as is too incontestibly proved by the innumerable scars by which their bodies are covered. The New Hollanders either burn or bury their dead; and in general if a mother dies, while suckling her infant, it is buried alive in the same grave. They are utter strangers to religion: they have no images, nor can they be said to entertain any idea of a future state.

These people, however, are acquainted with some remarkable customs, of which the first and most conspicuous is, depriving youths at the age of puberty of an upper front tooth. Many ceremonies precede the operation, which are conceived to bestow the more valuable property of certain brutes upon them, and the operation entitles them to the privileges of men, with whom they are now enrolled. They equip themselves with long tails in imitation of kangaroos; crawl on their hands and feet, and scrape up the earth like dogs; and remain motionless the whole night before the operation. After some preparation by the incision of the gum, the tooth is struck out by main force, but with considerable dexterity. The object of this custom is altogether uncertain; it has been supposed a tribute which one tribe could exact of another; but there is not sufficient evidence that this is the case. The custom is, however, widely, though not universally, diffused. Dampier affirms of those on the north-west coast, that "the two fore teeth of their upper jaw are wanting in all of them, men and women, old and young." Captain Flinders saw individuals at the south-west extremity who had preserved all their teeth. However, around the settlements at Port Jackson, there are no exceptions. Here it is the right front tooth which is extracted. On the north coast, it is the left; and in the Gulf of Carpentaria the men seen by Captain Flinders had lost both. We do not know whether the loss of members be deemed tributary among any nation where it is practised; but it has been lately asserted, that, on the death of the chief of the island of Owhyhee, each of his people must extract a tooth. The cause of mutilating the little finger of the women, according to the natives, is to avoid an embarrassment which would ensue to the fishing lines.

Another very extraordinary custom is the exact measure of retaliation observed for injuries. They have no laws; but blood must always be followed by blood. If children when at play receive a push, they return it by one of equal force; if a man is wounded, the aggressor is compelled to expose himself to the throwing of the sufferer's spear, or that of his friend; and if a man of one tribe should be unmercifully beaten by those of another, some individual of the latter must un-

Manners and customs.

dergo a similar punishment. Yet there are many treacherous and midnight murders, and as savages sleep extremely sound, this is the moment selected for vengeance. It rathers appears also, that the death of every individual, natural, accidental, or intentional, must be followed by shedding some person's blood. The disposition of the New Hollanders, as described by one who should know them well, is revengeful, jealous, courageous, and cunning. "The inhabitant of Port Jackson is seldom seen, even in the populous town of Sidney, without his spear, his throwing stick, or his club. His spear is his defence against enemies; it is the weapon he uses to punish aggression, and revenge insult. It is even the instrument with which he corrects his wife in the last extreme; for, in their passion, or perhaps oftener in a fit of jealousy, they scruple not to inflict death. It is the play-thing of children, and in the hands of persons of all ages. It is easy to perceive what effects this must have upon their minds. They become familiarized to wounds, blood, and death, and are repeatedly involved in skirmishes and dangers. The native fears not death in his own person, and is consequently careless of inflicting it on others." Nevertheless, it does not appear that the savages of New Holland are animated by the same treacherous ferocity as many of the neighbouring islanders. They are not cannibals: Strangers on the east coast, though surprised when asleep, have escaped with impunity. On the north coast they are more ferocious; but the sanguinary disposition of their European visitors may have sometimes excited the desire of revenge.

The New Hollanders consist of tribes inhabiting different districts; but contrary to what is known among all savages still less barbarous, the right of individuals to territorial possessions, which are transmitted by inheritance, is apparently recognized.

The whole of this vast country seems inhabited only by a single race of people, intimately resembling each other in person, appearance, and manners, and who have not undergone the slightest change since Dampier's visit in the year 1688. In every different part that Europeans have landed, however, a different dialect is spoken; and these general conclusions are deduced from a number of instances comparatively small. Few natives consent to hold intercourse with strangers. Captain Flinders circumnavigated the whole coast of New Holland without having beheld a single woman from the time of leaving Port Jackson until his return. It has been conjectured, on very slight probabilities, that New Holland has been peopled from Papua. The natives of Botany Bay call themselves *Gal*, distinguishing their tribe or family by prefixing the name of the place which they inhabit. There is a tribe in Abyssinia designed Galla; the Highlanders of Scotland are denominated Gaël; therefore, without investigating the source of affinities in name among people so remote from one another, we shall simply suggest, that Gal, Gaël, or Galla may signify nothing more than *people*. The present race presents a mortifying picture of mankind sunk in the lowest state of degradation, and, were we to judge hastily, we should say, they are incapable of civilization. The South Sea islanders have made wonderful progress in the arts and civilization, from the transient visits of Europeans. The natives of New Holland, who have witnessed the cultivation of the earth, the erection of houses, and the fabrication of apparel, for nearly thirty years uninterruptedly, still go naked, seek a precarious subsistence, and shelter themselves under rocks, or in caves, from the storm. Exceptions may be found, but they are only of a few individuals; nor is any change ever to be expected, but in selecting others in the earliest childhood; for so deeply rooted is their attachment to savage life, that a native carried to England, and supplied with every comfort, soon after his return stripped himself naked, and sought for greater enjoyments among his barbarous countrymen. See AUSTRALASIA, BOTANY BAY, and DIEMEN'S ISLAND. (c)

HOLSTEIN See DENMARK, vol. vii. p. 644.

HOLYHEAD, is a sea-port and market-town of North Wales. It is situated on a small island, on the north-west side of the island of Anglesey, and denominated in British *Caer Cybi*, or the fortified place of Cybi. The town consists of one principal street, with detached buildings. The collegiate, now the parochial church, is a handsome embattled cruciform structure, consisting of a chancel, nave, aisles, and transept, with a square tower, which supports a low flat spire. It appears to have been built about the time of Edward III. An assembly-room and baths, and a large new inn and hotel, have lately been opened. There is also here a free-school, established in 1757. This place seems to have been once in the possession of the Romans. On the summit of the mountain called Pen Caer Cybi, stands a circular building, (called *Caer twr*,) 60 feet in diameter, supposed by Pennant to have been a watch-tower. A long dry wall, 10 feet high, in many places faced and quite entire, runs along the side of the mountain. The precincts of the church-yard seem also to be ancient. Three of the sides of the parallelogram consist of massy walls, 17 feet high and 6 feet thick; the fourth is open to the harbour. At each angle is a circular bastion tower, and round the walls are two rows of round openings or oeillets, four inches in diameter, having the inside smoothly plastered.

As the island on which the town stands is the point of land nearest to Dublin, regular packets are stationed here for the accommodation of travellers passing between England and Ireland. The distance between Holyhead and Dublin is 20 leagues, a voyage which is generally performed in 12 hours, though sometimes in six. In stormy weather the packets have sometimes been two or three days at sea. Six packets are in the constant employment of the Post-office. One goes out every day except Thursday, and returns next morning. These packets are well constructed and well manned, so that serious accidents very seldom happen.

The harbour of Holyhead is formed by the cliffs under the church-yard, and a small island called Inys Cybi, on which there is a light. This harbour has been lately much improved. A pier has been built on the eastern side of it to enable vessels to ride at anchor in four fathoms of water. In connection with this improvement, a new road has been made quite across the country from Cadnant island, near Bangor ferry, to the harbour, which saves seven miles. A new light-house has also been erected on a small island, or rather projecting rock, to the west of the head called the South Stack. The light, which is a revolving one, is about 200 feet above the level of the sea. In order to see the lighthouse, persons are wafted over by ropes in a kind of basket. The promontory, called the Head, is a huge mass of rocks excavated by the sea into the most magnificent caves, one of which, called the Parliament-house, is peculiarly fine. It is accessible only by boats at half ebb tide, and exhibits grand re-

Holyhead, Holy Island.

ceding arches of different shapes, supported by magnificient pillars of rock. The promontory consists of lofty cliffs excavated into large caverns, which afford shelter to swarms of birds, such as pigeons, gulls, razor bills, ravens, guillemots, cormorants, and herons. The peregrine falcon is found on the loftiest craggs. As the eggs of many of the above mentioned birds are considered as delicious food, and are therefore in high request, many of the people of the country earn their subsistence in the dangerous occupation of collecting the eggs. In order to accomplish their purpose, a strong stake is driven into the ground at a little distance from the edge of the cliff, and a rope is tied to it of sufficient length to reach the lowest nests. The adventurer ties the rope about his middle, and, with the coil on his arm, he seizes it with both hands, and gradually descends the cliff, placing his feet against its sides, and shifting his hands with great caution. When he reaches the nest, he holds by the right hand, and with his left seizes the eggs, and places them in a basket slung over his back.

The island on which Holyhead stands is called Holy Island, and received this name from the number of pious persons who were buried upon it. It consists chiefly of bare rocks and sterile sands. In the southern part of it, near *Four Mile Bridge*, is a quarry of serpentine or marble, containing a green amianthus.

The channel, which divides this island from the rest of Anglesea, is narrow, and may be forded at some places at low water. The great Irish road passes over a bridge called Rhyd y Pont.

The following is the population of the town in 1811:

No. of inhabited houses, ...	539
No. of families, ...	701
Do. employed in trade and manufactures,	496
Males, ...	1317
Females, ...	1688
Total population, ...	3005

See Pennant's *Tour*; and *The Beauties of England and Wales*, vol. xvii. p. 245—255.

HOLY Island, is an island situated about two miles from the coast of Northumberland, but belonging, in all civil matters, to the county of Durham: (See Durham, vol. viii. p. 201. col. 2.) It is situated opposite to the mouth of the brook Lindis, from which it received the name of Lindisfarne. By the Britons it was called *Inis Medicante*, and by the English Holy Island, from being the residence of several of the fathers of the Celtic church, and also from having been the episcopal seat of the see of Durham during the early ages of Christianity in Britain. The church of the monastery is in ruins. Its north and south walls are still standing, though they decline greatly from the perpendicular. The east wall is fallen, but great part of the west still remains. The arches are in general strictly Saxon, and the pillars on which they rest are short, strong, and massy. The pointed windows indicate that the building has been repaired at a subsequent period. The length of the body of the church is 138 feet; its breadth 18 feet, and 36 feet including the two aisles. Mr Selby, the proprietor of the island, has lately repaired the weakest part of the walls. The stones appear red with fire, and are wasted away so as to resemble a honeycomb.

Holy Island, Holywell.

> " A solemn, huge, and dark red pile,
> Placed on the margin of the isle."
>
> Marmion.

The remains of the priory and offices stand on the south side of the monastery, the inside of the walls being built of whinstone, obtained from the rock, which forms a high natural pier on the south side of the island.

The parish church, situated to the west of the monastery, is a plain but spacious Gothic edifice. The pedestal of St Cuthbert's cross, once highly esteemed, is now called the Pelting Stone.

Holy Island is accessible at low water by all kinds of carriages, though there is considerable danger in crossing the sands without a guide. The island, which is a continued plain, is nine miles in circumference, and contains nearly 1020 acres, about one half of which is sand banks. On the north-east side of the island is a tongue of land about a mile long, and in several places not more than 60 yards wide. The tide may be here seen ebbing on the east, and flowing on the west. Though the soil is rich, yet, before the enclosure of the common in 1792, only 40 acres were in tillage. In 1790, the rent of the whole island was £320, and in 1797, £926. The town lies on the west side of the island. It appears to have been once much larger, from the names and ruins of the streets. It is principally inhabited by fishermen. The harbour, which is small, lies between the town and the castle, and it is defended by a battery. The castle stands on a lofty whinstone rock on the south-east part of the island, about 60 feet high, and accessible only by a narrow winding pass. It is generally garrisoned by a detachment of invalids.

The parish of Holy Island is likewise called Islandshire, and contains the chapelries of Kyloe, Lowick, Ancooft, and Tweedmouth.

Holy Island was made a bishop's see by King Oswald in 635. In 652, the church was enlarged, but was only made of timber and thatched; and, in 698, Eadberet, who was bishop for 10 years, covered the roof and walls with sheets of lead. The Danes landed on the island in 793, and a second time in 875, when Bishop Eardulph, along with the inhabitants of the island, took up the body of St Cuthbert, and left the island with all their relics and sacred utensils. After a pilgrimage of seven years, they at last settled in Chester-le-street.

According to the returns in 1811, there were in Holy Island—

Number of inhabited houses	132
Number of families	152
Do. employed in agriculture	67
Do. in trade and manufactures	47
Total population	675

See Scott's *Marmion*, canto ii. which contains a fine poetical description of Holy Island; the *Beauties of England and Wales*, vol. xii. p. 228; and Hutchinson's *History of Durham*.

HOLYWELL, or Treffynnon, is a town of North Wales, in Flintshire, which derives its name from a remarkably fine spring, which rises at the bottom of the hill just below the town. Holywell is pleasantly situated on the slope of a hill, abounding in lead ore, which rises beautifully above the town. The place is flourishing and well built, and consists of one long street, Holywell.

which is crossed by another near its centre of equal goodness.

The church was built in the year 1769. It is a plain neat building, with a square tower at the west end; but though it is furnished with a bell, yet, from its situation below the town, its sound is so inaudible, that it has been found necessary to summon the congregation by a person, who suspends a pretty large one from his neck by a leathern strap, and fixes a cushion upon his knee. This moveable spire walks along eliciting sounds from the bell, whenever the cushioned knee strikes the instrument. There are other three places of worship in the town, two for Roman Catholics, and one for Protestant dissenters.

The spring called St Winifred's well is reckoned one of the finest in the kingdom. It was found by one experiment to discharge *twenty-one tons* in a minute, and by another 84 hogsheads. In the course of nearly two miles from the source of the spring to its junction with the Chester Channel, its water drives one corn mill, four cotton manufactories, built in 1777, 1785, 1787, and 1790, a copper smelting-house, a brass-house, a foundry, a large copper smithy, a wire mill, a calamine calcinary, &c. The water boils up with great force into a well of a polygonal shape, covered by a colonnaded cupola, having its groined roof loaded with ornaments. It is supposed, but without much reason, to have been built by the Countess of Derby, mother of Henry VII. Near the well is a chapel in the pointed style, which seems to have been built before the time of Richard III. This building belongs to Mr Leo of Llanerch, and has recently been converted into a charity school. A precipitous hill above the church was the scite of a fortress belonging to Ranulph the third Earl of Chester. No traces of the building, however, are now to be seen.

The great mining concern, called the Holywell Level, began in 1774, and till lately was an unprofitable concern. The level is carried horizontally for the length of a mile into the hill, and serves both as a drain to the work, and as a canal for the delivery of the ore. Numerous vertical shafts have been cut from this horizontal archway, some of them in pursuit of the mineral veins, and others for the purpose of ventilating the mines. The products obtained from the hill are, 1. Limestone; 2. Chertz or petrosilex, which is ground for the use of the potteries; 3. Lead ore of two kinds, viz. cubic or dice ore, employed in glazing earthen ware, and white or steel-grained ore, containing some silver; 4. Calamine, or ore of zinc; 5. Blende, another ore of zinc, called Black Jack by the miners. The lead ore sometimes brings from thirteen to fifteen pounds per ton, and at other times not more than seven or eight pounds.

An account of the copper and brass manufactures of Holywell has already been given in our article Flintshire, vol. ix. p. 371. to which the reader is referred.

The following is the population abstract of the town of Holywell for 1811:

No. of inhabited houses, ...	1313
No. of families, ...	1541
Families employed in trade and manufactures,	752
Do. in agriculture, ...	117
Males, ...	2925
Females, ...	3469
Total population, ...	6394

See *The Beauties of England and Wales*, vol. xvii. p. 708, &c.

Homann, Homberg.

HOMANN, John Baptist, an eminent German geographer and mechanic, and a very excellent engraver of maps, was born at Kamlach, a village of Suabia, on the 20th of March, 1663. His parents, who were Catholics, intended that he should embrace the monastic life; but having repaired at an early age to Nuremberg, he became a convert to the tenets of Lutheranism, and devoted himself to the art of engraving, particularly that of maps, which he executed with a degree of correctness and elegance then very uncommon. His first performances of this kind gained him so great a reputation, that he was summoned to Leipsic, where he was employed in engraving the maps to Cellarius' *Orbis Antiquas*. On his return to Nuremberg, he undertook to execute the maps to Scherer's *Atlas Novus*, which was published at Augsburg in 1710. In the year 1702, he established at Nuremberg a manufactory of maps, from which there issued successively, specimens to the number of two hundred. In 1719, he published an *Atlas methodicus*, for young persons, in eighteen sheets. Under the direction, and with the assistance of another able geographer, Doppelmayer, he also undertook the execution of an astronomical atlas, which appeared, after his death, along with Doppelmayer's Elements of Astronomy, in 1742. Besides maps, he likewise constructed small armillary spheres and pocket globes, and a very curious and ingeniously contrived geographical time-piece.

The scientific and mechanical talents of Homann were deservedly held in high estimation; and his merit was not suffered to languish unrewarded. He was patronised by the Emperor Charles VI. who appointed him his Majesty's geographer; and also by Peter, the Great, of Russia. The Royal Society of Berlin admitted him a member of their institution. He died in the year 1724. The manufactory of maps, which he established at Nuremberg, subsists to this day, and is still conducted under the auspices of his name.

Homann is chiefly known as an excellent engraver of maps; but he likewise possessed a great deal of geographical and astronomical knowledge; and with an active and enterprising spirit, he combined an inventive genius and uncommon mechanical skill. (z)

HOMBERG, William, an eminent chemist, was born at Batavia, in the Island of Java, on the 8th of January 1652. His father was a Saxon, who had entered into the Dutch service, and obtained the command of the arsenal of Batavia. Having left this settlement, and gone to Amsterdam, he sent his son to the principal universities in Germany and Italy, where he successively pursued the studies of law, anatomy, botany, astronomy, and chemistry. He was admitted to the bar at Magdeburg in 1674; but having become acquainted with Otto Guericke of that city, the celebrated inventor of the air pump, he devoted most of his time to the acquisition of the sciences. He now went to the university of Padua, where he studied medicine, anatomy, and botany. After visiting Rome and Bologna, where he discovered the method of making the Bologna stone luminous, he went through France to England, and laboured for some time with our celebrated countryman Mr Boyle. Returning to Holland, he resumed his anatomical studies under De Graaf, and took out his medical degree at Wirtemberg. His passion for travelling, however, prevented him from settling to the practice of medicine. After visiting Baldwin and

Kunkel, and exchanging some of his chemical secrets for their methods of preparing phosphorus, he visited the mines of Saxony, Hungary, Bohemia, and Sweden. He next returned through Holland to Paris, where he remained for some time; and when, at the desire of his father, he was about to leave the metropolis, the great Colbert made him such high offers in the name of the King, that he was induced to settle in Paris. He embraced the Catholic religion in 1682, and in the following year he was disinherited by his father for having renounced the faith of his ancestors. In 1685 he again went to Rome, where he practised medicine for some years with great success. On the 4th February 1699, he was admitted a member of the Academy of Sciences, and was allowed the constant use of the laboratory of the Academy. The Duke of Orleans, afterwards Regent of France, erected a magnificent laboratory in 1702, and put it under the charge of Homberg. He allowed him a pension, and in 1704 appointed him his first physician. In 1708, he married Mademoiselle Dodart, the daughter of an eminent medical practitioner; but being naturally of a weak constitution, he lived only a few years, and was carried off by a dysentery, to which he had been liable, on the 24th September 1715. Homberg was not the author of any separate work; but he published no fewer than 102 memoirs in the volumes of the Academy of Sciences, on various subjects, on chemistry, optics, pneumatics, electricity, anatomy, natural history, and the fine arts. See his Eloge in the *Memoirs of the Academy for* 1715. Hist. p. 82.

HOME, Henry, Lord Kames, one of the senators of the College of Justice in Scotland, and an eminent writer both on professional and other subjects, was born in the year 1696. His father, George Home of Kames, was a gentleman of an ancient and honourable family, though of small fortune, in the county of Berwick; his mother was a daughter of Mr Walkinshaw of Barrowfield.

He was educated privately; and, about the year 1712, he was bound by indenture to attend the office or chambers of a writer to the signet in Edinburgh, as a preparatory step to his entering upon the profession of a writer or solicitor before the supreme court. An accidental circumstance, however, afterwards induced him to change his views; and he determined to abandon the more limited occupation of a writer, and qualify himself for the functions of an advocate. With that view, he resolved to supply, by assiduous application, the defects of his imperfect education; and he accordingly resumed the study of the ancient and modern languages; while, at the same time, he endeavoured to acquire a competent knowledge of the sciences. His attention seems to have been particularly directed towards metaphysical investigations, for which, throughout the whole course of his life, he entertained a decided predilection.

In the year 1724, Mr Home was called to the Scottish bar, which was, at that period, graced with the talents of many individuals, who afterwards rose to the first eminence in their profession. Although his mind was abundantly stored with solid learning and legal knowledge, and he possessed, in a high degree, the talents of an ingenious reasoner; Mr Home was not gifted with those shining powers of oratory, which are calculated to bring a young practitioner rapidly into notice. Accordingly, it was not till after the publication of his first work on the law, that he began to enjoy even a moderate share of practice. That work, which consisted of a folio volume of the *Remarkable Decisions of the Court of Session*, from the year 1716 down to the period of its publication, appeared in 1728. Mr Home's manner of pleading was peculiar to himself. He never attempted to speak to the passions, or to captivate his hearers by the graces of oratory; but addressed himself solely to the judgment of his audience; employing a strain of language only a little elevated above that of ordinary discourse, which, even by its familiar tone and style, fixed the attention of the judge, while it excited no suspicion of rhetorical artifice. It would appear, however, that his ability lay more in the devising of ingenious arguments to support his own side of the question, as an opening or leading counsel, than in reply; for which he seems to have wanted that ready command of copious elocution, which is necessary for extemporaneous discussion. There was one peculiarity attending his mode of replying which is worthy of notice. This consisted in a fair concession and abandonment of all the weaker points of his cause. By yielding these at once to his antagonist, he succeeded in creating a favourable impression of his own candour, and a persuasion of the strength of his cause; while, at the same time, he frustrated all attack on those weak parts, which might have given matter of triumph to his opponents, and had a prejudicial influence on the more solid grounds of his plea. But the feature by which Mr Home was principally distinguished as a barrister, consisted in the faculty which he possessed, in a very eminent degree, of striking out new lights upon the most abstruse and intricate doctrines of the law, and of subjecting to the scrutiny of reason those rules and maxims which had become venerable only from long and inveterate usage, having no solid foundation in any just or rational principle.

In 1732, he published a small volume under the title of *Essays on several Subjects in Law, &c.* These subjects had been suggested to him during the course of his employment as a counsel in several important causes; and they contributed greatly to establish the character of the author as a profound and scientific lawyer. From the period of their publication, accordingly, Mr Home appears to have been engaged in most of the causes of importance which occurred in the Court of Session. While occupied with the duties of a laborious profession, however, he did not neglect the pursuits of literature and science, to which he seems to have been at all times ardently devoted; and a considerable portion of his time was also given to the enjoyments of society, in a numerous and respectable circle of acquaintance. He lived in habits of intimacy with many of the first literary and philosophical characters of the age, and frequently corresponded with them on the subjects connected with his favourite pursuits.

In the year 1741, Mr Home married Miss Agatha Drummond, a younger daughter of James Drummond, Esq. of Blair, in the county of Perth, a lady possessed of an excellent understanding, and an enlightened and solid judgment in the conduct of life, with much sweetness of temper, and gentleness of manners. In the course of the same year, he published, in two volumes folio, *The Decisions of the Court of Session, from its Institution to the Present Time, abridged and digested under proper Heads, in the form of a Dictionary*,—a work of great labour, and of the highest utility to the profession of the law in Scotland.

During the rebellion in 1745-6, the course of judicial procedure, in the northern part of the kingdom, was interrupted by the disordered state of the country, and the Court of Session did not meet for a period of eleven months. Mr Home employed that interval in various researches connected with the history, laws, and ancient usages of his country, which he afterwards digested into a small treatise, and published in the year 1747, under the title of *Essays upon several Subjects, concerning British Antiquities.* These essays, although they contain some curious and important deductions, and exhibit a great deal of ingenious reasoning, are by no means esteemed among the most valuable of the works of their author.

We have already observed, that Mr Home's mind was peculiarly turned to metaphysical speculations, for which he found leisure even amidst the pressure of his professional employment. In the year 1751, he published his *Essays on the Principles of Morality and Natural Religion.* This work, in which he endeavoured to place the great principles of morals on a firm and immutable basis, unaccountably drew upon him, from certain quarters, the reproach of scepticism and impiety; and his opinions, particularly on the abstruse question of *free will*, were attacked with great asperity by various writers. Some of these were of so intolerant a spirit, that nothing less could satisfy their zeal, than the interference of ecclesiastical authority, to repress opinions which they conceived to be contrary to the canons of the established church, and subversive even of the fundamental principles of religion. To his opponents, Mr Home made a formal reply, under the title of *Objections against the Essays on Morality and Natural Religion examined.* This controversy attracted the attention of the General Assembly of the Church of Scotland; and a motion was made in the committee for overtures, which was supposed to be indirectly levelled, among others, against the author of the Essays. The motion occasioned a very warm debate, but was finally negatived. However, Mr Anderson, a clergyman, and one of the most zealous of Mr Home's antagonists, resolved not to let the matter rest here. He gave in a petition and complaint to the presbytery of Edinburgh against the printer and publisher of the *Essays on the Principles of Morality and Natural Religion,* requiring that the presbytery should summon them to appear before them, and declare the name of the author of that work, in order that he might be subjected to ecclesiastical censure. The persons complained against appeared by their counsel, and gave in formal defences; but Mr Anderson died during the course of the proceedings. The defendants, however, waving all objection to the want of a prosecutor, consented that the court should give judgment on the merits of the case; which, after undergoing some discussion, terminated in the rejection of the complaint.

In the month of February 1752, Mr Home was appointed one of the Judges of the Court of Session, by the title of Lord Kames. His promotion gave general satisfaction to the country, as his abilities and knowledge of the laws, no less than his integrity and moral virtues, had raised him high in the public esteem. To the discharge of his duties, as a Judge of the Supreme Civil Court, he brought an acute understanding, an ardent feeling of justice, and a perfect acquaintance with the laws of his country; which, amidst the variety of pursuits in which his comprehensive mind had been engaged, had always received the principal share of his attention. His judgments, which were always formed with deliberation, had deservedly the greatest weight with the Court, especially on all questions of recondite jurisprudence. Towards the bar he uniformly conducted himself with a proper courtesy and respect; listening to the arguments of the senior counsel, who pleaded before him, with patient attention, and animating the diffidence of the younger barristers by kind indulgence and urbanity of demeanour. In his character he occasionally displayed something of the humourist; and, even on the bench, he could not always repress his constitutional vivacity, which sometimes broke out in amusing sallies, when the subject of discussion led to a ludicrous train of thought, or when a happy repartee was suggested by the wit of the counsel.

A society had been instituted in Edinburgh, in the year 1731, for the advancement of medical knowledge, the plan of which was afterwards extended, at the suggestion of the celebrated Maclaurin, to subjects of philosophy and literature. It was now known by the title of *The Society for Improving Arts and Sciences,* but more generally by that of *The Philosophical Society of Edinburgh.* At what period Mr Home first became a member is uncertain; but he appears to have been elected its president about the beginning of the year 1769; and in the volume of the *Transactions* of that learned body, published in 1771, there are three papers of his writing, viz. *On the Laws of Motion; On the Advantages of Shallow Ploughing;* and, *On Evaporation.* They exhibit the same ingenuity which is conspicuous in all his productions; but the papers on physical subjects are not built on sound philosophical principles.

In the year 1755, Lord Kames was appointed a member of the *Board of Trustees for the Encouragement of the Fisheries, Arts, and Manufactures of Scotland;* and, about the same period, he was chosen one of the commissioners for the management of the forfeited estates annexed to the crown, of which the rents were destined to be applied to the improvement of the Highlands and Islands of Scotland. In the discharge of these important trusts, he was a zealous and faithful servant of the public. He regularly attended the stated meetings of these boards, generally officiating as chairman, and taking a most active concern in all their proceedings. In the midst of his professional and literary occupations, he was at all times easy of access to the meanest individual who had any application to make; and was ready not only to advise, but even to assist the ignorant and needy suitor in bringing his claims fairly into view.

In 1757, he published *The Statute Law of Scotland Abridged, with Historical Notes,* and two years afterwards he gave to the world his *Historical Law Tracts,* each in one volume 8vo. The latter work has undergone several editions, and stands deservedly high in the estimation of the public. It is one of the few works which unite law with philosophy, and the study of human nature; and it has accordingly received the praise, not only of juridical authors, but of the writers on politics and morals, both of our own and of foreign countries. In 1760, appeared his *Principles of Equity,* in which he traces historically the origin of the courts of equity in each of the united kingdoms, and endeavours to ascertain those general rules by which a court of equity ought to be governed. The active mind of Lord Kames, however, did not confine its efforts to those studies and researches which were more intimately connected with his profession, but exerted its powers in various pursuits of a generally interesting nature. In the course of the education of his own children, he was led to the composition of an elementary work suited to the minds of young persons, and calculated at once to improve the understanding, and to cultivate just notions of morality. This little work he published in 1761, in a small volume under the title of *Introduction to the Art of Thinking*. It is divided into two parts; the former containing a series of moral and prudential maxims, and the latter a regular illustration of those maxims by stories taken either from real history, or fictitious narratives.

It appears from the letters of some of Lord Kames's correspondents, that he had for several years meditated an extensive work on the principles of criticism. This design he afterwards carried into execution by the publication of his *Elements of Criticism*, which first appeared in the year 1762, in three volumes 8vo. In this elaborate work, it was the object of the author to subject the impressions made on the mind by the productions of the fine arts to the standard of reason, by shewing, that what is generally called taste is by no means arbitrary, but depends on certain principles or laws of the human constitution; and that a good taste consists in the consonance of our feelings with those laws.

From the period of the publication of the last mentioned work, Lord Kames appears to have devoted himself for a few years exclusively to his professional occupations. On the 15th of April 1763, he was appointed one of the Lords of Justiciary, that is, one of the Judges of the supreme criminal tribunal in Scotland. The duties of that situation he continued to discharge, to the end of his life, with equal diligence and ability. In the year 1766, he received a very large addition to his income by the succession to the estate of Blair-Drummond, which devolved on his wife by the death of her brother. The seasons of vacation were now spent at Blair-Drummond, where he began to execute a variety of agricultural improvements on an extended scale, which, while they set a great example for the imitation of the neighbouring landholders, have proved of the most solid and permanent benefit to the proprietor and his heirs. Among these plans of improvement was one of a nature so extraordinary, as to be generally regarded at first as chimerical, but which ultimately succeeded far beyond the most sanguine views of its contriver. We allude to the operations commenced and carried on by his lordship on the moss of Kincardine; of which we shall have occasion to take some notice in the article MOSS in this work. With these substantial improvements he combined many plans of embellishment, suggested by those great features of natural beauty which the surrounding scenery exhibits.

Towards the end of the year 1765 Lord Kames published a small pamphlet on the progress of the flax husbandry in Scotland, of which the principal object was to shew, the expediency of encouraging the culture of flax of the native growth of the country. At the same time his lordship, availing himself of a most extensive acquaintance with the principal landholders in Scotland, endeavoured, with a laudable zeal, to stimulate their exertions in diffusing a spirit of industry among their cottagers and dependents, by the introduction of such species of domestic manufactures, suited to both sexes, as, without any considerable expence on the part of the proprietors, would ameliorate the condition, and multiply the comforts, of the lower orders, and thus lay the solid foundation of an increase of their own revenues. Among those patriotic plans of national improvement, in which Lord Kames, as a member of the board of trustees for the encouragement of arts, took a most active concern, was the great and useful project of a navigable canal between the rivers Forth and Clyde, which was begun in 1768, and from which, since its completion, the internal commerce of the country has derived the most essential benefit.

In the year 1766, Lord Kames published his *Remarkable Decisions of the Court of Session, from* 1730 *to* 1752. The reports contained in this volume consist of 130 cases, comprehending the most important causes which had occurred in the course of his own practice while at the bar.

For many years Lord Kames had been employed, during his leisure hours, in collecting materials for a *History of Man*. The design of this great work, however, as at first conceived, was found to be too vast; and he afterwards wisely determined to confine his plan within narrower limits. The work was at length published in the year 1774, under the title of *Schetches of the History of Man*, in two volumes 4to. Although published in the form of separate essays or dissertations, it is digested with a considerable degree of systematic regularity, and is valuable not only from the great variety of important objects which it embraces, but on account of the genius and ability displayed in their discussion.

In the year 1776, he published his *Gentleman Farmer*; a work of great utility at the period of its publication, and which affords a singular specimen of the undiminished vigour of his mind at the advanced age of eighty. Even at this late period of his life, his constitution appeared to have suffered nothing from the attacks of old age. There was yet no sensible decay of his mental powers; and, what is still more extraordinary, he possessed the same flow of animal spirits, the same gaiety and vivacity, and the same ardour in the pursuit of knowledge, for which he had been distinguished in his early years.

In 1777, he published his *Elucidations respecting the Common and Statute Law of Scotland*, in one volume 8vo: and in 1780, his *Select Decisions of the Court of Session*, in one volume folio. The latter publication contains 264 reports of the most important cases decided by the court, between the years 1752 and 1768, and forms a supplement to the cases formerly published under the title of *Remarkable Decisions*. The last work of Lord Kames was his *Loose Hints on Education*, published at Edinburgh in the year 1781, when the author was in the 85th year of his age.

Although apparently by no means of a robust frame of body, Lord Kames had hitherto enjoyed an uncommon share of good health; but in the beginning of the year 1782, when he had nearly completed his 86th year, he was seized with a disorder of the bowels, which, being attended with no pain, gave him, for a considerable time, very little apprehension. Finding, however, after some months, that the disease had not yielded to medicine or regimen, he began to regard it as likely to terminate fatally. During the summer term of the year above mentioned, he regularly attended to his official duty in the courts of session and justiciary, and at the end of the term, he went, as usual, with his family to Blair-Drummond. He also attended the autumn circuit; but, on his return, his strength decreased daily, although the serenity and cheerfulness of his temper remained unabated. He left Blair-Drummond in the beginning of November, and continued, for some little time, to attend the meetings of the court of session; but he soon became sensible that his strength was not equal to the effort. On the last day of his attendance, he took a separate and affectionate farewell of each of his brethren. He survived that period only about eight days, and died on the 27th of December 1782, in the 87th year of his age.

In his person, Lord Kames was very tall, and of a thin and slender form. His countenance was animated, and strongly marked with the features of intelligence and benignity. At every period of his life he had a high relish for the pleasures of society; and it was usual for small and select parties to meet at his house in the evenings, during the winter and summer sessions, without invitation. In these parties, the discussion of literary topics was agreeably blended with innocent sallies of mirth and pleasantry; and the graver conversation of a Smith, a Blair, and a Fergusson, was relieved or enlivened by the native wit and polished manners of a Cullen, or the sprightly fancy and whimsical eccentricity of a Boswell. The artless and ingenuous disposition of Lord Kames led him, at all times, to express his feelings and opinions without reserve or disguise; and this propensity, combined with a certain humorous playfulness of manner, might frequently convey to strangers the unfavourable idea of a bluntness and levity, derogatory from that dignity and attention to decorum, which one so naturally associates with talents and eminence. But this impression was soon effaced by that vigour of intellect, that frankness, integrity, and candour, which his conversation never failed to display. He engaged with interest in the discussion of almost every topic that occurred, whether of ordinary life, literature, or science; and although naturally communicative, he was always as ready to listen to the opinions of others as to deliver his own sentiments. To the introduction of political subjects, however, in common conversation, he had a strong dislike; and when the conversation happened to take that turn, he either took no part in it, or endeavoured to divert it by some timely pleasantry, or guide it with address into a different channel.

To the distinguishing features of Lord Kames' character as a lawyer, a judge, an author, and a man, we have had frequent occasion to allude in the course of the preceding narrative. He certainly contributed more than any other individual, to explain, illustrate, and define the origin, progress, and character of the laws and institutions of his country; his unwearied attention to agriculture and internal improvement, and his zealous encouragement of every useful project, bear sufficient testimony to his public spirit; and, however widely he might occasionally err in his speculations on subjects of strict science, his many and valuable publications on literary and philosophical subjects, will prove a lasting monument of his genius and industry. See Lord Woodhouselee's *Memoirs of the Life and Writings of Lord Kames*. The writer of this article has also been favoured with a perusal of the MSS. of John Ramsay, Esq. of Ochtertyre, in which there are many interesting particulars illustrative of the characters of Lord Kames and other individuals, whose talents contributed to elevate the literary reputation of their native country during the eighteenth century. (z)

HOME, JOHN, a clergyman of the church of Scotland, but best known to the public as author of one of the most classical tragedies in the English language, was a descendant of one of the ancestors of the Earl of Home. It was once reported, that he had some pretensions to the title of the Earl of Dunbar, but upon what grounds we have never been able to learn. His father was clerk, or, as it might be termed in England, recorder of the town of Leith.* Our poet was born at Leith in September 1722. He received the elementary part of his education at the parish-school of his native place; after which he went to the university of Edinburgh, and there went through the customary course of the languages and philosophy with the reputation of a respectable and diligent student. At the university he was the intimate companion of several of those eminent men, who, like himself, afterwards contributed so highly to raise the literary reputation of Scotland about the middle of the eighteenth century. Among these were Drs Robertson and Blair, and Professor Adam Ferguson. The circle of his intimate friendship afterwards included David Hume, and Lord Kames. Being educated for the church, he had passed through the divinity-hall, and was about to enter upon the duties of the clerical profession, when he was suddenly called to forsake his studies by the rebellion that broke out in Scotland in the year 1745. On the approach of the rebels, the citizens of Edinburgh assembled, and formed themselves into an association for the support of their sovereign, and the defence of the city; and in this association Mr Home was appointed to be lieutenant of a company of volunteers. In the first crisis of alarm, it became a question among those who had taken up arms, whether they should wait for the approach of the rebels within their walls, or march out to meet them, and act with the king's army. Mr Home, with the more active spirits, was in favour of the latter plan; and while the bulk of the volunteers remained in the Scottish capital, he was one of a much smaller number who solicited and obtained permission to follow the army of Hawley into the field. At the unfortunate battle of Falkirk, he was taken prisoner by a party of Prince Charles's troops, and was for some time confined a prisoner in the castle of Downe. From thence, however, he soon afterwards contrived to effect his escape and public tranquillity having been restored by the victory of Culloden, he resumed his studies, and was licensed to preach. In the same year, 1746, he was presented to the living of Atholstaneford, in the county of East Lothian. It gives a poetical interest to the name of this parish, that it had successively for clergymen two poets of respectable names, Mr Home having succeeded in that living to Blair, the author of *The Grave*. In this retired situation, however, we cannot suppose the dramatic muse of Mr Home to have found herself so congenially situated as the more sombrous genius of his predecessor. Accustomed to the sweets of literary society, and elegant in his pursuits, he probably felt the life and duties of a country parish priest far from being delightful. To a mind teeming with dramatic conceptions, the offices of visiting, catechising, and spiritual rebuking, must have been somewhat irksome. He appears, however, to have sometimes taken the recreation of a visit to England; and on one of those occasions, he met with Collins the poet, whose mind immediately felt a pleasing congeniality with that of Home. In his *Ode on the Superstitions of the Highlands*, we have almost the only record that Collins has left of his personal friendship, when he says,

> Go not regardless while these numbers boast
> My short-liv'd bliss; forget my social name,

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* It should be observed, however, that the English recorder's office is of higher dignity than that of the Scottish clerk, who does not sit, like the former, on capital cases.

But think far off, how, on the southern coast,
I met thy friendship with an equal flame.

The tragedy of Douglas, though the first play of Mr Home's that was brought upon the stage, was not the first of his composition. He had before written *Agis*, a tragedy, of which we shall have occasion to speak hereafter. The plot of the tragedy of Douglas, as few will probably need to be told, was suggested by the ancient ballad of Gill or Child Morrice. Hearing a part of that beautiful old song sung by a lady one evening after a supper party in Edinburgh, Mr Home remarked, that he thought it contained the germs of a tragedy; and very soon made good his opinion, by commencing to dramatise the story. Douglas made its first appearance on the Edinburgh theatre, which was then in no unflourishing condition, in the year 1756. When the managers received the MS. they readily accepted it, put it into rehearsal, and prepared for giving it a magnificent representation. The transaction, however, coming to the knowledge of the elders of the kirk, they, in their great zeal, first remonstrated with the author on the heinous sin he was committing. Failing in this remonstrance, they endeavoured to terrify the performers from representing it; but with no better success. Author and actors remained equally incorrigible, and nothing remained for the incensed elders to do, but threaten to expel, and for ever disqualify for the ministry, not only their disobedient poet, but even such of his clerical friends as had been wicked enough to go to see his piece performed at the theatre. In pamphlets and advertisements, they thundered their anathemas against those implements of Satan, the actors, who had led aside, or at least abetted in his wandering, the lost sheep of their flock. The presbytery of Edinburgh published an admonition and exhortation against stage-plays, which was ordered to be read in all the pulpits within their bounds, in a Sunday appointed. In this proclamation, there was no mention of Mr Home or his play, though it was evidently against him that this spiritual artillery of obsolete laws and fanatical prejudices were levelled. To avoid a formal expulsion from the church, Mr Home, in 1757, resigned his living, and with it the ecclesiastical profession, and wore for ever after a lay habit. Similar as the Puritans of England and the Scottish Calvinists might have been half a century before, this ejection of an amiable and accomplished clergyman from the Scottish Kirk, for the crime of writing a tragedy, which did honour to the genius of the nation, excited among the more liberal part of the Scotch, and much more generally in England, a sense of indignation at the injustice, and ridicule at the absurdity of the procedure. That leaven of bigotry happily is now far extinct; we believe the last mark of it is to be found in the article HOME in the Biographical Dictionary of Mr A. Chalmers, the writer of which article gravely denies the treatment of Mr Home to have been unjust, since the constitutional laws of the Kirk of Scotland denounced stage-plays. If the writer of this luminous opinion were at present flourishing in Spain, he might argue with equal justice in favour of the burning of heretics, on the grounds of the ancient laws of the Catholic church—as if an enlightened age were for ever bound to follow the dead letter of primitive barbarism. Happily, in Protestant communities, such an example of clerical hostility to the cause of literature stands alone: for parallels to it we must go back to times of Paganism and Popery. It may remind us of the persecution of Æschylus, in consequence of the clamour of the Athenian priests, or of the influence of the monks in Spain, when neither the patronage even of Philip IV. nor the orthodoxy of Lope de Vega's works, were sufficient to screen him from the personal virulence of the ecclesiastics. At no very distant period, indeed, during an epidemical disorder, the inhabitants of Seville renounced the amusement of the theatre, as the surest mode of averting Divine vengeance. To return, however, to our author, his tragedy of Douglas was extolled, on its first appearance, by the literary circles of the North, in terms that were perhaps rather unqualified. David Hume gave it as his opinion, that it was one of the most interesting and pathetic pieces ever exhibited on any theatre; he even gave it a preference to the *Merope* of Maffei, and that of Voltaire. The rest of the philosopher's panegyric on our author, in which he alluded to Shakespeare, may, for the credit of his taste, be left unquoted. The poet Gray, in one of his letters to a friend, renders an homage to the play of Douglas, that is perhaps not much lessened by his fastidious allusion to its defects. "I am greatly struck," he says, "with the tragedy of Douglas, though it has infinite faults. The author seems to me to have retrieved the true language of the stage, which had been lost for these hundred years; and there is one scene between Matilda and the old peasant, that strikes me blind to all its defects." Jackson, in his *History* of the *Scottish Stage*, informs us, that when this tragedy was originally produced in Edinburgh, the title of the heroine was Lady Barnard. The alteration to Lady Randolph was made on its being transplanted to London. Its success at the Edinburgh theatre induced Mr Home to offer it to the London managers, where, notwithstanding its rising celebrity, and all the influence used in its favour, it was refused by Mr Garrick. Mr Rich, however, accepted it, and it was acted for the first time at Covent Garden, March 14, 1757, with some applause, but by no means such as indicated the future celebrity which it was to obtain.

On resigning his living, Mr Home repaired to England, where the munificent patronage and unremitting friendship of the Earl of Bute made him ample amends for the abandonment of his profession. Lord Bute having become first minister on the accession of his present majesty, appointed him in March 1763 a commissioner for sick and wounded seamen, and for the exchange of prisoners of war; and in the next month of the same year, he was nominated conservator of the Scotch privileges at Campvere in Zealand. From the period of the exhibition of Douglas, down to the year 1778, Mr Home brought five other tragedies before the public. Of these, *Agis*, as has been already mentioned, had been composed before that of Douglas. Mr Garrick had formerly refused this piece as well as Douglas; but as it was now considerably altered, and the author's reputation established, the manager brought it forward at Drury Lane in 1758. The play is founded on a story in Spartan history. It is pretended that the author has kept up in the character of Agis a continued allusion to the misfortunes of Charles the First; and the figurative retrospect of the conduct of the Scots towards their sovereign, was charitably ascribed by the conjectures of English criticism to the author's vindictive feelings towards his countrymen. The allusion was in all probability either casual or imaginary—the imputed motive is inconsistent with all that is known of the character of Home. Agis was certainly heard with impartiality, and even with that partial disposition which the author of Douglas had a right to expect. It had the additional advantage of good acting, and of two solemn musical processions. But the intrinsic merit of the piece could not secure to it a lasting popularity. On perusing it, the poet Gray writes this melancholy sentence to Dr Warton. "I cry to think that it should be by the author of Douglas. Why, it is all modern Greek. The story is an antique statue, painted white and red, frigid, and dressed in a negligée, made by a mantuamaker of Yorkshire." Mr Home's third tragedy was the *Siege of Aquileia*. It was acted with indifferent success at Drury Lane, in 1760. From the title, we should expect, that the author would have adhered, with general fidelity, to the circumstances, as they are recorded in history, of the defence of that city by the legions of Gordianus, against the gigantic tyrant Maximin; but, in reality, the incidents of the play agree much nearer with the history of the Siege of Berwick, defended by Seton against the arms of Edward III.; and it was conjectured, with some appearance of plausibility, that Mr Home had received his first hint from the latter story; but disliking to bring Edward the Third before an English audience, in the light of a brutal tyrant, in which the siege of Berwick too strongly exhibited him, he thought proper to preserve the circumstances only under the disguise of more ancient names. This play is regular in its structure, and the language in some passages is fine; but, on the whole, the incidents are too few, the distress too unvaried, and the catastrophe too clearly anticipated. Mr Home's muse cannot be said to have prospered beyond the time when she was rich enough to lend images to Ossian. The shrieking of the spirit of the waters was an admired expression in the description of the tempestuous night in Douglas, which seems to anticipate much of the spiritual imagery of Macpherson. Gray the poet puts a query in one of his letters, whether Home borrowed this from Macpherson, or Macpherson from Home. Without pretending to enter on the wider question of Ossian's authenticity, we shall only notice that the play of Douglas appeared some years earlier than the fragments ascribed to Ossian. The latter, as we have seen, was acted in 1757; Macpherson did not come before the world till 1760. By the *Fatal Discovery*, Mr Home's next tragedy, it would seem that our author was willing to be reimbursed for whatever hints of fancy he had lent to the Gaelic muse, and accordingly he supplied himself in this piece with much of the lamed phraseology of Fingal. But whatever might be the real demerits of the *Fatal Discovery*, the London public seems not to have been disposed to receive it with an equitable judgment. To such a height, we are told in the *Biographia Dramatica*, had party prejudice risen against Mr Home, on account of his enjoying the patronage of the Earl of Bute, that it was found necessary to conceal the author's name during the first nights of its representation; and, after the twelfth night, Mr Garrick was threatened with having his house burnt down if he continued it: an injunction with which the managers thought it advisable to comply. *Alonzo*, Mr Home's next tragedy, was more successful than any other of his productions, *Douglas* alone excepted. It had a considerable run on its first appearance, and added much to the rising reputation of Barry as an actor; but it never obtained the rank of what is called a stock play, nor was afterwards performed, except at provincial theatres. The language of the tragedy of *Alonzo* possesses considerable force and purity, though the cadence of its versification is like all the blank verse of that period, too little varied in the pauses, and monotonously concludes the rhythm with every line. The story is also romantic and lucidly brought out, but it is rather too much like an echo of *Douglas*. Ormisinda brings us back Lady Randolph, She is not indeed a widow; but has been forsaken for eighteen years by the husband of her early love, who had groundlessly suspected her virtue. They had married unknown to her father, and their meetings were in a solitary place; where a confidential servant, in order to give the semblance of protection to Ormisinda, assumed the plume and vesture of a brother. Deceived by this appearance, Alonzo had abandoned her, wandered in foreign countries, and returned only in disguise to fight with the Moors in behalf of Spain. In his absence Ormisinda has secretly reared his son at a distance from her, and unconscious of his birth. Like Douglas, he bursts from obscurity into martial reputation; and offers to become her champion without knowing that she is his parent. Alonzo conquers the Moorish champion, throws off his disguise, declares his marriage with her from whom he has been eighteen years separated, and, in a scene which is pretty striking, demands, as the reward of his services, that the king shall sentence her, his own daughter, to die. The conscious innocence of Ormisinda,—the agony of her wrongs,—the bursts of her affection towards Alonzo,—and her maternal feelings at the sight of her boy rushing to combat with his unknown father,—compose a strong situation of terror and pity; and the moment when she throws herself between their swords, is one of rivetting interest. It may be questioned, however, if the effect would not have been much better had the termination been fortunate. In plots where a happy denouement would not be merely satisfactory, but joyous and exultingly triumphant, the policy of killing the tragic victims is very doubtful. Ormisinda was not like Lady Randolph, who, though her son was restored, had only a second and apparently not a distractedly beloved lord to be reconciled with; she had all the pledges of filial, maternal, and conjugal love to redeem, as well as honour, and the inheritance of a throne; and the catastrophe that severs her from all those blessings, seems to depend more on the tragical resolution of the poet, than on that overawing *fatality which gives dignity to dramatic slaughter*.

Alfred, our author's last tragedy, was acted in Covent Garden in 1778, but was only performed for three nights.

It is impossible to follow this detail of Mr Home's dramatic career, without a melancholy reflection on the power of genius itself being included in the sentence of mutability which is passed on all earthly blessings. With *Alfred* he took his leave of the stage, and retired to Scotland, where he continued to reside during the greater part of his remaining life. In 1778, when the late Duke of Buccleugh raised a regiment, under the name of Fencibles, Mr Home received a captain's commission, which he held till the peace. A few years before his death, he published the *History of the Rebellion in Scotland in* 1745: a work of which great expectations were formed; but whether he delayed it until his powers of mind had lost their vigour, for he was now seventy-eight, or did not feel himself at liberty to use all his materials, the public was not satisfied. For a considerable time before his death his mental faculties were impaired, and his health was much affected by a dangerous fall from his horse. He died at Merchiston house, on the 4th September 1808, at the advanced age of eighty-five. (*)

HOMER, (the Grecian poet.) Without leaning to the faith of those who have denied the existence of Homer, we cannot avoid noticing the remarkable circumstance of his existence having been called in question. Both learning and ingenuity have been employed in attempting to prove, that neither the Iliad nor the Odyssey were the production of a single genius, but composed by the rhapsodists, who recited those poems in detached parts; and that the name of Homer, which, in the Eolian dialect of Greek, signifies "blind," was either applied to some personage wholly fanciful, or, by way of eminence, to some strolling declaimer of the Iliad, who may have executed parts of the poem, but cannot be supposed to be the author of the whole. It may seem a paradoxical way of annihilating an individual to multiply his existence; but yet, by proving a diversity of Homers, if such a thing could be proved, our homage to the single author of the Iliad would be shaken, and the reputation of a sacred name would fall with its loss of unity. Annius of Viterba pretends to give the authority of Archilochus, an author to whom he ascribes the most remote antiquity, for the existence of eight different authors of the Iliad, among whom are gravely registered Apelles the painter, and Phidias the statuary. But for the comfort of those who may feel alarmed at the threatened dismemberment of the Homeric existence, it must be mentioned, that this Annius of Viterba, who was a Dominican friar, and master of the sacred palace under Pope Alexander VI., was an impostor who had not even skill to palm upon the world the MS. page of this ancient Archilochus, which he pretended to find, and stands upon record as one of the most impudent and clearly convicted of literary forgers. The book, which he called the Genuine Remains of Sanconiathon Manetho, &c. brought him the same species of reputation that accrued to the younger Ireland from his Shakespeare MSS., or to Mr John Pinkerton from his execrable additions to Hardyknute.

By far the most formidable opponent of the unity of the author of the Iliad is the learned German Professor Wolff, who supposes Homer to be either an imaginary being, or, at most, one of the earliest of the rhapsodists. In the works which he prefixed to the works and remains of Homer and the Homerides, there are several false inferences, deduced from admissible facts, brought forward with a boldness that might indeed have been expected from a writer who arrogantly pronounced his work to be above all critical objections, and who predicted that no Grecian scholar should attack it with impunity.

In opposition to all scepticism regarding Homer, every candid mind will agree that the settled and prevailing belief of antiquity is not to be made light of in such a question. It is true that Homer's birth-place, as well as his age, are disputed, but such controversies are not apt to be started about imaginary beings. It is unreasonable to say, that a poet so illustrious as Homer, if he had been the acknowledged author of the Iliad, must have been known to his own contemporaries. Only a few scattered anecdotes of Shakespeare himself have reached the present day. In an age, such as the probable age of Homer, had a man of genius a better chance of finding contemporary biographers? When Massinger was buried, all that could be told of him, in the inscription upon his tomb, was, "Here lies Philip Massinger, a stranger." To adduce all the proofs that could be given of great poets being neglected by their contemporaries, would unhappily be to write the history of the greater part of them. In forming our opinion of narratives that exceed the accustomed phenomena of nature, we cannot be sufficiently cautious of making the creed of a past age the standard of our own belief. But tradition that is free from the marvellous, is fairly entitled to confidence, and the tradition which assigns a single author to the Iliad, a tradition which Lycurgus and Aristotle believed, has surely nothing in it so incredible as that a work, so remarkable for simplicity of design, should have been the work of fortuitous and successive composers. Great works of science may, indeed, be thus built up by accumulation, but great poems and pictures are not usually constructed by a multiplicity of artists. Nor, if the Iliad had been the work of successive rhapsodists, is it easy to conceive by what poetical effort of modesty those authors suppressed their respective rights upon the gratitude and admiration of posterity.

We must distinguish, however, between the credit that is due to the general tradition of Homer having been a wandering reciter of his own poetry, and the more specific facts that are pretended to be given as the history of his life. The most ancient work of this kind is the life of Homer attributed to Herodotus. Whether this be the genuine production of Herodotus, we are far from pretending to decide. The opinion of Professor Heyne, which was apt to be deliberately formed, is unfavourable to its authenticity, as he pronounces it impossible to ascertain either the age or country of Homer. The learned Vossius also rejected its authority on the ground, that no writer makes mention of the work previous to Stephen of Byzantium, and Suidas. This argument, though it comes from a great name, is certainly not quite conclusive. By far the most important objection to it is the different calculations of chronology exhibited in Herodotus the historian of Greece, and the Herodotus to whom this life of Homer is assigned. The former, in his Euterpe, speaks of himself as posterior to Homer by only 400 years; while the latter computes a period of 622 years, and the expedition of Xerxes across the Hellespont, a difference of nearly 200 years. On this account, Eustathius wishes to assign the life of Homer to another Herodotus, surnamed Olophyscius, instead of the historian of Halicarnassus. Admitting the above objections in their full force, it cannot be affirmed that they amount to a demonstration of the biography itself being either spurious, or fraught with internal marks of falsehood. On the contrary, the birth-place, which it gives to the author of the Iliad, corresponds with an inference most plausibly drawn by an enlightened traveller from the poet's descriptions of external nature, that he paints them with the very circumstances that would occur to a native of Chios or Smyrna. If Homer was born at the latter place, the vicinity of Herodotus's birth-place, would naturally make him anxious to collect every tradition respecting him; and in the wandering life and disastrous voyages which those traditions describe, there is every thing which the state of society in such an age renders probable. It cannot well be doubted that the author of the Iliad and the Odyssey was a traveller, as they are both the evident offspring of a mind which had contemplated nature and human life in a full variety of aspect and manners, and of one who had felt much from the opposite dispositions of good and bad in his own species; who, according to the circumstances then existing in society, had

> "Walked in every path of human life,
> Felt all its passions, and to all mankind

> Doth now, will ever, that experience yield,
> Which his own genius only could acquire."
>
> AKENSIDE, *Inscription for the Bust of Shakespeare.*

Our ingenious countryman Wood[*] had a higher opinion of the authority of the work in question; and although some allowance may be made for the gratification of the traveller, in finding that theory respecting Homer's history, which he had himself so plausibly deduced from his landscapes and similes, confirmed by a work ascribed to so venerable a name as that of Herodotus, yet Wood's remarks are worth attending to: "It may be here requisite," he says (p. 189, *Essay on Homer,*) "that I take some notice of the ancient life of Homer, handed down to us, and ascribed to Herodotus. The life of Homer is supposed by several not to be the genuine production of that historian. As it is impossible to imagine a collection of circumstances which have less the appearance of fiction, I do not see why we should not suppose that this was the last and most probable account that the historian could get. As for the observation that they belong to the lowest sphere of life, I fear it is suggested by modern distinctions of rank unknown in those times. When we are told, by way of depreciating this written life, that it is conducted with the spirit of a grammarian; that there is nothing in it above the life which a grammarian might lead himself; nay, that it is such a one as they commonly do lead, the highest stage of which is to be master of a school, we are treated with objections which arise much more out of a knowledge of modern than ancient times. The character of a grammarian was unknown, not only to Homer, but to Herodotus; and when it did appear, was much more respectable than of late, when, by an easy transition, it is connected with the name of schoolmaster, as in the present case, and conveys very false ideas of the state of knowledge and learning. Of the same sort is the stricture upon the extempore verses of this treatise, which, far from being an argument against it, I take to be the most genuine mark of the age to which it pretends. When, in a written composition, the distinction of prose and verse was of a short standing, what we here call extempore verses, which are so often interspersed in the works of Herodotus, and the oldest of the Greek writers, I suppose to have been quotations from that period of knowledge previous to the common use of writing, when prose was confined to conversations, and all compositions were in metre, that they might be more easily remembered." In this life of Homer, attributed to Herodotus, the name of the poet's mother is said to have been Critheis, a native of Smyrna: he was the offspring of illegitimate love.

> "No sickly fruit of faint compliance, he
> Stampt in the mint of Nature's ecstacy."
>
> SAVAGE.

Critheis had been left an orphan. Her tutor, whose name was Cleanax, having disgraced her for her frailty, she was obliged to fly from her native place, and, after wandering for some time, arrived at the banks of the river Meles. There she was delivered of the infant, who, from the place of his birth, was called Melesigenes, a name which he bore till it was changed to Homer after his blindness. Phemius, an inhabitant of Smyrna, who taught music, took the unfortunate mother into his house, married her, and adopted the child Melesigenes. The youth for some time assisted them in the school of music, but after their death was seized with a desire of seeing foreign countries, and embarked with a Phenician shipmaster. Among other places, he arrived at Ithaca, where he learnt the adventures of Ulysses; but his stay was unfortunately prolonged till he was struck with ophthalmia, which the ignorance of a pretender to the healing art soon made incurable. Already he had been a poet, and he now consoled his blindness by composing the Iliad. With this treasure in his memory, he wandered from place to place, and subsisted by reciting it. Universal tradition thus exhibits to us the greatest genius of antiquity as wandering about in blindness, and supported by the spontaneous kindness of those whom he visited. But the idea of such mendicity must not be confounded with the repulsive and squalid associations which the word beggary brings to the mind in our own artificial state of society, when disgrace covers the supplicant, and when the feeling of compassion carries contempt, and not kindness, along with it. In simple times, the traveller went abroad, and sought protection and food with the assurance, that, whenever he saw the human countenance, he should meet with the natural charity of the human heart. He made his way with confidence, for hospitality was the virtue and the point of honour of primeval society. A picture of such hospitality is given in the Odyssey, when Mentor and Telemachus arrive at the dominions of Nestor. The King, who knows nothing of the visitants, invites them to the royal table, and, not until he has feasted them, puts the question, "*Strangers, what are you?*" But Homer did not visit foreign countries with merely the common claims to hospitality, religiously respected as those claims were sure to be. He travelled in the character of bard and reciter, of which an image was renewed in modern Europe among the minstrels and the troubadours. Of the latter description of poets, we know that many held an honourable place at the most splendid courts, were the inmates of palaces, and the suitors of noble dames. The Greek itinerant bard, in times when books and writing were unknown, must have been a character not coldly respected as a stranger, but esteemed and beloved for his powers of entertainment. Poetry was then not only the ornament of sentiment and beautiful fiction, but embraced all that was the mental amusement, and all that could be called the knowledge of mankind. It taught them what they believed to be their history; celebrated their mythology; gave them romantic conceptions of the past and the present world; and gave additional pleasure to the heart, by the charm which it afforded to the ear. Such was the profession of the ancient poet; but which, nevertheless, though immeasurably removed above the contempt of contemporary society, must have been exposed to many incidental calamities. The very virtue of hospitality arose out of a state of society, that rendered travelling and navigation fatiguing and perilous. When the poet could only recite his works, the honours and caresses due to genius and originality alone might often be lavished on the least inspired of the profession, who drew their stores of entertainment from a memory tenacious of the compositions of others; and hospitable as the times might be, the general partiality of the undistinguishing multitude, for impudence and flattery, might often favour the mere pretenders to

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[*] *Essay on Homer.*

poetry, while the lofty mind of the true poet could not stoop to canvass for popularity.—In the life of Homer, already mentioned, we find the prince of poets encountering adversity in many shapes. At several places it tells us of his applying to the rulers of the state for maintenance at the public expence, and promising to immortalize their history by his compositions. If the author of the life, whoever he was, contrived those traditions, it is singular that he has told by anticipation a story so nearly resembling the fortunes of Tasso and of Dryden. Among the Phocians it is also related, that a perfidious brother poet, Thestorides, after having received Homer in his house, drew from him the story of the Iliad, and passed it off for his own. Homer, it is added, followed him to Chios, where Thestorides was reciting his works, and obliged the plagiary to fly from his presence. His kindest reception is said to have been at Chios, where, assuming gaiety from his easy circumstances, he composed the mock heroic of the Frogs and Mice. There, also, he married, and had two daughters, one of whom died a virgin, and the other is supposed to have perpetuated his race in the Homerides, who, for many generations, lived by reciting the Iliad and the Odyssey. On this account of Homer's residence in Chios, whether fabulous or true, are founded all the local traditions of places consecrated by his name. Among others, that of the hollow in the rock, which bears the name of his school, but which Tourneforte and Chandlers have so entirely discredited.

It is not known what separated Homer from his family, but he quitted Chios, according to this account, at an advanced age to recommence his wanderings. Those were principally at sea; and the knowledge which the poet displays of all the rude art that was known to the shipwright and seaman of ancient times sufficiently evince, that Homer had witnessed a considerable deal of navigation. Many of his voyages are said to have been disastrous; a circumstance which we can well believe, when we consider that the only ships which his experience enabled him to describe were destitute of anchors, and built without a nail of metal to secure them. An illness which at last seized him, obliged him to stop at the island of Ios, and there he died. Strabo, Pliny, Pausanias, Aristotle, and Aulus Gellius, agree with this account of the place of his death and interment. A tomb in that island was long celebrated as the depository of his venerated remains, to which the states of Argos sent a solemn deputation every five years to offer libations.

Such are a few of the traits of his life which are given in the work attributed to Herodotus. Among the places that have laid claim to the honour of his birth, Antimachus thinks that he was born at Colophon; Aristarchus, at Athens; Pindar, at Smyrna; Aristotle supposes that he was born, as well as that he died, in the island of Chios. Suidas assigns him to Cyprus, others to Pylos, Rhodes, Mycenæ, Ithaca, Salamis, and Argos. In fact, the guesses at his birth-place lead us pretty nearly over the whole map of Asia Minor, the Peloponnesus, and the Archipelago. Even Egypt has had its advocates for this distinction; so that the whole ancient world may be said to have claimed him. The poet Martial, when called upon for his opinion on the subject, could only reply in an epigram, that such a genius belonged to the world at large, and it is true that genius, like the light, belongs to all that can enjoy it; but unfortunately epigrams will not settle points of history. The Emperor Adrian applied to the oracle to solve the question, and was told that he was certainly born in Ithaca; but the oracle seems to have converted few to its opinion. The opinion of antiquity seems generally to lean towards either Chios or Smyrna having been his birth-place. Wood, who, after describing Balbec and Palmyra, travelled through Greece with the works of Homer in his hand, has adopted, as we have already mentioned, an ingenious mode of inferring from the landscapes and natural similes of the poet, the place in which Homer first received his impressions of the scenery of nature. "If we survey," says that traveller, "the map of the world with attention, I think we may discover that his first impressions of the external face of nature were made in a country east of Greece, at least as far as we may be allowed to form a judgment, from his describing some places under a perspective, to which such a point of view is necessary; as, for example, when he places the Locrians beyond Eubœa. This piece of geography, though very intelligible at Smyrna or Chios, would appear strange at Athens or Argos. His description of the situation of the Echinades beyond sea opposite to Elis, has something equivocal in it, which is cleared up, if we suppose it addressed to the inhabitants of the Asiatic side of the Archipelago. But if, with Mr Pope, we understand the words "beyond sea" to relate to Elis, I think we adopt an unnatural construction to come at a forced meaning; for the old Greek historians tell us, that those islands are so close upon the coast of Elis, that in their time, many of them had been joined to it by means of the Achelous, which still continues to connect them with the continent, by the rubbish which that river deposits at its mouth. I think I can discover another instance of this kind in the 15th book of the Odyssey, where Eumæus, the faithful servant of Ulysses, is described entertaining his disguised master with a recital of the adventures of his youth. He opens his story with a description of the island of Syros, his native land, and places it beyond or above Ortygia. Now, if we consider that Ithaca was the scene of this conference between Ulysses and Eumæus, it will appear that the situation of Syros is very inaccurately laid down; for in reality this island, so far from being placed beyond or farther from Ortygia, should have been described as nearer to it. An ingenious friend thinks that καθυπερθεν may relate to the latitude, and that Homer meant to describe Syros as north of Ortygia; but I cannot help thinking that the application of high to northern latitudes, is much later than Homer.

As therefore the same description would have been perfectly agreeable to truth had it been made in Ionia, is it not reasonable to suppose that the poet received his early impressions of the situation of Syros in that part of the world, and had upon this occasion forgotten to adapt his ideas to the spot to which the scene is shifted. If my conjecture is thus far admitted, I beg leave to proceed to a farther use of it, in attempting to throw some light on this obscure expression τροπαι ἠελιοιο. It is important to that part of the poet's character now under consideration, to have his sense of these words restored if possible; for they have been urged as an argument of his gross ignorance of geography, by those who think they relate to the latitude of Syros, and that this description places that island under the tropic * * * * *. I beg leave to carry the reader for a moment to the Asiatic side of the Archipelago, in order to examine whether a view of the landscape under that perspective offers any appearances to which those words can be naturally applied without violence to their literal meaning. No part of our tour afforded more entertainment than the classical sea prospects from this coast and the neighbouring islands, where the eye is naturally carried westward by the most beautiful terminations imaginable, especially when they are illuminated by the setting sun, which shews objects so distinctly in the clear atmosphere, that from the top of Ida I could very plainly trace the outline of Athos on the other side of the Ægean Sea, when the sun set behind that mountain. This rich scenery principally engaged the poet's attention; and if we consider him as a painter, we shall generally find his face turned this way. In the infancy, and even before the birth of astronomy, the distinct variety of this broken horizon would naturally suggest the idea of a sort of ecliptic to the inhabitants of the Asiatic coast and islands, marking the annual northern and southern progress of the sun. Let us suppose the Ionians looking south-west from the heights of Chios at the winter solstice, they would see the sun set behind Tenos and towards Syros, the next island in the same south-west direction; and having observed, that when he advanced thus far he turned back, they would fix the turnings (*τροπαι*) of the sun to this point. I submit it as matter of conjecture, whether this explanation does not offer a more natural interpretation of the passage than any which has yet been suggested. In pursuance of the same method of illustrating Homer's writings, I shall draw some conjectures with regard to the place of his birth, or at least of his education, from his similes. Here we may expect the most satisfactory evidence that an enquiry of this obscure nature will admit. It is from these natural and unguarded appeals of original genius, to the obvious and familiar occurrences of common life, that we may not only frequently collect the customs, manners, and arts of remote antiquity, but sometimes discover the condition, and, I think, in the following instances, the country of the poet." After enumerating several similes to support his theory, the essayist proceeds to the following: "When the formidable march of Ajax is compared to a threatening storm coming from the sea, I must observe as an illustration, not of the obvious beauty of the simile, but of the poet's country, that this can be no other than an Ionian, or at least an Asiatic storm; for it is raised by a west wind, which, in those seas, can blow on that coast alone. When, again, the irresistible rage of Hector is compared to the violence of Zephyrus buffeting the waves, we are not immediately reconciled to that wind's appearance in that rough appearance so little known to western climates, and so unlike the playful Zephyrus of modern poetry. But before we condemn Homer as negligent of nature, we should see whether he is not uniform in this representation, and whether this is not the true Ionian character of Zephyrus. The very next simile of the same book is as much to our purpose, where the numbers, tumult, and eagerness of the Grecian army collecting to engage, are compared to a growing storm which begins at sea, and proceeds to vent its rage upon the shore. The west wind is again employed in this Ionian picture, and we shall be less surprised to see the same allusion so often repeated, when we find, that of all the appearances of nature, of a kind so generally subject to variation, there is none so constant upon this coast. For at Smyrna, the west wind blows into the gulf for several hours, almost every day during the summer season, generally beginning in a gentle breeze before twelve o'clock; but freshening considerably towards the heat of the day, and dying away in the evening. During a stay of some months in this city, at three different times, I had an opportunity of observing the various degrees of this progress, from the first dark curl on the surface of the water, to its greatest agitation, which was sometimes violent. Though these appearances admit of variation, both as to the degree of strength, and the precise time of their commencement, yet they seldom entirely fail. This wind, upon which the health and pleasure of the inhabitants so much depend, is by them called *inbat*. The Frank merchants have long galleries running from their houses, supported by pillars, and terminating in a chiosque or open summer-house, to catch this cooling breeze, which, when moderate, adds greatly to the oriental luxury of their coffee and pipe. We have seen how happily the poet has made use of the growing violence of this wind, when he paints the increasing tumult of troops rushing to battle, but in a still, silent picture, the allusion is confined to the first dubious symptoms of its approach, which are perceived rather by the colour, than by any sound or motion of the water; as in the following instance. When Hector challenges the most valiant of the Greeks to a single combat, both armies are ordered to sit down to hear his proposal. The plain thus extensively covered with shields, helmets, and spears, is, in the moment of this solemn pause, compared to the sea, when a rising western breeze has spread a dark shade over its surface. When the reader has compared the similes I have pointed out with the original materials which I have also laid before him, I shall submit to his consideration, as a matter of doubtful conjecture, whether the poet, thoroughly familiarized to Ionian features, may not have inadvertently introduced some of them in the following picture, to which they do not so properly belong. When Eidothea, the daughter of Proteus, informs Menelaus at Pharos, of the time when her father is to emerge from the sea, the circumstance of Zephyrus, introduced in a description of noon, darkening the surface of the water, is so perfectly Ionian, and so merely accidental to the coast of Egypt, that I cannot help suspecting the poet to have brought this image from home."

That the Iliad displays abundance of geographical knowledge, is certainly no internal proof either for or against its being the work of one individual; but if we suppose it to be the work of a single genius, upon the grounds of that mind alone which had conceived so lofty a plan, being able to accomplish its magnificent execution, we shall find in the geography of its author unquestionable proofs of his having been an extensive traveller. Strabo has left a commentary on the geographical parts of the Iliad and Odyssey; and others, such as Apollodorus and Menogenes, wrote on the same subject, though unfortunately only the titles of their works have reached posterity. Homer, in the midst of all his splendid machinery, was regarded as so faithful a painter of real existence, that his catalogue of the Grecian forces was respected as a valuable record in ancient Greece, and appealed to by its jurisprudence. In some cities it was enacted by law, that the youth should get the catalogue by heart. Solon, the lawgiver, appealed to it in justification of the Athenian claim against the pretensions of the Megareans, when the right to Salamis was so warmly contested by Athens and Megara. And the decision of that matter was at last referred to five Spartan judges, who, on their part, admitted the nature of the evidence, and the affair was accordingly determined in favour of the Athenians. Three other litigated cases of property and dominion are said to have been determined by reference to Homer's geography. In Homer's age there was no other way of acquiring knowledge but by travelling. To the curiosity respecting his own species, which must have possessed the ardent mind of the poet, and impelled him to brave the dangers of sea and land, the veracious Strabo adds another very probable motive of his travels, which was the wish to make his fable accord with the mythology of the people whom he introduced on his scene of action. For this purpose, says Strabo, he consulted the religious records and the oracles that were suspended in the temples. At that period there were hardly any other historical monuments known. The priests held the sceptre of public opinion, and all history was consigned to the oracles. Diodorus says, that Homer visited the isle of Delphos. After the second sacking of Grecian Thebes by Alcmeon, the prophetess Manto, daughter of the famed Tiresias, had been sent to Delphi as making part of the spoils, where she acquired great renown by her talent for composing oracles. The meeting of Homer with such a lady is interesting to the imagination. Homer, says the historian, borrowed some striking verses of the oracle, either as ornament or authority to give weight to his works.

It would be curious to ascertain in what state Homer found the poetry of Greece when he commenced his career; but the question is involved in almost impenetrable obscurity. While he is hailed as the father, he was certainly not the inventor of poetry. According to the Greek library of Fabricius, there were seventy Greek poets anterior to him. The greater part of them were musicians. Among these Linus is cited, who, it is said, rehearsed the first expedition of Bacchus and Orpheus, who sung the Argonautic expedition. The assertion of Suidas, that Homer drew his story of the Iliad from that of Corinnos, who composed it during the Trojan war, seems to be only the dream of a lexicographer. Tzetzes, a versifier of the 12th century, who made a commentary upon Lycophron, and a bad poem called the Chiliade, would have us believe that Homer borrowed his Iliad from Dictys Cretensis, a writer to whom a manuscript certainly most ancient, but not original, was ascribed, which was found in the reign of one of the Cæsars, in a tomb that was thrown open by an earthquake. When we are told that Dictys followed Idomeneus to the siege of Troy, and wrote a history of it in prose, we have quite enough of this phantom gazetteer. The story of Homer's purloining a manuscript poem from the priestess of Delphi, which is gravely repeated by Ptolemy Ephaestion, is almost too ridiculous to be worth noticing; and we are almost ashamed to mention another hypothesis, which has found an advocate in the absurdity of modern times, viz. the theory of Bryant, which supposes Homer to have found the materials of his Iliad in a temple of Egypt, and to have allegorized the contents under the fiction of Grecian names. According to this reverie, for it merits not the name of a theory, Menelaus, Agamemnon, Helen, &c. were all fantastic personages drawn from Egyptian theogony, and naturalized in Greece. Menelaus is evidently the Pharaoh Menes; Agamemnon is the Turkish word Aga prefixed to Memnon, whose harp resounded at the touch of the rising day. The wealthy Mycene never existed but in the vanity of Thucydides, and the credulity of Herodotus. Troy never existed but on the shores of the Nile. The historical part of this hypothesis is quite upon a par with its etymology, which, with its Agas and Memnons is not so diverting, but equally credible with Swift's derivation of Hector, Ajax, and Alexander.

The epoch of Homer has been not less a subject of disputation than his country. Herodotus says in his Euterpe, that he lived 400 years before his own (the historian's) time. In the chronicle of the Parian marbles, Homer is said to have been in his highest renown at the year of the chronicle 675, which would place the date of the Iliad 2707 years from the beginning of the present century; but venerable as the authority of the Parian marbles may appear, they seem to assign a later date to the great poet than his writings, and the manners of society which he describes, render probable. It is more consistent with his writings to suppose, that he was born not long after the siege of Troy, and that he had finished both his poems half a century after the town was taken. As the first interesting stories he heard when a boy were those of the exploits performed in the Trojan war, in his riper years he had still an opportunity of conversing with the old men who had been engaged in it. Their immediate descendants would, according to this supposition, be his contemporaries; he might know their grandchildren, and live to see the birth of the fourth generation. It is true, that this hypothesis makes the birth of Homer prior to the Ionian migration, which Thucydides places 80 years after the siege of Troy; but in this there is no solid objection, as we know that there were Ionians in Asia prior to the colony of that name being brought thither. The circumstance of Homer ascribing double the strength of modern men to one of the heroes of the Iliad, is no decisive proof that he looked back to a very distant period. Such fanciful exaggerations of the strength of men's immediate ancestors may be found in many romances of the middle ages, that must have been composed within fifty years of the lifetime of those personages to whom the poet ascribes a size and strength surpassing sober belief. The account which Homer gives of the family of Æneas continuing to reign over the Trojans after the Greeks had demolished Troy, though at variance with Virgil's fable, (a circumstance of no great consequence as to its credibility,) has all the air of having been drawn from contemporary information. Such an account of the family of Æneas it would have been difficult, as well as useless, for Homer to have forged. Now the succession of Æneas's great-grandchildren to the kingdom of Troy is the latest fact which the poet has left on record. The Æolian migration most probably disturbed that very generation in their possessions; and from Homer, who is ever minute in his historical accounts, being silent respecting such a disturbance, it may be inferred, that he did not live to be acquainted with it. The other and later era which has been assigned to our poet, makes him contemporary with Lycurgus, and, connected with it, there is a tradition of Homer and the lawgiver having met in the island of Chios. But the picture of society which Homer exhibits does not accord with this tradition. When we look to the verisimilitude of his descriptions, we must believe that he painted the natural world and all its manners from the life. There is no trace of his affecting to give it an antiquated air, or of wishing, as a modern poet would probably be inclined to do, to study simplicity of objects for picturesque effect; on the contrary, whenever he luxuriates in description it is in painting artificial objects. Those who bring down Homer, therefore, so low as the time of Lycurgus, seem to forget that such a poet and such a legislator belong to different states of society. It has been questioned, and indeed it appears more than questionable, if the art of writing was known in the days of Homer. If we consult the poet himself upon this question, we shall find that in all his comprehensive picture of civil society there is nothing that decidedly conveys an idea of letters, or of reading. The words Σηματα λυγρα, it is true, in the letter mentioned in the Iliad, which Bellerophon carries to the king of Lycia, have been quoted as a proof of alphabetical writing; but the generality of the term has much more the appearance of merely symbolical signs, or hieroglyphics, than of what we call writing. That such symbolical marks of thought were known in the rudest ages, there can be no doubt; and what has been already alluded to in the travels of the poet as a possible and even probable fact, namely, his consulting the records of different temples, must be taken with this understanding, that such records were, in all probability, also symbolical or hieroglyphical. The introduction of prose writing into Greece took place at so late a period, as to leave it by much the more probable supposition, that alphabetical writing was unknown to Homer; for when prose writing is of recent date, the alphabet cannot have been long in use. Homer, therefore, there is every reason to think, could neither read nor write; he recited his own works from memory, and hence it is little wonderful that he addresses the Muses as the daughters of that faculty of the mind. In modern times, when the memory is at once distracted by so many pursuits, and obliged to lean on so many artificial assistances, we are apt to under-rate its powers when employed upon a single object, and trained by habitual exercise upon that object. To an ancient poet like Homer, his memory was not only the mother of his muse, but his constant and indispensable guardian. The rhapsodists also preserved his works by oral tradition; and if their subsistence depended in a profession where there were rivals to detect the errors of each other, upon the accuracy with which they recited those poems, they were perhaps more safe from corruptions and interpolations, or at all events from omissions in recitation, than we might be apt to imagine, by ascribing the same lax exertions of memory to those reciters, which arise in modern times from the constant reliance upon writing. It may be doubted whether the rhapsodists made such havock in the sense of Homer, as the perverted ingenuity of *writing* commentators has made in that of Shakespeare.

Lycurgus, the legislator of Sparta, is said to have been the first who collected the fragments of Homer's poetry during his travels in Asia Minor, and on his return by the island of Chios. Three hundred and seven years afterwards, Pisistratus, who erected at Athens the first public library that is mentioned in Grecian history, gave directions to a body of the learned for preparing an edition of the poet more correct than that of Lycurgus, and Solon and Hipparchus are said to have assisted in the undertaking.* At the destruction of Athens, in the invasion of Xerxes, the Iliad and Odyssey were taken from thence, and conveyed to Persia; and the despot himself seems to have respected this monument of taste and genius, since a part of the collection was found at Susa during the conquests of Alexander. It is perhaps to this epoch that we may assign the edition of the Odyssey which was rectified by Aratus, and which bears the name of the Aratæan edition. Alexander's enthusiasm for the memory of Homer is one of the noblest traits of his character. He charged Anaxarchus and Callisthenes to revise the copies of Lycurgus and Pisistratus; and Aristotle put the last hand to this precious edition, called the edition of the casket. After the battle of Arbela, when the conqueror had found, in the tent of Darius, a casket of gold, enriched with stones of inestimable value, he there deposited the two poems of Homer, and laid the treasure along with his sword every night under his pillow. After the death of Alexander, Zenodotus of Ephesus was charged, by the first of the Ptolemies, with the task of revising the edition of the casket. The last edition belonging to this period of high antiquity is that which Aristarchus, the greatest critic of his age, published under the auspices of Ptolemy Philometer, about nineteen centuries and a half ago, and which has served as a model for all collections of the works of Homer both in the middle ages and modern times.

The first edition of Homer since the invention of printing, was that of Demetrius Chalcondyles of Athens, and of Demetrius of Crete. It is entirely in Greek, is very magnificent, and now exceedingly scarce. It appeared at Florence in December 1488, in one folio, and had been collated with the commentaries of Eustathius. It was not till half a century after, that the works of Homer appeared again in Greek, with the entire commentaries of Eustathius.† This edition, the only complete one of the commentary of Eustathius, had long been regarded as a *chef d'œuvre* of sound criticism and correctness, till the learned discovered innumerable faults in it, by comparing it with MSS.; and the improvement of taste at last threw contempt on the barren prolixity of the commentary. Six years after the Roman edition of Eustathius, there appeared at Leyden the first esteemed edition of the prince of poets, that had a Latin version. It contained also the scholia of Didymus, a commentator assigned to the age of Augustus. We notice here only those editions which may be said to form an epoch in the illustration of Homer. Joshua Barnes brought out at Cambridge the Greek and Latin texts of Didymus, with his own commentaries. The edition of Samuel Clarke appeared at London in 1734; that of Ernesti at Leipsic in 1764. Villoison, who was sent to Venice by the French government to collect ancient relics of literature, found in the library of St Mark, an unique copy of the Iliad of the 10th century, with the remarks of sixty of the most famous critics of antiquity, such as Aristarchus and Zenodotus. It appeared, that this manuscript had been made from a copy in the library of the Ptolemies that was burnt by the barbarian Omar. Villoison remained two years at Venice to copy it with his own hand, and printed it in a folio volume, entirely Greek. As the original possessor of this literary treasure had joined to it many various and lost editions of the poet, this publication of Villoison may be called the *Homeri variorum* of antiquity. Wolff and Heyne are the two latest editors of Homer. Their merits have been so frequently treated of in the reviews and literary journals of our own time, that we forbear to descant upon them.

The memory of the great poet has received not only the homage of commentators and editors of his works,

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* Diog. Laert. Plut. in Hipparcho.

† With the following title, *Homeri Ilias et Odyssea, Græce,* cum *Commentariis Græcis Eustathii, Archipiscopi Tessalonicensis; Romæ, apud Bladum et Giuntum,* 1542 and 1550, 4 vols. in folio.

but of travellers, who have carried the reader's imagination to the scene of his action. Among these may be noticed Tournefort, the French naturalist, who understood the classical as well as his favourite vegetable world. Richard Pococke also carried his researches into Greece, though with less satisfaction to the public curiosity than into other quarters. Lady Mary Montague visited the Troad, though somewhat hastily, and saw, or imagined that she saw, the tomb of Achilles. Doctor Chandler visited Asia Minor and Greece in 1764-66, and made some conjectures that have not received much credit. In conjecturing the exact situation of Troy, and of the scene of Homer's travels, modern travellers have not been more successful than the ancients. Wood, who, on many points, makes ingenious and probable conjectures, is far from having settled the controversy of the Troad; and Chevalier and Gell, who succeeded him in the same attempt, have been less learned and much more gratuitous in their suppositions. To the real admirer of Homer the controversy will probably appear of less importance than it has been made. For the difficulty of finding, at the end of 3000 years, the site of a town, of which an ancient poet says, that, in his own time, the very ruins had disappeared, (*etiam periere ruinæ*,) there is surely an apparent and sufficient reason in the changes and ravages which 30 centuries can produce. By such a difficulty, no sober mind would consider itself bound to adopt the wild idea, that no such war as the Trojan ever existed; although that supposition would render the Iliad a much more astonishing production than it really is.

The critical judgments that have been passed upon Homer would fill entire libraries. Horace assigns him a place as a moral teacher above Chrysippus and Crantor, the leaders of the two most famous schools of philosophy. Porphyry, in later times, composed a treatise on the philosophy of Homer. On the other hand, Pythagoras has condemned him to Tartarus, for having imparted false notions of the Divinity, and Plato banished him from his ideal republic. Yet amidst the abstracted and elevated ideas of the latter philosopher, it is easy to perceive the most forced and sophistical reasons in his motives for condemning the poets, and he even redeems our opinion of his taste by the manner in which he ordains this banishment to be put in force. Plato, it should be recollected, admits in nature only two existences, the original idea, and the being which is the resemblance of or copy of that idea. By the original idea he understands God, or the Divine thought, and by the other existences all the forms which God created conformably to his own conceptions. All objects being then only copies of this first model, the arts which imitate them produce only copies of copies, which can serve for no good purpose. If then, says Plato, (speaking of his own ideal republic, which can hardly be called even the copy of a copy,) a poet should present himself amongst us who knows how to express every thing in nature by imitation, we should testify our veneration for him as for a sacred person, who deserves to be admired and cherished; but we should tell him that our political economy did not admit of such persons among us, and we should send him to another city after having sprinkled him with perfumes, and crowned his head with flowers. It must be owned, that even the vanity of a poet could hardly be offended with such a sentence. When Plato comes to speak of Homer himself, it is with the deepest reverence for his genius. He owns that the respect and love which he has felt since his infancy for his writings almost arrests his tongue from condemning him, and that he considers him as the maker of all poets who have succeeded him, particularly those of the drama. After this apology, he demonstrates at great length that the gods of the Iliad are calculated to give us unworthy notions of divinity, a fact which, *philosophically* considered, it is not very difficult to prove. To exculpate Homer from this heavy charge, both his ancient and modern admirers have recourse to allegory; and in this system of explaining the Iliad, have mixed a vast deal of absurdity with a very small portion of truth. It is true that there was allegory and emblem both in ancient religion and philosophy; and some of the fictions of Homer carry their allegorical meaning in their appearance. But to see nothing in the whole Iliad but moral abstractions personified, is an idea as intolerable to common sense as to poetical feeling. Such a forced explanation of the Iliad would after all leave the poem quite as immoral as it is in its plain interpretation. Suppose we take Jupiter for the power of God, Destiny for his will, Juno for his justice, Venus for his mercy, and Minerva for his wisdom, we shall still find the theology of Homer as defective as if we take things as they are in the Iliad, that is, if we understand his deities to be influenced by the passions of men. Homer painted the gods just as the vulgar belief represented them. It was impossible for him to have done otherwise, for he could not create a new religion; but if we could suppose it possible for him to have surpassed the limits of human intelligence, and to have anticipated the higher notions of Plato respecting the divinity, it would not have been his interest as a poet to have refined his mythology into the pure theism of the philosopher. The moment that he had ceased to consider the inhabitants of Olympus as impassioned beings, there was an end to all our interest in their actions. Divinity, in its true attributes, is not a subject for romantic fable.

The touch-stone of more recent refinement in sentiment and manners has been applied with the same absurdity to his heroes, as the standard of pure theology has been to his divinities. In the times which he described, the power of a man's body constituted the greater part of his estimation in society. He who could support the heaviest load of armour, and who could give and take the hardest blows, was a formidable man or a hero. When this superiority was once recognised, it established his rank in exact comparison with others; and hence it is so common in Homer's heroic descriptions to hear a warrior of acknowledged bravery confess that another is superior to him. At present the equality of arms and the principle of honour would make a man ashamed of such a confession. But in Homer, Æneas says without shame to Achilles, "I know that thou art more valiant than me," which is, in other words, "I know that thou art stronger." Æneas adds, "*but, however, if some god protects me, I shall be able to conquer.*" And this is a general principle, which to a certain extent may be said to constitute all the morality of the Iliad, namely, that power, success, and wisdom, all come from the gods. When Agamemnon excuses his outrage upon Achilles, he says that some god had disturbed his reason. It is the protection of this or that divinity that gives the Greek and Trojan heroes each a triumph in his turn; it is the gods who spread consternation among the armies, or inspire them for the combat; but we must not regard this intervention of the deities as diminishing the glory of the successive warriors. We see clearly that Homer does not lessen their importance on that account. On the contrary, the epic spirit of the piece is heightened by this machinery, because it is clearly perceived that the heroes thus favoured of heaven, rise in the opinion of their associates and adversaries on that account. Achilles excepted, there is not a hero of the Iliad who does not at some time or other retire before another. What distinguishes the bravest, such as Ajax and Diomede, is, that they fight as they retreat. And it may be observed, to the glory of Homer, that, in spite of this divine intervention, which we might expect to confound all distinctions of human bravery, he still preserves the distinctive character of greatness in his heroes, even when yielding to supernal influence.

It is a singular trait in the Iliad, that the sullen rest of its hero Achilles should form the main-spring of the action. His absence appears to be the cause of the disasters of his countrymen, which prolong the contest. This, so far from being a defect in the plan of the action, is an artifice which carries internal evidence of the whole plan being the invention of one great mind; all the prowess of the successive agents that are described, ministers to the ultimate triumph of him by whom Hector is to fall. In the fire and spirit of this ancient hero, Homer has not certainly left what it would be absurd to seek for in ancient poetry, a model of pure morality; but he has consummated the picture of all that must have commanded the respect of warlike and barbarous times, and has in fact pourtrayed a being that would, under different circumstances, in all ages predominate over the rest of his species, by his pride and energy. It may be necessary to notice the vulgar tradition of his being invulnerable all over but in the heel; but Homer does not debase the courage of his hero by such a fable: nor is his character of stern pride unrelieved by circumstances that touch us with an interest in his fate. His youth, his beauty, his maternal descent from a goddess, the certain prediction that, while he could find no conqueror, he was one day to perish in the Trojan war, prepare us for the part of no vulgar hero.

To enter on a minute criticism of the Iliad would far exceed our limits. The most superficial readers are probably acquainted with the hackneyed objections that have been made to its prolixity of speeches and military details, to the minuteness and surgical description of wounds, the ferocity of its manners, and the abusive epithets which the heroes exchange when they quarrel. The French criticism of La Motte and Perrault has gone even so far as to blame the simplicity of its manners, and to throw contempt on Achilles for cooking his own dinner. The majority of those objections are frivolous. It is true that the primitive abundance of expletives, and the Greek loquacity of Homer, may at times be excessive; but the dramatic air which the constant dialogue gives to the Iliad, would be ill exchanged for the conciseness of mere narrative. The diversity of Homer's battles, as an eminent critic has observed, shews an invention next to boundless; the technical terms of the wounds that are described, appear technical to us, only because the language of science is derived from Greek; and the fastidious taste that is offended with the bold simplicity of ancient manners, would with equal propriety find fault with Salvador Rosa for not having adorned his mountain scenery with terraces and gravel-walks. Achilles cooking his dinner is certainly a considerably more poetical personage than Louis the XIV. would have been if La Motte had made him the hero of an Epopee, treading on a velvet carpet, and commanding the Maitre d'hotel to prepare his fricasees.

The excellencies of the Iliad, independent of the beautiful and sonorous language to which it belongs, may be summed up in the vastness and variety of the picture of existence which it spreads before us; the spirit and perpetual motion of its agents; the relieving interchanges of an interesting inferior world, and a heaven of voluptuous and gay mythology; the progressive swell and importance of the story; and the art with which the very rest of Achilles is made subservient to the evolution of his grandeur; the full physiognomy of human character displayed in every age and situation of life; the unstudied strength of his circumstances in description; and the contagious spirit with which he seizes the mind to sympathy with his martial passion: Such an apocalypse of life, from its sublimest tumults to its minutest manners, was never communicated by another human imagination.

If Homer has erred at all, it is from the wealth, or rather from the pathos of his genius, in giving so strong a countervailing interest to the character of Hector. This unquestionably diminishes our exultation in the triumph of Achilles. Yet who would wish that fault undone? Here is the generosity of genius, even in the poet, scorning the bigotry of national hatred that would depreciate the heroism of an enemy. It is, perhaps, repeating superfluously, what few have to be told, that the character of Achilles, so unlike the *inexorabilis acer* of Horace, has a relief of the noblest traits of compassion and generosity amidst the fury of his savage passions. The concluding book of the Iliad teems with the most touching circumstances of his generosity. He receives King Priam, joins him in his tears at the recollection of their respective losses; perfumes the body, and orders it to be kept out of the father's sight, lest it should shock the grief of the king; places it himself in a litter, fearing that Priam might burst into a fit of exasperation, and should exasperate himself also; and, finally, refreshes him with food and sleep in his tent, and takes him by the right hand as a friend. In recognizing such traits of compassion in the proverbially savage Achilles, one is tempted to believe, that humanity is not so modern a virtue as some would have us believe.

The Odyssey speaks less to the imagination than the Iliad, but it introduces us to a still more minute and interesting view of ancient manners, and it awakens with deeper effect the softer passions that appear but rarely in the other poem. It is strange, that La Harpe, who redeems much of his bad French taste by an apparently sincere enthusiasm for the genius of Homer, should say, that the Odyssey is devoid of the eloquence of sentiment. If by sentiment we mean the sickly misanthropy, or the rampant enthusiasm which distinguishes so many modern productions, there is certainly nothing of the kind in the Odyssey; and the difference of circumstances in which human nature was then placed, must be fairly estimated,* before we can even

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* Many Oriental countries retain to this day manners of society nearly similar to those described in the Odyssey. There is nothing more remarkable in those manners than the degree of refinement to which profound dissimulation is carried in all ranks. The stranger accommodates his language much less to his own sentiments, than to his hopes and fears, or the countenance of those he meets. The arts of disguise are, in those countries, the great arts of life; and the character of Ulysses would form a perfect model for those who wish to make their way with security and respect. Cruelty, violence, and injustice, are also so evidently the result of defective

pardon many maxims of moral conduct which Ulysses practically avows: but if by sentiment we mean the unsophisticated feeling of the heart, where, it may be asked, shall we find it, if it is not found in the pathetic situations of Telemachus, the conjugal love of Penelope, and the return of Ulysses to his home, with all the circumstances that attend it, his aged dog expiring with joy at his feet, and his father relating to him, while he retains his disguise, all the little circumstances of his childhood that could awaken his tenderest associations.

Besides the Iliad and Odyssey, Homer is said to have composed another poem, entitled *Margites*. It is now lost. It is said by some to have been a comedy; but, from some verses in the contest between Homer and Hesiod, it may be rather conjectured to have been a piece of mockery and satire. Margites is the name of a person in a verse that is preserved by Plato, who is described as knowing many things, and knowing nothing well. Such a character may have been the original hero of Homer's satire, and been thus damned to everlasting memory, like the Mac Flecknoe of Dryden. The little mock heroic of the *Battle of the Mice and Frogs*, is well known, from Parnell's translation, to the English reader. Professor Heyne supposes it spurious, because he finds scarcely any verses in it that breathe the spirit of Homer; but this is no decisive argument, as Homer might be the worst of all parodists, though the best of original poets. The hymns attributed to him deserve more attention, as, along with those of Callimachus, they form a curious historical monument of the popular superstitions of antiquity. Unfortunately, in the numerous collection of them which Clarke's *Homer* exhibits, there is only one perhaps, viz. the *Hymn to Apollo*, which is not apocryphal; and the scholiast of Pindar throws doubts even upon that one. But Thucydides recognised in that ode the touch of Homeric genius, and the suffrages of a scholiast has certainly no right to be put in competition with that of so elegant a writer. As to the epigrams that have been occasionally ascribed to him, they carry internal proof of their spuriousness. (e)

HOMICIDE, (*Homicidium*), in law, is the killing of any human creature. This act is of three kinds, according to the circumstances in which it is perpetrated, viz. *justifiable*, *excusable*, and *felonious* or *culpable*.

Homicide is *justifiable* when the act is committed under some unavoidable necessity, and infers no degree of guilt or blame; as, for instance, by virtue of such an office as obliges one, in the execution of public justice, to put to death a malefactor, who hath forfeited his life by the laws and verdict of his country. This act is also considered justifiable in some cases, either for the advancement of public justice, or for the prevention of some atrocious crime.

Homicide is *excusable*, when a person engaged in a lawful act is, without intention, the cause of another's death. Excusable homicide is of two kinds; either *per infortunium*, by misadventure, or *se defendendo*, in self-defence, including homicide upon *chance-medley*, whereby a man kills another, who assaults him, in the course of a sudden brawl or quarrel.

Felonious or *culpable* homicide has different degrees, which distinguish the offence into *manslaughter* and *wilful murder*; in the last of which, the act, being committed from malice and forethought, admits of no defence, and subjects the criminal to the highest punishment of the law. See Blackstone; Erskine; and Hume *On Crimes*. (z)

HOMOLOGOUS SIDES and ANGLES. See GEOMETRY, vol. x. p. 214, col. 1.

HOMOPHONI, in music, denotes the unison whose ratio is 1=1, and whose expression in Farey's notation is 0. See FIRST *Minor*.

HONAN. See CHINA, vol. vi. p. 214, col. 1.

HONDURAS, or HIBUERAS, a maritime province of the Spanish kingdom of Guatimala in America, which the Spaniards calculate to extend 185 leagues from north to south, and 50 from east to west. The surface is in general mountainous, and is intersected by deep vallies, conducting numerous rivers down to the sea; but part of the coast is extremely low and marshy. A hot and humid atmosphere renders the province unhealthy, unless on the shore, where regular breezes refresh the inhabitants; and here epidemical diseases rarely prevail. Thunder showers are frequent during the warmest season, sometimes raging with great violence. This province is penetrated by a large bay, called the Bay of Honduras, to which our notice shall be more particularly directed: the coast abounds in dangers to the mariner from rocks and shoals; and all along its margin are keys, that is, peninsulas or promontories, between creeks and the mouths of rivers. These keys are known by different names, as St George's key, Turneff key, Ambergrease key, and the like; and some of the islands pass by the same denomination.

Climate.

Natural productions.

Some authors affirm, that gold and silver are found in Honduras; but, according to the late traveller Humboldt, it scarcely presents any metallic mines. Vegetation is in remarkable luxuriance, and the plants numerous and diversified. Grapes are produced twice a year from the vines; sugar canes, coffee, cotton, and indigo, are abundant, and also grain of several kinds; but the inhabitants are too indolent to avail themselves of the benefits of nature. The most important plants, in a commercial view, are mahogany and logwood; the former is employed for all descriptions of furniture in Britain and America, and the latter for dyeing. Chiefly for the purpose of obtaining these two commodities, a British settlement has long been established in the Bay of Honduras; and a vast quantity of the former is exported annually. The mode of procuring it, is to dispatch a skilful negro to climb the highest trees on lofty places, for the purpose of discovering mahogany in the woods, which is generally solitary, and visible at a great distance, from the yellowish hue of its foliage. A gang of from ten to fifty slaves is then sent out to erect a scaffold around each tree that is select-

Mahogany.

government, that it is unnecessary to look for any other general cause of the scenes of this sort with which Homer abounds, in common with other ancient writers, and agreeable to the present manners of those countries. For, when every man is, in a great measure, judge in his own cause, vices of this class are not only more frequent, but, in *foro conscientiæ*, less criminal than in a civilized state, where the individual transfers his resentments to the community, and private injury expects redress from public justice. Where the legislature does not engage for our personal security, we have a right to use such means as are in our power to destroy the aggressor who would detroy us. In such cases, bodily strength and courage must decide most contests, while, on the other hand, craft, cunning, and surprise, are the legitimate weapons of the weak against the strong. In the heroic times, homicide was so common, that we see the poet alluding to a fugitive murderer taking shelter under the roof of a stranger, (to escape, not public justice, but the revenge of the relations of the deceased,) as a familiar occurrence in life.

Mahogany. ed, and to cut it down about twelve feet from the ground. When felled, the logs are, with much labour, dragged to the banks of the streams, and being formed into rafts sometimes of 200 united, are floated as many miles, to places where the rivers are crossed by strong cables, and then the owners separate their respective shares. It is said that the boughs and limbs afford the finest wood, but in Britain mahogany is more valued on account of size; and none is allowed to be exported to the United States of America exceeding 20 inches in diameter. **Logwood.** The logwood, on the other hand, affects low swampy grounds, growing contiguous to fresh water creeks and lakes, on the edges of which the roots, the most valuable parts of the wood, extend. It is sought in the dry season, and the wood-cutters having built a hut in the vicinity of a number of trees in the same spot, collect the logs in heaps; and afterwards float up small canoes in the wet season, when the ground is laid under water, to carry them off. This is considered a very unhealthy employment.

Animals. Many wild animals inhabit the province, among which are two kinds of tiger as generally described; but they are more probably of the leopard species, the Brasilian and black tiger. Both of them are fierce; they are said sometimes to attack man; but their depredations are chiefly confined to cattle. The tapir, which is nearly the size of a small cow, is reputed to inhabit the thickest parts of the forests in the neighbourhood of creeks and rivers, and is very rarely to be seen by day. There are different kinds of wild hogs, three species of the armadillo, and numerous monkeys. Of birds may be named the turkey, concerning whose native country naturalists have expressed doubts, but here it lives in pairs in the most sequestered recesses of the woods, and cannot easily be taken alive. It never survives in captivity, and the young hatched from eggs, generally wander away to the original haunts of the mothers. The toucan, oriole, macaw, and pelican, are common. A great quantity of honey and wax are obtained from the bees of this country, which construct their combs in holes of the earth. The rivers abound in fish; and the manati and turtle are the constant objects of pursuit on the shores.

Inhabitants. In regard to the inhabitants of Honduras; the total population of the province, consisting of natives, Americans, Spaniards, and English, with African slaves, is said to have diminished. We are quite ignorant of any calculations as to its amount; but that of the British settlement in the Bay of Honduras, is computed at about 3700 or somewhat more, of which there are 200 white inhabitants, rather more than 500 people of colour and free blacks, and 3000 negro slaves. Neither are we acquainted with the precise geographical limits of the settlement, or the number, extent and position of the towns belonging to the Spaniards. Formerly the principal English establishment was at St George's Key, which is a healthful and agreeable situation, still containing a number of good houses, but now it is at Balize, a town at the mouth of a river of the same name, called Wallix by the Spaniards. It consists of about 200 houses, many of which are spacious and well finished; all are built of wood, and for the most part raised 8 or 10 feet from the ground on mahogany pillars. An agreeable and picturesque effect is produced by groups of lofty cocoa trees, and the foliage of the tamarind thickly interspersed, while they afford to the inhabitants a grateful shelter from the fervour of the sun. This town is accessible to an enemy only from the sea; for it is totally environed behind by a morass, extending many miles into the country, which, during the rainy season, is nearly covered with water. A strong fort lately erected in a commanding situation guards the channel of approach; and the inhabitants have formed a militia as a farther means of defence.

Trade. The principal trade of the British settlement consists in the export of mahogany, logwood, and tortoise shell; while the articles of import are chiefly for the consumption of the settlers, being those of British manufacture, and salted provisions for the slaves. They also obtain cattle from the Spaniards, who, besides, carry on considerable traffic in cotton bed-covers, which are much esteemed in that province. The Bay of Honduras is reckoned a very favourable situation for trade; and the preservation of the settlement occasions no expence to government, as the revenue somewhat exceeds the expenditure.

History. During the last and preceding century, the coast and islands of Honduras were a great resort of pirates, who found sufficient subsistence and concealment to enable them to commit their ravages against defenceles vessels. On the largest island, called Ruatan or Rattan, about 30 miles long, rich and fertile, there is a small Spanish outpost; but, according to Philip Ashton's *Memorial*, it was uninhabited in 1723. Previous to the year 1763, English mercantile adventurers had established themselves on the coast, at which time the court of Spain admitted them to remain on condition that their fortifications should be demolished. However, all were taken prisoners or dispersed in 1782; and having been enabled to return in 1784, under a treaty with the Spanish government, they finally settled at Balize. Here they remained undisturbed until the year 1798, when the Spaniards having fitted out an armament, made an attempt to capture the town. They were speedily repulsed, and the colony has never since had to dread any enemy. See Alcedo *Diccionario;* Uring's *Voyages and Travels;* Ashton's *Memorial;* and Henderson's *Account of the Settlement of Honduras.* (c)

HONEY is a saccharine vegetable secretion, most abundant in the nectarium of flowers. Some authors consider it an elementary principle of all vegetables without exception: They suppose that it exists in every part of plants, and that their life is dependent on its presence. We do not know, however, that the saccharine matter of plants is universally convertible into honey. It is much more copiously diffused in certain flowers than in others, both of the same and of different species: in some it cannot be recognised, and the weather has always a powerful influence on its secretion. A hot and sultry atmosphere, charged with electricity, is considered most favourable to the production of honey. Honey seems to be of various quality, sometimes of a grateful taste and odour, sometimes pungent and bitter, or even of a deleterious nature, which probably originates from the flowers.

This substance appears in its sensible shape when collected by bees, a tribe of insects which may almost be considered as reduced under the dominion of man. But naturalists are not agreed whether honey undergoes a particular elaboration in their bodies, thence deriving its flavour and consistence, or whether it is merely collected and is still seen in its pristine state. A bee having entered a flower, apparently absorbs the liquid nectar by its proboscis, whence it is conducted to an intestinal sac exclusively appropriated for its reception, commonly called the honey bag. The animal is then plump and cylindrical, and returning to the hive, disgorges the contents into cells selected for that purpose. By repeated accumulations the cell is filled, and then sealed by concentric circles of the thin-

Honey,
Honiton.

nest wax, begun at the circumference and closed in the centre. There it is kept, as is supposed, for winter store; at least no other use is assigned to it: but we cannot be sufficiently reserved in classing distant anticipations among the instincts of animals. It is principally in the more civilized countries that bees are confined in hives. In many places, they form their combs in trunks of trees, and also in cavities of rocks, and the earth. In India, there is a species which constructs a single comb of very large dimensions, attached to the under part of the bough of a tree well sheltered. During winter, a great portion of the honey thus preserved, is undoubtedly consumed; and it is understood that the safety of an ordinary hive is endangered if there be a smaller quantity than twelve pounds at the end of autumn. Honey is supposed by some of the most acute naturalists, as Huber, to contain the principles of wax, whence the bees are enabled to build their combs without collecting it from vegetables; and he describes a method of arranging a hive, whereby they may be forced to work in this substance. The relative proportions of honey and wax in a hive are not ascertained; the latest observations allot about three or four pounds of wax to one hundred of honey.

The finest honey is collected by swarms leaving the parent hive, and it always becomes darker and coarser in proportion to the age of the combs. Its quantity and quality, both depend very much on the nature of the surrounding vegetation; hence, in cultivating bees, particular attention should be paid to the abundance of flowers. Honey and wax are very considerable articles of traffic, and profit may undoubtedly be derived from bees with little trouble and trifling expence. Most part of the honey imported into Britain comes from Germany, Russia, and America, with which we could very well dispense by a little more attention to bees. Probably ten times the number of hives now existing could be subsisted in the country. Mr Huish, a late author, by a moderate calculation, endeavours to shew, that in the year 1817, the profit from one hive purchased in 1812 should be £57 : 15 : 4, while ten remain to carry on the stock. He considers the chief obstacle to the culture of bees, to centre in the use of the common hive; and that, on the whole, it is better that they should be destroyed at the end of the season.

The combs being withdrawn from the hive, are to be laid on a fine sieve above a vessel, into which the best honey will be received. gentle heat will disengage the next in quality; and the whole remaining mass may be then subjected to a press, whereby the remainder will be extracted. A certain quantity of wax and other impurities always pass over, which renders it necessary to expose the honey contained in the vessels again to heat, and this admits their rising to the surface, when the whole can be removed. The purification of honey is conducted after a different process, according to the country wherein it is practised, and premiums have been offered for the best mode of doing so on the continent. Honey should be chosen of an agreeable odour, sweet, clear, and new, but it may be preserved a year or longer in the comb, still retaining most of its properties. See Huber, *New Observations*; Huish, *Treatise on Bees*; Reaumur, *Memoires sur les Insectes*; Bonner on *Bees*, and our article **Bee**, vol. iii. p. 411, 412. (c)

HONITON, a burgh and market town of England, in Devonshire, is situated in a delightful vale, upon a gentle eminence, on the south side of the river Otter, commanding a fine view of the surrounding country, which is extremely beautiful. It consists chiefly of a spacious and handsome street, running from east to west, through which passes the high road from Exeter to Chard. Two other streets cross this at right angles, one on the north-west leading to Cullumpton, and the other on the north leading to Taunton. Through the principal street flows a stream of pure water, which the inhabitants receive from a dipping-place opposite almost every door. The buildings, which are almost all modern, were covered with slate, in consequence of the town having been twice destroyed by fire in 1747, when three-fourths of it were reduced to ashes, and, in 1765, when nearly 180 houses were consumed. In 1790 and 1797, it suffered considerably from fire. There is a chapel in the town, called All-Hallows chapel, which is a neat structure, with a square embattled tower of flint. It was built in 1765. The church is situated on a high eminence, about three quarters of a mile from the town, and contains some ancient monuments. There is here a small free-school for boys, and a school of industry for girls; and three meeting-houses for the Presbyterians, Baptists, and Independents.

Honiton
||
Hooghly.

The town is governed by a portreve and bailiff, who are chosen annually. It sends two members to Parliament. The number of voters is 350. The chief articles of manufacture here are broad lace and edgings, which are principally sent to London. A great trade is carried on in butter, which is also sent to the London market.

The following is the population abstract of 1811, for the burgh and parish:

Number of inhabited houses, ...	581
Number of families, ...	581
Do. employed in manufactures, ...	349
Males, ...	1280
Females, ...	1455
Total population, ...	2735

See Polywhele's *History of Devonshire*; and the *Beauties of England and Wales*, vol. iv. p. 299.

HOOF. See Veterinary Medicine.

HOOGHLY, a river in Bengal, and the port of Calcutta, is formed by the junction of the Cossimbazar and Jellinghy, the two westernmost branches of the Ganges. The Hooghly, though by no means the largest branch, has the deepest outlet to the sea, and is considered by the Hindoos as the true Ganges, or most sacred part of that river. It is the only branch which is commonly navigated by large vessels; but its entrance and passage are nevertheless extremely dangerous, not so much from the shallowness of the channel, as from the number of the sand-banks which project into the sea. At its junction particularly with the Roopnarrain, there is a large sheet of water formed, which is full of shoals; and, as the bed of the Hooghly turns to the right, many vessels are lost, by being carried, with the force of the tide, up the Roopnarrain, which more directly faces the approach from the sea. There is also, at this bend of the Hooghly, a dangerous sand named the James and Mary, around which the channel seldom continues the same for eight days in succession, and requires very frequent surveys. The bore, which commences at Hooghly point, where the river first contracts itself, is perceptible above the town of Hooghly, nearly 70 miles distant, and so rapid is the progress of the tide, that it passes through this extent in four hours. It does not run on the Calcutta side; but proceeds along the opposite bank, from which it crosses at Chitpoor about four miles above Fort William, and rushes with great violence past Barnagore, Duckinsore, &c. At Calcutta, it sometimes occasions an instantaneous rise of five feet, and, upon its approach, it is necessary for boats to quit the shore, and go for safety into the middle of the river. (*q*)

HOOGHLY, a district in the province of Bengal, extends along both sides of the river Hooghly, and is situated principally between the 20° and 23° of North Latitude. It is bounded on the north by the districts of Burdwan and Kishenagur; on the south, by the sea; on the west, by Midnapoor; and on the east, by Jessore, and the Sunderbunds. It consists entirely of low, flat, and fertile land; but, though one of the earliest of the East India Company's acquisitions, and immediately adjoining to the town of Calcutta, where a constant market is found for its produce, three fourths of it still remain in a state of nature, the habitation of alligators, tigers, and reptiles. The division nearest to the sea, particularly, is covered with jungle, and is remarkably unhealthy, and thinly inhabited. Salt of an excellent quality, (and possessing, in the opinion of the natives, a peculiar sanctity, because extracted from the mud of the most sacred branch of the Ganges,) is manufactured on the coast for the government. The whole district is intersected by rivers, so as to render it capable of complete inland navigation; but these remote streams are greatly infested by river pirates, who rob in gangs, and frequently apply torture for the purpose of extorting the discovery of concealed property. (*q*)

HOOGHLY, an ancient town in the last mentioned province, situated on the west side of the river of the same name, about 26 miles above Calcutta, in North Latitude 22° 54′, and East Longitude 88° 28′. It was a place of considerable importance under the Mogul government, and was the seat of their custom-house for collecting the duties of merchandize carried up the western branch of the Ganges. It is now comparatively of little note, but still tolerably flourishing, and well inhabited. The French, Dutch, Portuguese, and Danes, had originally factories at Hooghly; and, in 1632, while in the possession of the Portuguese, it was the scene of the first serious quarrel between the Moguls and Europeans. After a siege of three months and a half, it was carried by assault by the Mogul army, and the greater part of the Portuguese were put to the sword, or taken prisoners. In 1640, the English were permitted to build a factory at this place; but their trade was greatly restricted, and subject to continual exactions. In 1686, they were involved in hostilities with the native powers, in consequence of a quarrel between some of their soldiers and those of the nabob; and though peace was speedily restored, they withdrew their settlement to Chittanuttee, or Calcutta. See Bruce's *Annals of the East India Company*; Rennel's *Memoir of a Map of Hindostan*; Lord Valentia's *Travels*; and Hamilton's *East India Gazetteer*. (*q*)

HOOKAH is the name of a pipe for smoking, in great use among eastern nations. It consists of a globular vessel of glass, nearly filled with water, in which two tubes are inserted; a perpendicular one which holds the tobacco, and an oblique one to which the mouth is applied. The smoke is thus rendered peculiarly agreeable, by passing through the water.

HOOKE, ROBERT, an eminent natural philosopher, was born at Freshwater, on the west side of the Isle of Wight, on the 18th July 1635, and for the first seven years of his life was in a very infirm state of health. His father, who was the minister of the parish, educated him under his own roof, as he had been such a sickly child that he was not expected to live. He was at first intended for the church, but after beginning the Latin grammar, his health became so weak, and he was so much subject to headache, that his parents despaired of making him a scholar. Being thus left to the direction of his own genius, he amused himself in the formation of toys, and he even succeeded in the construction of a wooden clock, that exhibited in a rough manner the hours of the day, and in the formation of a full rigged ship, about a yard long, which had a contrivance for firing some small guns as it sailed across a piece of water. This circumstance led his parents to the resolution of putting him an apprentice to a watch-maker, or a painter; but by the death of his father in 1648, neither of these plans were adopted. He was placed, indeed, for a time under the celebrated painter Sir Peter Lely; but he soon found from experience, that he had chosen a profession which the state of his health would not allow him to prosecute. He was therefore sent to Westminster school, and was kindly taken into Dr Busby's house, where he made great progress in Latin, Greek, Hebrew, and other oriental languages. He made also considerable progress in Euclid, and, as Wood informs us, he invented and communicated to Dr Wilkins *thirty different modes of flying!*

In the year 1650 according to Mr Wood, and 1653 according to Mr Waller, he went to Christ's Church, Oxford. In 1655 he was introduced to the Philosophical Society there. He was employed to assist Dr Willis in his chemical experiments; and he afterwards laboured several years in the same capacity with Mr Boyle. He received instructions in astronomy from Dr Seth Ward, Savilian professor of that science in Oxford, and was henceforth distinguished for the invention of various astronomical and mechanical instruments, and particularly for the air-pump which he contrived for Mr Boyle.

In consequence of perusing Ricciolus's *Almagest*, which Dr Ward put into his hands, he was led, in the years 1656, 1657, and 1658, to the invention of the balance or pendulum spring, one of the greatest improvements which has been made in the art of horology: (See HOROLOGY, chap. iii. p. 137.) He mentioned this discovery to Mr Boyle, who, as Dr Hooke remarks, "immediately after his Majesty's restoration, was pleased to acquaint the Lord Brouncker and Sir Robert Moray with it, who advised me to get a patent for the invention; and propounded very probable ways of making considerable advantage by it. To induce them to a belief of my performance, I shewed a pocket-watch, accommodated with a spring applied to the arbor of the balance to regulate the motion thereof. This was so well approved of, that Sir Robert Moray drew me up the form of a patent; the principal part whereof, viz. the description of the watch so regulated, is in his own hand-writing, which I have yet by me. The discouragements I met with in the management of this affair, made me desist for that time." In the agreement between Dr Hooke, Mr Boyle, Lord Brouncker, and Sir Robert Moray, which seems to have been drawn up about 1663, it was provided, that out of the first £6000 of profit, Dr Hooke was to have three-fourths; of the next £4000, two thirds; and of the rest, one half: but the other partners in the patent very improperly insisted upon the insertion of a clause, giving to any of themselves the sole benefit of whatever improvements they might make upon his invention.

About the same time Hooke contrived the circular pendulum, which was shewn to the Royal Society in 1663, and which was afterwards claimed by Huygens. This pendulum, which is described in Hooke's Animadversions on the *Machina Celestis* of Hevelius, does not vibrate backwards and forwards, but always in a circle, "the string being suspended above at the tripedal length, and the ball fixed below, as suppose at the end of the fly of a common jack. The motion of this circular pendulum is as regular, and much the same with those mentioned before; and was made to give warning at any moment of its circumgyration, either when it had turned but a quarter, a half, or any lesser or greater part of its circle. So that here you had notice not only of a second, but of the most minute part of a second of time." See Derham's *Artificial Clockmaker*, p. 97.

The establishment of the Royal Society in 1660, afforded to Dr Hooke numerous opportunities of extending his reputation. He published in 1660, a small tract on the ascent of water in small tubes by capillary attraction, in which he shewed that the height of the water was in a certain proportion to their bores. A debate arose on this subject in the Royal Society in April 1661; but Hooke's replies were considered so satisfactory, and raised him so high in the estimation of the Society, that in 1662 he was appointed curator of experiments to that distinguished body. He was also one of the 98 persons who were declared members of the Royal Society, at a meeting of the council held May 20th, 1663, by virtue of the power given them by the charter for two months. He was admitted to the society on the 3d of June, and was peculiarly exempted from all payments. In the same year he took his degree of Master of Arts, and the Repository of the Royal Society in the White Gallery of Gresham College was committed to his care. About this time he drew up a list of enquiries for the use of those who might have occasion to visit Greenland or Iceland. Those which respect Iceland are numerous and interesting; and one of them is particularly deserving of notice: "Whether spirits appear; in what shape; what they say and do; any thing of that kind very remarkable, and of good credit:" In May 1664 he delivered the astronomical lecture at Gresham College for Dr Pope, who was absent in Italy; and in the same year Sir John Cutler gave him a salary of £50 per annum, for reading a course of mechanical lectures, under the direction of the Royal Society. These lectures were afterwards published in 4to, in 1679, under the title of "*Lectiones Cutlerianæ*, or a collection of lectures, physical, mechanical, geographical, and astronomical, made before the Royal Society on several occasions, at Gresham College; to which are added divers miscellaneous discourses." On the 11th January 1664, the Royal Society settled upon him a salary of £30 per annum for life, for his labours as curator of experiments; and on the 20th of March of the same year, he was appointed to succeed Dr Dacres as professor of geometry in Gresham College. In the year 1665, Hooke published his "*Micrographia*, or some physiological descriptions of minute bodies, made by magnifying glasses, with observations and enquiries thereupon." All the figures in this work were drawn with his own hand, and many of them are a kind of standard representations, which have been copied by succeeding authors. The best are those of the common mite, flea, louse, gnat, and ant. A new edition of it with abbreviated descriptions appeared in 1745, in which the baroscope, the hygroscope, and the engine for grinding optic glasses, were wholly omitted. During the recess of the Royal Society, on account of the plague in 1665, he accompanied Mr Wilkins and other ingenious authors into Surry, where they continued their philosophical labours. In 1665, at one of the first meetings of the Royal Society, Dr Hooke produced a very small quadrant for observing the minutes and seconds, by means of an arm moved with a screw along the limb of the quadrant. His explanation of the inflexion of a direct into a curvilineal motion, was read to the Society on the 23d May 1666.

On the 19th of September 1666, he laid before the Royal Society a model for rebuilding the city of London, which was destroyed by the great fire; but though his plan was not executed, he was appointed one of the surveyors under the act of parliament; a situation in which he realized a considerable sum of money, which was found after his death in a large iron chest, that appeared to have been shut up for 30 years. The irritable temper of our author now involved him in several quarrels, in all of which he conducted himself with impropriety. In our life of Hevelius, we have already given an account of his controversy with that astronomer respecting the comparative merits of plain and telescopic sights. In 1671, he attacked Newton's theory of light and colours; and in 1675 he had a warm dispute with Mr Oldenburg, the secretary to the Royal Society, in consequence of his pamphlet, entitled, "A Description of Helioscopes, and some other Instruments, made by Robert Hooke," in which he complains that Oldenburg had not done him justice respecting his invention of pendulum watches. The dispute terminated by a declaration of the Royal Society, who took the part of their secretary. In 1676, he published his "Description of Helioscopes, and some other Instruments," a work which contains many curious inventions, some of which are described in anagrams. Upon the death of Oldenburg in 1677, Hooke was appointed to the vacant office of secretary; and while he held that situation, he published between 1679 and 1681 the seven numbers of the *Philosophical Collections*, which have always been regarded as a part of the Philosophical Transactions.

About this time the natural peevishness of his temper began to become quite intolerable: He claimed as his own the inventions and discoveries of every other person; and he became so reserved in communicating his own labours to the public, that though he read his Cutlerian lectures, and exhibited new inventions to the Royal Society, yet he never left any account of them to be entered in the registers. When the *Principia* appeared in 1686, he laid claim to the discovery of the doctrine of gravitation, a claim which was warmly resented by Sir Isaac Newton. Hooke, no doubt, had the merit of stating, that gravitation was the power which kept the planets in their orbits, and he even made some experiments to determine the law by which it was regulated; but what a vast interval is there between this conjecture, happy as it is, and the splendid discoveries of Newton!

In the year 1687 he suffered a severe loss by the death of his brother's daughter, Mrs Grace Hooke, who had lived several years with him; and the distress of his mind was still farther increased by a Chancery suit with Sir John Cutler respecting his salary. In 1691, Archbishop Tillotson employed him in contriving the plan of the hospital near Hoxton, founded by Robert Ash; and out of gratitude for his services, that distinguished prelate obtained for him the degree of M. D. When the Chancery suit with Sir John Cutler was determined in his favour in 1696, he was so overjoyed, that he left an account of his feelings in his diary, expressed in the following manner: "DOMSHLGISSA, that is, *Deo, optimo, maximo, sit honor, laus, gloria in sæcula sæculorum, Amen.*" "I was born on this day of July 1635, and God hath given me a new birth; may I never forget his mercies to me! while he gives me breath may I praise him!" In order to induce him to complete some of his inventions, the Royal Society requested him, in 1696, to repeat most of his experiments at their expence, but the infirm state of his health prevented him from complying with their request. During the two or three last years of his life he is said to have sat night and day at a table, so much engrossed with his inventions and studies, that he never undressed himself or went to bed. Emaciated with the gradual approach of old age, he died in Gresham College on the 3d March 1702, in the 87th year of his age, and was buried in St Helen's church, Bishopsgate Street, his funeral being attended by all the members of the Royal Society who were then in London.

Besides the works which we have mentioned, he published in 1677 his *Lampas*, or *Descriptions of some mechanical improvements in lamps and water poises.*

The most important of Dr Hooke's inventions, was undoubtedly the method of regulating watches by the balance-spring, which has since his time been carried to the highest perfection. Huygens has commonly been considered as the author of this invention, but there is no doubt that Hooke had invented it about 14 years before. The posthumous works of Dr Hooke, collected from his papers by Richard Waller, secretary to the Royal Society, with a life of the author prefixed, were published in 1705. Another life of Hooke was published in Ward's *Lives of the Gresham Professors*, p. 109. Lond. 1740. The papers which Hooke contributed to the Philosophical Transactions, will be found in volumes i. ii. iii. v. vi. ix. xvi. xvii. and xxii. of that work.

The following list of Dr Hooke's inventions is taken principally from a MS. of the late Dr Robison, professor of natural philosophy in the university of Edinburgh.

1655. Hooke discovered that the barometer indicated changes in the atmosphere, and was connected with the weather. Before the year 1652 the same discovery was made by the Rev. Mr Gregory of Drumoak. See our Life of JAMES GREGORY, vol. x. p. 506. note.

1655. Contrived the clockmaker's cutting engine.

1656. Contrived a 'scapement for the small vibrations of pendulums.

1656. Invented the spiral spring for regulating the vibrations of a watch balance.

1658. Contrived the Boylean or double barrelled air-pump.

1660. Used the conical pendulum for procuring a minute division of time.

1660. Explained capillary attraction by affinity.

1660. Found that the catenarian curve was the best form for an arch.

1663. Invented his marine barometer and sea gage; and also the method of supplying air to the diving bell.

1664. Invented a quadrant by reflexion, and a clock for registering the weather.

1664. Proposed the freezing of water in a fixed temperature; and in 1684 the boiling of water as another fixed point.

1664. Applied a screw for dividing astronomical instruments.

1665. Proposed to find the earth's parallax by means of a zenith telescope, also by observing the moon in distant places, and in a solar eclipse.

1666. Nov. 28. Invented the spirit level.

1668. Proposed his theory of combustion. See his *Micrographia* and *Lampas.*

1669. Proposed a pendulum, or a drop of water as a standard measure. Proposed a camera obscura with a lamp.

1674. Invented the areometer.

1674. Tried the famous experiment with Newton on the inflexion of light.

1678. Proposed a steam engine on Newcomen's principle.

1679. Shewed that the path of a falling body compounded with the earth's motion is an ellipse.

1680. First observed the secondary vibrations of sounding bodies;—that a glass touched with a fiddle bow threw water into waves at four points, and that the fundamental sound was accompanied with its harmonics.

1682. Observed the separability of heat and light by a glass plate.

1687. Observed the rapid propagation of sound through solid bodies.

Hooke appears also to have been the first who explained the rise of vapour by a dissolving power in the air, and who took a just view of the arrangement of iron filings round a magnet. See HEVELIUS and HUYGENS. (π)

HOOKER, RICHARD, an eminent English divine, was born at Heavitree, near Exeter, in the year 1553, or, according to Wood, in 1554. His parents, who were by no means in affluent circumstances, intended to educate him for some mechanical trade; but his schoolmaster at Exeter, having discovered his natural endowments and capacity for learning, prevailed with them to allow him to continue at school. His uncle, John Hooker, who was then chamberlain of the town, recommended him to Jewel, bishop of Salisbury, who, after examining into his merits, took him under his protection, and got him admitted into Corpus Christi College, Oxford, of which he was chosen fellow in 1577. Before this last period, however, Hooker had the misfortune to lose his patron; but his talents and excellent disposition soon procured him other valuable friends in Dr Cole, then president in his college, and Dr Sandys, bishop of London. The bishop placed so much confidence in Hooker's character, that he entrusted his own son to his care.

In 1577, Mr Hooker took his degree of M. A., and in the same year he was elected fellow of his college. In 1579, he was appointed deputy-professor of the Hebrew language in the university; but for some cause, which cannot now be ascertained, he and some others were expelled the college by the vice-president, to which, however, they were again restored in the course of two or three weeks. In 1581, he entered into orders, and was soon after appointed to preach at St Paul's Cross in London. Through the great simplicity of his character, he was, about the same time, entrapped into a foolish and unfortunate marriage with a woman who had neither beauty nor portion to recommend her, and who has been represented by Wood as "a silly clownish woman, and withal a mere Xantippe." In consequence of this imprudent step, he lost his fellowship, and was obliged to quit the university before he had obtained any preferment. He was therefore obliged to support himself as well as he could, until the latter end of the year 1584; when he was presented by John Cheney, Esq. to the rectory of Drayton-Beauchamp, in Buckinghamshire, where he led a most uncomfortable life with his wife Joan. In this situation, he received a visit from his friend and pupil Sandys, in company with another pupil, Mr Cranmer, a grand-nephew of the celebrated Archbishop Cranmer. These young men found their learned and respected tutor in a common field, with a Horace in his hand, tending a small flock of sheep, in the absence of his servant, who had been called away to assist his mistress in some domestic business. When released from this duty, his friends accompanied him to his house, where they had an opportunity of witnessing the vexation and misery to which he was constantly subjected, from the churlish and capricious conduct of his wife. Upon their return to London, Mr Sandys acquainted his father with Hooker's deplorable situation, who took a warm interest in his concerns, and got him appointed master of the Temple, in 1585. Although this was a fine piece of preferment, Hooker soon discovered that London was not a place that suited his temper and disposition; and several circumstances conspired to excite in him the desire of obtaining the retirement of a country living. At the time when he was chosen master of the Temple, he got involved in a controversy with Travers, an afternoon lecturer there,—a man, it is said, of learning and good manners, but zealously attached to the Geneva government. This controversy led Hooker into a serious examination of the form and principles of church-government, which terminated in his celebrated work *Of the Laws of Ecclesiastical Polity*, the foundation and plan of which were laid while he was at the Temple. But in this residence he found himself incapable of carrying on the work to his own satisfaction; and he therefore entreated the archbishop, Whitgift, to remove him into some more quiet situation, in a letter which exhibits an interesting picture of that union of piety, simplicity, the love of learning and retirement, which formed the predominant feature of his character. "My lord," says he, "when I lost the freedom of my cell, which was my college, yet I found some degree of it in my quiet country parsonage. But I am weary of the noise and oppositions of this place; and indeed God and nature did not intend me for contentions, but for study and quietness. And, my lord, my particular contests here with Mr Travers have proved the more unpleasant to me, because I believe him to be a good man; and that belief hath occasioned me to examine mine own conscience concerning his opinions. And to satisfy that, I have consulted the Holy Scriptures, and other laws, both human and divine, whether the conscience of him, and others of his judgment, ought to be so far complied with by us, as to alter our frame of church-government, our manner of God's worship, our praising and praying to him, and our established ceremonies, as often as their tender consciences shall require us. And in this examination I have not only satisfied myself, but have begun a treatise, in which I intend the satisfaction of others, by a demonstration of the reasonableness of our laws of ecclesiastical polity. But, my lord, I shall never be able to finish what I have begun, unless I be removed into some quiet parsonage, where I may see God's blessings spring out of my mother earth, and eat my own bread in peace and privacy; a place, where I may without disturbance meditate my approaching mortality, and that great account, which all flesh must give at the last day to the God of all spirits."

In consequence of this application, he was presented, in 1591, to the rectory of Boscomb, in Wiltshire; and in the same year, he obtained other valuable preferments in the cathedral of Salisbury. At Boscomb he finished four books of his *Ecclesiastical Polity*, which were entered at Stationer's-hall in the month of March 1592, but not printed till 1594. In the following year he quitted Boscomb, and was presented by Queen Elizabeth to the rectory of Bishop's Bourne, in Kent, where he resided during the remainder of his life, discharging the duties of his office in the most conscientious and exemplary manner. In this place he composed the fifth book of his great work, which was dedicated to the archbishop, and published by itself in 1597. He also finished the 6th, 7th, and 8th books, but did not live to publish them; and it has been much disputed whether we have these books genuine as he left them. In the year 1600, he caught a severe cold, in a passage between London and Gravesend, which produced a lingering and painful illness, that at length put a period to his life, in the 47th year of his age. He died on the 2d of November 1600. Notwithstanding the severity of his indisposition, he persevered in his studies to the last. A few days before his death, his house was robbed. When informed of that circumstance, he enquired whether his books and written papers were safe; and being answered that they were, "then," said he, "it matters not, for no other loss can trouble me."

The personal character of Hooker may be gathered from the preceding narrative of his life. As an author, the church is indebted to him for the most profound and ingenious defence of ecclesiastical establishments that has ever appeared. His treatise on *Ecclesiastical Polity*, indeed, has been admired both at home and abroad, as a work of deep and extensive research, and of acute and sound reasoning; and the author has been universally distinguished by the honourable titles of "the judicious," and "the learned." Of this valuable work, Pope Clement VIII. is reported to have said, that "there were in it such seeds of eternity as will continue till the last fire shall devour all learning." When King James I. ascended the throne of England, he is said to have asked Archbishop Whitgift for his friend Mr Hooker; and being answered, that he had died a year before the queen, who expressed great concern when she received the news, he replied, "And I receive it with no less, as I shall want the desired happiness of seeing and discoursing with that man, from whose books of church polity I have received such satisfaction." He afterwards added, "though many others write well, yet in the next age they will be forgotten; but, doubtless, there is in every page of Mr Hooker's book the picture of a divine soul; such pictures of truth and reason, and drawn in so sacred colours, that they shall never fade, but give an immortal memory to the author."

Besides the eight books of *Ecclesiastical Polity*, and his answer to Travers's *Supplication*, Hooker left some sermons, which were collected and published with his works in folio. An octavo edition has also been printed at Oxford. (z)

HOOQUANG. See China, vol. vi. p. 214.

HOO-TCHEOO-FOO. See China, vol. vi. p. 211.

HOPS. See Agriculture, vol. i. p. 319; and Brewing, vol. iv. p. 470.

HORACE, Quintus Horatius Flaccus, one of the most celebrated of the Roman poets, was born at Venusium, a town in the confines of Apulia and Lucania, in the consulship of Aurelius Cotta and Manlius Torquatus. His father was the son of a freedman, and fol-

Horace.

lowed the employment of a tax-gatherer. This was the poet's own account, and most likely to be true. Some of his enemies, however, reproached him with his father having been a fishmonger (*Salsamentarius*), and one of them said to him, *Quoties ego vidi patrem tuum brachio se immungentem.* His father, however, though of humble origin, appears to have been a man of liberal sentiments, and to have given his son an excellent education, as the son has recorded in these lines so honourable to the memory of both:

"Causa fuit pater his:* qui macro pauper agello
Noluit in Flavi ludum me mittere, magni
Quo pueri magnis è centurionibus orti
Lævo suspensi loculos tabulamque lacerto,
Ibant octonis referentes Idibus æra:
Sed puerum est ausus Romam portare docendum,
Artes, quas doceat quivis eques, atque senator
Semet prognatos: vestem servosque sequentes
In magno ut populo si quis vidisset; avita
Ex re præberi sumptus mihi crederet illos.
Ipse mihi custos incorruptissimus omnes
Circum doctores aderat, quid multa? pudicum
(Qui primus virtutis honos) servavit ab omni
Non solum facto, verum opprobrio quoque turpi.

* * * * *

Nil me pœniteat sanum patris hujus." - - - -
SAT. VI. LIB. I.

At the age of eighteen, Horace was sent to Athens, for the purpose of finishing his education, by the study of philosophy and Greek literature. Whilst he was in that city, Marcus Brutus, in his way to Macedonia, stopped at the university, and, being pleased with Horace, took him along with him on his journey. Brutus afterwards entrusted a legion to his care as military tribune. As the poet, in his writings, freely confesses, that he had no great genius for fighting, it may be suspected, that it was by his wit and companionable talents that he had ingratiated himself with Brutus. At the battle of Philippi, he describes himself, with some humour, as throwing away his shield, to be disencumbered in his flight. By the victory of the opposite party, his property was forfeited, but his life was spared. In his indigence he wrote verses, and so recommended himself to Virgil and Varius, that, with the generosity of true poets, they recommended him to Mæcenas. At the first interview with that noble patron, as he tells us in the satire already quoted, he behaved with diffidence, and simply told Mæcenas what he was. The nobleman, as was his custom, said little in reply, and did not send for him again till nine months after, when he admitted him among the number of his friends, and made him easy in his circumstances. Horace proved so agreeable to Mæcenas, that he made him his familiar companion, in which capacity he accompanied him to Brandusium, in that journey which the poet has so agreeably described in verse. He also introduced him to Augustus, who delighted in his society, and used to call him *homuncio lepidissimus.* When seated between Virgil and Horace, the emperor used to say, that he was between sighs and tears; alluding to the uneasy respiration which afflicted Virgil from a chest complaint, and to Horace's tender eyes. Horace was certainly a courtier, and he did not lay on his flattery in faint colours; nor does he seem to have troubled his patrons with any recurrence to those maxims of public liberty, which he must have learned with Brutus, and which had led him into the field of Philippi; but, on the other hand, he makes allusion to great republican names with the spirit of a Roman and of a poet; and he lived among the great with *personal* independence, for he declined the post offered to him by Augustus of being his private secretary.

Horace || Horn.

The incidents of his life are few. His person is described as short and inclined to corpulence, and his temper as easy and obliging. He passed his time between Rome, his Tiburtine or Sabine villa, and the soft climate of Tarentum, to which he fled in winter. Though an Epicurean enjoyer both of society and of sensual pleasures, his writings breath a fondness for rural retirement, and he seems often to have returned from the satiety of vice, to the calm of virtue and repose. He died in his 59th year, and was interred near his patron Mæcenas. Horace is the only one of the Latin lyric poets who has come down to posterity; a circumstance for which the judgment of Quinctilian may console us, who assures us, that they were scarcely worthy of perusal. In Horace have been supposed to be united, if not individually surpassed, the gaiety of Anacreon, the majesty of Alcæus, and the fire of Pindar. We must leave it to the lovers of voluptuous literature to decide, whether the revelling of the Teian bard possess not a lighter grace of ecstacy than that of the Roman? The soul of pleasure is in both; but Horace's moral reflections (Epicurean as his philosophy was) are often like a drapery to his luxuriant images, that encumbers their joyousness without communicating decorum. In the parallel with Pindar, he presents a clear and rapid brilliancy of thought, more pleasing, if less astonishing, than the vague and obscure sublime of the Theban poet, as well as a richer variety in his subjects. He may be called, perhaps without a rival, the master of expression; and such is the harmony and diction of his odes, that an apt quotation from them always sparkles like a gem when it illustrates the most eloquently expressed thought in the page of any language. Of all poets he is the most frequently quoted. To the merits of style, harmony, and fancy, must be added his knowledge of human nature, and of the principles of human manners, exhibited in that part of his writings where the tone of fancy and poetical diction is purposely relaxed; in his satires, to wit, where we take him to our bosoms for his good humour, and where his good sense instructs us in the language of friendship. His epistle to the Pisos has, perhaps, been too much considered as an attempt on his part to give a preceptive theory of the whole art of poetry. It is, in fact, only an epistle upon the subject, in which his design is evidently desultory. Horace knew poetry too well, to think of submitting so ethereal a subject to the trammels of systematic theory; and it is not his fault, if the world has been since annoyed with sickening attempts to teach the art of inspiration. The infallibility of all his tenets of taste it is not our business here either to impeach or support; but, in a general view, it must be confessed, that his maxims, though misapplied by pedants to narrow the range of dramatic genius, have, with reference to all that was then known in that species of poetry, a most respectable weight and felicity. (n)

HORATII. See ROME.

HORIZON, ARTIFICIAL. See QUADRANT.

HORN, a musical wind instrument, which, whether of the short kind, called a bugle horn, or the long coiled kind, called a French horn, has a scale of intervals alike defective, and similar to that of the common TRUMPET, which see. The supplying of chromatic notes to the scale of the French horn, so as to render it an instrument of general use in an orchestra, is said

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[*] Speaking of the better traits of his character.

Horn-pressing.

to have been first attempted in the beginning of the 18th century, in Germany; and since 1740, Messrs Messings, Spandau, Porto, Leanders, Petrides, &c. have succeeded here in different degrees, in supplying all the requisite notes to the horn, by means of the hand, or a turned block of wood thrust into the mouth of the instrument, so as to alter the length of the sounding part of the tube, in the requisite degrees, during performance.

The late Mr Charles Clagget, as we have explained in our article Chromatic *French Horn*, attempted to accomplish the same thing, by means of two attached tubes, one half a tone higher than the other, either of which the performer could blow at pleasure; but it did not succeed, so as to continue in use. In 1810, Mr William Clare invented and transferred to Mr Perceval, opposite St James's Palace, the patent for a polyphonian French horn, whose scale is rendered complete by means of finger-holes in its sides, and keys like those of a flute. (ε)

HORN, Cape. See Fuego, vol. x. p. 24. col. 2.

HORN-Pressing, is the art of moulding or forming toys and various articles in horn or tortoise-shell. These animal substances are capable of being so softened by the application of a moderate heat, that they can be moulded by pressure into any required shape, and the surface may be imprinted with any design in the sharpest and most delicate relief. Another valuable property is, that pieces may be made to adhere firmly together without any cement. In the article Button-*Making*, we have already given a description of the method of pressing horn buttons, by means of iron moulds and a strong vice. The same machine, and similar moulds, are used for knife-handles or other simple articles; but for making hollow articles, such as snuff-boxes, tooth-pick cases, powder-flasks, tubes of opera-glasses, ink-horns, &c. a screw-press is used. The process is extremely simple: The horn or tortoise-shell is boiled in water until it becomes softened, and is then put into moulds of iron or brass, made in two or more pieces, and with cavities between them to correspond with the article which is to be fabricated, and, with all its intended ornaments, engraved in the interior surface of the mould. This mould being made hot, the horn or shell is put between its two halves, and the mould being put in a small screw-press, the halves are forced together to imprint the horn, and press it into the cavity of the mould. If the article has any considerable relief, this cannot be done at one heat, and therefore the press, with the moulds in it, is put into a copper, and boiled still longer: it is then taken out, and, by a lever applied to the screw, it is screwed tighter, so as at length to obtain the impression desired. When a single piece of horn or tortoise-shell is not sufficiently large to fill the mould, two or more pieces are put together: they are cut to fit to each other with a proper degree of overlap, and when sufficiently softened by boiling in water, the surfaces are forcibly pressed together, and they will thus be united as firmly as if they were originally in one piece. The screw-press employed for this business is very simple, being only an iron frame, with a screw through the top of it; and, for the convenience of putting it in and out of the boiler or copper, a small tackle of pulleys is fixed just over the copper, and by the side of it is a block of stone, with a hole or cavity in it large enough to receive the press, and hold it firmly upright, whilst a lever or wrench is applied to the screw to turn it round and produce the pressure, which being done, it is again returned into the boiler. To obviate the inconvenience of thus lifting the press in and out of the boiler, Messrs Poltzapffell and Deyerlin of London have made the machine represented in Figs. 1. and 2. of the Plate. Plate CCXCIX. Fig. 1. being a section, and Fig. 2. an elevation, AA is a box or case of cast iron; B, a boiler or copper to contain the water; and C, the grate for the fire, which is to be placed beneath it to heat the water; E is the flue or chimney, at which the smoke passes off; FFG is a press, made very strong, of cast iron, and capable of being drawn up out of the water, or let down into it at pleasure, by means of racks *a*, *a* at each side, which are actuated by pinions *d*, *d*; the axes *o* of these pinions extend across the machine, and have each a wheel N at the end; and these wheels are moved at the same time by two arms or endless screws, cut upon an axis, which extends from one to the other, and is turned by the handle H: the press is guided in this ascent or descent by grooves in the side of the boiler. When raised up out of the water, the moulds, with the horn or tortoise-shell between them, are put beneath the presser I, and a severe pressure is produced by turning the wheel K. This wheel has an endless screw R upon its axis, which works the teeth of a large wheel L, fixed on the top of the screw P. The screw is received into a female screw formed within the box or presser I, which is guided and prevented from turning round by the cross bar *e e*, through which the presser is fitted; by this means, when the screw P is turned round by the wheel L and endless screw, the horn or tortoise-shell is pressed between the moulds; the press is then lowered again into the water of the boiler, in order to be still farther softened by the boiling; but when the press is down in the boiler, the screw can be screwed tighter by turning the wheel K until the desired impression is obtained. By turning the handle N, the press is then raised up out of the boiler, and by turning back the wheel K, the pressure is released, and the moulds can be removed.

Horn-pressing, Horns.

Messrs Poltzapffell and Deyerlin's machine for horn-pressing.

Plate CCXCIX. Fig. 1. & 2.

The Figures X, Y and Z represent a pair of moulds proper for forming a cylindrical snuff-box: X is the internal mould for the box, into the bottom of which a piece of shell, softened by boiling, and cut round, is first placed; and round the inside a long slip is curled, the ends being made to lap over with a proper joint. The external mould Y is then put into the cavity of the horn, and is forcibly pressed by the screw so as to give the horn the shape of Y when it is withdrawn from the mould: a similar mould is used for making the lid of the box. Small boxes, and those which are slightly raised, can be made from one single piece without joining; also tooth-pick cases and similar articles.

The Chinese are famous for making lanterns of horn very thin and transparent. We are informed, in the *Annales des Arts*, that they employ the same methods as we do of effecting the joinings by softening the horn in hot water, but that they use a long beam or lever, for making the pressure. This method is for making up the leaves of horn from small pieces; but as the boiling would disfigure these leaves, they are united together to form the lanterns, by warming them at the fire, and pressing the edges of them together by hot pincers, made flat on the inside; by this means the joints are so perfect that they can scarcely be perceived. See a translation of this paper in the *Repertory of Arts*, 2d Series, vol. xxix. An account of the manufacture of Chinese lanterns, will be found in the *Memoires des Sçavans Etrangers*, tom. ii. p. 350, in a Memoir by M. D'Incarville. (J. F.)

HORNS. See Anatomy, *Comparative*, vol. ii. p. 24.

HOROLOGY.*

History.

Horology is the art of constructing machines for measuring time. The word is derived from the Greek ʽΩρολογιον, (through the Latin *horologium*,) compounded of *ὡρα, an hour*, and *λεγω, to read* or *point out;* hence *ὡρολογιον*, a machine for indicating the hours of the day.

Toothed wheels applied to clepsydræ.

Vick's clock, Plate CCC. Fig. 1.

Clocks made by Pacificus and Gerbert.

Long before sun-dials were invented, clepsydræ, or water clocks, had been made in the most remote periods of antiquity, and were used in Asia, China, India, Chaldea, Egypt, and Greece, where Plato introduced them. Julius Cæsar found them even in Britain, when he carried his arms thither; and it was by them he observed, that the nights in this climate were shorter than those in Italy: (See his *Commentaries*, lib. v. xiii.) Toothed wheels, although known a considerable time before, were first applied to clepsydræ by Ctesibius, a native of Alexandria, who lived 140 years before the Christian era. At what time, or by whom, was invented the clock with toothed wheels, crown wheel 'scapement, and the regulator in the form of a cross suspended by a cord with two weights to shift on it, can now only be guessed at, as no positive information on this subject has been handed down to us. It was this kind of clock, a large turret one, which Charles V. king of France, surnamed the Wise, caused to be made at Paris by Henry Vick, who was sent for from Germany for the express purpose, and which was put up in the tower of his palace about the year 1370. Julien le Roy, who had seen this clock, has given some account of it in his edition of Sully's *Regle Artificielle du Temps*, Paris 1737: (See Plate CCC. Fig. 1. and the Description of the Plates at the end of the volume.) Before a clock could be brought even to the state of the one made by Vick, there must have been many alterations and progressive improvements upon that which had first been projected, so that it must have been invented at least two or three centuries before Vick's time. As the same word for a sun-dial among the Greeks and Romans was also that for a clock, disputes have arisen, whether the *horologia* of Pacificus and of Gerbert were sun-dials or clocks. Father Alexander asserts that the horologium of Gerbert was a clock; while Hamberger supposes it to have been a sun-dial, from the pole star having been employed in setting it. Pacificus was archdeacon of Verona about the year 850. Gerbert was pope, under the name of Silvester II. and made his clock at Magdeburg, about the year 996.

Richard of Walingford's clock.

Richard of Walingford, abbot of St Albans in England, who flourished in 1326, by a miracle of art constructed a clock, which had not its equal in all Europe, according to the testimony of Gesner. Leland too, an old English author, informs us, that it was a clock which shewed the course of the sun, moon, and stars, and the rise and fall of the tides; that it continued to go in his own time, which was about the latter end of Henry the Seventh's reign; and that, according to tradition, this famous piece of mechanism was called *Albion* by the inventor.

"In 1382," says Father Alexander, "the Duke of Burgundy ordered to be taken away from the city of Courtray, a clock which struck the hours, and which was one of the best known at that time, either on this side or beyond seas, and made it be brought to Dijon, his capital, where it still is in the tower of Notre Dame. These are the three most ancient clocks that I find, after that of Gerbert."

History.

Gerbert's clock.

"We know no person," continues this author, "more ancient, and to whom we can more justly attribute the invention of clocks with toothed wheels, than to Gerbert. He was born in Auvergne, and was a monk in the abbey of St Gerard d'Orillac, of the order of Saint Bennet. His abbot sent him into Spain, where he learned astrology and the mathematics, in which he became so great a master, that, in an age when these sciences were little known, he passed for a magician,† as well as the Abbot Trithemius. From Spain he came to Rome, where he received the abbacy of Bobio in Italy, founded by Saint Columbus; but the poor state of its funds compelled him to return to France. The reputation of his learning and uncommon genius, induced Adalberon, Archbishop of Rheims, to establish him, in 970, as rector of the schools there, and at the same time to make him his private secretary. It was near the end of the tenth century, about the year 996, when he made at Magdeburg this clock, so wonderful and surprising, *by means of weights and wheels*. He was Archbishop of Rheims in 992, a situation which he held during three years then archbishop of Ravenna in 997, and at last sovereign pontiff, under the name of Silvester II. in 999; and he died at the beginning of the fifth year of his pontificate, in 1003." The clock constructed by Gerbert seems to have been made after he left Rheims, and before his appointment to Ravenna; and it is highly probable, that this was the period when clock-making was introduced into Germany.

"William Marlot," continues the same author, "to show how wonderful this piece of work was, makes use of an expression which can hardly be suffered in our language: *Admirabile horologium fabricavit, per instrumentum diabolica arte inventum.*"

Since toothed wheels had been known above 1300 years before Gerbert is said to have made his horologium, and above 1100 after they had been applied to the clepsydra, and as they were also sculptured on Trajan's column at Rome, where they are still to be seen, there seems to be nothing unaccountable in Gerbert's having fallen on the way of applying wheels to make a clock different from the clepsydræ, which had been long in use. Besides, Father Alexander seems to have investigated the history of horology more profoundly and indefatigably than Hamberger; and Gerbert may have made use of the pole star, for other purposes than merely to set a sun-dial by it, and probably for the purpose of drawing a meridian line, in order to regulate his clock. If it were a sun-dial, as some suppose, why does Marlot, who wrote at Rheims in 1679, consider it as such a wonder, since it appears from our *History of* Dialling, that dials were well known, and in common use, 1600 years before Gerbert's time? Hamberger, however, admits, that the clock was invented in the eleventh century; and he thinks it probable, that we are indebted to the Saracens for it. Now Gerbert's clock was made near the commencement of the same century. The college in Spain, where he had been instructed, had Arabians or Saracens among its

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* The Editor is indebted to Mr Thomas Reid for the following article on Horology.

† It may have been for a crime of this kind that he was afterwards banished from France.

professors, and was at that time the only place in Europe where any learning or science was to be found.

The argument against Gerbert's horologium being a clock, in our acceptation of the word, is, that he made use of the pole star, as if to set a sun-dial by it; and yet we have no positive information that it was a sundial. Berthoud admits, that such a clock as Vick's could not have been a new invention; and he thinks, "that the different parts which compose the balance clock, have only been made after a long train of research and of time, which supposes the highest antiquity for the successive discoveries, and that clocks were not known in France till the middle of the 14th century."

The art of horology might be going slowly on in Germany, though the balance clock was unknown in France till 1370, previous to which Vick had been sent for. Had this not taken place, it might perhaps have remained still longer unknown. It must be allowed, that there is something inconsistent in Father Alexander's argument, for giving the clock to Gerbert, and refusing it to Pacificus, "because it was not known in France till 250 years after. The discovery was of too great utility not to be spread abroad, particularly in monasteries, where it was so much required to regulate the office of the night. In the famous monastery of Cluny, however, the sacristan, in 1108, went out to see the stars, in order to know the time when to awaken the monks to prayer." In the early stage of the art very few clocks could have been made, and those which were constructed could not be of much use.

"As all arts are at first imperfect," says Hamberger, "it is observed of these clocks, that they sometimes deceived; and hence in the *Ordo Cluniacensis Bernardi Mon.* the person who regulated the clock is ordered, in case it should go wrong, 'ut notet in cereo, et in cursu stellarum vel etiam lunæ, ut fratres surgere faciat ad horam competentem.' The same admonition is given in the *Constitutiones Hirsaugiensis.*" From what is said here, it may be inferred, that even those who had clocks in the earliest periods, could not place much dependance on their time-keeping; and with great probability we may suppose, that many a palace and monastery might continue a long time unprovided with such a machine. It was near the end of the 15th century before they came to be in use among private persons.

The art of clockmaking seems to have been introduced into Europe, by some of the Romish clergy. They were, in general, especially the higher orders, possessed of wealth, time, and leisure to cultivate such of the arts and sciences as were then to be attained; and if the art of horology did not originate with them, they certainly were among the first who did every thing in their power to promote and encourage it. Time measuring being so desirable for the regulation of the stated services required of the church, which took place at all hours of the day and night, their attention was naturally called to a subject in which they were so much interested.

Those who wish for more information on the origin of clocks, are referred to the following works. *The Artificial Clockmaker*, by William Derham, D. D. London, 1698. *Traité general des Horloges*, par le R. P. Dom. Jacque Alexandre, Religieux Benedictin de la congregation de Saint Maur. A Paris 1734. A Dissertation by Hamberger in Beckmann's *History of Inventions*, vol. iii. Lond. 1797. *Histoire de la Mesure du Temps par les Horloges*, par Ferdinand Berthoud, mechanicien de la marine, &c. &c. A Paris 1802. This last is a very interesting work, for an amateur in horology, and was the result of seven years labour, when the author was at a very advanced period of life. To these may be added *Histoire de l'Astronomie Moderne*, tom. i. p. 60, edition de 1785, and *Histoire de l'Astronomie Ancienne. Eclaircissemens*, liv. iv. § 34. liv. ix. § 5. Vitruvius's *Architecture.* Pollius Vitruvius lived 40 years before Christ, and was architect to Augustus. In a triumph of Pompey, among the spoils brought from the East, was a water clock, the case of which was strung round with pearls. *Pliny*, lib. xxxvii. cap. i. *Memoires de l'Academie des Inscriptions*, tom. xx. p. 448.

General description of a clock. PLATE CCC. Fig. 1 & 4.

It would be a waste of time to describe the nature of wheels and pinions, as this kind of machinery is now so generally known. It may be sufficient to remark, that a clock or a watch movement is an assemblage of wheels and pinions, contained in a frame of two brass plates, connected by means of pillars; the first or great wheel of which, in an eight day clock movement, has concentric with it a cylindrical barrel, having a spiral groove cut on it. To this cylinder is attached one end of a cord, which is wrapped round in the groove, for any determined number of turns, and to the other end of the cord is hung a weight, which constitutes a power or force to set the wheels in motion. Their time of continuing in motion will depend on the height through which the weight has to descend, on the number of teeth in the first or great wheel, and on the number of teeth or leaves of the pinion upon which this wheel acts, &c. The wheels in spring clocks and in watches are urged on by the force of a spiral spring, contained in a hollow cylindrical barrel or box, to which one end of a cord or chain is fixed, and lapping it round the barrel for several turns outside; the other end is fixed to the bottom of a solid, shaped like the frustum of a cone, known by the name of the *fusee*, having a spiral groove cut on it; on the bottom of this cone, or fusee, the first or great wheel is put. The arbor on which the spring barrel turns, is so fixed in the frame, that it cannot turn when the fusee is winding up; the inner end of the spring hooks on to the barrel arbor, and the outer end hooks to the inside of the barrel. Now if the fusee is turned round in the proper direction, it will take on the cord or chain, and consequently take it off from the barrel. This bends up the spring; and if the fusee and great wheel are left to themselves, the force exerted by the spring in the barrel to unbend itself, will make the barrel turn in a contrary direction to that by which it was bent up. This force of the spring unbending itself, being communicated to the wheels, will set them in motion, and they will move with considerable velocity. Their time of continuing in motion will depend on the number of turns of the spiral groove on the fusee, the number of teeth in the first or great wheel, and on the number of leaves in the pinion upon which the great wheel acts, &c. The wheels in any sort of movement, when at liberty or free to turn, and when impelled by a force, whether it is that of a weight or of a spring, would soon allow this force to terminate; for, as the action of the force is constant from its first commencement, the wheels would be greatly accelerated in their course, and it would be an improper machine to register time or its parts. The necessity of checking this acceleration, and making the wheels move with an uniform motion, gave rise to the invention of the *escapement*, or *'scapement* as it is commonly called. To effect this, an alternate motion was necessary, which required no small effort of human ingenuity to produce.

General description of a watch. PLATE CCCII. Fig. 1.

CHAP. I.

On the Escapement, or 'Scapement.

On escapements.

The escapement is that part of a clock or watch connected with the beats which we hear them give; and these beats are the effects of the moving power, carried forward by means of the wheels in the movement to the last one, which is called the *swing wheel* in a pendulum clock, and the *balance wheel* in a watch. The teeth of this wheel act on the pallets or verge, which are of various shapes, and which form the most essential part in a 'scapement; the drop from each tooth of the swing or balance wheels, on their respective pallets, giving one beat or impulse to the pendulum or balance, in order to keep up or maintain their motion; and were it not for the pallets which alternately stop the teeth of the swing or balance wheels, the motive force would have no check. Hence it is, that, by this mechanism of the 'scapement, the wheels in the movement are prevented from having their revolutions accelerated, which would take place to such a degree, as to make the machine run down in a minute or two; whereas, from the resistance opposed by the pallets, it is kept going for twenty-four or thirty hours, for a week or a month, or even for twelve months. In the clocks or watches, however, which as a matter of curiosity have been made to go so long, it was not possible to have an accurate measure of time.

Crown wheel and verge 'scapement.

PLATE CCC. Fig. 2.

PLATE CCC. Fig. 3.

No part of a clock or watch requires so much skill and judgment in the contrivance of it, and so much care and nicety in its execution, as that of the 'scapement; none of the 'scapements of the present day require this more than the ancient crown wheel and verge 'scapement, which when nicely executed, upon the proper principle, does extremely well for a common pocket watch. But this is a thing hardly now to be met with. From the time of Dr Hooke, and during the last century, many ingenious contrivances for 'scapements were suggested; but the number of them adopted in practice is very limited. The crown wheel and verge 'scapement is represented in Fig. 2, where V is the verge and C the crown wheel, *p*, *p* the pallets, and BB the balance. It is the oldest that is known, and must have been the only one used in clocks, for several centuries, previous to the middle of the seventeenth, or towards the end of it. Although it has been so long in use, and so well known to every clock and watch-maker, that its merits are now overlooked, and held in little estimation, yet, if it is duly considered, it will be found to have been a very masterly and ingenious device. The crown wheel and verge are of such an odd shape, that they resemble nothing that is familiar to us. Yet some ancient artist had contrived it for the purpose (and it certainly was an ingenious thought) to give an alternate motion to a plain wheel, or cross, which he had suspended from the upper end of its axis by a string, or which at first might rest on the lower end of the axis or *foot pivot*. This plain wheel was like the fly of our common kitchen jack. In place of this circular rim, or plain wheel on the axis, there were some of them that had two arms upon it, forming something like a cross; on these were made a sort of notches, concentric to the axis, in which were hung a small weight on each arm, which, by shifting more or less from the centre, the clock was made to go slow or fast. From the weightiness of this kind of balance, and the rude execution of the work, the friction on the end of the foot pivot would be so great that it is probable there was some difficulty to make the clock keep going for any length of time. Recourse was then had to suspend the balance by a small cord, so that the end of the lower pivot should not rest on the foot of the potence. This ingenious idea has in modern times been adopted both by Berthoud and Le Roy, who have had the balances in some of their marine time-keepers suspended by a very small wire, or a very delicate piece of watch pendulum spring wire. The mechanism of the movement of these old clocks is exactly the same as has been frequently made for an alarm. To construct this, and apply it to a clock, there was hardly a step to go; and therefore in all probability the invention of the alarm part took place before that of the striking part, though some have thought otherwise. The contrivance of the striking part was a more complex process, and less likely to take place.* The alarm-clock is represented in Fig. 3.

This opinion is strongly corroborated by the observations of Hamberger in Beckmann's *History of Inventions*. "These horologia," he remarks, "not only pointed out the hours by an index, but emitted also a sound. This we learn from *Primaria Instituta Canonicorum Præmonstatentium*, where it is ordered that the sacristan should regulate the horologium, and make it sound before matins to awaken him. I dare not, however, venture thence to infer, that these machines announced the number of the hour by their sound, as they seem only to have given an alarm at the time of getting up from bed. I have indeed never yet found a passage where it is mentioned that the number of the hour was expressed by them; and when we read of their emitting a sound, we are to understand, that it was for the purpose of awakening the sacristan to prayers. The expression *horologium cecidit*, which occurs frequently in the before-quoted writers, I consider as allusive to this sounding of the machine. Du Fresne, in my opinion, under the word *Horologium*, conceives wrong the expression *de ponderibus in imum delapsis*, because the machine was then at rest, and could raise neither the sacristan or any one else, whose business it was to beat the *scilla*."

When an alarm is set off, the weight, which is the moving force of it, very soon falls to the bottom, and then the alarm ceases.

In attempting to make the first 'scapement, there can be little doubt that something of the circular or cylindrical kind was contrived, and the only thing which could give it an alternate motion, was either a spiral spring or a pendulum; but these things being then unknown, the clockmaker was obliged to seek after other methods, and at last produced the crown wheel and verge 'scapement. How came it that means so complicated were fallen on, when those which were more simple and better were overlooked?

Discovery of the pendulum by Galileo.

It is a very singular circumstance, that a small ball or weight, when suspended by a slender thread, and drawn a little aside from the perpendicular, on

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* In many parts of India, where public clocks are unknown at this day, they strike the hours upon a plate of silver, or silver alloyed with another metal, of a lenticular form, about 18 inches in diameter. It is hung on a frame by a doubled string; and when the hour is pointed out, either by their sand-glasses, clepsydræ, or water-dropping instruments, which they sometimes use, they strike with a wooden hammer on the middle of the circular plate, and thus indicate, by the number of blows, the hour of the day. The sound which is produced is strong, clear, and pleasant. This contrivance is used in many of the towns and camps throughout India.

Discovery of the pendulum.

being let go, continues to vibrate for a considerable time, and with the utmost regularity. Many things in domestic life were hung up or suspended by strings, and were every day seen or observed; yet what a long time elapsed before any thing of this kind was ever thought of, or applied to regulate the motion of a clock! It is said that Galileo took his idea of a pendulum from the motion of a lamp, suspended from the roof or ceiling of a church, which had been accidentally set a vibrating. He used the simple pendulum in his astronomical observations, long before it was applied to a clock. Some of the earlier astronomers, as well as Galileo, used a common string and ball, which they made to vibrate a little while, during the time of an observation of any of the heavenly bodies. Yet even these astronomers did not think of its application to clocks. Some watch-finishers, when their watch is finished, for want of a pendulum clock, regulate it by means of a ball and string, which will answer very well, by taking 50 vibrations of a pendulum's length for seconds, in the same time that the wheel ought to make one revolution.

As gravitation is the principle on which the pendulum is founded, it cannot properly be considered as an invention, as some have called it, whatever name may be given to it when applied to regulate the motion of a clock. The pendulum having before this been long known in its simple state, and used as a sort of time-measurer, it was no wonder that the idea of applying it to a clock, was entertained by several persons nearly about the same period. The movement of the old balance clocks was not adapted for the application of the pendulum, so as to give motion to it; the wheels in it were all flat ones except the crown wheel, and no other 'scapement at this time was known but that of the crown wheel and verge; so that, without considerable difficulty and invention, the pendulum could not well be applied to this construction of a clock movement. The pocket watch had been made a considerable time before this, and the construction of its movement, which had a contrate wheel in it, would naturally lead them to that of one which would adapt itself to the motion of a pendulum, as by means of the contrate wheel the crown wheel could be made to stand in a vertical position; whereas, in the old balance clocks, the position was horizontal. Galileo seems early to have discovered the properties of the pendulum, and the investigation was prosecuted with great success by Huygens. The son of Galileo applied the pendulum to a clock at Venice in the year 1649; but to what sort of a movement we cannot pretend to say, though we suspect, from that want of success which seems to have attended his trials, that he had not adopted the contrate wheel movement already mentioned as the most proper for it. We know that Huygens made use of this sort of movement, as the only one fit to be regulated by the motion of the pendulum, which he had also applied. Of late, another candidate for the application of the pendulum to a clock has been brought forward by such respectable authority, that leaves little or no room to doubt of its authenticity. Mr Grignion informs us, "that a clock was made in 1642, by Richard Harris of London, for the church of St Paul's, Covent Garden, and that this clock had a pendulum to it."

Pendulum first applied to a clock in 1649, by the son of Galileo.

It appears, from unquestionable evidence, that Galileo, mathematician to the Grand Duke of Tuscany, first discovered the properties of the pendulum, used it in his astronomical observations, and wrote a tract explaining the principles of it. This tract was translated from the Italian into French at Paris, printed in 1639 in a duodecimo volume, and sold by Pierre Ricolet. He intended to apply it to a clock, but this he never put into execution. Father Alexander says, "that they had nothing better than the balance clocks in France until the year 1660."

The application of the pendulum to a clock, and of the spiral form of a pendulum spring to the balance of a watch, were the greatest improvements that could possibly have been made in the machinery of time-measuring, and they both happened to take place nearly about the same period.

Huygens's clock. PLATE CCC. Fig. 4.

Notwithstanding the application of the pendulum, and the ingenious contrivance of cycloidal cheeks by Huygens, in order to make the long and short vibrations be performed in nearly as equal time as possible, yet the clock did not keep time with that correctness which was expected: This arose from the great extent of the arc of vibration, the lightness of the pendulum ball, the great *dominion* which the clock had over the pendulum, and the bad effects produced by the cycloidal cheeks, which, however excellent in theory, were never found useful in practice. See Fig. 4. where a front view of the cycloidal cheeks is represented in Fig. A. This led artists and amateurs of the profession to think of farther means of improvement; accordingly, about the year 1680, a clock was made by W. Clement, a clock-maker in London, having in place of the crown-wheel and verge 'scapement, a 'scapement which was nearly the same as the common recoiling 'scapement of the present day. The swing-wheel S W was flat, having a sort of ratchet or saw-like teeth; and the pallets P, P had a remote resemblance to the head of an anchor, by which it acquired at that time the name of the *anchor 'scapement*. See Fig. 5. The ball of the pendulum was made much heavier than what had formerly been adopted, the arc of vibration much shorter, and the motive force much less. From the excellent time-keeping of the clock, this was found to be a great improvement, and hence this 'scapement was afterwards generally practised. It passed into Holland and Germany, and was hardly known in France until the year 1695. See *Histoire de la Mesure du Temps*, tom. i. p. 100.

Fig. A.

Anchor 'scapement. PLATE CCC. Fig. 5.

At the time when this clock of Clement's appeared, Dr Hooke claimed the invention of it as his, and affirmed, that after the great fire of London, in 1666, he had shewn to the Royal Society a clock with this very 'scapement. "Considering," says Sully, in his *Histoire des Eccappemens*, "the genius, and the great number of fine discoveries of this excellent man, I see no room to doubt that he was the first inventor of it." The pendulum with this 'scapement had received the name of the *royal pendulum*.

Graham's dead-beat 'scapement.

The *dead-beat* 'scapement of Graham's next succeeded, which was invented some time after the beginning of the eighteenth century, and has continued to be that which is generally used in regulators, or astronomical clocks, with a very few exceptions. See Fig. 6. About ten or fifteen years afterwards, it came to be known in France, and was adopted there also as the best for clocks intended to measure time very accurately. Lepaute, a very ingenious watchmaker in Paris, produced, about the year 1763, or some time before it, a 'scapement founded on that of Graham's dead-beat one. See Fig. 7. In Lepaute's, the rest of the teeth on the pallets was al-

Fig. 6.

Lepaute's improvement upon it. Fig. 7.

Lepaute's escapement. PLATE CCC. Fig. 7.

ways with the same effect, because it was on the same circle, whichever of the pallets it rested upon; the impulse given was also always the same on whichever pallet it was given, the flanches of the pallets being planes equally inclined. This was no doubt some improvement on Graham's; but the teeth of the swing wheel in Lepaute's consisted of sixty small pins, thirty being arranged on each side of the rim of the wheel; and where pin-teeth are used, oil, which is in some degree necessary, cannot easily be kept to them, the attraction of the rim of the wheel constantly draining the oil from these pin sort of teeth; an evil which is perhaps not easily to be got the better of, unless by using stone pallets and hard tempered steel pins.

Recoiling 'scapement. Fig. 8.

Notwithstanding the seeming superiority and great character which the dead beat 'scapement had long acquired over that of the *recoiling* one represented in Fig. 8. this last had, however, its partizans; and among them were artists and amateurs possessed of first rate talents. Such were Harrison, Professor Ludlam of Cambridge, Berthoud, Smeaton, and others Harrison, indeed, always rejected the dead beat 'scapement with a sort of indignation. The author of the Elements of Clock and Watch Making, has said a great deal in favour of the dead beat, and as much against that of the recoiling one, without having shown in what the difference consisted, or what was the cause of the good properties in the one, or what the defects in the other. It appears doubtful if these causes were known to him; yet he was very deservedly allowed to be a man of considerable genius. When pallets are intended to give a small recoil, their form, if properly made, differs very little from those made for the dead beat, as may be seen by the dotted lines upon the dead beat pallets in Fig. 6.

Comparison of the dead beat and recoiling 'scapements.

We shall endeavour to point out the properties and defects naturally inherent in each: When the teeth of the swing wheel, in the recoiling 'scapement, drop or fall on either of the pallets, the pallets, from their form, make all the wheels have a retrograde motion, opposing at the same time the pendulum in its ascent, and the descent, from the same cause, being equally promoted. This recoil, or retrograde motion of the wheels, which is imposed on them by the reaction of the pendulum, is sometimes nearly a third, sometimes nearly a half or more of the step previously advanced by the movement. This is perhaps the greatest, or the only defect that can properly be imputed to the recoiling 'scapement, and is the cause of the greater wearing in the holes, pivots, and pinions, than that which takes place in a clock or watch having the dead beat, or cylindrical 'scapement; but this defect may be partly removed by making the recoil small, or a little more than merely a dead beat. After a recoiling clock has been brought to time, any additional motive force that is put to it, will not greatly increase the arc of vibration, yet the clock will be found to go considerably faster; and it is known that where the arc of vibration is increased, the clock ought to go slower, as would be the case, in some small degree, with the simple pendulum. The form of the recoiling pallets tends to accelerate and multiply the number of vibrations, according to the increase of motive force impressed upon them, and hence the clock will gain on the time to which it was before regulated. Professor Ludlam, who had four clocks in his house, three of them with the dead beat, and the other with a recoil, said, "that none of them kept time, fair or foul, like the last: This kind of 'scapement gauges the pendulum; the dead beat leaves it at liberty." Were it necessary, many good proofs could be adduced of the excellent performance of clocks which had the recoiling 'scapement.

Comparison of the dead beat and recoiling 'scapements.

Let us now make a similar comparative trial with the dead beat 'scapement. An additional motive force being put to it, we find that the arc of vibration is considerably increased, and the clock, in consequence of this, goes very slow. There are two causes which produce this; the one is, the greater pressure by the swing wheel teeth on the circular part of the pallets during the time of rest; the other is, the increase of the arc of vibration. It was observed in the case of recoil, that an additional motive force made the clock go fast; and the same cause is found to make the clock having the dead beat go slow. As the causes are the same, and yet produce effects diametrically opposite, does not this evidently point out what is necessary to be done? The pallets should be so formed, as to have very little of a recoil, and as little of the dead beat; and here any variation in the motive force, or in the arc of vibration, will produce no sensible deviation from its settled rate of time-keeping. We have been informed, that a clock was given by Mr Thomas Grignion to the Society for the encouragement of Arts, Manufactures, &c. "which had a dead beat 'scapement, so constructed or drawn off, that any diminution or addition of motive force, would not alter the time-keeping of the clock." All the 'scapements of this kind which have been hitherto made, were commonly drawn off nearly in the same way as Mr Grignion's, that is, the distance between the centre of the pallets, and the centre of the swing wheel, is equal to one diameter of the wheel, and the line joining the centre of the pallets, and the acting part of them, is a tangent to the wheel, taking in ten teeth, and 'scaping on the eleventh. This is nearly the same as that represented in Plate II. of Mr Cuming's book. The only difference is, that Mr Grignion's circle of rest is the same on each pallet. But whether it possesses the properties which have been ascribed to it, shall be left to the determination of those who may chuse to try this experiment with it.

Clock makers in general have an idea, that, in a 'scapement, the pallets ought to take in seven, nine, or eleven teeth, thinking that an even number would not answer. This opinion seems to have arisen from the old crown wheel having always an odd number of teeth, because an even number could not have been so fit for it.

There seem to be no rules (as some have imagined) necessarily prescribed by either the recoiling or the dead beat 'scapement, for any particular distance, which the centre of the pallets ought to have from that of the swing wheel. The nearer that the centres of the swing wheel and pallets are, the less will be the number of teeth taken in by the pallets, when a tangent for them is drawn to the wheel. It is very obvious, that when the arms of the pallets are long, the greater will be the influence of the motive force on the vibrations of the pendulum, and *vice versa*, when the pallets are short, the angle of the 'scapement will naturally be greater than may be required, but this can be easily lessened by making the flanches so as to give any angle required. When this angle is not quite half a degree on each side, a very small motive force will keep a pretty heavy pendulum in motion. We have known a very good clock maker, who thought that the flanch of the pallets was an arbitrary or fixed point, which could be made only in one way, and it was some little while before he could be convinced of the contrary. The flanches may be made so long as to act something like detents, so as to stop the wheel altogether by the teeth, Escapement.

(see Fig. 5.) or they may be made so short, as to allow the wheel teeth to pass them altogether, without giving any impulse at all to them. It is true, that there would be no 'scapement here; only it shows that the flanch of the pallets may be made to give any angle of 'scapement, from a few minutes to two or three degrees. Whatever the angle of the flanches may be taken at, all that is requisite, is, to make the wheel 'scape so, that the tooth, when it drops on the pallet, shall fall just beyond the corner of the flanch, on the circular or recoiling part of the pallet.

Harrison's clock pallets without oil.

Harrison's clock pallets (which are sometimes made to act by means of very delicate springs, and sometimes by their own gravity), have a very considerable recoil, which was a most ingenious contrivance, to do away the necessity of having oil put to them. The construction of them seems to be but little known; and they have very rarely been adopted in practice. Indeed, it is a 'scapement of such a nature, that very few would be competent to execute it properly. The circumstances which led to the invention of them, were mentioned by Mr Harrison himself to the late Professor Robison. Having been sent for to look at a turret clock which had stopt, he went to it, though it was at a considerable distance from his home, and found that the pallets were very much in want of oil, which he then applied to them. On his returning, and ruminating by the way on the indifferent sort of treatment which he thought he had met with, after having come so far, he set himself to work, to contrive such a 'scapement, as should not give to others that trouble to which he had been put in consequence of this turret clock. Hence the origin of his pallets. A drawing and description of them will be given in a future part of this article.

Mudge's 'scapement.

The justly celebrated Mr Mudge, in a small tract, published in June 1763, relative to the best means of improving marine time-keepers, suggested, as a great advantage, that of making the moving power bend up at every vibration of the balance, a small spring whose returning force should be exerted in maintaining the motion of the balance, (see Fig. 9.) The first essay of this most ingenious contrivance was a small pocket watch, executed by himself, nearly about this period; and this is the same principle which, some years afterwards, he adopted and practised in those time-keepers which he made.

Plate CCC. Fig. 9.

Cuming's 'scapement.

About two or three years or so after the publication of this tract, Mr Cuming contrived a clock 'scapement, nearly on the same principle as that of Mudge's, where the motion of the pendulum was maintained by the force of gravity of two small balls, which acted upon it during the time of the descent. In this 'scapement, the centre of motion of the pallets is independent of that of the pendulum and verge, although the same, and concentric with them; two detents were applied for locking the swing wheel teeth, one for each pallet; from each of the pallet arbors a wire projected in an horizontal position, and on the end of these wires the balls were fixed, which were alternately raised up at every vibration of the pendulum, by means of the action of the swing wheel teeth on the pallets. In a periodical philosophical journal, it is insinuated that Mudge had borrowed the idea of the 'scapement, which he used in his time-keepers, from this of Cuming's. That Mudge's 'scapement was his own invention, is clearly evident from the historical facts which have been stated. And although there is an apparent similarity between Cuming's and it, yet we are not inclined to be of opinion, that Mr Cuming borrowed his from Mudge's. The 'scapement of the clock made by Cuming for his Majesty the king in the year 1763, is of the free or detached kind, a name which was not then known. The improvement which he himself made upon it two or three years after, was to keep up the motion of the pendulum by the gravity of two small balls, independent of the motive force through the wheels of the movement. In this 'scapement, he insists on the adjustment between the pendulum screws and crutch being made so as just to unlock the swing wheel and no more. This can then be only unlocked at the time, when the force of the pendulum in its ascent is nearly gone, and that the pendulum should not then meet with the arm of the ball, but to receive it, as it were, just before the descent of the pendulum has commenced. In that part of Mr Mudge's, each pallet and detent were formed in one, and the unlocking takes place a considerable while before the end of the vibration. Thus, the springs which maintain the motion of the balance are bent up, not only by means of the action of the swing or balance wheel teeth on the pallets at every vibration till the wheel teeth are locked, but are still a little more bent up when unlocking by the exertion or momentum of the balance, or pendulum itself, previous to the vibrations being nearly finished; and this is one of the greatest properties of this 'scapement, whether it is applied to the balance and spring, or to the pendulum. No 'scapement appears to be better calculated than this is, to keep the pendulum or balance constantly up to the same arc of vibration, notwithstanding its having what some have been pleased to call a *defect* in the recoiling one, that of opposing the balance or pendulum in its ascent, and promoting its descent. In the spring pallet 'scapement, as in the recoiling one, the pendulum is opposed in its ascent, and has its descent equally promoted; but there is still a difference between them, notwithstanding this similarity. In the spring pallet 'scapement, no retrograde motion is given to the wheels, pinions, and pivots, which produces that early wearing on them, and where the seconds' hand partakes also of this retrograde motion as in the common recoiling 'scapement. These are circumstances which have no place in that of the other. In such 'scapements as those now mentioned of Mudge's or Cuming's, it has been said by some, that it matters not what sort of work the clock movement is, or however ill it may be executed; since the motion of the pendulum is kept up by a force, which, in some degree, is independent of the motive force produced through the wheels in the movement. This may be so far true, yet there is no 'scapement, where any irregularity in the pitchings, pinions, &c. of the movement will be more readily discovered than in this, during the going of the clock, which will be very perceptible to the ear at the time of raising up the balls, or that of bending up the springs. We would therefore by no means advise, that this sort of 'scapement should be put to a movement of indifferent execution: on the contrary, it seems to require one finished in the best possible manner. The motive force put to it requires to be greater than that which is usually put to clocks having the dead beat 'scapement. It may be asked, whether weights or springs are the best for these sorts of 'scapements, which is perhaps a question not easy to be resolved. We confess that springs appear to be preferable; they seem to have, as it were, an alertness or quickness of action, when compared to the apparent heavy dull motion of gravity in the balls. The pivots which are at the centre of motion of the pallets and balls would be regarded by many as objectionable, from the belief that oil is necessary to them. Oil does not seem to us in the least degree requisite, considering the very small angle of motion which they would have; and we have always thought, for the same reason, that oil was not necessary to the pivots of such detents as were sometimes used in the detached 'scapement.

We shall now proceed to give a description of a clock 'scapement, on the same principle as that of Mudge's in his marine time-keepers, which was put to a very capital regulator or astronomical clock, made some years ago by Mr Thomas Reid, for Lord Gray's observatory at Kinfauns Castle. It had a mercurial compensation pendulum, and its time of going without winding up was forty-five days. The great wheel, the second wheel, and the swing wheel pivots, were run on rollers, three being put to each pivot. Rollers were first applied by Sully to the balance pivot of his marine time-keeper, and have since been adopted by Berthoud, Mudge, and others. They have sometimes been used for clock pivots, but in such an injudicious manner, that, in place of relieving the friction of the pivots, they have at last jambed them to such a degree, that the pivot could not at all turn or revolve upon them.

Description of a clock 'scapement by Mr Thomas Reid. PLATE CCCI. Fig. 1.

In Fig. 1. SW is the 'scapement or swing-wheel, whose teeth are cut not unlike those of the wheel for a dead beat, but not near so deep. P, P are the pallets, the upper ends of whose arms at *s*, *s* are made very thin, so as to form a sort of springs, which must be made very delicate; for, if they are any way stiff, the force of the swing wheel will not be able to bend them when raising up the pallets. In order that these springs may have a sufficiency of strength, and at the same time be as delicate as possible, they are cut open at the bending parts, as may be seen at Fig. 2. These springs come from a kneed sort of sole, formed from the same piece of steel, by which sole they are screwed on to cocks, which are attached to the back or pillar plate of the clock-frame. The pallet arms must be made very light and stiff, in order that their weight may have the least possible load or burden on the springs; *a*, *a* are the arms of the pallets, as represented in the front view, Fig. 1. and are fully as broad as is necessary. Their thickness may be made much less than this. An edge view of the pallet arms is seen in Fig. 2. The acting parts of the pallets at P, P, Fig. 1. should be made of such thickness as to allow room for inserting a piece of ruby, agate, or any fine or hard sort of stone, the thickness of the stone being a very little more than that of the 'scapement or swing wheel. Each of these stone pallets has a sort of nib or detent for the wheel teeth, which is left at the end of the pallet flanches, as may easily be seen at the left hand pallet, Fig. 1. These nibs are made for the locking of the swing wheel teeth, and their use will be more particularly explained afterwards. On the back of the pallets are screwed to each a kneed light brass piece *c*, *c*, as seen at Fig. 1. On the lower ends of these kneed pieces, the screws *d*, *d* are put through, serving the double purpose of adjusting the 'scapement, and setting the pendulum on beat. The upper part of the pendulum-rod is composed of a sort of frame, whose steel plates A, A, A, A, Fig. 1. are represented as being contained within the dotted circular lines; the thickness of these ring-sort of plates is seen at A, A, A, A, Fig. 2. This frame has three pillars to keep the plates properly together; and though they are not represented in the drawing, yet any one may readily conceive where their places ought to be, and what should be their length and height. At *e*, *e*, Fig. 1. is seen on each side the ends of a thin steel plate, or traverse bar, which goes from plate to plate, and is fixed in the frame. An oblique view of one of them is seen at *e*, *e*, Fig. 2. In the steel frame plates, there is a circular opening, as represented by the dotted inner circle, Fig. 1. This opening must be of such a diameter as to allow the swing wheel and the cock which supports it to come freely through; a part of the cock is seen at *f*, *f*, Fig. 2. the sole of which F is screwed to the back of the pillar plate of the clock; the other knee K turns up to receive the pivot of the arbor of the swing wheel, the pivot at the other end of this arbor being supposed to run in the fore plate, or in a cock attached to it, and is the pivot which carries the seconds' hand. This description of the manner by which the swing wheel is supported within the pendulum, it is to be hoped will be sufficiently understood, notwithstanding the want of a proper drawing of that part. The swing wheel S W, and part of its pinion arbor *g*, are seen edgewise at Fig. 2.; also the arm *a* of one of the pallets P, and its screw *d* bearing on the steel bar *e*, *e*. At the point of contact between the end of the screw *d* and the bar *e*, a small piece of fine stone may be inserted into each bar. This will prevent any wearing or magnetic attraction which might otherwise take place, if the screw was left solely to act on the steel bar; for the smallest wearing here would in some degree alter the effects of the 'scapement. In Fig. 1. B represents a part of the bar of the pendulum rod, which is fixed into the lower part of the steel frame; an edge view of this bar is seen at B, Fig. 2. At the upper part of the steel frame is inserted a piece *c*, *c*, Fig. 1. and 2.; in this piece the pendulum spring is fixed, whose top piece goes into a strong brass cock, which is firmly attached to the back of the clock-case, or to a large stone pier; the end of the projecting part of this cock is seen at DD, Fig. 1, and a side view of this part of it at DD, Fig. 2. The top piece of the pendulum spring has a long and strong steel pin through it, which lies in a notch made across on the upper side and projecting part of the pendulum cock. By this strong pin, the pendulum is suspended. In the side of the pendulum-spring top-piece, is made a large hole, so as to admit freely a strong screw, the head of which is seen at E, Fig. 2. This screw serves to pinch the top-piece and cock firmly together, after the pendulum has been made to take a true vertical position. This strong pin and screw are not represented in the drawing, but the description which has been given will, it is presumed, easily supply this want. In the pendulum spring *h*, *h*, Figs. 1. and 2. may be seen an opening in it, so as to have the appearance of a double spring, as seen at *h*, *h*, Fig. 2. This opening is made to allow the spring parts of the pallets *s*, *s* to be brought very near together, and this at the bending part of the pendulum spring, so that it and the bending part of the pallet springs should be as it were in one common centre. A part only of the cocks on which the spring pallets are screwed, is represented by *k*, *k*, Fig. 1.; *m*, *m* are the heads of the screws by which they are fixed to these cocks. It must be observed here, that the spring pallets are so placed, that they should act on the line of suspension and gravitation of the pendulum, which necessarily brings the swing wheel to the place where it is; no verge, crutch, or fork are required; the influence of

Fig. 2.

Description of a clock 'scapement by Mr Thomas Reid. PLATE CCCI. Fig. 1, 2.

the oil on the verge pivots, and the friction by the crutch or fork on the pendulum rod, are done away by this arrangement. The motion of the pendulum is kept up *entirely* by the force of the spring part of the pallets, independent of any impediment in the wheel work, so long as it has force sufficient to raise up the pallets readily and easily: this force may be considered as permanent and invariable, and so should be the arc described by the pendulum. If the length of the pendulum and of the arc it describes are invariable, so should be the time which is kept by the clock. Having described the parts which compose this 'scapement, it will now be requisite to shew their mode of action, which is extremely simple.

When the pendulum is set in motion, it will, by means of either one or other of the screws *d*, unlock the swing wheel; which, in the drawing, is represented as being locked by one of its teeth on the nib or detent part of the right hand pallet; and the moment when the wheel is unlocked, the tooth at the left hand pallet is ready to press forward and raise up the pallet; and, of course, it bends up the spring. Let the pendulum be now brought to the right hand side, the steel bar *e* will meet with the screw *d*, and carrying it or pushing it on, it will by this means unlock the swing wheel, and allow it to escape. At this instant, the wheel tooth meeting with the pallet on the left hand side, it will force its way on the flanch, and raise it up till it is stopped by the detent or pallet nib. Here the wheel is locked until the return of the pendulum to that side, when it will be again unlocked. From the time of the unlocking at the right hand pallet, till the same takes place at the left hand, the pendulum, during its excursion to the right, is opposed by the spring part of the pallets, and on its return it is assisted by the same part, until the pendulum comes in contact with the point of the screw *d* on the left hand part: Here it is again opposed in its excursion, as far as the arc it describes; and on its descent or return, it is assisted or impelled by that of the spring part of the pallet, in conjunction with the force of gravity. In this clock, all that the motive force through the wheels has to do, is to raise up the pallets, by bending up the springs, and these, along with gravity, maintain the motion of the pendulum.

When clocks of the common construction get foul in the oil, or dirty, the arc of vibration falls off, or is less than what it was when the clock was clean and free. In this 'scapement, however, when the clock gets foul, the force of the swing wheel teeth, on the detent part of the pallets, will be lessened, consequently the wheel will more easily be unlocked by the pendulum: hence we may expect a small increase in the arc of vibration; but whether this will affect the timekeeping, by making it slow, must be left to the experience of those who may think of making such trials. It appears to us, that if any lengthening of the arc of vibration takes place, it will be equally accelerated by the greater tension of the spring part of the pallets.

Another clock having the same kind of 'scapement, has since been made by Mr Thomas Reid, where the adjustments for 'scapement and beat are transferred from the pallets to the pendulum itself. By this means, these adjustments are not only easier made, but are effected without that danger to which the pallets are exposed, when this is done by the screws which are in them. This 'scapement has also been very advantageously applied, even where a verge and crutch were adopted.

The following is a scheme and description of another clock 'scapement, which the writer of this article contrived about twelve or fifteen years ago.

Another clock 'scapement by Mr Reid. PLATE CCCI. Fig. 3, 4, 5.

In Plate CCCI. Fig. 3. SW is the swing wheel, whose diameter may be so large, as to be sufficiently free of the arbor of the wheel that runs into its pinion, which in eight day clocks is the third. The teeth of this swing wheel are cut thus deep, in order that the wheel may be as light as possible, and the strength of the teeth little more than what is necessary to resist the action or force of a common clock weight through the wheels. They are what may be called the locking teeth, as will be more readily seen from the use of them afterwards to be explained. Those called the impulse teeth, consist of very small tempered steel pins, inserted on the surface of the rim of the wheel on one side only. They are nearly two-tenths of an inch in height; and the smaller they are, so much more room will be given to the thickness of the pallets. If they have strength to support about eighty or a hundred grains, they will be strong enough. There is no rule required for placing them relatively to the locking teeth, only they may as well be opposite these teeth as anywhere else. P, P are the pallets, whose centre of motion is the same with that of the verge at *a*. These pallets are formed so as to have the arms sufficiently strong, and at the same time as light as may be. That part where the arms meet at the angle at *a*, has a steel socket made out of the same piece as the arms, being forged together in this manner. This socket is made to fit well on the verge, on which it is only twisted fast; and is turned pretty small on the outside, in order to allow the arbors of the detents to be laid as close to the verge as may be, so that their centres of motion may coincide as nearly as possible. A perfect coincidence of the centres might be obtained by using a hollow cylinder for the verge, with the detent arbors running in the inside of it, but this would have occasioned more trouble. That part of the pallet frame, as it may be called, in which is set the stone for receiving the action or impulse of the small pin teeth, is formed into a rectangular shape, so as to allow room for a dovetail groove, into which the stone pallets are fixed, as may be seen at PP, Fig. 3, and at P, Fig. 4, which also gives a side view of the verge at *a*, and where the socket of the pallets is seen as fixed on the verge. At *b*, Fig. 4, is seen the outer end of one of the stone pallets made flush with the steel. That part of the stone pallets upon which the pin teeth act, may be seen in Fig. 3, where they are represented in their respective positions relative to the pin teeth. Their shape or form is exactly that which gives the dead beat. In Fig. 3. are seen the detents *d*, *d*, whose centre of motion is at *c*, *c*. They are fixed on their arbors by a thin steel socket, made as forged with the detents, much in the same way as the pallets were, as may be seen at *c*, Fig. 5, which gives a side view of one of the detents and its arbor. The screws *e e*, *ff*, in the arms of the detents, have a place made to receive them, which is more readily seen in Fig. 5. than in Fig. 3. The screws *e*, *e*, serve for the purpose of adjusting that part of the 'scapement connected with the pallets, pushing the detents out from locking the wheel, by means of the locking teeth. The ends of the screws *e*, *e* on the unlocking, are met by the ends of the stone pallets, one of which is represented at *b*, Fig. 4. The screws *f*, *f*, serve to adjust the locking of the wheel teeth on the detents. *g*, *g* are brass rectangular pieces or studs, which are fixed to the inside of the pillar frame plate, and may be near an inch in height. The ends of the screws *f*, *f* rest on the side of these studs, and according as they are more or less screwed through at the ends of

Fig. 4.

Fig. 5.

Another clock 'scapement by Mr Reid. PLATE CCCI. Figs. 3, 4, 5.

the detents, so much less or more hold will the detent pieces have of the teeth. These holding pieces of the detents are not represented in the drawing, as they would have made other parts of it rather obscure. They are made of stone, and are fitted in by means of a dovetail cut in a piece left for that purpose, on the inside of the detent arms, as may easily be conceived from the drawing, where it is represented in part at *e*, Fig. 5; and is in the line across the arm with the screw *e*, which is close by the edge of the detent stone-piece, which projects a little beyond the end of the screw. Having described the parts of the 'scapement, we shall now explain their mode of action. On the left hand side, the pin-tooth is represented as having just escaped its pallet, as seen in Fig. 3; but, previous to its having got on to the flanch of this pallet, let us conceive that the back of the pallet, or end piece *b* of it, had come, in consequence of the motion of the pendulum, to that side, and opposing the screw *e*, which is in the detent arm, pushes or carries it on with it, and consequently unlocks the tooth of the wheel which then endeavours to get forward; but the pin-tooth, at this instant of unlocking, meeting with the flanch of the pallet at the lower edge inside, and pushing forwards on the flanch, by this means impels the pendulum, and after having escaped the pallet, the next locking tooth is received by the detent on the right hand side, where the wheel is now again locked. In the mean time, while the pendulum is describing that part of its vibration towards the left hand free and detached, as the pallets are now at liberty to move freely and independently of the small pin-teeth, on the return of the pendulum to the right hand side, the detent, by means of the back of the pallet on that side, is pushed out from locking the wheel, and, at the instant of the unlocking, the wheel gets forward, and the pin-tooth is at the same instant ready to get on the flanch of its pallet, and give new impulse to the pendulum, as is obvious by what is represented in the drawing, Fig. 3. After the pin-tooth has escaped the pallet, the wheel is again locked on the opposite or left hand side; the pendulum moves on to the right freely and independently till the next locking on the left takes place, and so on. It may be observed, that the unlocking takes place when the pendulum is near the lowest point, or point of rest, and of course where its force is nearly a maximum. Without attaching any thing to the merits of this 'scapement, we may remark that the clock was observed from time to time by a very good transit instrument, and, during a period of eighty three days, it kept within the second, without any interim apparent deviation. This degree of time-keeping seemed to be as much a matter of accident as otherwise; and cannot reasonably be expected from this, or any clock whatever, as a fixed or settled rate.

Method of converting this 'scapement either into a recoiling or a dead-beat one.

This 'scapement being a detached or free 'scapement, can at pleasure be converted either into a recoiling or a dead beat one, without so much as once disturbing or stopping the pendulum a single vibration. To make a dead beat of it, put in a peg of wood, or a small wire to each, so as to raise the detents free of the pallets; and these being left so as to keep them in this position, the pin-teeth will now fall on the circular parts of the pallets, and so on to the flanch, and the 'scapement is then, to all intents and purposes, a dead beat one. To make a recoiling one of it, let there be fixed to each arbor of the detents, a wire to project horizontally from them about 3½ or 4 inches long; the outer ends of the wires must be tapped about half an inch in length; provide two small brass balls, half an ounce weight each, having a hole through them, and tapped so as to screw on the wires; the balls can be put more or less home, and be adjusted proportionably to the force of the clock on the pendulum. No recoil will be seen by the seconds' hand; yet these balls will alternately oppose and assist the motion of the pendulum, as much as any recoiling pallets can possibly do; and as their effects on the pendulum will be exactly the same, it may be considered as a good recoiling 'scapement. This sort of detached 'scapement, by becoming a dead beat, or a recoiling one, at any time when required, makes it convenient for making various experiments with the different 'scapements.

We shall now proceed to describe a clock 'scapement, whose pallets require no oil, invented by the late Mr John Harrison, who received the parliamentary reward of £20,000 for a marine time-keeper.

Harrison's clock escapement without oil. PLATE CCCI. Figs. 6, 7, 8.

In Plate CCCI. Fig. 6. SW is the swing-wheel, whose teeth are shorter than usual. On the verge is a brass arm, of a sort of cross and flat pronged form, as may be seen at *e*, *e*, *e*, Fig. 6. and at *e*, *e*, Figs. 7. and 8. Upon this arm are screwed two brass-cocks, marked *d*, *d*, in Fig. 6. and *d* in Figs. 7. and 8; the upper pivots of the pallet arbors, as seen at *a*, Figs. 7. and 8. run in these cocks, and the lower pivots in the end of the prongs. On the lower end of the pallet arbors is a brass socket to each, having freedom to move easily on them, and also a proper end-shake between the prongs and the pallet arms. On the end of the sockets, next the pallet arms, is rivetted a thin piece of brass to each, the piece on the socket of the driving pallet being shaped as seen at *h*, *h*, Figs. 6. and 7. and having two holes in it; one of these holes has a range, limited by a pin fixed to the brass arm from the verge; the other hole, which is at the outer end, allows range to a pin, which is fixed to an arm on the pallet arbor, as may be seen at Figs. 6. and 7. The piece of brass on the socket of the leading pallet arbor is shaped as seen at *k*, *k*, Figs. 6. and 8. having a tail which comes to rest on the outer edge of the cock *d*, after being carried a little way by the motion of the pallet; at the outer end, at *k*, is a small brass screw, serving as a counterbalance to the opposite arm or pallet hook. In this pallet arm is an opening, through which the swing-wheel comes, as may be seen at *l*, Fig. 8. the arm at the other end being filed thin down, leaving a sort of shoulder on it. AB, Fig. 6. is a stout piece of brass rivetted, or screwed, to the verge collet; CC is the steel crutch, having another arm, which comes up on the inside of the piece of brass; the ball or paume of the crutch is kept to the verge collet by a sort of spring collet, which has two screws outside, and through to the verge collet, the crutch having liberty to turn on the verge. The piece of brass AB has two short knees turned up, having a hole tapped in each to receive the two screws *s*, *s*, Fig. 6. whose ends bear on the upper arm of the crutch, and serve to move the arm to one side or the other, so as to put the pendulum or clock on beat; *p*, *p*, is a piece of hard wood put on the lower end of the crutch, having an opening in it, to clip or take in with the middle rod of a gridiron pendulum.

Mode of action in Harrison's pallets.

The parts of this 'scapement being described, it now remains to explain their action. The tooth of the swing-wheel, which has hold of the hook of the leading or right hand pallet, carries it on, until another tooth meets with the hook or notch at the end of the driving pallet arm. When this takes place, the wheel is made to recoil a little back; at this instant, the hook of the leading pallet gets free of the tooth, and is made to rise clear of the top of it, by means of the counterbalancing of the brass arm, and the screw *k* at the end of it. The tooth of the swing-wheel, which has now got into the notch at the end of the driving pallet arm, carries it forward until another tooth, meeting with the hook of the leading pallet, causes the wheel again to recoil. This allows the notch of the driving pallet to get free of the tooth, and the brass piece, which is on the pallet arbor, falls down, till it comes to rest on the pin in the brass cross piece, making the pallet notch get quite clear of the top of the tooth, and so on. There is a great deal of ingenuity displayed in the contrivance of this 'scapement, yet the nice and ticklish balancing of the pallets occasions some degree of uncertainty in their operations; and whether the great recoil which it has may not be against the time-keeping of the clock, remains, perhaps, yet to be proved. Was it this 'scapement which was in a clock of Mr Harrison's, at his house in Orange Street, of whose going Mr Short said, "That he could depend on it to *one second in a month*," and "that it had been going for fourteen years at this rate?"

Properties of a good 'scapement.

Properties of the spiral or balance spring, first pointed out by Dr Hooke,

and known to Mudge before they were discovered by Berthoud or Le Roy.

The properties of a good 'scapement are, that the impelling force should be applied in the most uniform and direct way, and with the least friction and loss of motive force; that it require little oil, or none; and that the oscillations of the regulator, whether it is a pendulum or a balance, be made in as free and undisturbed a manner as possible. The nice execution required in a 'scapement, whether for a clock or a watch, formerly engrossed so much of the attention of workmen, that they, in some measure, lost sight of the properties of the pendulum, as well as that of the spiral or balance pendulum spring, and thought that the time-keeping of their machines depended more on the 'scapement than on any other thing, without considering, that this, from principle, lies wholly, or almost wholly, in the pendulum and in the spiral spring. Berthoud imputes a notion like this to Harrison, for attempting to make the 'scapement in his timekeeper so that the long and short vibrations should be made in equal times. Whereas he says, "he ought to have looked for this in the isochronous property of the spiral or balance spring. But this property (he adds) was unknown at that time to the English artists; and was a discovery of those in France, from whom the English artists afterwards obtained it." If this be the case, how did it happen that Mr Mudge, long before the period when Le Roy and Berthoud disputed about the property of this spiral spring, each claiming the merit of having first made the discovery, mentioned in his tract, published in 1763, "That the pendulum or balance spring, from physical principles, made the balance perform the long and the short vibrations to equal times?" He learned this from Dr Hooke's works, with which he was well acquainted; and this property of springs was known to Dr Hooke, and pointed out by him nearly an hundred years before Mudge published his pamphlet. It is but too true, that few or none of the English artists seem to have been acquainted with these properties till very lately, though Mr Mudge had pointed them out so long before, and though they were contained in the works of Dr Hooke. Lepaute's book was published at Paris in 1767, and does not contain the most distant hint of those properties of the balance spring; hence they were not known there at the time when Lepaute wrote, otherwise he would have mentioned them. It was soon after this, that the disputes commenced between Le Roy and Berthoud regarding this subject.

Watch finishers always made the pendulum spring for the watches of their own finishing, while at the same time knowing nothing of its properties, the general practice was to taper them, so that the coils, when bending or unbending, should preserve an equal distance with one another; and this method has been used ever since the application of the spiral spring. Those who finished watches for Mudge and Dutton, were never employed to make the pendulum spring. This was always done at home by either Mudge or Dutton themselves, who, no doubt, endeavoured to make them as nearly isochronous as possible. This, among other causes, perhaps gave their watches the celebrity which they at that time had deservedly acquired.

The pallets of the 'scapement at the turret clock in Greenwich Hospital, are said to have been contrived by Mr Smeaton. The following narrative will show how he came to be concerned in it. It may be observed, that at that time he was one of the commissioners.

Escapement of the turret-clock at Greenwich Hospital.

The turret clock, which is in the cupola of Greenwich Hospital, was undertaken by the late Mr John Holmes, and executed under his directions by Mr Thwaites. But before any thing was done, Mr Holmes consulted two gentlemen, who happened to be his most intimate friends; the one was the Rev. Mr Ludlam of Cambridge, the other Mr John Smeaton, both of whom were very eminently qualified to give such advice as was wanted in this business, not only about the 'scapement, but how every part of the clock should be fitted up, so as to insure safety and utility in its performance. Several very long and masterly letters (of which Mr Reid has copies, though none of the originals were ever published) passed between them on that occasion, and evince much ingenuity. They agreed that the 'scapement should have a recoil. Mr Smeaton recommended, that the pallets, in place of having planes, as was common for their acting parts, should have curved surfaces, the leading pallet being concave, and the driving one convex; and when the pendulum was at or near to the extremity of the vibration, the 'scapement should then be nearly dead. This was, as he said, what "old father Hindley at York had ultimately come into!" Mr Ludlam advised, that the swing wheel teeth should be thick and deep, and of such a shape as to roll as it were on the pallets, and not to slide on them, which would prevent biting or wearing. The pallet arms were of brass, made so as to put it in the power of the clockmaker to take the pallets very easily out, when repairing was necessary. These methods had long before this been used by Harrison, and were adopted in a clock of his in Trinity College, Cambridge, as mentioned by Mr Ludlam. Broad rubbing surfaces were strongly advised by them. Mr Smeaton at this period took away gudgeons from a mill wheel, whose diameters were only 2¼ inches, and put others in their place of 8 inches with great success, as it afterwards proved. On the same principles which have just now been mentioned, was the 'scapement made for the clock, which Mr Thomas Reid put up in St Andrew's Church, Edinburgh; and although it has been going for about thirty years, there is not yet the smallest appearance of biting or wearing on the pallets.

'Scapements have been divided into classes, one of which has been called those of the remontoir kind. Now, the mechanism of a remontoir may be applied to any 'scapement, and even then it can hardly be said to form a part of it, more than the wheels of the movement, or the weight which moves them.

Remontoir.

The motive force passing through the wheels, may at times be unequally impressed upon the 'scapement either of a clock or watch. This idea gave rise to the invention of what has been called *remon-*

toirs; that is, that the movement should at intervals be made to wind up either a small weight, or bend up a delicate spring, which alone should give its force to the 'scapement, by which means the pendulum or balance was supposed to be always impelled by an equal and uniform force. The earliest thing of this sort was used about the year 1600. Huygens applied it to some of his clocks, and gives a description of it in his *Horologium Oscillatorium*; and Harrison had one in the marine timekeeper, which gained him the great reward. We are of opinion, that they are of no great use either to a clock or a spring time-piece; for if the pendulum of the one is well fixed, and the momentum of the ball is not too little, any small inequalities of the motive force through the wheels will hardly be perceptible; and in the spring time-keeper, the isochronism of the pendulum or balance spring is sufficient to correct any inequalities whatever in its motive force. As their mechanism, however, is curious, and has been rarely described, it may not be uninteresting to our readers to have such an account of it as would enable them to make and adopt it should they think it proper.

Description of the remontoir which was applied to the clock of St Andrew's Church, Edinburgh.

The one which we propose to describe, is that which was contrived by Mr Reid for the clock of St Andrew's church. Suppose a small frame, separate and independant of the clock frame, to contain two wheels, one of which is the swing wheel, having within it the 'scapement work. The other wheel is crossed out, so as to be as light as may be, the rim being left just so broad as to admit fixing on it seven kneed pieces or teeth, each about a quarter of an inch thick and half an inch long, three of which are on one side of the rim, and four on the other side. Three on each side have the knees of different heights, corresponding each to each. The fourth is a little higher than either of the third highest. The wheel on which these are fixed, has a tooth prolonged beyond the rim, of the same thickness and length as the others, making eight teeth in all, having a small space left between each. These teeth become as it were so many wheels in different planes, and are at equal distances from one another, with the same extent of radius coming to the centre of the swing wheel arbor, being just so much larger than that of the swing wheel, as to allow the swing wheel teeth to clear the arbor of it. The edge or side of the teeth which rest on the swing wheel arbor is a plane, and rounded off on the opposite side, to the point or angle formed by this plane. The arbor of the swing wheel has eight notches cut into it a little beyond the centre. These correspond to the eight teeth of the other wheel, and are sufficiently wide and deep to allow the teeth to pass freely through them. Each notch stands at an angle of 45 degrees to the one which is next it, which difference is continued along the arbor through the whole, making 360 degrees for one revolution of the swing wheel. On each of the arbors of these wheels was fixed a pulley having a square bottom, in which were set about ten hard tempered steel pins a little tapered, something like the pullies at the old thirty hour clocks, whose bottom was round in place of square. The pendulum was fixed to the wall of the steeple, as well as the frame containing the 'scapement work, and the apparatus which has been described. The arbor of the eight toothed wheel had one of its pivots prolonged with a square on the end outside. The clock frame containing the movement was in the centre of the steeple, and the pinion in it, which suppose to be that of the swing wheel, had one of its pivots also prolonged, and squared outside. These squared pivots were connected by a steel rod and Hooke's joints. The main weight of the clock being put on, must urge not only the wheels to turn, but that of the wheel having the kneed teeth; but some one or other of these teeth pressing on the arbor of the swing wheel cannot turn, consequently none of those in the large frame can turn, nor can the swing wheel turn here unless some other means are used. An endless chain was provided, and passed over the two pullies fixed on the wheel arbors, and through two common pullies, to one of which is hung the small weight which is to turn round the swing wheel, and to the other a counter weight. The weight which turns the swing wheel, has its force placed on that side so as to make the wheel act properly with the pallets; now, while the swing wheel is turning, (the pendulum being supposed in its motion,) one of the other wheel teeth is gently pressing on its arbor. Whenever this tooth meets with its own notch, it will, by means of the main weight, be made to pass quickly through it; *while passing*, the small weight is wound up a little by the main one; the succeeding tooth then meeting with the swing wheel arbor, rests on it for a quarter of a minute, till its notch comes about; it then passes in its turn, and so on. The swing wheel makes a revolution every two minutes, in which time the wheel with the eight teeth makes also one. The minute hand, by this mechanism, when passing one of the notches, makes a start every quarter of a minute; at every such passing, the small weight is wound up a little by the great or main one. After the clock had gone a considerable time with this, it was found that the kneed teeth got a little swelled on their parts of rest, by the force of the main weight which made them fall on the swing wheel arbor. To remedy this, an endless screw wheel was put on the arbor of the remontoir wheel, (or wheel with the kneed teeth,) working into an upright endless screw, on the upper end of whose arbor was fixed a pretty large fly, in order to lessen the velocity of the remontoir wheel, and make the kneed teeth fall gently on the swing wheel arbor. This helped the swelling greatly, but did not entirely prevent it, though it existed now in a less degree. The endless chain had also a tendency to wear fast; in consequence of this, and of no provision having been made for the swelling of the kneed teeth, by making the notches on the swing wheel arbor much wider than was required for them when newly finished and first applied, this part of the remontoir was taken away, and the rod, with Hooke's joint, was put on the square of a pivot of the swing wheel prolonged on the outside of its frame. These matters being guarded against, it might be well for some artist in future to try such a remontoir. During the four years it was in use, the clock went uncommonly well, and was the admiration of a gentleman who lived opposite the church, and who was an amateur in horology. One of Mr Reid's men who took an interest in this clock, said it did not do so well after the remontoir was taken away. This, however, may have been more owing to a change in the position of the weights, than to any thing else, occasioned by a chime of eight large bells being put up in the steeple. For the weights, in place of having their natural fall, were carried a great way up in the steeple above the bells and clock, in order to fall down again; and here a complication of rollers and pullies became requisite.

Description of the remontoir which was applied to the clock of St Andrew's Church, Edinburgh.

Harrison's remontoir.

Harrison's remontoir is a very delicate spring, which is bent or wound up eight times in a minute. Were it necessary, a more obvious description could be given of it than that which is given with his timekeeper. In Haley's, the remontoir spring is bent up

Haley's.

150 times in a minute. In the 'scapement of Mudge's marine timekeepers, what may be called the remontoir was bent up 300 times in a minute; the 'scapement here, became in some degree wholly the remontoir. A variety of 'scapements may be seen in *Thiout*, and in some of the modern periodical works; yet, for the purpose of common or ordinary sort of clocks, they are confined chiefly to those of the dead beat and the recoil. Where accurate performance is expected, some may have recourse to 'scapements of a different description.

Mudge's remontoir.

Clocks with one wheel.

About the year 1752, Le Roy, Lepaute, and other clockmakers in Paris, were much engaged in making clocks having only one wheel; and some had not even a single wheel in the movement. They were, however, more expensive in making, and performed much worse than those which were constructed in the ordinary way. Simplicity in the machinery seems to have been their chief object. It requires, however, experience to know what simplicity in machinery is; although apparently more simple, a clock having two wheels in it, will not be equal to that having three or four; yet it does not follow, that, by having more wheels, the clock will be proportionally better: it has already been mentioned that there are bounds which cannot be overstepped with impunity. This subject cannot be better exemplified than by making a comparison of one of Hindley's clocks, having two wheels, and giving thirty vibrations in a minute, with a clock giving the same number of vibrations in the same time and with three wheels. The first or great wheel, in one of Hindley's, had 180 teeth, the second or swing wheel 120, and the pinion 8. The number of these teeth, and of the pinion leaves, amounts to 308. In the other, the wheels were 48, 40, and 30, and two pinions of 8; the sum of these is 134; the difference is 174, being the number of teeth more in the one than in the other, and more than the sum of the teeth in the three wheeled clock.

Simplicity in wheel work considered.

WATCH ESCAPEMENTS.

General description of a watch movement. PLATE CCCII. Fig. 1.

We shall now proceed to give a short account of such watch 'scapements as have been thought worthy of notice, from the old crown wheel and verge to the modern free or detached 'scapement; but, in order that the reader may be able to follow our descriptions, we have given from Berthoud a view of an assemblage of wheels and pinions, to represent something like the movement of a watch or a small clock. They are contained in a frame made for the purpose of allowing them to be more readily seen. DE is the pillar plate, or pillar frame plate; GF the fore frame plate. A is the balance; the arbor or axis on which it is fixed is the verge, whose two pallets *p, p*, scape with the teeth of the crown wheel C. The pivots of the balance turn or run in the frame; those of the crown wheel C, and of its pinion *d*, run in the potence I, and in the counter potence H, both of which are screwed on the inside of the pillar plate, the arbor of the pinion *d* being at right angles to the axis of the balance. The contrate wheel K and its pinion C turn also in the frame; the teeth of the contrate wheel pitch into the balance (or crown) wheel pinion, and can turn or drive it; the third wheel L, and its pinion *b*, run in the frame; the teeth of the third wheel pitch into the contrate wheel pinion, and turn it. The centre or second wheel M and its pinion *a*, have a long arbor going beyond the outside of the dial RS. The second wheel M, pitches with the third wheel pinion *b*, which it likewise can turn. N is the first or great wheel, pitching with the second wheel pinion *a*. X is the ratchet, *m* the click, and *n* its spring. On the arbor of the great wheel the ratchet is fixed; and, on winding up the main spring, the ratchet and arbor turn freely in the hole at the centre of the great wheel, which keeps its place during the time of winding. OP is the main spring deprived of its barrel; the inner end of it hooks on to the lower part of the great wheel arbor, and the outer end is hooked to the rim of the barrel, but is here fixed to a temporary stud. The force of the main spring, after being wound up, sets all the wheels and pinions in motion, and would oblige the ratchet and arbor to turn round independent of the great wheel; by this the main spring would be instantly unbent, but is prevented from this, by the click *m* being forced by its spring *n* to fall into the teeth of the ratchet, applying its end to the face of the ratchet teeth; by this means the main spring must unbend itself very slowly, the motion of the wheels being checked by the 'scaping of the verge with the crown wheel teeth. Q is the cannon pinion, put spring tight on the arbor of the second wheel, whose socket or cannon goes outside or beyond the dial, where it is squared for the purpose of the minute hand being put on it. T is the minute wheel, *g* its pinion; the cannon pinion pitches into or leads the minute wheel; the hour wheel V having a hollow arbor or socket *t*, is put on the cannon pinion, and is led by the minute pinion which pitches into its teeth. It is on the socket of the hour wheel which comes a little above the dial, that the hour hand is put. When a wheel pitches with a pinion and turns it, the pinion is said to be driven by the wheel; if the pinion turns the wheel, the wheel is then said to be led by the pinion. The pendulum or balance spring *s s* has its inner end fixed to a collet, which goes spring tight on the arbor of the balance; the outer end is fixed or pinned to a stud fixed on the inside of the fore plate. In the action of the crown wheel teeth on the pallets, the balance spring is either bent up or unbending; it is by the small force of it, that the balance is made to give twice the number of vibrations that it would give without it. It should have been observed, that, by putting a key on the square of the cannon pinion, and turning it about, this will not only move the minute hand about, but will oblige the hour hand to follow slowly, in the ratio of one turn to twelve of the minute hand.

General description of a watch movement. PLATE CCCII. Fig. 1.

The first watches may readily be supposed to have been of rude execution. Having no pendulum spring, and only an hour hand, and being wound up twice a day, they could not be expected to keep time nearer than 15 or 20 minutes in the twelve hours. After the application of the pendulum spring, they would no doubt go considerably better, and may now be made to keep time sufficiently correct for the ordinary purposes of life. Indeed, when the crown wheel and verge 'scapement is executed with care, it will do uncommonly well. Let the angle of the verge be 93 or 95 degrees, the teeth of the crown wheel undercut to an angle of 28 or 30 degrees, and scaped as near to the body of the verge as just to be clear of it, (it is to be understood here that the verge holes are jewelled.) To carry the matter still farther, the body may so far be taken away as to admit the teeth near to the centre, which will tend to allow the vibrations of the balance to move more freely and independently; but this requires such nice execution *here*, and in other parts of the 'scapement, that from not having encouragement, few are fit to execute it, and therefore it may in general be safer not to bring the wheel teeth so near to the verge. Care must also be taken to have the balance of a proper diameter and weight, which has of late been much neglected

Crown wheel and verge 'scapement, and the proper method of executing it.

since the old fashion of half timing has been left off, that is, making the watch go without the pendulum spring, if it goes slow 30, 32, or 33 minutes in the hour, the balance may be considered of such a weight as to be in no danger of knocking on the banking from any external motion the watch may meet with in fair wearing. When the pallets of the verge are banked on pins in the potence, they should, to prevent straining, both bank at the same time, alternately the face of one pallet on a pin, when the back of the other is on its pin; or the banking may be done by a pin in the rim of the balance, but not near the edge of it. Which of the two is preferable, we shall not stop to determine.

Relative position of the balance wheel and contrate wheel arbors.

The verge watch, as has been already said, when properly executed, will perform extremely well. About thirty years ago or more, the writer of this article had some of them made up in such a way, that they went fully as well as any horizontal 'scapement, and for a longer time; this last requiring oil to the cylinder, after going ten or twelve months. Oil, however, should never be allowed to come near the wheel teeth or pallets of a verge. Verge or contrate wheel watches have, of late years, been very much overlooked and neglected in many respects, and in none more so than in the relative position of the balance wheel, and contrate wheel arbors. They are rarely seen but at a considerable distance from one another, which gives a very oblique direction in the pitching of the contrate wheel with the balance wheel pinion. It is well known, that where force is indirectly or obliquely applied, it will work under great disadvantage. These arbors ought to be placed as near to each other as can be. In order to obtain this, reduce the balance wheel pinion arbor *towards the end to the smallest size it will bear*, and turning a hollow out of that of the contrate wheel, will allow them to come very near the line of their centres. To get this pitching to the greatest advantage, some place the counter potence within the arbor of the contrate wheel, so as to have the line of the balance wheel pinion direct to the centre of *the contrate wheel*, as may be seen in Plate CCCII. Fig. 1.

It has been recommended by a very celebrated artist, that the movement wheels should be placed in such a manner as to act at equal distances from the pivots of those pinions which they drive, in order to divide the pressure or action of the wheel between the pivots, and that one should not bear more than the other. This is apparently sound reasoning; but having put it in execution, the pivots unexpectedly seemed to wear very fast, even more so than in the common barred movement; the pivots, it is true, were small, and the motive force rather great. It is to be wished that it were again tried by others to bring it to the test. No pivots have been found to stand so well as those in movements of the double barred sort.

On the pendulum spring collet.

A pendulum spring collet, made as it ought to be, is as seldom to be met with, as that which we have noticed regarding the *position* of the contrate and balance-wheel arbors. Yet simple as the thing is, it seems to require a rule to shew *how it should be done*, there appearing to be none, if we may judge by the greatest part of those which have hitherto been made. The ring of the collet should be no broader than to allow a hole to receive the pendulum spring, and the pin which fixes it. The *slit* in the collet, for the purpose of its being always spring tight on the inside taper of a cylinder or verge collet, should be put close to where the small end of the pin comes, when the spring is pinned in. The pendulum spring, in this case, will have the first or inner coil at such a distance, as to allow the point of a small screw-driver to get into the slit without any danger to the spring, when it is wanted to set the collet and spring to any required place. If the slit is put at the other end of the pin, where it is oftener than anywhere else, it is evident that the workman cannot get into it without danger. The outer end of the pendulum spring ought to be pinned or fixed into a brass stud or cock, in performing which operation it goes easily on; whereas with steel cocks or studs, there is a kind of crossness and trouble, which shews that they should never be used.

Pendulum-spring studs.

Studs are, in general, very improperly placed, being at a greater distance from the curb pins than is requisite. We have seen this distance so great, that the motion of the pendulum-spring between the stud and the pins was such, as to take away a part from every vibration of the balance; which is something like a pendulum when suspended to a vibratory cock, where it would not be allowed to have half the motion it would otherwise have acquired.

A few years ago, our modern improvers would have the joint transferred from the pillar plate to the brass edge, than which nothing worse could have been proposed. In the old way, the whole of the movement was kept in its place by the united assistance of the joint, and of the bolt and its spring; whereas, in the other way, the movement had its sole dependence on the pins of the brass edge feet, from which it would be disengaged by violent exercise on horseback, &c.

From what has been said of the imperfections in watches, it may be seen, that they are inevitable, arising from a want of energy of mind in workmen, of which not one in a hundred is possessed. Can it be supposed, that every new watch, which is purchased, is complete, and requires no assistance? Whoever thinks so, must be disappointed. Persons of this description, on finding it not to go as they expected, bring it to a watchmaker, many of whom cannot put it in a better state than that in which the workman left it. But it is not brought to him with the view of any thing being done to it, but to see what is the matter with it; never considering, that any irregular going or stopping must imply some fault or other, and is the very cause that brings them to the watchmaker. It does not follow, however, from this, that every watch which stops is badly executed; this will happen sometimes with those of the very best execution, and frequently from an over-nicety of execution. On its being left with him, he takes it down, to examine what is wanting to make it keep time. The owner, on being told afterwards that it will cost so much to make it do what is required, strongly suspects, though he is polite enough not to say it, that there must be some imposition on the part of the watchmaker. Much is the trouble which many have of rectifying the faults of work given in to them, and thought to be complete, and much money is paid to others to have them rectified. We have known four guineas paid to a workman for doing a particular branch; and not being executed to the satisfaction of the watchmaker, he has given half as much more to another to have it corrected. There are as few excel in this art as in those of sculpture, painting, and engraving, which are called the fine arts, a name to which the other is equally entitled, but which labours under the great misfortune that few or none are able to appreciate its merits.

The old 'scapement, even after the application of the pendulum-spring, not giving that satisfaction which was required, induced Huygens and Hooke to think of other means of improving it, or to substitute a superior mechanism in its place. In this pursuit, the mechanical talents of Hooke stood conspicuously eminent over those of the justly celebrated Huygens.

Huygens' watches gave rise to the lever 'scapement, PLATE CCCII. *Fig.* 2.

Hooke's 'scapement the origin of the duplex.

Some of the movements of Huygens' watches, or time-keepers, were much larger than those of our box chronometers. The contrate wheel was cut into teeth of the same form as those of the common crown wheel, and made to 'scape with a verge of the usual kind. On the axis of this verge was a sort of contrate or crown wheel, having teeth like the ordinary contrate wheel, which drove a pinion fixed on the axis of the balance. The verge, when 'scaping with its wheel, caused the balance to make several revolutions from every impulse on the pallets. Some of them had no pendulum-spring, having been made perhaps before its application. When the balance made several revolutions in every vibration, each being two seconds, this 'scapement would be but ill suited for the coils of a pendulum-spring. Those having the pendulum-spring appeared about 1675. This was the origin of half-timeing, upon seeing, when the pendulum-spring was applied, that it made the balance give two vibrations in the same time that it gave one without it. About the same period, Dr Hooke brought into notice his watch with a new 'scapement; which, for seventeen years before, he had been privately endeavouring to improve. This was very different from the old crown wheel one, and as much so from that of Huygens. It had two balances, on the axis of each of which was a toothed wheel, pitching into one another. The verge or axis of these balances had each a pallet on it. The balance-wheel was flat, having a few ratchet or saw-like teeth; its arbor run in the frame, parallel to those of the balances, at a point equally distant from them; the three points forming, as it were, the angles of an equilateral triangle. When a tooth of the balance-wheel gave impulse on one pallet, the other, by the pitching of the two wheels, was brought about to meet another tooth, (after the wheel had escaped from the pallet on the opposite side,) in order to receive impulse in its turn. There was a pendulum-spring on one of the balances, and the object of their being pitched together was to prevent the effects of external motion on them, while it served the double purpose of bringing alternately about the pallets, which still gave some recoil to the wheels by the reaction of the balances. Although this was a very ingenious contrivance for a 'scapement, yet it appears not to have given that satisfaction which was expected from it, (probably from indifferent execution, which, from Sully's account, was the case,) and the old one was again adopted. However, some years afterwards, other artists, among whom was Dutertre, were attracted by this 'scapement of Dr Hooke's, and were led, from time to time, to make improvements on it. From it originated the duplex 'scapement, which has of late years been so much in repute. A large old German clock had a 'scapement on the same principle as the above, of which the maker's name is unknown. Dr Hooke's claim to his own 'scapement, remains however undisputed.

Tompion's 'scapement.

The famous Tompion, who contributed greatly to bring the art of Horology in England to that reputation which it had acquired, for a long period of sixty years or more, during which he practised it, made a 'scapement about 1695, and flattered himself with being very successful. The verge or axis of the balance was a small solid steel cylinder, cut across at the middle, and nearly half way down; along the length way of this part cut across, a deep angular notch was made, forming a sort of pallet on the right hand side; the balance wheel was flat, and much like Dr Hooke's; and the spaces between the teeth sufficiently wide to allow the cylinder to turn freely between them. When a tooth of the wheel impelled the pallet, and when on escaping from it, the tooth following dropped on the outside of the cylinder, near the left edge, resting on the cylinder during this vibration of the balance, after passing the left edge, and meeting a little recoil, it got on the pallet, and gave a new impulse, which was given only at every second vibration. An excellent property was observed in this 'scapement, that any inequalities in the motive force made no deviation in its time-keeping; but the friction of the balance wheel teeth on the cylinder and its edges was so great and destructive, that it was given up in consquence of it.

Graham's 'scapement. PLATE CCCII. *Fig.* 3.

Knowing what Tompion had been doing, being bred under him, Graham, a good many years after, set to work with the cylinder 'scapement, and ultimately succeeded. Although this 'scapement is now pretty generally known, yet we may be allowed to give an account of what he did. In place of Tompion's solid cylinder he made a hollow one; on the points of the wheel teeth of Tompion were raised something like small pins or stems, on the tops of which a sort of inclined or curved wedge-like teeth were formed, of such a length as to have very little freedom when in the inside of the cylinder, and the outside of the cylinder to have the same freedom between the point of one tooth and the heel of the other. A notch or opening was made across the cylinder, not quite half way down the diameter; the edges of the cylinder made by this opening were dressed so that the curved edge of the tooth might operate easily on them; the right hand edge was flanched outward, the left one rounded; when the balance was at rest, and the wheel in its place to 'scape, the point of the tooth got then just in on the cylinder edges, and no more; a second notch was made below the other, to allow the bottom of the wheel to pass, leaving hardly a fourth of the circumference of the cylinder, the other leaving more than a semicircle. The highest part of the wedge or curved tooth being on a circle, greater or beyond that on which the point was, it is evident that, if the wheel is urged forward, it will make the cylinder to turn, and the angle of 'scapement will be according to the height of the wedge: When a tooth of the cylinder wheel escapes from the left edge of the cylinder, the point of it falls into the inside of the cylinder, after reposing there, and then passing and impelling the right hand edge; on escaping it, the point of the succeeding tooth drops on the outside of the cylinder, where it reposes; on the return of the balance, it gets on the left hand edge, giving a new impulse, and so on. The teeth impel at both edges of the cylinder, giving by each a vibration to the balance.

This 'scapement being the best of any that had preceded it, (Debaufre's perhaps excepted) procured for Graham's watches a very considerable reputation, as their performance was much superior to that of those of the old construction. However, on comparing the going of some of Graham's with those of a later date, we confess that none of his, though excellent, were ever equal to them in this. The cylinders were rather large in diameter, the balance too light, the motive force too weak, and he had great difficulty in obtaining good pendulum spring wire, meeting sometimes with iron, where he expected steel wire. Watches having the cylinder 'scapement were not known in France till 1728, when Julien Le Roy commissioned one of them from Graham. They were losing their character here, some time before the introduction of the duplex, which contributed afterwards still more to bring them down. The duplex will in its turn be supplanted, for reasons which will be afterwards noticed. Flat movements, shallow balance wheels, steel and brass of bad materials, from the difficulty of getting them good, injudicious execution, and low prices, must have tended to make the cylinder 'scapements so bad as they were of late; many of the cylinders were destroyed and cut to pieces in a very few years, and some of them could not last so long. Let these be compared with the cylinder 'scapements of old Hull, many of which that we have seen, have little or no impression even on their edges, after having been in use thirty years and upwards. Of what did Hull's art consist? There must have been some causes for it; but what these are, we shall not attempt to conjecture. As Graham, with whom he was instructed, did, Hull soldered in the plugs of his cylinders, with silver solder, which caused a very tedious process afterwards in making the cylinder; but this is not offered as any reason for his excelling in the art of cylinder 'scapement making. The acting edges of the teeth have hitherto been made too thin, particularly for steel cylinders, with the view of lessening the friction; but, from cutting soon, this friction increased, and was worse than a greater friction which was constant.

When the vibrations of the balance are at the lowest point, the resistance of the pendulum spring is at the least; but the more it is bent or unbent, the greater is the resistance; consequently, when at the height of the wedge or tooth, it is greater than when the tooth first begins to act. Two or three different curves for this purpose have been imagined; one approaching nearly to a right line, which is supposed to give the wheel time to acquire a velocity during the passing of two-thirds of the curve, and the least resistance of the spring, by which the other third more readily overcomes, when the resistance to it is at the greatest. This has been thought to give a greater extent to the arc of vibration, and has been adopted by the French artists. Another curve, where equal spaces make the balance describe equal portions of a circle, is thought to give the least wearing to the edges of the cylinder, and is that which is practised by our 'scapement makers. Arguments equally good for either, it appears, might be given.

The weight and diameter of the balance, are circumstances very materially connected with the wearing on the cylinder edges. Whatever will prevent this wearing, should be carefully attended to. When the diameter is large, the balance must of consequence be less heavy; a sort of sluggishness in its motion takes place, the pendulum spring making great resistance to the teeth passing the cylinder edges, and causing wearing to go rapidly on. On the contrary, when the diameter is small, and the weight at a proper medium, there is an alertness in the vibration; the momentum of the balance has such force over the pendulum spring, that it allows the teeth to pass the edges quickly; and hence there is a less tendency to wear them. The diameter of the balance should be less than that in a verge watch of equal size, nor should it be heavier than just not to allow setting, unless where a going in time of winding is used. The cylinder 'scapement, on the whole, must be allowed to be a very excellent one; and where care is taken to have it made as it ought to be, such watches will give very good performance. Provision for oil on the cylinder should be made as ample as can be admitted; that is, the part where the tooth acts, should be as distant from the notch where the wheel bottom passes as possible, and at the same time more distant from the upper copper plug; the lower notch should not be longer than to give freedom to the wheel bottom to pass easily. When they are made long, which they frequently are, the cylinder will break there if the watch receive a slight shock from falling. The acting part of the tooth, as has already been noticed, should not be too thin, nor the stems too short. If the diameter of the balance is too great, any addition of motive force will make the watch go slow; if too little, the watch will go fast; and if, of a proper weight and diameter, any addition of motive force will make no change on the time-keeping. We have made the motive force more than double, and no change took place; the pendulum spring no doubt had its share in keeping up this uniformity. Balances whose diameters are rather small, will have a natural tendency to cross farther, that is, the arcs of vibration will be greater than where the diameters are great. Their weight will be in the ratio of the squares of their diameters; from which it follows, that if the balance is taken away from a watch which has been regulated, and another put in its place, having the diameter only one half of the former, before the watch could be regulated with the same pendulum spring, the balance would require to be four times heavier than the first. One way of estimating the force of a body in motion, is to multiply the mass by the velocity. Let us then calculate the respective forces of two balances whose diameters are to one another as two to four. The radii in this case express the velocity. According to this principle, we shall have for the small balance two for the radius, multiplied by eight of the mass, equal to sixteen, and for the great one, four of the radius by two of the mass, equal to eight; sixteen and eight are then the products of the mass by the velocities; consequently they express the force from the centre of percussion of each balance; and as it is double in the small one, it is evident that the arcs of vibration will be greater, having the faculty of overcoming easily any resistance opposed to it by the pendulum spring, without requiring any additional motive force.

Method of estimating the precise momentum of watch balances.

Let us take an example done in another way, which is the square of the product of the diameter multiplied by the velocity or number of degrees in the vibration, and this again multiplied by the mass or weight, so as to compare the relative momentum of two balances of different diameters, &c. Suppose one balance to be .8 of an inch in diameter, the degrees of vibration 240, and the weight eight grains; the other .7 of an inch in diameter, the arc of vibration 280°, and the weight 10 grains.

$$240 \times .8 = 192 \times 192 = 36764 \times 8 = 294112.$$

$$280 \times .7 = 196 \times 196 = 38416 \times 10 = 384160.$$

The balance having the smaller diameter, has its momentum to that of the greater, as 384 is to 294. When the arcs of vibration are great, the nearer to isochronism will the long and short ones be.

When a little expence in the cylinder or horizontal 'scapement is not grudged, a ruby cylinder is certainly a great acquisition to prevent wearing on the edges; if it is not steel cased, and wholly of stone, it is so much the better, giving a little more scope to extend the limits of the banking, the steel crank of the other confining the extent of banking. There is no doubt a greater risk of breaking than in the cased one; yet this might be considerably lessened were some attention paid to make the notch which frees the bottom of the wheel, as has been proposed in the case of the steel cylinder, no longer than is necessary. It would be desirable to have the cylinder formed by the strata of the sapphire or ruby, being placed in a vertical position instead of a horizontal one. This is surely attainable, when we know that diamond splitters can distinguish the strata or layers of the diamond, a stone which may be supposed more compact than either the ruby or sapphire. We have seen a cylinder, wholly of stone, in a watch belonging to a gentleman, who was wearing it when between 70 and 80 years of age; he used frequently to let it fall without any accident happening to the cylinder. Three small griffs or cocks placed on the potence plate, so as to allow the balance edge to come into notches fitted for it, and having sufficient freedom, would prevent either the cylinder or the cock pivot from breaking. A little practice should make the stone cylinder easier, and perhaps cheaper made, than the cased one; at all events, even on equal terms, it ought to be the preferable of the two. From what has already been said, it appears that the weight and diameter of the balance are matters not merely arbitrary; for if the motive force is too great for that of the force of the balance, the watch will go fast when in the laying or horizontal position, and slow when in the vertical or hanging position: By diminishing either the motive force, or making the balance heavier, the watch may be made to go the same in both positions. The properties of the pendulum spring may conduce a little to this. It is in some degree a desideratum for a pocket watch to have the balance pivots and holes made so that the balance with its spring, when in a state by itself, and free of any communication with the wheels, should vibrate the same length of time, whether it is in a vertical or a horizontal position. We know when it is in the last, that it will continue to vibrate twice the length of time that it will do in the other. We are humbly of opinion that this could be come at. But who will be at the trouble and expence to make such experiments as may lead to it? Mr Earnshaw's pivots, with flat ends and shallow holes, should come very near to this object. About forty years ago we used to hollow out the ends of balance pivots.

Invention of the art of jewelling watch pivot holes, by M. Facio.

In the interim, between Tompion's having left off his trials in attempting the horizontal 'scapement, and Graham's having brought it to a state of perfection, M. Facio, a native of Geneva, having discovered the art of piercing holes in rubies, or any hard precious stone, came to Paris with this art as a secret; and not being well received, either by the Duke of Orleans, at that time regent of France, or by the watchmakers, he repaired to London with it about the year 1700, which was at that time a school where the art of horology was more cultivated than at Paris. He was admitted a member of the Royal Society, and having entered into a kind of partnership with a native of France, who had been settled in London, whose name was Debaufre, they carried on the business of watch-jewelling.* Facio's partner had, at this time, contrived a new 'scapement; it was a dead beat one, which was the thing now sought for. The balance and balance-wheel holes of it were jewelled; the pallet was made of diamond, formed from a very short cylinder of two-tenths of an inch in diameter; the upper end of the cylinder was cut down nearly one-half of the diameter, and flanched to the lower end and opposite side, rounded off from the circular part of the base left at top, to the lower end of the flanch, resembling something like a cone bent over, and wanting a part of the top. Two flat balance-wheels, having ratchet or crown wheel sort of teeth, were on the same arbor, the teeth of the one being opposite to the middle of the spaces of the other; the distance between these wheels was a little less than the diameter of the cylinder; the drop of the teeth in scaping falls on what was left of the upper base of the cylinder, (the lower base being taken away in forming the pallet) and near to the edge formed from the flanch; here they rested during the time of the vibration of the balance. On the return, the tooth gets on the flanch, and passes over it, during which, giving impulse to the balance, and escaping at the lower end, a tooth of the other wheel drops opposite on the same base of the cylinder, and so on. A watch having this 'scapement, and bearing Debaufre's name, was put for trial into the hands of Sir Isaac Newton, who, in shewing it to Sully in 1704, gave a very flattering account of its performance. It attracted Sully's notice very much, but thinking it by no means well executed, and not being quite satisfied with two wheels, it was thought that an improvement would be made by having one wheel only and two pallets, which was part of the scheme of the 'scapement he adopted for his marine time-keeper made in 1721. Considering the genius which Sully was allowed to possess, this was by no means an improvement on Debaufre's 'scapement.

Debaufre's 'scapement. Plate CCCII. Fig. 4.

Account of the labours of Sully, who first made a marine time-keeper.

Although an Englishman, Sully's name was unknown to his countrymen; and would have remained so, had it not been for the accounts given of him by the French artists, in whom he excited an emulation, and whom he inspired with a taste to acquire such a pre-eminence in their profession as had been before unknown to them. Julien le Roy, who was intimately acquainted with Sully, and Berthoud, are uncommonly lavish of their encomiums on him. Soon after he had completed his apprenticeship with Mr Gretton, watchmaker in London, he went over into Holland, Germany, and Austria, and attracting the notice of several of the princes and nobility, he was much employed by them. Having seen, in the library of Prince Eugene, the *Memoirs of the Royal Academy of Sciences of Paris*, he eagerly acquired the French language in order to read them. This excited in him a strong desire to see Paris, to which he repaired about the year 1713 or 1714, under the patronage, and in the suite of the Duke of Aremburg, at whose hotel he lodged, with a pension of 600 livres. He had not been long there, when our countryman Law of Lauriston, under the authority of the court of Versailles, got him engaged to establish a manufactory of clocks and watches. In consequence of this he came twice to London, and having carried away a great number of workmen at a vast expence, and spent much money on tools and other articles, Law began to murmur, and the establishment in two years or little more fell to the ground. This made him complain bitterly of his bad fortune to a friend; but fortunately a nobleman to whom this was mentioned, feeling much for the disagreeable situation in which Sully was placed, sent him in a present some shares in the public funds, value 12,000 livres, which enabled him, for several years afterwards, to pursue very zealously his favourite scheme of making a marine time-

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* Some of Debaufre's family, or name, were at this profession in London so late as 1775.

keeper to ascertain the longitude at sea. In this attempt he was not so successful in his first trials, as he had led himself to expect. It was in general believed, however, that had he lived he would have been the first to have deservedly acquired one or other of the premiums which were before that time offered by four of the greatest maritime powers in Europe, to those who should produce a time-keeper which could ascertain, to a certain extent, the longitude at sea. Philip the Third, who ascended the throne of Spain in 1598, was the first who proposed a reward of 1000 crowns for this invention. The states of Holland soon after followed his example, and offered 100,000 florins. The British Parliament, in the reign of Queen Anne, voted £20,000 sterling for the same purpose; and the Duke of Orleans, Regent of France, in 1716, promised, in the name of the King, 100,000 livres. Sully may literally be said to have died a martyr to the cause in which he was engaged. Having got a false address to a person who it was said was occupied in the same pursuit with himself, he got so overheated in his anxious and vain endeavours to find him out, that he died in a few days after at Paris, in the month of October 1728, and was buried with great pomp in the church of St Sulpicius. Sully acted so conspicuous a part in the profession, that no apology is necessary for giving this short account of him.

Rewards offered for ascertaining the longitude at sea.

Debaufre's 'scapement possesses an advantage over Graham's.

It may be observed here, that Debaufre's 'scapement has this advantage which is not in Graham's, that the impulse is given the same in every vibration; and the time of rest on both sides is the same, bearing mostly on the foot pivot end, and a little on the sides of the pivots; and not wholly on the sides of the pivots, as in Graham's. Having made one or two watches, to which this 'scapement was put, they were found to perform very well; and we would recommend it to the attention of 'scapement makers: A little practice will make the execution of it very easy. The two thin steel wheels may at pleasure be placed at any distance from one another; their diameters should be as large as can be admitted between the potence foot and the verge collet. An agate, or any hard stone for the pallet, whose height is half the spaces between the teeth, or a little less, is fixed on the verge or axis of the balance; the level of the base of the pallet on which the teeth rest being a very little above that of the line of the centre of the balance-wheel pinion. The teeth must be a very little undercut, so that the points only may rest on the pallet. The verge should be placed more inward in the frame than in the common contrate wheel movement, in order to give room for the balance-wheels. The necessity of a contrate wheel movement for this 'scapement is a trifling objection, which will wear away in spite of prejudice.

Abbé Hautefeuille's 'scapements.

Plate CCCII. Fig. 5.

In 1722, the Abbé Hautefeuille, who long before this had at Paris disputed, in a process of law with Huygens, the right of the invention and application of the pendulum-spring to the balance of a watch, published a quarto pamphlet, containing a description of three new constructions of 'scapements for watches. One of these was the anchor, or recoiling 'scapement, on the verge of which was attached a small toothed segment of a circle, or rack, working into a pinion, which was the axis of the balance. The idea of the axis of the balance being a pinion, seems to have been taken from the 'scapement of Huygens, with this difference only, that the balance should not make so many revolutions as that of Huygens, and is contrived so as to make scarcely one revolution at every vibration. This 'scapement is the same as it came from the hands of Hautefeuille, without any improvement having been made upon it even to this day, although a patent was taken out for the same invention above twenty years ago, by some person in Liverpool. The name of lever watches, which they received from the patentees, is that which is generally given to those having this 'scapement, which is the same that Berthoud has described in his *Essai sur L'horlogerie*, published in 1763; see tom. ii. No. 1933, and plate xxiii. fig. 5, of which our Figure is a copy. Berthoud, under certain modifications, introduced the principle of this 'scapement into some of his marine time-keepers.

Dutertre's 'scapement for a watch.

Plate CCCII. Fig. 6.

A very able and ingenious artist at Paris, M. Dutertre, who was zealous in his profession, and had considerable success in his pursuits, invented, in 1724, a new 'scapement, or rather improved that of Dr Hooke's with two balances, which has already been described. The additions and improvements, however, which he made, were so great, as to give him a sort of title to claim it as his own, and to render it, in the opinion of good judges, the best 'scapement by far that was known at that time. The additions which he made, consisted in putting another wheel upon the same arbor with the first, but it was considerably larger in diameter, having the same number of teeth with the other, and forming the principal merit of the 'scapement. The balance arbors at one place were made rather thicker than usual, for the purpose of having notches cut across them, and as deep as to the centre. This part of the arbors becomes then a semicylinder. The larger wheel, which may be called that of *arrête*, or repose, is placed on its arbor, so as to correspond with the semicylinders and their notches, the points of whose teeth are made just to clear the bottom of the notches, alternately passing one of them, and resting on the semicylindrical part of the other. The action of the two wheels shall now be explained. Let us suppose, that one of the larger wheel teeth, after reposing on one of the semicylinders, is, on the return of the vibration of the balance, admitted to pass through the notch; after having passed, a tooth of the impulse-wheel falls on the corresponding pallet, gives impulse, carrying it on till it escapes; when another tooth of the wheel of repose falls on the other semicylinder, and rests there until the return of the vibration of the other balance; when it passes the notch in its turn, and the corresponding pallet presenting itself, is impelled by a tooth of the impulse-wheel, and so on. Hooke's 'scapement had a small recoil; the aim of Dutertre was to make a dead beat one of it, in which he succeeded. There is a drawing of this 'scapement in Plate xiv. fig. 4. of Berthoud's *Histoire de la Mesure du Temps*. He says, "that the properties of this 'scapement are such, that sudden shocks do not sensibly derange the vibrations; that the pressure of the wheel-teeth of *arrête* on the cylinders, corrects the impulse that the balance receives from the wheel-work, which, on the motive-force being doubled, prevents the vibrations from being affected."

Dutertre's clock 'scapement.

Fig. 7.

In Plate xli. fig. 16. of the first volume of Thiout's work, is a drawing of this 'scapement, modelled for that of a clock, described at page 101. He says, "Fig. 16. is an escapement of the Sieur Jean Baptiste Dutertre, which has only one pallet, on the axis of which is the fork. The two ratchets or wheels are on the same arbor, when the pallet escapes from the small ratchet; the larger one, which is called the ratchet or wheel of *arrête*, rests on the arbor of the pallet, and leaves the vibration to be pretty free. On the pallet's returning to meet with the teeth of the small ratchet, the pallet-arbor, or cylinder, being notched or cut across into the centre, allows the wheel of *arrête* to pass, and the wheel of impulsion, after getting a small recoil, gives new force to the vibration; so that in two vibrations only one of them is accelerated: Hence it was thought, that the half of the vibrations being *free*, and independent of the wheel work and its inequalities, they would be more correct than others; but experience did not confirm this." This is, then, the duplex 'scapement, or the nearest possible approach to it.

It is more than fifty years since we saw a small spring clock having this 'scapement, made by a very ingenious clockmaker of this place, whose name was Robert Brackenrigg. It may be supposed to have been made a very few years after Thiout's work was published.

In 1727, Peter le Roy gave an account of a 'scapement which he had made, having one pallet on the axis of the balance and a notch below it, a wheel of *arrête*, and one of impulse, as described in the preceding 'scapement; so that one-half of the vibrations were independent of the wheel-work. Dutertre claimed the pretended invention of Le Roy, who, finding it not to answer his expectations, gave it up. That Dutertre made the one which is represented in Plate xli. of Thiout, we have no doubt; and there is unquestionable authority, that he brought Dr Hooke's to the improved state which has just been mentioned. It is said, that he had made a free or detached 'scapement; but no account whatever has been given of it.

Tyrer's or duplex 'scapement.

PLATE CCCII. Fig. 8.

The duplex 'scapement, as it is now called, was introduced into its native country about thirty years ago or more, under the name of Tyrer's 'scapement, the name, it is supposed, of him who put the last hand to improve that which came in a lineal descent from Dr Hooke. In place of the notch being made right across the arbor, as has been mentioned before, Tyrer's had a very small cylinder or roller, whose diameter was .03 of an inch, into which was made, in a longitudinal direction, a deep angular notch of 30 or 40 degrees. The cylinder was sometimes of steel, but most frequently of ruby. When the points of the teeth of the wheel of repose fall into the notch, they meet with a very small *recoil* by the balance, in what may be called the returning vibration. This goes so far as to make the point of the teeth for a little to leave the notch, at the side opposite to that by which it came in. The balance on returning, is now in the course of that vibration when it is to receive impulse from the wheel, which takes place immediately on the tooth of the wheel of repose leaving the notch and the small cylinder, and as soon as the tooth of impulse escapes from the pallet,—the next tooth of repose falls to rest on the small cylinder, and so on.

This 'scapement of Tyrer's is much superior to that of the cylinder, or horizontal one; it is almost independent of oil, requiring only a very little to the points of the wheel teeth of repose. It can carry a balance of much greater momentum, and, when well executed, performs most admirably. But there are so many circumstances or minutiæ to be attended to in it, that some of them may at times escape the eye of the most judicious and careful; the watch may stop, and yet the 'scapement be in every other respect as complete as possible. This has often given the wearer cause to complain, and to suspect the qualities of his watch, and hence watchmakers have been induced to abandon this 'scapement, and adopt inferior ones. The pallets of Tyrer's were at first very thin. We frequently urged the necessity of having them made much thicker, and were pleased to see that this was gradually adopted. Why should they not be made as thick as the pallet of a detached 'scapement? There is no 'scapement which requires to have the balance wheel teeth more correctly cut, or the steady pins of the cock and potence more nicely fitted to their places in the potence plate. The minutiæ alluded to were, too much or too little drop of the impulse teeth on the pallet, the 'scapement not set quite so near to beat as might be, the balance rather heavy, or the points of the teeth of repose too much or too little in on the small cylinder. In a good sizeable pocket watch, the wheels having fifteen teeth, the ratio of the diameter of the wheel of repose to that of impulse may be as .520 of an inch to ·400, the cylinder .030. The angle of 'scapement will be 60 degrees, taking from the escape of the impulse tooth, to that of the tooth of repose falling on the cylinder; the balance passes 20° of these, before the impulse tooth gets again on the pallet, consequently it has only 40 degrees for the acting angle of the 'scapement. There is a variety of 'scapements in Berthoud's *Histoire*, which appeared in 1802, many of which are of very inferior note to that of Tyrer's, and yet he takes no notice of the latter. This is remarkable, as he surely must have seen it, considering the great number of them which were made.

'Scapement with semi-cylindrical or tumbling pallets.

PLATE CCCII. Fig. 9.

While Dutertre was engaged with Hooke's 'scapement, an artist in England, whose name is unknown, produced a 'scapement with the dead beat, which seems at that time to have been the great object of pursuit. Julien Le Roy having got one of these watches, showed it to Sully in November 1727, and told him that it was a 'scapement very deserving of notice. Thiout mentions it as a 'scapement of M. Flamenville having two pallets of repose; and says that it had much attracted the attention of the English watch-makers, who had made it for three or four years. (See page 108, plate xliii. fig. 26. of his first volume.) With our workmen it went by the name of the 'scapement with the tumbling pallets. The axis of the balance had two semi-cylindrical pallets, whose faces stood in the same plane or centre of the axis; the balance wheel was the common crown wheel one, the teeth of which got a very small hold of the pallets. When escaping from the face of one pallet, a tooth on the opposite side dropped on the semi-cylindrical part of the other pallet, where it rested during the going and coming of the vibration; getting then on the face, it gave new impulse, escaping in its turn; the pallet on the opposite end of the verge received a tooth on the semi-cylindrical part, and so on. After having been laid aside for some time, it was of late years taken up by several, who no doubt must have thought well of it.

Kendal's 'scapement.

PLATE CCCIII. Fig. 1.

Among these was Kendal, a man possessed of no common talents. He transformed it into one having two crown wheels on the same pinion arbour, the tops of the teeth in the one pointing to the middle of the spaces in the other, and with only one pallet, the diameter of the semicylinder being of any size. (See Plate CCCIII. Fig. 1.) About thirty years ago we had some watches made with this 'scapement, and after a few years trial gave them up. The principle of the 'scapement is good, as long as the parts of it remain unimpaired, and the oil continues fresh; but the acting parts having such a small hold of one another, get soon altered, which causes a great deviation from the rate of time with which it first sets out. They cannot be expected to last long, unless with a diamond pallet, and a steel wheel of the hardest temper.

Free or detached 'scapement.

The *free or detached 'scapement* is that in which the greater part of the vibrations of the balance is free and independent of the wheels, the balance wheel being

Free or detached 'scapement.

then locked; when unlocked, it gives impulse which only takes place at every second vibration. In Mudge's detached 'scapement, the impulse is given at every vibration. The progress which has of late years been made in improving the detached 'scapement has been very wonderful, when we consider that half a century ago the name of this 'scapement was unknown. The first rude draught of any thing like it, appears to be that of Thiout's, described at page 110 of the first volume of his work, and shewn in Plate xliii. fig. 30, which he calls "A 'scapement of a watch, the half of whose vibrations appear independent of the wheel work, during the time they are made. A hook retains the ratchet or balance wheel; the return of the vibration brings the pallet to its place of being impelled by the wheel; in the returning, the hook is carried outwards, and leaves the wheel at liberty to strike the pallet, and so on. This sort of 'scapement cannot act without the aid of a spiral or pendulum spring."

Peter Le Roy's 'scapement is the next step that was made towards this invention. He contrived it in 1748, and, like Thiout's, it has hardly ever been made use of. Both of them have a great recoil to give the wheel before it could be disengaged, and their arcs of free vibration are not much extended. Berthoud informs us, that in 1754 he made a model of one, which he gave to the Royal Academy of Sciences. Camus, on its being shown to him at that time, told him that the late Dutertre had made and used such a 'scapement, having a long *detent* and free vibrations. Nothing appears now to be known of the construction of Dutertre's, and Le Roy seems to have acknowledged the priority of it to the one he contrived in 1748. "My thought, or invention," he says, "was not so new as I had imagined. Dutertre's sons, artists of considerable repute, shewed me very soon after, a model of a watch in this way by their late father, which the oldest Dutertre must still have. This model, very different from my construction, is, however, the same with respect to the end proposed."

The detached 'scapement in Le Roy's time-keeper, which was tried at sea in 1768, is very different from that of 1748.

Berthoud's model of a detached 'scapement.

Berthoud, in his *Traite des Horloges Marines*, published in 1773, has given, in No. 281, an account of the principle on which the model was made in 1754; and, in No. 971, a particular description of the parts composing it, which are represented in plate xix. fig. 4. of that work. It may be somewhat interesting to lay before our readers what is contained in No. 281. "I composed," says he, "in 1754, an escapement upon a principle, of which I made a model, in which the balance makes two vibrations in the time that one tooth only of the wheel escapes, that is to say, the time in which the balance goes and comes back on itself; and, at the return, the wheel escapes and restores, in one vibration, the motion that the regulator or balance had lost in two. The 'scapement-wheel is of the ratchet sort, whose action remains suspended (while the balance vibrates freely) by an anchor, or click, fixed to an axis carrying a lever with a deer's-foot joint, the lever corresponding to a pin placed near the centre of the axis of the balance. When the balance retrogrades, the first vibration being made, the pin which it carries turns a little back the deer's-foot joint, and the balance continuing freely its course, its liberty not being disturbed during the whole of this vibration, but by a very small and short resistance of the deer's-foot joint spring. When the balance comes back on itself and makes the second vibration, the same pin which it carries raises the deer's-foot lever in such a way, that the anchor which it carries unlocks the wheel, in order that it may restore to the balance the force which it had lost in the first vibration. This effect is produced in the following manner: In the instant that the deer's-foot jointed lever is raised, the wheel turns and acts upon the lever of impulsion, formed with a pallet of steel which acts upon the wheel, and with another arm which acts on a steel-roller placed near the axis of the balance; and, in the same instant that the wheel acts upon the lever of impulsion, the second arm, which its axis carries, and which is the greatest, stays on the roller, and the motion of the wheel is communicated to the balance almost without loss and without friction, and by the least decomposition of force. As soon as the wheel ceases to act on the lever of impulsion, it falls again, and presents itself to another tooth." "To render the vibrations of the balance more free and independent of the wheel-work," continues Berthoud in No. 282. "and diminish as much as possible the resistance it meets with at every vibration, the pin must be placed very near the centre of the balance, so that the lever may not be made to describe a greater course than that required to render the effect of the click perfectly sure, and while the balance turns, and makes its two vibrations, prevent only one tooth of the wheel from escaping; an effect which would be dangerous, by the seconds' hand, which is carried by the wheel, announcing more seconds, or time, than the balance by its motion would have measured. It was the dread of such a defect that made me then give this 'scapement up, which, I confess, seemed to be rather flattering; but it did not give to the mind that security in its effects which is so necessary, particularly in marine time-keepers, the use of which is of too great consequence, to allow any thing suspicious in them to be hazarded."

Arnold's 'scapement. PLATE CCCIII. Fig. 2.

Earnshaw's 'scapement. Fig. 3.

The principle given here by Berthoud is the same as that of the detached 'scapements now made, although the parts of the model are more complex. This 'scapement had received a variety of modifications under his hand. In 1768, he had five marine clocks planned to have spring detents to their 'scapements, the lifting spring being placed on the roller, or pallet, which received the impulse. These were not finished till 1782. Subsequent improvements, made by the late Mr Arnold and others, can hardly be considered as differing very materially from those of Berthoud. This 'scapement in pocket watches may sometimes come under such circumstances as have been noticed with Tyrer's; but no other can well be admitted into box-chronometers, whether it is made in the manner of Arnold, or in that of Earnshaw. In the 'scapement of Arnold, (see Fig. 2.) that part of the face of the pallet, at the point or nearly so, on meeting the cycloidal curved tooth to give impulse, rolls, as it were, down on this curve, for one half of the angle, and in the other goes up; or it may be thus expressed—the curve goes in on the pallet for the first part of the impulse, and comes out during the last. In making this curve too circular near the point of the tooth, as has been done by some, when the drop is on the nice side, the pallet has to turn a little way before the wheel can move forward, which has sometimes caused stopping; but, where attention is given to the proper form, this is not likely to happen. In that of Earnshaw, (see Fig. 3.) the face of the pallet is considerably undercut. Here, the point of the tooth will slide up for the first part of the impulse, and down in the last; in the first it seems to have little to do, and may acquire some velocity in order to overcome the part it has to perform in the last. The face of the pallet being undercut, had been found requisite from experience, as is said, in order to prevent cutting or wearing. In Berthoud's box-chronometers, or time-keepers, the face of the pallet is made straight, or in a line to the centre. One of these, after twenty-eight years going, the greater part of which was from Europe to India, and in the Chinese seas, was put into our hands, and neither the face of the steel pallet, or that of the detent, had the least appearance of being any way marked. This was the more remarkable, as the wheel was uncommonly thin. It must have been made of very fine brass. The wheel had ten teeth; the ratio of the diameter to that of the roller, or pallet, was .580 to .340; the balance weighed 174 grains, and made two vibrations in a second. The balance was suspended by a short and weak spring, which had been broken by some accident before we got it. The length of this suspension spring required to be .9 of an inch, and of so delicate a nature that many were made for it before the chronometer could be brought any way near to time. It seemed, indeed, to have more influence on the timing than any spiral spring could possibly have. Each of the balance pivots turned between the rollers, which were more than one inch in diameter; and from them and the suspension spring, perhaps, arose that ease and freedom in the motion of the balance, in consequence of which the balance wheel teeth had little to do when impelling the roller or pallet; and this may have been one cause why the pallet face was not cut or marked. It may be observed, that it had the common spiral balance spring, and a compensation consisting of two laminæ, or blades of brass and steel, pinned together and rivetted; and in the moveable end was a screw, which, by its connection with an arm in which the curb pins were placed, served to regulate for mean time. Three screws in the balance were also used for this purpose.

When the diameter of the pallet roller has a considerable proportion to that of the wheel, the angle of 'scapement will be less, and the hold on the face of the pallet will also be less; but the impulse given will be more direct, and the chance of stopping, from any counter-action by external motion, will also be greatly lessened. In this angle more must be included than that which is made from the drop of the tooth to its escaping the pallet. The angle of 'scapement is included between the point where the tooth escapes from the main pallet or roller, and the point to which the lifting-pallet comes in returning, after having passed the lifting-spring. There can be no 'scaping unless the lifting pallet has passed the lifting spring: It is then again ready to unlock the wheel. It is desirable, that the unlocking of the wheel should be made with the least possible resistance to the vibrations of the balance; which is attained, by having the end of the lifting-pallet as near to the centre of the balance as is consistent with its getting such a hold of the lifting-spring, that, in its course, it can readily and easily bring out the detent from locking the wheel. The hold of the tooth on the detent should not be more than the hundredth part of an inch. But, in doing this, the supplementary angle becomes greater, and increases the angle of 'scapement; and therefore it may be proper to have the lifting-pallet a little longer. A little additional length will greatly reduce the angle of 'scapement, and not much increase the evil of a greater resistance to the vibrations of the balance.

In a box chronometer, where the balance wheel has twelve teeth, and the whole angle of 'scapement is to be 60°, it is required to find the ratio of the diameter of the wheel to that of the roller. The supplementary angle being taken at 15°, the angle of impulse must then be 45°, which is rather wide as otherwise; but it will be less than this, when the thickness of the points of the teeth, and the spaces for drop and escape, are not taken into the computation. Now 360° being divided by twelve, the number of the wheel teeth, gives 30° for the quotient; and again divided by 45, the number of degrees for the angle of impulse, the quotient will be 8°. The diameter of the wheel is supposed to be .6 of an inch. To find that of the roller, say, as 12 : 6 : : 8 : 4. Four-tenths of an inch is the diameter required for the roller, which will give somewhat less than 45° for the angle of impulse. The diameter of the roller may be found in another way, sufficiently near for practice. The diameter of the wheel is .6 of an inch, or .600; then say, as 113 : 355 : : .600 : 1.885; this last being divided by 12, the number of the wheel teeth, gives for the quotient .157, the distance between the teeth. This distance taken as a radius for the roller, would give 60° for the angle of impulse. About one-fourth more of this added, will give .200 for the radius, so that the angle may be about 45°.

Owen Robinson's 'scapement.

PLATE CCCIII. Fig. 4.

Nothing should be overlooked, which can contribute to make the balance unlock the wheel with the least possible resistance. When the wheel is locked by the extremity of the teeth, it must be easier unlocked than when the locking is at a less distance from the centre. The unlocking cannot be done easier than with such a wheel for a detached 'scapement as was contrived about fifteen years ago by Owen Robinson, (see Fig. 4.) a very judicious 'scapement maker, who wrought long with the late Mr Arnold. This wheel is like that for Tyrer's 'scapement. The long teeth of *arrête* rest on the detent, and the upright teeth give impulse. It is evident that the unlocking with such teeth must be very easy, when compared with the teeth of those wheels which are made after the ordinary way.

Lest what has been said concerning the principle of a detached 'scapement may not be sufficient, we shall endeavour to describe the 'scapement itself, such as it is at present commonly made, so as to give an idea of it, and of the manner by which it acts. The balance-wheel of a pocket chronometer has fifteen teeth not very deep cut, and a little under cut on the face. A notch cut into a round piece of steel or roller, which is thicker than the wheel, forms the face of the pallet. Sometimes a small piece of ruby or sapphire is inserted into the notch at the face of the pallet, for the wheel teeth to act upon, so that no wearing may ensue. The ratio of the diameter of the wheel to that of the roller, is that of .425 to .175. When the wheel and roller are in their places, the wheel supposed to be locked, the roller must turn freely between two teeth, having only freedom, and not much more. From the centre of the roller to the point of one of the teeth, that next the last escaped, let a line be drawn at a tangent to this tooth. On this line is placed the detent and lifting springs. The detent piece, on which the wheel is locked, is a small bit of fine stone, either ruby or sapphire, set into steel, formed into a delicate spring, of such a length as to be equal to that of the distance of two or three spaces between the teeth, with a sole and steady pin at one end, which must be fixed to the potence plate by a screw. This is what is called the *detent spring*, the end of which goes within a little distance of the circle described by the extremity of the lifting pallet. On the left hand side of the detent spring is attached another called the *lifting spring*, which cannot be too delicate, but is made a little thicker towards the outer or lifting end than anywhere else. This end of the lifting spring projects a very little beyond that of the detent spring. On the arbor of the roller and balance, and placed near the roller, is twisted a short and thick steel socket, in which is set a bit of precious stone, the face of which is made flat, and nearly in a line with the centre, behind it is chamfered on towards the point, and made rather thin than otherwise. This is called the *lifting pallet*. The length or height is made so as to unlock the wheel to the best advantage, that is, by only carrying the detent a short way beyond the unlocking. This excursion is to be confined to as small an angle as may be. Near to the detent piece is fixed a stud, in which is a screw to regulate the depth of the detent into the wheel teeth. The point of the screw should be hardened, and have a part of the ruby detent to rest upon it, when the detent spring presses that way. When the balance is at rest, the face of the lifting pallet is very near to the outer side and end of the lifting spring. If the balance is brought a very little about to the left, the lifting pallet will pass the end of the lifting spring. On the balance being now turned towards the right, at the moment of the wheel being unlocked, the main pallet or roller presents itself, to receive the point of one of the teeth, and is impelled with considerable force; meanwhile the detent falls again to its place, and locks the wheel. The balance having completed this vibration, returns. In the returning, the lifting pallet pushes the lifting spring easily aside, being no longer supported by the detent spring when turning in this direction, that is, from the right to the left, the detent is again ready to be disengaged on the next return of the balance to the right, and so on.

Mudge's detached 'scapement.

The detached 'scapement of Mudge was contrived about sixty years ago or thereabouts, if we may reckon from the year 1766, when he showed it to Berthoud, who was then in London, and who informs us that it had been made a considerable time before.

PLATE CCCIII. Fig. 5.

This 'scapement consists of a wheel and pallets, like those made for the dead beat 'scapement of a clock, only the wheel teeth are not cut half the depth. On the verge or arbor of the pallets is placed an arm of any length, generally a little more than that of the pallets. The end of the arm is formed into a fork-like shape. On the axis of the balance is a short pallet, whose acting end may be of a small circular form, having the sharp part of the angles blunted, coming a little way within the prongs of the fork, which alternately acts, and is acted upon. There is also on the balance axis a small roller, having a notch in it. On the end of the arm is attached a small steel piece or index, in a plane which may be either above or below the prongs of the fork; this index is on the outside of the roller, when the free part of the vibrations is performing, and prevents the wheel teeth from getting away from the place of rest. On the return of the balance, the index passes with the notch in the roller to the opposite side. Meanwhile the short pallet gets into the fork, meeting with one of the prongs, pushes it on a very little way, and thus disengages the teeth of the wheel from the circular part of the pallet, where they rest during the free excursions of the balance. During the disengaging, the teeth get upon the flanch of the pallet, and give impulse, which causes the opposite prong of the fork to come forward on the short pallet, and communicate impulse to it. In Mudge's 'scapement, as drawn in the plate for the work published by his son, there are two short pallets, and the prongs of the fork lie in different planes. The impulse in this 'scapement is given at every vibration; and it seems to have done uncommonly well, particularly in the watch which he made for her Majesty Queen Charlotte. It is by no means suited for the execution of ordinary workmen, as it requires more address than usually falls to their share. The late Emery was much taken up with it; and although he had a little success, and had the aid of a very excellent hand, yet he experienced considerable difficulties. It might be somewhat easier managed, by adopting Lepaute's mode of Graham's dead beat, which we have tried.

Howells' detached 'scapement.

PLATE CCCIII. Fig. 6.

In 1792, a very neat and ingenious detached 'scapement was contrived by the late Howells, founded on that of Kendal's, (in whose hands he had occasion frequently to see it,) in which the wheel teeth rested on the cylindrical part of the pallet, during a part of the going and returning vibrations of the balance. See Fig. 6. In the other, after impulse is given on the face of the same semicylinder, and just before the tooth is quitting it, a detent is presented to receive one of the wheel teeth, by which the action of the wheels is suspended during the greater part of the going and returning vibrations, the pallet being then free and independent of the wheels. This 'scapement is composed of two crown wheels on the same arbor, the points of the one being opposite to the middle of the spaces of the other. On the axis or verge of the balance, which stands quite close to that of the balance wheels, is a semi-cylindrical pallet, whose diameter should be according to the angle of 'scapement required, which will also regulate the distance of the wheels from each other. The pallet is put near to the collet on which the balance is rivetted; a small arbor, having very fine pivots, is run in so as to stand parallel with that of the balance, and placed at some distance outside of the wheels, but where a line drawn from it, and passing at equal distances from the points of the wheel teeth, when continued, shall fall in with the centre of the balance; on this arbor is fixed an arm, at the end of which is a small fork and index; on the verge or balance axis, and near the lower end, is a short pallet, and a roller connecting with the fork and index, in imitation of Mudge's, acting in the same way as has been described, but only in the locking and unlocking part. Where the arm passes between the wheel teeth, which may be at ninety degrees or so from where they act on the pallet, are fixed two detent pieces, one for each wheel; opposite to the arm, and in the same line. A part of it is prolonged beyond the arbor outside, by way of a counterpoise, where two screws in fixed studs serve here as a banking to it. It may easily be conceived, that one of the wheels being locked, suppose that on the left, the balance, when returning from the left to the right, will, by means of the short pallet and forked arm, &c. carry the detent away; and just as the point of the tooth is free, the face of the semicylinder is presented, to meet with a tooth of the same wheel and get impulse; but before this tooth has nearly escaped, the detent is ready to receive a tooth of the opposite wheel, and so on. This 'scapement gives an impulse at every vibration, as is done in Mudge's. In the tenth volume of the *Transactions of the Society for the Encouragement of Arts, &c.* there is a description and drawing of it. It may be observed, that were the semicylindrical pallet faced with a piece of precious stone, the 'scapement would go on for a considerable time without falling off.

In the marine keepers which Mr Mudge himself

Mudge's crown wheel or remontoir 'scapement.

had made, the 'scapement is on a very flattering principle, which he had suggested as the means of improvement many years before he put it in practice. Its good performance seems to have been unequalled; and it is singular, that, notwithstanding the efforts of three or four of the best hands that could be got to the establishment set up by Mr Mudge, junior, in order to put these 'scapements to time-keepers which they were employed to make, not one was ever produced that was at all equal to the original ones. The 'scapement is *apparently* very complex, elaborate, and of course expensive in making; yet, when once executed, it will be permanent in its effects, and require no after adjustment like the common detached one. After what has happened, it is not likely that it will be again adopted. The basis of it is that of the curious old crown wheel and verge. In place of the verge being in one, having two pivots and the balance rivetted on it, let us conceive that each of the pallets of the verge has an arbor and two pivots, and that the balance is on a double kneed crank, having a pivot at the end of each knee, one being near to the foot, the other near to the collet on which the balance is rivetted; these pivots, and those of the pallet arbors, are in one upright line, coinciding and concentric with one another, having their motion, as it were, free and independent of each other, unless when in a part of the action of the 'scapement; the face of the pallets, in place of being flat, are hollow, or a little curved, having a nib at the edge to lock the wheel by. On the lower end of the lower pallet arbor is an arm projecting nearly as far as the bending of the crank knee, in which is fixed a pin that acts on the inner side, and near to the end of the arm, and is alternately acted upon; close by the arm, and on the pallet arbor, the inner end of a spiral spring is fixed; the outer end is in a stud, having a certain tension or bending up before fixing in the stud. The upper pallet arbor has the same as has been described to the lower one, and a pin in the upper knee of the crank. It may easily be conceived, that the length of the crank knees ought to be such as to allow it to sweep round and behind the crown wheel, its boundary or banking being that of the crown wheel arbor, or its pinion arbor. When the pallets are not raised up, and the wheel unlocked, the tendency of the spiral springs is to bring them down within the spaces of the crown wheel teeth. Suppose the upper pallet raised up, and the wheel locked, the under one being in the reverse position, and the balance vibrating towards the right, the pin in the upper crank will of course meet with the small arm, and carrying it on a little way, the wheel-tooth gets disengaged, by which the wheel getting forward, the lower pallet is raised up, and the wheel is again locked. In the interim, the upper arm being carried on a few degrees, by means of the momentum of the balance in vibrating, bends up the spiral still more than what was done by the wheel raising up the pallet, the re-action of which in the returning vibration gives impulse by means of the arm on the pin of the crank. The pin in the lower crank now getting forward, meets with the arm of the lower pallet arbor, carries it on, the wheel gets disengaged, and so on. This 'scapement cannot set itself off; for before this can be effected, the balance must get some degree of external circular motion in its plane. The balance may be said to be free in that part of the vibration, after the pin of one crank has left its corresponding arm till the pin of the other meets with its arm; this is, however, very momentary. The balance had on its arbor two spirals or pendulum springs, for the purpose of obtaining the most isochronous vibrations. Something in this way had been proposed by one of the Bernoullis. Drawings and a description of this 'scapement will be found in the work published in 1799, by Mr Thomas Mudge, junior. The compensation, like every thing of Mudge's, is ingenious; though nothing of this kind can ever be equal to that of being in the balance itself. The train of wheels went contrary to the ordinary direction, and we have no satisfactory reason assigned for it.

Breguet's revolving 'scapement.

Although the balance in pocket watches may be put very well in equilibrium, yet many things contribute to make them go unequally in different positions, such as in hanging, laying, &c. which require time, and give a great deal of trouble, before they can be completely corrected. In order to get the better of this, Breguet, an eminent watchmaker in Paris, contrived a 'scapement, which, with the pendulum spring stud, revolved round the centre of the balance once every minute. By this means, whether the balance was in equilibrium or not, the going of the watch was little affected by it, as every part of it was up and down in the course of a minute, which compensated any want of equilibrium. This contrivance is merely mentioned by Berthoud in his *Histoire*, as he did not think himself at liberty to give any description of it, since Breguet had a patent or *brevet d'invention* to make them. We have heard it said that the same invention had been made before by the late Mr John Arnold.

Those who wish for farther information respecting 'scapements, may consult *Traité d' Horlogerie*, par M. Thiout, *Histoire de la Mesure du Temps*, par M. F. Berthoud, and the *Transactions of the Society for the Encouragement of Arts, Commerce, &c.*

CHAP. II.

On Compensation Balances.

On the compensation against heat and cold in time-keepers.

Compensation against the effects of heat and cold in timekeepers, has been one of the greatest improvements that could have been applied to them. Without this they would have been far from keeping time, and would have varied continually with the temperature of the atmosphere, so that no fixed or settled rate could have been obtained. The detached 'scapement will show this more than any other; for if there is no compensation to it, the watch will vary nearly thirty seconds in twenty-four hours. The influence of oil on the cylinder 'scapement becomes in itself a sort of compensation, and the effect of changes of temperature is much less obvious in it than in the detached 'scapement. There is very great reason to believe that Harrison was the first who applied a compensation; but there are no written documents to warrant us in ascribing to him the honour of the invention, to which, however, we think he has a just title. Some very imperfect hints had been given by Martin Folkes, Esq. President of the Royal Society in the year 1749, of Harrison's having some mechanism of this sort in the three timepieces which had been made prior to the fourth, which gained the reward voted by parliament. But as no description of it was ever made public, the French artists have had it in their power to claim a priority in the invention. In Harrison's fourth machine, it is known that the compensation piece in it was composed of laminæ of brass and steel pinned and rivetted together in

Compensation Balances.

several places. Perhaps those in the three former differed little or nothing from this.

Berthoud's first compensation against heat and cold.

The first pocket watch made in Europe with a compensation was by F. Berthoud. It was begun in 1763, and finished in the beginning of 1764; and was sold in London in 1766, to Mr Pinchbeck, for his Britannic Majesty King George the Third. The compensation was effected by laminæ of brass and steel pinned together; one end of which being fixed to the potence plate, the other acted on a short arm from a moveable arbor, a longer arm having the curb pins in it, being made to move nearly in the circle of the outer coil of the spiral spring. It had a common crown wheel and verge 'scapement, and a going in time of winding. The balance was so heavy as to set, being sixteen grains in weight, and the vibrations were four in a second. Mr Kendal adopted this mode of compensation in some of his pocket watches.

Mudge's compensation by a spiral of brass and steel soldered together.

Mudge, some time before the year 1770, made a watch for Mr Smeaton, in which the compensation was effected by two long slips of brass and steel soldered together; being dressed up, it was turned up into a spiral, as close together in the coils as to be free, and no more. The inner end was fixed to a circular curb wheel, a short portion of the outer end had a pivot, bent in the circle of the outer coil, and supported by a small stud, through a hole of which it moved freely; at this end was the curb pins, between which the spiral or pendulum spring passed; the effect of heat or cold on it, was counteracted by the spiral compensation piece. The 'scapement of this was the cylindrical one; and so long as the oil kept clean and fresh, the compensation might be useful to it. In 1774, we made one or two of the same sort for horizontal watches. At that time no better 'scapement and compensation were known, at least so far as came under what was then the common practice.

Le Roy's compensation by common thermometer tubes and balls PLATE CCCIV. Fig. 1.

In the voyage undertaken for the trial of Le Roy's Time-keeper in 1768, and published by Cassini in 1770, along with the description and drawings of it, Le Roy has given that of a compensation balance, which is exactly like those of the present day, only the laminæ are pinned together, in place of the brass being melted on the steel. The compensation of the time-keeper, however, was not of this kind; it consisted of two glass tube thermometers, bent nearly into the form of a parallelogram, with a small ball at one end to each, the other open, and filled partly with mercury, partly with spirit of wine, fixed to the axis of the balance opposite one another: the balls lay very near to the axis. It would appear that Le Roy had not thought of a metallic compensation, until the return of the time-keeper from the voyage of trial. He had taken the idea of this from getting an account of Harrison's, which was sent to the Royal Academy, signed by Ludlam, who was one of the scientific gentlemen appointed by the Commissioners of the Board of Longitude to take Harrison's account of his time-keeper, previous to any part of the reward being paid him.

In a life of Peter le Roy, the son of Julien, the method of compensation is erroneously ascribed to that artist's father, to whom "we are indebted," says the writer of the article, "for the method of compensating the effects of heat and cold on the balances of chronometers, by the unequal expansion of different metals; a discovery which has been brought by our English artists to a state of great perfection, although it had been laid aside by the inventor's son Peter."

It is difficult to understand how this mistake should have been committed; for the following account of the discovery, given by Peter le Roy himself, is in direct contradiction to the preceding statement.

Compensation Balances.

Le Roy's compensation by common thermometer tubes and balls.

"Observation V.—*Sur la compensation des effets de la chaleur et du froid.*

"Selon la gazette du commerce, et la rapport *signé* Ludelam, envoyé à l'academie: pour remedier aux irregularités produites dans les montres marines par la chaleur et par le froid, *M. Harrison se sert d'une barre composée de deux pieces minces de cuivre et d'acier de longeur de deux pouces, rivées ensemble dans plusieurs endroites, fixées par un bout, et ayant de l'autre deux goupilles au travers desquelles passe le ressort du balancier. Si cette barre reste droite dans le tems temperé, (comme le cuivre recoit plus d'impression de la chaleur que l'acier,) le coté de cuivre deviendra convexe au tems chaud, et le coté d'acier le sera au tems froid. Ainsi les goupilles fixent tour-à-tour les parties du ressort, selon les differens degrés de chaleur, et l'alongent ou le racourcissent: d'ou nait la compensation des effets du chaud et du froid.*

"Si j'avois connu cette ingenieuse methode avant d'avoir pensé à mes thermometres, je n'aurois vraisemblablement point hesité à en faire usage dans ma machine.

"J'ai balancé quelque tems, si je ne devois pas lui donner la préference. J'ai même fait quelques essais dans cette vue. J'en parleroi bientôt: mais apres y avoir pensé murement, et avoir mis à part, autant qu'il m'a été possible, ce penchant qui nous parle en faveur de nos productions, mes thermometres m'ont paru préférable," &c. &c.

See *Memoire sur la meilleur maniere, de mesurer le tems en mer*, p. 55, 56, inserted at the end of *Voyage fait par ordre du Roi in* 1768, *pour éprouver les montres marines inventées par M. le Roy*, &c. par M. Cassini, fils, Paris, 1770.

Berthoud employs different ways of compensation before he had it in the balance.

PLATE CCCIV. Figs. 2, 3.

As must always be the case in the infancy of any branch of science, various methods are fallen on before it arrives at its most improved state. Berthoud, Arnold, and others, had recourse to different modes of compensation before they arrived at the one which gave them complete satisfaction. The former, in his first machines, used small wires of brass and steel, combined nearly like the gridiron pendulum, to effect the purpose of compensation; to those of a later date, was applied a straight piece, composed of laminæ of brass and steel pinned together, acting on the short arm of a lever. In the end of the other arm, which was long, the curb pins were fixed. Even with those balances which were afterwards made, and composed of brass and steel pinned together, he adopted as a supplementary aid, the straight compensation piece with the moveable arm and curb pins. Considering the talents he possessed, and the great experience which he must have had, this seems a little curious; as we think, where there is a complete compensation in the balance, it *alone* should be sufficient, and that the curb pins would tend to disturb the pendulum spring rather than give any aid to the compensation. The more free the pendulum spring is, the chance is more in favour of good performance, when the compensation balance is supposed to be fit and complete for what is required.

Arnold's compensation balances. Fig. 4.

In some of Arnold's balances, two pair of laminæ were placed parallel to the diametrical arms; on the middle of them was fixed a small wire which came through the rim, outside of which, and on the end of the wires, a small ball was fixed to each. These balls were pushed out or drawn in by changes of temperature. The arguments given in favour of such as Earnshaw's, which

Balance Springs.

Earnshaw's compensation balances. Plate CCCIV. Fig. 3.

are turned first on the stee and again on the brass, after being melted on the steel, are certainly very strong and convincing, and nothing can well be said against them, and yet there appears to be a softness in such a balance that cannot exist in those where the laminæ are set or turned up by hand. There is undoubtedly a great deal more trouble in making the last, and though it has been said that they cannot be true or round when made in this way, yet we have seen some of those done by Owen Robinson, as round and true as any turning could make them, and possessing a degree of stiffness that cannot exist in the other; they have been even unscrewed, or taken to pieces, and again put together, without altering the rate of the chronometer. After all we are not aware, that chronometers with the one balance actually perform better than those with the other.

It may be observed, that on the rim of the turned balances, which is separated into two, there are small pieces of brass, made to slide backwards and forwards, according as it may be found requisite, when under the process of adjusting for heat and cold. In the other, this is done by screwing backwards and forwards the pieces of brass which turn spring-tight on small screws left at the outer end of the laminæ, and are bent in the same circle with them. Both balances have what are called meantime screws, placed in the vertical line of the hanging position, which serve to adjust them to their rate of time, &c. We have seen and made compensation balances with three arms, and three pieces, and three meantime screws, which were stiff, and answered very well.

CHAP. III.

On Balance or Pendulum Springs.

Balance springs.

The invention and application of the spiral spring to the balance of a watch, is by the foreign artists in general ascribed to Huygens, while they admit the idea of a straight spring having been long before this applied by Dr Hooke. It was in 1658 that Dr Hooke observed the restorative action of springs, when he put one to the balance of a watch, and applied for a patent to secure his right of invention. The profits were to be divided between himself, Sir Robert Moray, Mr Boyle, and Lord Brouncker. It was not carried into effect, in consequence of a quarrel between the parties, on account of a very unreasonable demand on the part of these gentlemen. Nor was it till 1674 that Huygens claimed the same discovery. Hooke charged Huygens with plagiarism, through the intervention of Mr Oldenburgh, Secretary of the Royal Society, who communicated to him, when he was twice in England, the registers of the society, and also corresponded with him upon the subject. In 1665, Sir Robert Moray requests Oldenburgh to tell Huygens that such watches had already been made in England, and to ask him if he does not apply a *spiral* spring to the balance arbor? It may be asked, where had Sir Robert seen a spiral spring? The natural answer is, that he must have seen it in the hands of Dr Hooke.

On nothing does a chronometer depend so much as in the good quality of the pendulum spring: great as the power of the rudder is, in controuling and regulating the motion of a ship, it is not more extraordinary than that of this spring, in regulating the motions of a chronometer, and we may be allowed to say, that it possesses something like *invisible* properties. It may be set so as to make the machine go fast or slow, in any position required, while neither its length, nor the weight of the balance, are in any way altered. Le Roy thought that he had made a great discovery, and it must be granted to be one, when he found, "that there is in every spring of a sufficient extent, a certain length where all the vibrations, long or short, great or small, are isochronous; that this length being found, if you shorten the spring, the great vibrations will be quicker than the small ones; if, on the contrary, it is lengthened, the small arcs will be performed in less time than the great ones." Notwithstanding this condition of *sufficient extent*, the isochronous property will remain no longer than while the form of the spring is preserved, as it originally was. Should the coils be more compressed or taken in, the long vibrations will now be slower than the short ones; and, on the contrary, if they are more let out or extended, the long vibrations will be faster than the short ones. A more general principle for obtaining the quality of isochronism, may be applied, by making the spring act proportionally, in an arithmetical progression, according to its tension. Every five degrees of tension should make an equilibrium with a given force or weight, of ten grains, that is, 5, 10, 15, 20, &c. degrees of tension, should be balanced by 10, 20, 30, 40, &c. grains. To try small springs by this process would require a very nice and delicate tool. In order to obtain these properties in pendulum springs for his timekeepers, Berthoud made them thicker gradually from the outer to the inner end; our old English way is the reverse of this. Whatever may be the form of the spring, whether flat or cylindrical, the best and most direct way is to try them in the timekeeper itself, by taking four hours going, with the greatest force the main spring can give, and then four hours with the least. It is of consequence to have these springs hard, or well tempered.

Properties of balance springs.

CHAP. IV.

On the Jewelling of Pivot Holes.

Jewelling of pivot holes.

Our chronometers, from the art of jewelling the pivot holes, may be said to have acquired a durability and character, which they would not have otherwise received. It must not be imagined that there is any time keeping principle or improvement in a jewelled hole more than in a brass one; and, notwithstanding what has been said in favour of the last, few will be hardy enough to run the hazard of having the balance, and balance wheels, to move in brass holes. It is very well known, that in a common verge watch, where the balance holes are jewelled, its motion will be kept up for a longer time than when it runs in brass holes. The friction at the balance holes cannot be supposed to be less than at those of the fusee; for, in the time of one-fourth of a turn of the fusee, the balance must make more than what is equivalent to 9000 revolutions. Berthoud regretted much that he had not an opportunity of getting the pivot holes of his time-keepers jewelled; yet, from that versatility of genius which he possessed, he supplied admirably the want of this, in a manner that very few could have equalled. Some of the balances in his time-keepers were made to give six vibrations in a second, while others gave only one. His number *eight* made one vibration in a second, and was the one which gave the best performance of all those that he had constructed. It seems to have been considered as a wonderful discovery, that jewelled holes wore down the pivots, and thickened the oil, after they had been used for upwards of a hundred years. How came this not to be sooner observed, when so many were engaged in making chronometers, and that too in considerable numbers? That pivots, from a length of time, even with good oil, and with greater probability from bad oil, may have got, as it were, glued in their holes, there is little reason to doubt; but this never arose from particles wearing away from either the steel or the stone, by the friction of the pivot. Let any one try to whet a graver, which requires some degree of force, on a polished Scotch pebble, for instance, and they will find that no exertion whatever will make the graver bite the stone, or the stone the graver; for where any effect of this kind takes place, it must be nearly mutual. The hardness of the Scots pebble is well known to be much inferior to that of the ruby or sapphire. After being exposed to the air for a considerable time, oil gets viscid and thick, which arises, as has been observed by chemists, from its absorbing or attracting oxygen. We suspect that oil, from this cause *alone*, may become more glutinous at a jewelled hole than at a brass one. By its application to brass it soon acquires a bluish green tinge, as if something acted upon it. This is owing to the metal becoming oxidated by the joint action of the oil and air. The oxide thus formed combines with the oil, and forms a metallic soap, which is much less tenacious than that formed at a jewelled hole. By the continuation of this process, the hole in brass in time becomes wider, and the oil disappears, leaving the pivot and hole in a greater or less degree wasted; and instead of the oil we have the metallic soap, which has hitherto been considered as rust. To be convinced, however, that this is not the case, we need only attempt to wipe it off from the pivot, from which it easily parts, and which it would not do were it really rust. Oil, however, can have no action on the jewelled hole, and any change that is effected by the oil must be confined to the steel pivot, on which its action is so exceedingly slow, that a great length of time must elapse before the oil is decomposed and disappears; and hence what has been called rust in a brass hole, is seldom or never met with in a jewelled hole. If a little fine Florence oil is put into a small phial for about two-tenths of an inch deep, and remain for a few years, it will become exceedingly viscid and glutinous, and will be intermixed with parts tinged with red of various shades. The same appearance is sometimes seen at jewelled pivot holes, and has been erroneously supposed to be produced by the operation of the pivot on the hole. It is singular that oil will act more forcibly on fine brass than on the common sort, or even on copper; a metallic soap somewhat resembling verdigrease will soon show itself on the former, while the latter will have no appearance of being injured. But we are not to infer from this, that copper holes would be preferable to those made in fine brass; for although the oil in this case would be more durable, from its acting more slowly on copper than on brass, yet the increase of friction from the copper would more than counterbalance this advantage. It can hardly have escaped the eye even of the most indifferent observer, that oil acts more readily and forcibly on new than on old work. On the former, it will frequently show itself in the course of 24 hours. Oil varies so much in its quality, that some will become so thick and viscid in the course of a few months, as to stop the machine altogether. This has occurred in the experience of a very celebrated artist, who informs us that "his regulator, which has been found to go to a greater degree of accuracy (though not to a second in two months, as has been said *of* others) than even that at Verona, as observed by the astronomer Cagnoli, or that at Manheim, as observed by Mayer, was found to perform very indifferently after being cleaned, and at the end of three or four months stopped altogether, which arose from the application of bad oil." We are of opinion, that where the pivots are small, and the revolutions of the wheels quick, jewelled pivot holes are the best. It will not be an easy matter to do without oil, particularly in pocket or box chronometers, although astronomical clocks or regulators may be so constructed as not to require it.

CHAP. V.

On the Machinery for going in time of Winding.

Machinery for going in time of winding.

The earliest machinery for going in time of winding, is the simplest and best that has yet been produced, although, upon the whole, it may not be so convenient in its application. In the old thirty hour clocks, the first wheel of the going part had on its arbor a fixed jagged pulley A: (See Plate CCCIV. Fig. 6.) On the arbor of the first wheel of the striking part was a moveable jagged pulley H, with click and ratchet to it. Over these, and through or under the pullies of the counter weight *p* and main weight P, went an endless cord, woven either of silk or cotton. Both parts of the clock were carried on by a single or main weight; and, when winding it up, this was done by the striking pulley; by which means, the weight acted constantly on the going part. This is a method which we adopted in some common regulators, and afterwards found it was the same that Berthoud had used in some of his. The moveable and winding up pulley with its ratchet was on a fixed stud, having a click and spring, which were fixed to one of the plates, as was also the stud. The other pulley was on the arbor of the first wheel, and fixed to it. The only inconvenience and objection to this contrivance, particularly in eight day clocks, arises from the wearing of the cord on the jagged part of the pullies, which produces a great deal of dust, and makes the clock get sooner dirty than it would do, if this was effected in a different way. In clocks which go a month, or six months, as some of Berthoud's did, this will be very much obviated, particularly with a fine and well wove silken cord.

First mechanism for this purpose. PLATE CCCIV. Fig. 6.

Another mechanism for going in time of winding.

There is a very ancient way of going while winding, which was long applied to the fusees in clocks and watches. On the inside of the great wheel is another wheel, whose teeth are cut to look inward to the centre, upon which acts a pinion of six, which runs in the bottom of the fusee, and is turned round with it. The fusee arbor is free within both the great wheel and the fusee; upon it is fixed the fusee ratchet, and a wheel with about half the number of teeth of those in the inward toothed wheel. It is evident, that if the fusee arbor is turned round, the wheel fixed on it, which acts also into the pinion of six, will by this make the pinion turn; and this again, acting on the inside wheel teeth, will apply as much force to it, as the fusee requires in setting up. When wound up, the click in the great wheel, as in the ordinary way, stops the fusee by the ratchet from running back. This method takes six times longer of winding up than by the common way; and the great strain which is laid on the pinion and inside wheel teeth, soon destroys them. With a little more apparatus, a fusee of this kind can be made to wind up whichever way the arbor is turned; hence it got the name of the *drunken fusee.* (See the particulars of it in *Thiout,* vol. ii. p. 383. and Plate xxxviii. Fig. 14.)

Drunken fusee.

A later mechanism for going in time of winding.

A going in time of winding, of later application to clocks and regulators, consisted of an arbor within the frame, on which was a pin, and an arm inside, with a nib and deer's foot joint; another arm on the outside when pulled down, served to make the jointed nib rise and pass the third wheel teeth; a spring acting on the pin brought the nib in a contrary direction, to act on the third wheel teeth, by which it gave motion to the swing wheel during the time of winding, and continued to do so until getting clear of the teeth.

Mechanism generally adopted.

The general method which is now adopted, both in clocks and chronometers, consists of an auxiliary spring, ratchet, and detent. In clocks, two springs are sometimes used; being doubled round, are screwed by one end to the back of the auxiliary ratchet; the other end is made to act against the arms or crosses of the great wheel. On the opposite side is the click, which acts with the barrel ratchet; and when the force of the weight is taken off by winding up, the force of the springs act on the great wheel, and not being allowed to bring the auxiliary ratchet forward, which they would do; but this is prevented by the detent, consisting of an arbor whose pivots run in the frame, and an arm acting against the face of the small teeth in the auxiliary ratchet.

When this method is applied to a clock or watch fusee, there is a circular and flat steel spring screwed or made fast by one end to the inside of the great wheel; in the other end is a small hole, opposite to which is made a short and circular slit in the great wheel. A pin in the auxiliary ratchet is placed so as to correspond to the hole in the spring and the slit in the great wheel, through both of which it comes; the slit gives range for the bending up of the spring. When the force of the main spring does not act on the fusee, which is taken off when winding up; the auxiliary ratchet, and detent which has a slender spring to keep it to its place, serve the same end as has been described for the clock.

This mechanism for going in time of winding was invented by Harrison.

The mechanism of this going in time of winding, was first exhibited by Harrison in his time-keeper, when explaining its principles to the commissioners who were appointed to receive them. It has been said that he took the idea of it from having seen an analogous contrivance in an old kitchen jack, where it had been applied to keep the spit turning while the jack was winding up. There has been a great deal of ingenuity displayed even in jack-making. It is singular, however, that it was never thought of to apply vanes or wings to the fly, which could have been set so as to regulate the velocity according to the greater or less weight with which the spit might be loaded; but, simple as the setting of these wings would be, it might not be so easy to prevail upon the cook to take the trouble of either understanding or using them. The water-jack, which has been known in this country for more than seventy years, is very convenient in this respect, as it is so easy to make the discharge of water at the cock to run full, half, or quarter, on the small kind of mill-wheel which drives the whole of the machinery belonging to the jack.

A great many years ago, we contrived an easy way of making a going in time of winding for a clock, to several of which it was applied. The third wheel has a socket (with a small shoulder) truly fitted to it, the hole being soundly and smoothly broached. That part of the third wheel pinion arbor, which works in the socket, must also be truly turned, and made as smooth as any pivot, so as to be free, easy, and without shake. The end of the socket, which is not in the wheel, should be smooth and flat; its diameter outside about three tenths of an inch, and to apply to a flat smooth steel shoulder formed on the pinion arbour. On the side of the wheel opposite that on which the socket shoulder is placed, let there be fixed a small steel pin, distant from the centre about three-tenths of an inch, the height of it being about one-tenth. Make a piece of brass so as to have a fine small ratchet-wheel on it, of about four-tenths of an inch in diameter, with a sort of hoop or contrate wheel rim on one side of it, three-tenths and a half in diameter inside, the thickness being a little more than that of an ordinary contrate wheel of a watch, and the depth one-twentieth of an inch. The ratchet-wheel and hoop have a socket common to both, which is twisted on the third wheel pinion arbor; this socket on that side of the hoop inside, is the smallest matter lower than the edge of the hoop; on this part of the socket is fixed the inner end of a small and weak spiral spring, of two or three turns, the outer end having fixed to it a small stud, with a hole in it, that goes over on the steel pin of the third wheel, which works in a short circular opening in the ratchet wheel or bottom of the hoop, of a sufficient range for the spiral spring to keep the clock going during the time of winding up. The detent for the ratchet has one of the pivots of its arbour in the back frame plate, the other runs in a small cock attached to the inside of this frame plate, and sufficiently clear of the third wheel on that side. The edge of the hoop, when the socket is twisted home, should allow the third wheel to have freedom during the action of the spiral spring on it. In applying this going in time of winding apparatus to a clock, it will easily be seen in which way the small ratchet teeth must be cut, and also in which way the spiral spring must exert itself. During the action of winding up, this allows the minute hand to make a retrograde motion, but it resumes its place as soon as the weight is at liberty.

Mr Reid's contrivance for going in time of winding.

In the early part of the last century, a considerable intercourse was carried on between Holland and Port Seaton, by the ship owners of Prestonpans, in East Lothian. Among the imports, was old iron in hogsheads, and many of the articles were little worse for being used, as by a law with the Dutch, no iron work was allowed to be repaired. Among the things which came home, were some camp jacks, of a very ingenious construction, and evidently of German origin. Two or three of them, one of which we have seen, are still in that neighbourhood. It was composed of the usual wheels and pinions, endless screw, and a small fly, rather weighty. The frame mounted on an upright stand, was about four feet or more in height. A thin and narrow iron bar, of four or five feet long, was attached to the stand, and could be made to slide up and down on it, nearly the whole four or five feet; one edge of it was toothed like a straight rack, and worked into the pinion of the first wheel, by means of a weight or weights hung on a hook at the lower end of the bar; when the weight and bar came to the lowest point, it was easily moved up to the greatest height, when the jack was to be wound up. The pinion had a hollow socket, and could turn freely round the arbor of the first wheel; on the lower end of the socket was a

Machinery for going in time of Winding.

ratchet which rested on the first wheel, where the click and spring was placed to act with the ratchet, which by the hollow socket allowed the pinion to turn freely backward when winding up; on the weight being allowed to act on the rack, all the wheels were made to turn the proper way, and so on. An idea occurred to us, that, in place of the rack moving, a machine might be made to go by its own weight, by means of a pinion turning down on the toothed edge of a fixed rack. A scheme shall be given for a box chronometer of this construction, which supersedes the necessity of either fusee, barrel, spring or chain. A contrivance of a similar kind, has lately been communicated to the Society of Arts in Paris, by M. Isabelle, and is described in the *Bulletin de la Société d'Encouragement*, No. 52. The same method, which has been known for a considerable time, is used at Liege by Hubert Sarton, who makes eight day spring clocks on this plan.

Mr Reid's box chronometer without fusee, barrel, spring, or chain.

On the arbor of the first or great wheel, is fixed what may be called the fusee ratchet, working with the click and spring, which are on the auxiliary or going ratchet; in the last is fixed a pin, which comes through the end of the auxiliary spring, and the circular notch in the great wheel, which is keyed on in the same way as in the case with a fusee; and having also a detent and spring for the going ratchet, the whole forming the great wheel, and the mechanism for going in time of winding. On the great wheel arbor, close to the main ratchet, let a small bevelled wheel be fixed, of any small number of teeth, fully stronger than those in the great wheel, the back of the bevelled wheel lying against the main ratchet: indeed both might be made from one and the same piece of brass. Supposing the diameter of the pillar plate to be 2.25 inches, that of the great wheel would be 1.5 inch, and the number of teeth 72; the bevelled teeth being half an inch in diameter, would admit 24 teeth; and if made a little thicker than the great wheel, the teeth would be sufficiently strong. Another bevelled wheel, of the same diameter and number of teeth as the other, is fixed on a pinion arbor, (a hole being made in the potence plate, to allow the bevelled wheels to pitch together,) which is placed within the frame in a horizontal direction, in that line which passes through the centres of the great and second wheels; one of the pivots runs in a cock inside of the potence plate, and placed near to the great wheel arbor; the other, which is a little beyond the pinion head, runs in a cock fixed on the outside of the potence plate. This pinion has sixteen leaves of the same strength as the teeth of the bevelled wheels, and runs in with the edge of a toothed rack; every revolution will be over the length of one inch on the rack, and equal to four hours, or one turn of the great wheel; the second wheel pinion being 18. The length of rack supposed to be 8 inches, would allow the time of going to be equal to 32 hours, 8 inches multiplied by 4 being equal to 32. Were the rack 12 inches long, it would admit the time of going to be 48 hours; or the diameter of the pinion might be increased from .333 to .500 parts of an inch, and the time of going would then be somewhat more than 30 hours. Let a slip of wood be made 15 inches long, $\frac{4}{5}$ths of an inch broad, and rather more than $\frac{1}{8}$th thick, on one side of this, and close to the edge, let another slip of the same dimensions, but not quite so broad, be set on edge at a right angle to the side of the other; this will form a pattern to have two such cast in brass from it; after being dressed up, one is left plain, the other so as to have twelve inches of teeth made on one of the edges; the plain one is screwed to the inside of the case, and the other is screwed on to the plain one, having the toothed edge on the right hand side of the pinion, so as to make the second wheel and pinion turn the proper way. To the ring or cap which incloses the movement of the chronometer, are attached three pieces of brass, kneed up at each end; the distance from the ends is about two inches and a half, in which are holes made quite parallel to one another, and go on three steel rods, 15 inches long and $\frac{2}{10}$ths of an inch in diameter, fixed in the lower and upper ends of the case, and parallel to one another, and near to the dial of the chronometer. The case may be either of wood or brass, having a door on one side, which serves the purpose of getting at the chronometer, either to observe the time, or to push it up after it is nearly run down. In the lower part of the cap, a recess may be made to receive any additional weight requisite to load the chronometer with, in order to give greater extent of vibration to the balance; the upper part of the case should, if necessary, be hung in gimbols, and the lower end loaded with lead to keep it steady. A chronometer might be easily fitted up in this way to go eight days, by giving more length of rack, a greater weight to the bottom of the cap, more teeth to the bevelled wheel which is on the horizontal pinion arbor, fewer to that which is on the arbor of the great wheel, and the second wheel pinion to make more revolutions for one turn of the great wheel. Suppose the great wheel 80, and the second wheel pinion 16, one turn will be equal to five hours; the bevelled wheel which is on it (being 16) will have a revolution also in five hours; the bevelled wheel which turns it, having 24 teeth, will make a revolution in seven hours and a half. The rack being 25.6 inches long, the pinion of 16 making a revolution on it in seven hours and a half, and $25.6 \times 7.5 = 192$, the number of hours in eight days. The length of the case, being thirty inches, could be no inconvenience where eight days going without winding is obtained. A similar, and we think a preferable, construction might be adopted, by having the chronometer fixed, and a weight hung to the lower end of the rack, which, as in the case of a jack, would keep up the motion required for the chronometer. This plan, however, of a moveable rack, would require a space for the rack to move in equal to twice its length.

Machinery for going in time of Winding.

CHAP. VI.

On the Dividing and Cutting Engine.

Dividing and cutting engines.

AMONG the inventions in the art of Horology produced in this country, may be mentioned that of the wheel-dividing and cutting engines, which are said to have been invented by Dr Hooke. In the preface to the fourth edition of Derham's *Artificial Clockmaker*, he remarks, that "the invention of cutting engines, (which was Dr Hooke's,) fusee engines, and others, were never thought of till towards the end of King Charles the Second's reign." It is well enough known that he contrived and used an endless screw and wheel for the purpose of dividing astronomical instruments, in 1664. The wheel-cutting engine was contrived by him in 1655; and, about the same period, he discovered that the barometer indicated changes in the atmosphere, and was connected with the weather. Ten years afterwards, he proposed a clock to register the rise and fall of the barometer, which was executed by Mr Cuming, in a clock made for his present Majesty. Sully carried over to Paris, wheel-cutting engines, which were much admired there, not only for their beauty, and fanciful execution, but also for their utility. The French artists unwillingly admit our claim to this invention; and could they have brought forward documents to the contrary, it would most readily have been done. They maintain, that it could not have been invented and improved at the same time by any one man, an opinion in which we must agree with them. A wheel-cutting engine, and one which could divide almost any number, by means of an endless screw and toothed wheel, was made about 70 years ago by Hindley of York, which came afterwards into the possession of Mr Smeaton, from whom Mr Reid purchased it 30 years ago. As Hindley knew what had been done in this way by Dr Hooke, this seems to have been made in imitation of his, with some additions and improvements, as it is evidently not copied from that which is described in Thiout's work, vol. i. p. 53, plate xxiii. fig. 1. said to have been invented by M. P. Fardoil, watchmaker at Paris. Ramsden's dividing engine, for which he got a considerable premium from the Board of Longitude, was executed on this principle, the great merit of which consisted in having a more perfect screw than had hitherto been made. See our article GRADUATION, vol. x. p. 352, for a copious history of *Dividing Engines*, and a full account of the engines invented by Ramsden and Troughton.

CHAP. VII.

On Equation Clocks.

Equation clocks.

THE first equation clock, which is a very ingenious contrivance to shew both mean and apparent time, was made in London about 120 years ago. The following history of the invention is given by Berthoud in his *Histoire*.

"The most ancient equation clock," says he, "which has come to our knowledge, is that which was placed in the cabinet of Charles II. King of Spain, and which is mentioned at the end of *The Artificial Rule of Time*, by Sully, (edition 1717,) who gives the following account of it, from an extract of a letter of the Rev. Father Kress, of the society of Jesus, written to Mr Williamson, watchmaker of the cabinet of his Imperial Majesty, of the 9th January 1715.

"What Mr Baron Leibnitz says, in his remarks at the end of Sully's book;—that if a watch or clock did of itself make the reduction of *equal time* to *apparent*, it would be a very fine and convenient thing;—on this subject I have to tell you, that from the years 1699 and 1700, there has been in the cabinet of King Charles II. of glorious memory, King of Spain, a clock with a royal pendulum, (a seconds' pendulum,) made to go with weights and not with springs, going four hundred days without requiring to be once wound up. I have, by order of his Majesty, and in his presence, seen and explained the instructions, which were sent from London with watches, which contained many curious things. I had orders to go every day to the palace during several months to observe the said clock, and compare it with the sun dial. And at that time I remarked, that it shewed the equation of time *equal* and *apparent*, exactly according to the Tables of Flamstead,* which are found likewise in the Rodolphine Tables," &c.

Sully, at the end of the letter of which an extract has just been given, makes the following remarks, page 9:

"What the Rev. Father Kress relates of the clock of the late King of Spain, is very true. It is more than twenty years since such clocks were made in London, and I believe that I am the first who applied this mechanism (for equation) to a pocket watch, twelve or fourteen years ago."

The following is a description of a very excellent and curious equation clock, which belonged to the late General Clerk. It was left, with several other things, to the late Sir John Clerk, and entailed on the house of Pennycuik.

Description of an equation clock.

The clock goes a month, strikes the hour, and has a strike silent piece. The 'scapement of it is made after that of John Harrison's, requiring no oil to the pallets; (see p. 119.) and the pendulum is a gridiron compensation one, composed of five rods, three of which are steel, the other two of zinc, or some compound of zinc. On the dial are seen the hours, minutes, and seconds, and their hands. The minute hand keeps mean or equal time; the equation of time is given by a hand with a figure of the sun on it, which makes a revolution every hour as the minute hand does, only for the most part it goes sometimes a very little slower, and sometimes a little faster than the minute hand, keeping solar or unequal time, and shows at all times when the sun is on the meridian. The age and phases of the moon are also represented, the days of the year and of the month, the degrees of the ecliptic, and the signs of the zodiac, the rising and setting of the sun, the length of the day, &c. The dial is a twelve inch arched one. Concentric with the arch, is a sort of ring plate wheel of 365 teeth, making its revolution in a year, or 365 days. Its diameter is about 8 inches, and the breadth of the rim or ring 1¼ inch nearly. On this ring plate, at the outermost circles containing divisions, are laid down the days of the year; and on the space next within, are the names of the months, the days being numbered by the figures 10, 20, 30, and so on. The next circles contain the 360 degrees of the ecliptic; the space within has the signs of the zodiac, and the numbers 10, 20, and 30 marked for the degrees in every sign, and corresponding with the days of the year and of the month when the sun is in any of these signs. The innermost circles contain what may be called the divisions of the semidiurnal arcs. On the space outside of this, are marked the corresponding hour figures in Roman characters. This is what gives the time of the rising and setting of the sun, and the length of the day.

In the annual plate ring, are rivetted six small brass pillars, one inch and one tenth of an inch in height, whose opposite ends are screwed by steel screws, and their heads sunk into a plain ring wheel neatly crossed into six arms, the diameter being five inches and three quarters of an inch, and the breadth of the rim three-eighths of an inch. The back of this plain ring is distant from the back of the annual plate ring one inch and a quarter. The plain ring is at the centre, screwed on a brass socket, having a square hole in it. Within the frame of the clock movement, and at a perpendicular distance of six inches from the centre wheel holes, a steel arbor is run in, and at one end prolonged about an inch and a half beyond the fore frame plate, somewhat like a stud. The pivot in the fore plate is of such a length and thickness, as to allow a square on its outside. It is on this square that the equation elliptic plate is put, and above it is put on the annual plane ring by means of its socket, with a square hole in it. That part of the arbor which is above this socket is round, and serves as a stud for the moon's age ring.

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* The earliest equation Tables were calculated by our first Astronomer Royal Mr Flamsteed, at Greenwich.

Description of an equation clock.

Moon's age.

Lunar phases.

socket, to revolve on it freely and easily. The moon's age ring turns within the annual plate ring, and is divided into 59 equal parts, numbered 3, 6, 9, and so on to 29½. Its diameter is five inches and one-eighth; its breadth fully three-eighths of an inch, and it is connected with a plain wheel neatly crossed into six arms, of the same diameter and breadth of rim as the moon's age ring, having six small pillars, nearly an inch in height rivetted into it, and the moon's age ring screwed at the opposite ends of three of them, by three sunk steel screws. This plain ring has a socket, which runs or turns on the stud, above the annual plain wheel; the face of the moon's age ring comes flush up with that of the annual plate ring, and both come up to the back of the dial, in which an opening in the arch is made, in order to show a great part of what is on these rings. From the top of the arch, across the opening, and down in a straight direction, is stretched a very fine wire, serving as an index to the days of the year, the moon's age, &c. The annual plate ring and the moon's age ring move or turn from the right to the left hand, yet separately and independently of each other. On the inside shoulder of the socket of the moon's age ring is screwed a small bevelled wheel, having 37 teeth, and one inch in diameter, the use of which will be afterwards explained. In the dial is a circular opening of one inch and three quarters in diameter, a little below the opening in the arch; in this opening is exhibited the lunar globe of an inch and a quarter in diameter, made of brass and silvered; one half of it is perpendicularly painted black, in order to give the phases, the new and the full moon. On the arbor of the lunar globe are two wheels, one of 63 teeth, and about an inch in diameter, the other a bevelled one of the same diameter, and with 37 teeth. Both are placed below the lunar globe; the wheel of 37 and the globe are fast on the arbor, the wheel of 63 being keyed spring-tight above the bevelled one. The arbor of the lunar globe is in the plane of the dial or nearly so, and this bevelled wheel takes or pitches into that of the same number, which is screwed on the moon's age ring socket as before mentioned; and by means of holes in the ring, the whole, that is, the globe, the bevelled wheels, and moon's age ring, &c. can be made to turn together, when the moon is at any time setting to its proper age. The pivots of the lunar globe arbor run on cocks which are screwed on to the back of the dial. Behind the globe, and at a little distance from it, is screwed on to the back of the dial, a sort of concave or hollow hemisphere of thin plate brass, painted inside of a sky blue colour.

On the moon's motion.

We shall now proceed to show how the moon's motion is produced. On the top of the month nut socket, where it lies in the plane of the dial, is cut a right handed double endless screw, working into a small brass wheel of 15 teeth, which is on the lower end of a long arbor, standing upright in a slit made in the dial. This slit is covered by a large circular silvered plate, on which are engraved the hours, minutes, and seconds; on the upper end of this long arbor, is a pinion of 8, which carries about the wheel of 63, and with it, at the same time, the bevelled wheels, globe, and moon's age ring. The pivots of the long upright arbor, run in small cocks attached to the back of the dial. The month nut, or hour wheel socket, makes a revolution in twelve hours, carrying the hour hand. The revolution of the moon's age ring is made in 29 days, 12 hours, and 45 minutes. The wheel of 63 and 15 being multiplied together, the product is 945, and this divided by 8, the number of the pinion, gives 118.125 times six hours, which being reduced gives the lunation, or a revolution of the moon's age ring as above, of 29 days, 12 hours, 45 minutes. The time of the revolution may be made out by another way. It is evident that one tooth of the small wheel of 15 is turned every six hours, of course the wheel will be made to have a revolution in 90 hours, and so will the pinion 8. Then if we say as 8 : 90 :: 63 : 708.75 hours, which is also equal to the given lunation of 29 days, 12 hours, 45 minutes. To produce the annual motion of the ring plate wheel of 365 teeth, the month nut is cut into 42 teeth, and makes its revolution, as was said before, in 12 hours, and turns a wheel of 84, concentric with which is a pinion of 8, leading a wheel of 96, having concentric with it a pinion of 12, leading the wheel of 365, which is the plate ring circle, having on it the days and months of the year, the degrees of the ecliptic, &c. turning once round in 365 days. Now as $365 \times 96 \times 84 = 2943360$, this product, divided by that of $42 \times 8 \times 12 = 4032$, will give 730 times twelve hours, or 365 days. The pinion of 12 is put on a square, which comes in and through a small hole in the large silvered circular plate; the wheel of 96 is put on a round part of the arbor just below the pinion, and is keyed spring tight on it; by means of a small key which fits the square, to turn the pinion, the annual wheel of 365 teeth can be set to any required day of the month, which can be done without disturbing any of the motion-wheels. The setting of the moon's age ring is equally free as this is from any disturbing cause. The diameter of the month nut wheel of 42 is one inch, and three and a half tenths of an inch; that of the wheel of 84 is 2.5 inches, and near to a tenth and a half more. The wheel of 96 is three inches; its pinion of 12 is .307 of an inch, the pinion of 8 is .316 of an inch in diameter.

The minute pipe-wheel of 56 teeth, and 1.8 inch in diameter, runs on the arbor of the centre wheel, carrying the minute hand. It turns in the common way, the minute wheel *m* of the same number and diameter, whose centre lies nearly under that of the other, about .6 of an inch to the right of the middle line of the fore frame plate, and 1.7 inch from the centre of the minute hand wheel. The arbor of the minute wheel has a pinion of 8 leading in the common way the hour wheel of 96, whose diameter is 3.25 inches, that of the pinion is .426 of an inch. This pinion of 8 is put on the arbor, by means of a square, and with the minute wheel both are fast on the arbor. See Plate CCCIV. Fig. 7. The upper side of the wheel may be distant from the lower face of the pinion about .7 of an inch, the lower side having a proper freedom of the fore-plate. Two wheels, one a plain wheel of 38, the other a bevelled one of 38, having the same diameter 1.2 inch, are screwed together, and on a socket common to both; the flat wheel is the uppermost, and is pretty close to the back of the bevelled one, whose teeth look downwards; their socket turns on the minute wheel pinion arbor, between the lower face of the pinion and the upper side of the minute wheel, having a proper end shake between them; the back of the flat wheel of 38 is below the lower face of the pinion .4 of an inch. These wheels of 38 can be made to turn on the minute pinion arbor, independent of it and the minute wheel. The minute wheel and pinion arbor extends a little way beyond and below the minute wheel, perhaps one inch and three or four tenths more to the end of its pivot; it extends also beyond the face of the pinion more than .6 of an inch to the end of its pivot, which runs into a cock C screwed on the fore frame plate. There is a part formed on the arbor of a flat circular shape, and whose thickness is rather more than that of the diameter of the arbor; in the

PLATE CCCIV. Fig. 7.

Equation Clocks.

Description of an equation clock.

PLATE CCCIV. Fig. 7.

middle of this is a hole tapped, into which is screwed a stud, standing at right angles to the arbor; a bevelled wheel of 38, and diameter 1.2 inch with its socket turns on this stud, which is placed on the arbor at that distance, so that the two bevelled wheels may fairly pitch into one another; the minute wheel is crossed into four, and through one of the cross's openings, the bevelled wheel B which is on the stud gets to pitch with the bevelled wheel *b* which is above the minute one. On the inside of the pillar plate is screwed a cock A, near 1.2 inch in height, and so that the middle part of the upper knee shall be opposite to the lower end and pivot of the minute pinion arbor. On one end of another arbor in length about 2.1 inches, having a shoulder on it, is rivetted a bevelled wheel *c* of the same diameter and number of teeth as the others; another shoulder of just a sufficient thickness is made on this arbor at the back of the bevelled wheel; the rest of the arbor is nearly straight all the way, to the shoulder of a pivot which is at this end; from this shoulder the arbor is squared down for about .6 or .7 of an inch, to receive the socket of a small wheel W of 32 teeth, which turns behind the pillar plate; this wheel is nearly one inch in diameter, and a cock K is screwed on the back of the pillar plate, in which the pivot of the wheel of 32 runs; a pin is put through the socket and square, to keep the wheel fast to its place on the arbor. When the shoulder at the back of the bevelled wheel bears on the outside of the kneed cock, which is on the inside of the pillar plate, the cock having a hole in it which allows the arbor to go through and to turn in it, then the pivot of the arbor will run in the cock which is at the back of the pillar plate. The inside bottom of the bevelled wheel, which is rivetted on the shoulder of this arbor, has the end of the arbor made flush with it, and a hole made in the end and centre of the arbor to receive the lower pivot of the minute pinion, in which it runs or turns, the bevelled wheel which is on the stud being supposed to be set as low down as it shall meet and pitch properly with that which is at the end of the other arbor. It will now be seen that the end shake of these arbors, when combined, will lie between the minute pinion cock on the fore plate, and that which is on the back of the pillar plate. Let us suppose that the bevelled wheel, which is at the end of one of these arbors, remains as it were stationary, and that the minute pinion and wheel are carried about by the minute pipe wheel, which is on the arbor of the centre wheel; during a revolution of the minute wheel and pinion, the bevelled wheel, which turns on the stud, will be carried not only round with its stud, but is made to make another revolution by means of its turning round on the teeth of the bevelled wheel, which is stationary, causing the bevelled wheel, and the flat wheel connected with it, which are below the minute pinion, to make two revolutions in the hour; and as the flat wheel of 38 teeth turns the sun hand wheel of 76 teeth and 2.3 inches in diameter, this last must make its revolution in an hour. Its socket turns freely on that of the minute pipe wheel, which carries the minute hand; between the sun hand wheel and this minute pipe wheel, is a slender spiral spring, the inner end of which is fixed to the lower end of the sun's wheel socket, the outer end being fixed in a stud on the upper surface of the minute hand wheel. This spring is for the purpose of keeping forward the sun hand to its place, notwithstanding any shake which may be among the teeth of those wheels concerned in the equation motion work. The sun's hand is of brass gilded, having the figure of the sun on it, at a little distance from the end which points to the minute divisions. The sun's hand lies between the hour and minute hands; the wheel of 76, which carries it, besides the motion of going once round in an hour, has at one time a small motion retrograde, at another a small motion progressive, according to the equation; and there are four times in the year when the minute and sun hands are nearly together. One half nearly of the sun wheel is crossed out, on that side in which the sun's hand lies, in order that the equilibrium of the hand and wheel may be as nice as possible, whatever may be the position of the sun hand.

Equation Clocks.

Description of an equation clock.

From the centre wheel hole on the fore frame plate, towards the left hand, and a little upwards, take, with a pair of compasses, a distance of 3.8 inches, and sweep an arch; and then from the centre of the hole, in which the arbor runs, which carries the annual plate wheel, take in the compasses an extent of 4.6 inches, and sweep another arch so as to intersect the first, the place of intersection will be that of an arbor having pivots, one of which runs into a cock, screwed on the back of the pillar plate; the other runs into a cock screwed on the front of the fore frame plate; a notch is made on the edge of each frame plate to admit the arbor to come into its place. On the end of this arbor, which is just behind the pillar plate, is fixed a rack or segment of a circle 5 inches radius, having 32 teeth cut on it, and cut from a number on the engine plate of 318; the rack-teeth pitches into the small wheel of 32, which lies behind the pillar plate, and whose centre coincides with that of the minute pinion arbor, as mentioned before. On the other end of this arbor, and beyond the fore frame plate a very little, is fixed an arm of 4.5 inches long, having at the end of it a smooth hard steel pin, which bears on the edge of the annual elliptic equation plate, being made to do so by means of a coil or two of watch main spring not very strong, attached to the arbor, near to the inside of the fore frame plate, the outer end being fixed to one of the pillars, or to a stud fixed for that purpose on the inside of the fore plate. The elliptic equation plate is a very irregular sort of a figure, as may be conceived in some degree by the description of its shape; its greatest length over all is 6.5 inches; the centre is 3.8 inches from the broadest end, and 2.7 inches from the narrowest; the nearest edge across the centre is about one inch, and the edge opposite is 1.8 inch; the greatest breadth of the broad end is near to 4 inches, that of the narrowest end is 2.8 inches. During the course of its annual revolution, the edge of the elliptic plate makes the arm which has the steel pin in it rise to various heights, and fall as variously to different depths. By this rising and falling, the rack which is at the opposite end of the arbor, is made to have a motion sometimes backward, and at other times forward, which it communicates to the small wheel of 32, behind the pillar plate, and of course to the bevelled wheel of 38 on the same arbor, with it. This continually causes a small change of place, to the bevelled wheel of 38, consequently a change of place to that which turns on the stud, and hence to the wheel carrying the sun hand; this change is what gives the equation, shewn by the difference of time between the minute and sun hands. When the pin in the arm falls, the equation or sun hand goes forward, and when rising it goes backward.* The greatest negative equation for 1815, on the 3d day of November, is 16 minutes, 14.9 seconds, which, added to the greatest positive equation for the same year on the 11th of February, is 14 minutes, 36.5 seconds, making in all 30 minutes, 51.4 seconds; so that one tooth of the wheel of 32 may be nearly equivalent to one minute of equation. To trace properly a true figure to the equation plate, must be a

Description of an equation clock.

very tedious and nice operation; for this purpose the rack, and all the wheels immediately connected with the equation, must be put into their places, as also all those which give motion to the annual plate, and to have a spring tight arm, having a sharp point to it, bearing on the face of the brass plate which is to be the elliptic one: the sharp point must lie so as to coincide with the side of the steel pin, when bearing on the edge of the elliptic plate. The sun and minute hands being on, and the annual plate set to the 1st of January, the equation hand set to the equation for that day, then by setting forward the minute hand until 12 or 24 hours have elapsed, the equation hand may be changed to what it ought to be, in the same time; so by going on step by step in this way, the figure of the equation plate may be truly done. The rack must be artificially made to assist in this; and when the revolution is completely at the end, before taking out the rack and the equation wheels, marks must be made to one of those teeth, which must be marked by its corresponding space in the other wheels, so that when they are again put into their places, they shall give such equation as was done when tracing for the elliptic plate.

Mechanism for shewing the day of the month without any shifting, except in leap years.

Besides the days of the month, which are shewn on the annual plate, there is a common month ring, having 31 figures engraved on it, placed as usual at the back of the dial. One of these figures is shifted every day through the whole ring when the month consists of 31 days; and two figures at the last are shifted at once when the month consists of 30 days, to bring the ring to the first day of the succeeding month; and at the 28th of February four figures are shifted, so as to bring the ring to the 1st of March: by this means the day of the month ring requires no shifting or correcting at these periods, as those in the common way do. To produce this motion, five short steel pins are placed in a circle, on the under side of the elliptic plate, whose radius may be about half an inch, and set at such a distance from one another as to correspond with the number of days between February and April, between April and June, between June and September, between September and November, and between November and February. This may be done by applying the elliptic plate on a cutting or dividing engine, having the number 365 on the dividing plate. When fixed on the engine, and set to the first point of the number, make a point for February on the elliptic plate, then count off 61 from the dividing plate, which will give the place for the pin on the 30th of April; another 61 will bring it to June 30th; 92 will give the 30th of September; 61 the 30th of November; and 90 more will bring it to the 28th of February, the point which was set out from. When the pins are put in the elliptic plate, that for February will require to be longer than the others, for a reason which will be explained when we come to shew the use of these pins. The month-wheel of 84 teeth, and whose diameter is 2.75 inches, has its centre on the left hand side, distant from the central perpendicular line 1.4 inch, and from the centre hole in the fore frame plate 2 inches. The month wheel, as usual, is turned about by the month nut. A long piece of brass forming two arms, each four inches in length, has a small arbor through the middle of the whole length of eight inches. The pivots of this arbor run into small cocks, attached to the front of the fore plate, keeping the long piece of brass very near to the plate; indeed a great part, particularly the end of the upper arm, and towards it, is sunk partly into the fore plate. This long piece of brass is placed so that one of the arms shall come to the socket of the month wheel, and the other, with its end nearly below the circle in which are the five pins, in the annual elliptic plate described as before. A spring is placed below this upper arm to keep it up, unless when any of the pins get on the end of the arm and press it down. The end of the arm is chamfered, or made so that any pin, when approaching it, gets easily on, and presses it down gradually, by means of ascending the chamfered part as it were; and when past this, it meets with a flat and very narrow place, where it cannot remain longer than some time short of 24 hours, say 16 or 18 hours, or perhaps not so long. After having passed the flat part, it meets with a chamfered side opposite to that of the first. Besides that of freeing the pin, this is made for the purpose of more easily setting back or forward the annual plate.

PLATE CCCIV. Figs. 8, 9.

The month wheel has its socket equally long on both sides, and quite straight; the length of each may be .6 or .7 of an inch. Two small brass pillars are rivetted on the upper side, and opposite one another, each at a distance from the centre of the wheel about .7 of an inch, (see Figs. 8, 9.) the height of the pillars from the wheel to the shoulder about half an inch; and from the shoulder of each pillar a sort of straight pivot is prolonged, about one half inch more; the diameter of these pivots about one-tenth of an inch; that of the pillar .2 of an inch. There is another socket which goes easily on the lower or under socket of the month wheel, which is rivetted in a rectangular piece of brass, about an inch long, and half an inch broad, or nearly so, say .4 of an inch. In this piece of brass, on the side opposite that of the socket, are also rivetted two small and straight brass pillars, about an inch in length, and the diameter about one-tenth of an inch. There are holes in the month wheel, to allow these pillars to go easily back and forward in them; their places will be equally between the month wheel socket and the pillars which are rivetted in the month wheel. The other ends of the small straight pillars are made fast, by two small steel screws, to a piece of brass, which is formed to correspond with two broad crosses of the month wheel. Only one of them is made to have at the end a segment of a circle, whose radius is nearly equal to that of the month wheel. On this segment three teeth are cut, equal in their spaces and form to those of the month ring. In the arms or crosses of the segment are three holes, one of which goes easily over or on the upper socket of the month wheel; the other two holes go easily on the small straight pivots which have been already mentioned. This segment cannot be put on the ends of the small pillars, till the socket of the rectangular piece of brass is put on the lower socket of the month wheel, having previously made the pillars connected with it to pass through their holes in the month wheel. It will be easy to perceive, that when the segment is put on to its pillars, and a sufficient space left behind the month wheel and the rectangular piece of brass, its socket may be made to pump up and down on that of the month wheel, and at the same time carrying the segment back and forward with it; a pin in the month wheel stud keeps the month wheel socket always to its proper end shake, notwithstanding any motion of the segment backwards and forwards. Below the rectangular piece on its socket, a small groove is turned out of it, for the purpose of a forked piece getting in on it; this forked piece is formed on that end of the arm which lies along the fore plate, and on to the socket or centre of the month wheel.

From the preceding description, it is evident that when any of the elliptic plate pins come to press down that end of the long arm which lies near and under

Description of an equation clock. PLATE CCCIV. Figs. 8, 9.

them, the forked end will raise up the grooved socket, and the segment which is connected with it; hence the teeth of the segment will meet with pins which are at the back of the month ring, and by their means will turn the month ring. On the month wheel is fixed a pin, which, in common, shifts the day of the month ring; but in those months in which there are only 30 days, the pins in the elliptic plate, which press down the end of the arm, make the segment be pumped up only so far as to meet with one of the pins at the back of the month ring, which is a little longer than the other two; and one day being shifted by it, and another by the fixed pin in the month wheel, this makes the shifting from the 30th to the 1st day of the succeeding month. The pin in the elliptic plate for the month of February being longer than the others, presses the end of the arm a little more down, consequently the pumping up of the segment must be to a greater height; by this means the three teeth on the segment get hold of the three pins on the back of the month ring; this, with the fixed pin in the month wheel, are ready to shift four teeth of the month ring, viz. from the 28th of February to the 1st of March; and, by this very ingenious sort of mechanism, the month ring shows always the right day of the month, except on the 29th of February in leap-years. It may be necessary to notice, that the fixed pin in the day of the month wheel must be placed at such a distance from the first tooth on the segment, as is equal to the space between the teeth on the segment. The month ring is not attached by rollers to the back of the dial in the usual way, but runs in four rollers, which are fixed on four brass studs on the fore frame plate. This is for the conveniency of seeing more easily the operations of the segment with the month ring, when the segment is pumped up and down.

The construction of the month wheel, and of the apparatus for shifting the month ring, will be better understood from Figs. 8 and 9, where AA is the month wheel; B, B, two arms or crosses nearly similar to those of the month wheel, having a hole in the centre which goes freely on the upper socket of the month wheel; on one of these arms is a segment of a circle, nearly of the same radius as that of the month wheel, having three teeth cut on it, like those of the month ring; *a*, *a*, are two brass pillars rivetted on the upper side of the month wheel, the upper ends being formed into a sort of pivots; on these and the month wheel socket, the segment is made to move freely up and down. C is a rectangular piece of brass, into which a socket is rivetted, which moves up and down on the lower socket of the month wheel, having a groove turned out on it, which receives the forked end of the arm, which pumps it up and down; *b*, *b*, are two small brass pillars, which are rivetted also into the rectangular piece of brass, having two holes in the month wheel, through which they pass easily up and down; the other ends of them go into the segment at *b b*, and are screwed to it by means of two small screws. On one of the arms of the month wheel is screwed a small kneed sort of cock *d*, having a pin fixed in it, for turning the day of the month ring in the usual manner.

CHAP. VIII.

On Repeating Clocks and Watches.

Repeating clocks and watches.

To those who do not sleep well, nothing can be more convenient and useful than a repeater, whether it is in a watch, or in a small fixed clock. A history of this invention is given by Mr Derham in his *Artificial Clockmaker*. Berthoud, in his *Histoire*, has given the following account of it, which is taken chiefly from Derham.

"The art of measuring time, (says Berthoud,) was again enriched with two fine and useful inventions before the end of the seventeenth century. One was the equation clock; the other, which is the most precious, and of the most general utility, is that kind of striking which has been called repeating. It is of the most ingenious mechanism, and when added to a clock, serves to make known at pleasure, at every instant of the day or night, without seeing the dial, the hour and the parts of the hour, which are pointed out by the hands of the clock. Both these inventions are due to the English artists."

Repeating motion-work invented by Mr Barlow.

"The clocks in question here, (says Derham,) are those which, by means of a cord when pulled, strike the hours, the quarters, and even some the minutes, at all times of the day and of the night. This striking or repeating was invented by a Mr Barlow, towards the end of the reign of King Charles II. in 1676."

It is not mentioned by Derham, whether Barlow was a watchmaker or not. We have heard it said by old watchmakers, that he was a clergyman. This seems in some measure confirmed, by his having applied to Tompion to make his repeating watch, when he was about to obtain a patent for the invention.

"This ingenious invention," continues Berthoud, "which had not been before thought of, made at the outset a great noise, and much engaged the attention of the London watchmakers. On the idea alone which each formed of it, they all set to work to try the same thing, but by very different ways; whence has arisen that great variety in the work of repeating motions, which was seen at this time in London.

"This discovery continued to be practised in chamber clocks until the reign of James II. It was then applied to pocket watches. But there arose disputes concerning the author of the invention, of which I shall simply relate the facts to the reader, leaving him to judge of it as he thinks proper."

Towards the end of the reign of James II. Mr Barlow applied his invention to pocket watches, and employed the celebrated Tompion to make a watch of this kind according to his ideas; and at that time, conjointly with the Lord Allebone, chief justice, and some others, he endeavoured to obtain a patent for it.

Quare's repeating motion-work.

Mr Quare, an eminent watchmaker in London, had entertained the same notion some years before, but not having brought it to perfection, he thought no more of it until the noise excited by Mr Barlow's patent awakened in him his former ideas. He set to work, and finished his mechanism. The fame of it spread abroad among the watchmakers, who solicited him to oppose Barlow's privilege to obtain a patent. They addressed themselves to the court; and a watch of the invention of each was brought before the king and his council. The king, after having made trial of them, gave the preference to that of Mr Quare.

The difference between these two inventions is this:—The repetition in Mr Barlow's watch was effected by pushing in two small pieces, one on each side of the watch case, one of which repeated the hour, the other the quarters. Quare's watch repeated by means of one pin only fixed in the pendant of the case, which, being pushed in, made the repetition of the hours and quarters, the same as is done at this present time, by pushing in once only the *pendant* which carries this pin.

Difference between Quare and Barlow's repeaters.

This invention of repeating the hours in small fixed clocks and in watches, was soon known and imitated in France; and these machines were very common in 1728, when the celebrated Julien Le Roy was much occupied in their improvement. It was at this period that he made the repeating clock of which a description is given at the end of *The Artificial Rule of Time.* This was made for the bedchamber of Louis the Fifteenth of France.

The first repeaters, even those of Quare's, as well as others, gave the number of the hour according to the length pushed in of the pendant; which was very inconvenient, by striking any hour, whether the pendant was pushed home to the snail or not. This frequently caused mistakes, in regard to the true hour which ought to have been given. From the report of our predecessor, Mr James Cowan of this place, who went to Paris in 1751 for improvement in his profession, and who executed some pieces under Julien Le Roy, it was *he* who introduced the mechanism into repeaters, which prevented the watch from striking any thing but the true hour. This, we think, was done to the repeating clock for Louis the Fifteenth's bedchamber. In this construction, unless the cord or pendant made the rack go fully home to the snail, it either struck none, or struck the true hour, which was a very considerable improvement. The piece employed for this purpose is called the *all or nothing* piece. Considering the great talents which Julien Le Roy possessed, we have no reason to doubt of this improvement being his.

Difference between the repeating and striking motion-work.

"Although the *repetition*," says Berthoud, "such as is now in practice, is a particular kind of striking, its mechanism differs totally from that of the striking clock; 1st, Because every time that it is made to repeat, the main repeating spring is wound up, whereas, in the common striking part, the main-spring is wound up only once in eight days, fifteen, or a month: 2d, In the repetition we must substitute for the count-wheel, which determines the number of blows that the hammer must strike, a contrivance wholly different. The first author of this ingenious mechanism substituted for the count-wheel a piece, to which, in regard to its form, he gave the name of the *snail.* The snail is a plain piece, divided into twelve parts, which form steps, and come gradually in from the circumference towards the centre. It makes a revolution in twelve hours. Each of the steps is formed by a portion of a circle. Every time that the clock is made to repeat the hour, the pully which carries the cord is connected with and turns a pinion, which leads a rack, whose arm falls on one or other of the steps of the snail, (on the cord being pulled), and regulates the number of blows which the hammer ought to give; and as this snail advances only one step in an hour, it follows, that if it is wanted to be made to repeat at every instant in the hour, we should have always the same number of blows of the hammer; whereas, in setting off the wheel-work of an ordinary striking movement more than once in the hour, we would have a different hour. A count-wheel would then not be fit for a repetition. The mechanism of the repetition has a second snail, which bears four steps also in portions of a circle, to regulate the blows which the quarter hammers must give."

The count and hoop wheels, and locking plate of the old striking clocks, for regulating the number of blows of the hammer, and locking the wheel-work, was excellently contrived. It had only one inconvenience, for when set off by accident, it would prematurely strike the hour to come: this made it requisite to strike eleven hours before it could be again brought to the hour wanted. Had it not been for the invention of the repeater, these would have continued, and would have been still made in the modern clocks, the same as in the ancient ones. But the snail of the repeater showed that it could be adapted for regulating the number of blows for the hammer of a common striking clock, and has prevented the inconvenience of striking over a number of hours, before the clock could be set to the right hour of striking.

"We owe to Julien Le Roy," continues Berthoud, "the suppressing of the bell in repeating watches, a change which has made these machines more simple, by rendering the movement larger, more solid, and less exposed to dust. These watches, which he called *raised brass edges*, are of a more handsome form. From the time of this celebrated artist, all the French repeaters have been made according to this model; but in England, where repeating watches were invented, they make them for the most part with a bell; and in Spain, this construction is still more preferred. In repeating watches without a bell, the hammers strike on brass pieces, either soldered or screwed to the case. Repeating watches with a bell, have also, as those without one, the property of being *dumb*, that is to say, of being able to make it repeat at pleasure, without the hammers being allowed to strike on the bell, or brass pieces."

This effect is produced after the pendant is pushed in, by putting the point of the forefinger on a small spring button, that comes through the case. Being a little pressed in, it opposes a piece against the hammers, which prevents them from striking either a bell or the brass pieces inside of the case; by which means the blows for hours and quarters are *felt*, though they cannot now be easily heard. This makes this kind of repeaters very convenient for those who are deaf, as during the dark of night they can feel the hour at a time when they cannot *see* it. These *sourdine* or dumb parts have been left off of late years; yet they are not without their advantages, as has been now shown.

Le Roy's repeaters.

The late Julien Le Roy had tried to render repeating watches more simple, by suppressing the wheelwork which serves to regulate the intervals between the blows of the hammers, and also the main repeating spring. This celebrated artist succeeded in these, to construct new repeating movements, of which several have been made. But it appears that the public have not found them very convenient, so that this mode of composing them has not been imitated.

The only one of this kind which we have seen of Julien Le Roy's, was a very good one in the possession of John Rutherfurd, Esq. of Edgerston. Although they have not been copied, they certainly deserve to be so.

Repeaters with springs in place of bells.

Repeaters have of late been made with springs in place of bells, which are a very ingenious substitute, it must be allowed, of Swiss invention, though they are as superfluous as bells. Considerable trouble is necessary in making and placing them. They ought never to be recommended, if it could be avoided; but we are often obliged to yield to the fashion of the day, even when it does not coincide with our own opinion. When three or more hammers are used to give the quarters, we then would admit springs in place of bells, as when they are well tuned, they give a most beautiful chime for the quarters: were bells introduced for this purpose, they would give a clumsy appearance to the watch. Julien Le Roy saw good reasons for setting aside the bell; and no plan of a repeater will ever be superior or equal to that of his, which Graham frequently adopted in many of his watches, though his repeating motions were different; Julien Le Roy's having what is called the plain, and Graham's the *Stogden* motion, a most ingenious contrivance, requiring great judgment to plan, and nice execution in making it. This motion is well adapted for half quarters: Though we have hardly seen a French repeater with it, yet it is not unknown to the foreign artists, as appears from Thiout's work, tom. ii. p. 367, plate xxxvi. fig. 3. Paris, 1741. This repeating motion must have got its name from the inventor. Upon inquiring after him when in London, in the year 1770, we learned, with much regret, that he had died a few months before in a charity work-house, at a very great age. The name appears to be German; but whether he was a foreigner or an Englishman, we have not been able to learn.

We shall now lay before our readers a complete description of the repeating movement and motion-work of clocks and watches, which we have taken principally from Berthoud's *Essai sur L'Horlogerie*.

General description of a repeating movement and motion-work.

Clocks that have a striking part, strike of themselves the hours, and some strike the hours and half hours; but those having a repeating part strike only on a cord being pulled, if it is a clock; and if it is a watch, when the pendant or pusher is forced home; thus two hammers strike the hour and the quarters, which the hands point to on the dial. We shall see by the description of a repeating clock, how this is produced; but before doing so, we shall give a general idea of this ingenious mechanism, which is nearly the same for a clock as for a watch.

Plate CCCV. Fig. 1, 2, 3.

In order to make a clock repeat the hour, (see Plate CCCV. Fig. 2.) the cord X is drawn which is wound round the pulley P, fixed on the arbor of the first wheel of a particular wheel work, the sole object of which is to regulate the intervals between each blow of the hammer. The arbor of this wheel has on it a hook, which takes hold of the inner end of the repeating main-spring contained in the barrel B, Fig. 3. On this arbor is also a plain wheel G, Fig. 1. having 15 pins in it which serve to raise the hammers, twelve of them for the hours, and three for the quarters. The number of blows that the hour hammer strikes, depends on the greater or less course which the pin wheel G is made to take when pulling the cord, and this course depends itself on the hour pointed at by the hands on the dial. Thus, if the cord is drawn when it is twelve hours and three quarters, the pin wheel is obliged to make an entire revolution; at this instant the repeating spring brings it back, in which course it makes the hammer give twelve blows for the hours, and then three for the quarters. To distinguish the quarters from the hours, a second hammer is added, which, with the first, makes a double blow at each quarter.

It must now be shewn by what means the course which the pin wheel takes is regulated on the cord being pulled, and how it is proportioned to the hour which the hands point to on the dial.

A wheel S, or minute wheel, of the dial work, Fig. 3. has its arbor prolonged, and outside of the back of the pillar plate. (In this case, and in common, the repeating work is put between the dial and foreplate of the frame.*) It carries the piece *sh*, Fig. 2. the pin of which *c* turns the star wheel E, which takes twelve hours to go once round, and carries with it a piece L, called the *hour snail*, divided into twelve parts tending to the centre of the star wheel. Each of these parts forms different depths, like as many steps, which gradually come nearer the centre, and which serve to regulate the number of the hours which the hammer must strike. For this purpose the pulley P carries a pinion *a*, which pitches in with a portion of a wheel C, Fig. 2. called the *rack*. When the cord is pulled, and the rack is in consequence made to advance towards the snail, the arm *b* stops on such a step of the snail as it may meet with in its course; and, according to the depth of this step, the hammer strikes a greater or less number of blows. It will strike only one hour if the arm *b* of the rack is stopped on the step 1, the most distant one from the centre, as then the pin wheel getting only one of its pins engaged, the hammer strikes only one blow. If, on the contrary, the step 12, which is the deepest and nearest the centre, is met by the arm *b* in its course, which cannot get there until the pin wheel shall have made one turn, then the spring in the barrel bringing it back, will cause the hammer to give twelve blows.

Plate CCCV. Fig. 2.

It remains to be seen how the quarters are repeated. The piece *s*, Fig. 2. which turns the star wheel, and takes one hour to make a revolution, is carried by another snail *h* (called the *quarter snail*,) formed by four divisions, making three paths or steps, on one of which, when the cord is pulled, the arm Q of a piece QD, called the *finger*, places itself, and according as the step is nearer or farther from the centre of the snail, the end D of the finger finds itself more or less aside from the centre *a* of the pulley P; so that when the pull of the cord is finished, and the pulley returns by the force of the spring in the barrel, one of its four pins acts on this finger, namely, the one which it finds at a distance from the centre *a*, which answers to the elevation of the arm D, and this is what determines the blows for the quarters: thus when the finger is applied on the pin nearest the centre of the pulley, the hour hammer strikes only the number of hours that the snail L and the arm *b* of the rack have determined. If the finger is placed on the second pin, it does not stop the pulley till after the hour hammer has struck the hour, then a quarter, and so on for the three quarters. Having thus given an idea of the essential parts of a repeater, let us now proceed to a particular description of a complete repeating clock with an anchor 'scapement.

Repeating clock with an anchor 'scapement. Plate CCCV. Figs. 1, 2, 3, 4, 5.

Plate CCCV. Figs. 1, 2, and 3. represent all the parts of a repeating clock, seen in plan. Fig. 1. represents the wheels and pieces contained within the frame, or what are put between the two plates, with the exception of the anchor A, which is placed in this way, to shew the 'scapement.

The wheels B, C, D, E, F, are those of the movement. B is the barrel, which contains the clock main-spring. The great wheel is fixed to the bottom of the barrel B, and pitches into the pinion of the wheel C, which is the great intermediate wheel. D is the third or the centre or minute wheel.† E the fourth wheel, or that where the contrate wheel was usually placed. F the ratchet, or 'scapement wheel. The centre wheel D makes a revolution in an hour. The pinion on which this wheel is fixed, has its pivot prolonged, which passes through the fore plate, Fig. 3. This arbor or pivot, Fig. 4. enters spring tight into the cannon of the minute pipe wheel *m*, seen in perspective, Fig. 5. which makes also, by this means, a turn in an hour. This cannon carries the minute hand; and its wheel *m* pitches into

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* This part of the repeating work, with the dial wheels, go under the general name of the *motion work*.

† Our workmen give the name of minute wheel to what Berthoud gives the name of the returning wheel; and what he calls the minute wheel, obliges us to make it the centre or third wheel, in conformity to their language.

PLATE CCCV. Figs. 1, 2, 3, 4, 5.

the returning or minute wheel S, of the same number of teeth, and of the same diameter as the wheel *m*. The pinion of the wheel S makes twelve revolutions in the time that the hour wheel C makes one. The wheel C, which is one of the dial wheels, takes then twelve hours to make one revolution, and is that which carries the hour hand.

It must be observed, with regard to these three wheels, C, *m*, S, which are called dial wheels, that they are always the same, whether the clock is a striking one or a repeating one; their effect being, to cause the hour or dial wheel C to make a revolution in the space of twelve hours. The wheels G, L, M, N, Fig. 1. and the fly V, form the wheel work of the repeating part. The object of this wheel work, as has already been mentioned, is to regulate the interval between each blow of the hammer. The ratchet R, and the pin wheel G, are fixed on the same arbor in common with the wheel L, within whose centre it freely turns. The spring *r*, and the click *c*, are all placed on the wheel L.

When the cord X, which is wound round the pulley P, Fig. 2. is pulled, the ratchet R, Fig. 3. fixed on the same arbor as the pulley, retrogrades, or goes backward, and the inclined planes of the teeth raise the end of the click at O. Then the repeating spring brings back the ratchet, whose teeth butt or stop against the end of the click, which carries about the wheel L, and the wheel work M, N, V: but while the ratchet R thus carries the wheel L, and while the pin wheel G, and the pulley P of Fig. 2. which are fixed on the same arbor, turn also, the pins of the wheel G act on the pieces *m*, *n*, Fig. 1. whose arbors prolonged carry the hammers *l*, *m*, Fig. 2. Each piece *m*, *n*, is pressed by a spring, to bring forward the hammers, after the pins had made them rise up or go backward. The spring *r* is only seen, which acts on the piece *m*; that which acts on the piece *n*, is placed under the plate which carries the motion work, Fig. 2. The piece *o* serves to communicate the motion of that of *m* to the arbor or piece *n*, which carries the hour hammer.

The piece, (*bascule*,) or see-saw *m x*, Fig. 1. is moveable on the arbor which carries the quarter hammer. On this arbor below *m x*, an arm like that of *m* moves, on which act the three pins placed on the under side of the wheel G. These three pins serve to raise the quarter hammer fixed on the arbor which carries the piece *m*. It is this hammer which the spring *r* presses. When the cord is pulled, the wheel G is made to go backward, the pins of which come to act on the back part of the arm *m*, which yields, and comes from *m* to *x*. The small arm which is below for the quarters, makes the same motion; and when the repeating spring brings back the wheel G, a small spring, which acts on these pieces *m*, obliges them to get engaged between the spaces of the pins, and to present the right planes on which these pins act to raise the hammers.

The pulley P, Fig. 2. carries the pinion *a*, which pitches into the rack *b* C, the effect of which is, as has been said, to make the point *b* go upon the steps of the snail L, and determine the number of blows which the hour hammer must give.

The star wheel E, and the snail L, are fixed together by two screws. This star moves on a screw stud V, Fig. 2. attached to the piece TR, moveable itself in T. This piece forms, with the plate, a small frame, in which the star E and snail L turn. One of the radii or teeth of the star bears on the jumper Y, which is pressed by the spring *g*. When the pin *c* of the quarter snail turns the star wheel, the jumper Y moves out, receding from V the centre of the star, until the tooth of the star arrives at the angle of the jumper, which happens when it has made half of the way which it ought to do. Having escaped this angle, the inclined plane of the jumper pushes it as it were behind, and makes it precipitately finish the other half; so that from the changing of one hour to another, that of the star and of the snail is done in an instant, which is when the minute hand points to the 60th minute on the dial.

PLATE CCCV. Fig. 2.

The jumper finishing thus in turning the star, each tooth placed in *c* comes on the back of the pin *c*, and makes the *surprise s*, to which it is fixed, advance. The surprise is a thin plate, adjusted on the quarter snail; it turns with it by means of the pin which comes through an opening made in the surprise; the advance which the star wheel teeth causes the surprise to make, serves to prevent the arm Q of the finger from falling into the step 3, which would make the three quarters be repeated when at the 60th minute. As soon as the star changes the hour, it then obliges the *surprise* to advance to receive the arm Q; so that if the cord is pulled at this instant, the hammer will strike the precise hour.

The arm Q and the finger are moveable on the same centre. When we have drawn the cord, and when the pins of the pulley have freed or left the finger at liberty, then the spring *p* makes the arm Q fall on the quarter snail, and the finger D presents itself to one or other of the pins in the pulley. These two pieces can turn one on the other, and be moved separately: This serves in the case where the arm Q going to fall on the step *h* of the quarter snail, and the finger D being engaged in the pins of the pulley, this arm bends and yields to the pins of the pulley, which at this instant cause it to retrograde or go backward; it is necessary that the pin for the present in hold can make the finger move separately from the piece Q. The spring B brings back the finger D, as soon as the pin has retrograded, so that it may present itself to the pin which stops for the hour alone, or for the quarter, if the arm falls on the step 1, &c.

Having seen the most essential parts of the repetition, there remains only one of which an idea must be given, and which we shall endeavour to make the reader understand. This is the *all or nothing*, which has this property, that if the cord is not fully drawn, so as to make the arm *b* of the rack C press on the snail L, the hammer will not strike, so that by this ingenious mechanism, the piece will repeat the exact hour, if otherwise it will not repeat at all.

We have seen, that when the cord X is pulled, the pin wheel G, (Fig. 1.), oversets the piece *m*, and makes it come to *x*; and that before the hammer can strike, a small spring must bring back this piece *m*, to put it in holding with the pins; after that, it is easy to see that if, in place of allowing the piece *m* to take its situation, it were made to be still more overset, the repeating spring bringing back the pin wheel, the hammer would not strike while this piece remained overset; this is precisely the effect that the piece TR (Fig. 2.) produces, which is on that account called the *all or nothing* piece. This is effected in the following manner: The piece *m* (Fig. 1.) carries a pin, which goes through the plate by the opening *o*, (Fig. 2.); if we pull the cord, the pin wheel causes the piece *m* to move, as we have just now seen. The pin which it carries comes to press against the end *o* of the all or nothing piece, and sets it aside, so that the pin shall arrive at the extremi-

Plate CCCV. Figs. 1, 2, 3, 4, 5.

ty, which is a little inclined: But the spring *d* tending to bring back the arm *o*, the inclined plane obliges the pin to describe still a small space, which takes the arm *m* (Fig. 1.) entirely out of the reach of the pins, so that the hammer cannot strike unless the pin is disengaged from the end of the arm *o*. To effect this, the arm of the rack must come and press on the snail L, which moves on a stud V, fixed to the all or nothing piece TR. Now, in pressing the snail, the arm *o* of the pin is set aside, which getting free, gives liberty to the arm *m* to present itself to the pins of the wheel G, and to the hammers that of striking the hours and quarters given by the dial work and hands.

The ratchet R (Fig. 3.) is that of the click and ratchet work of the movement; *c* is the click, *r* the spring. The ratchet R is put on a square of the barrel arbor; this square being prolonged, serves to wind up the spring by means of a key; B is the barrel in which the spring or motive force for the repetition must be put; V is a screw, called the eccentric or pivot carrying piece: On the part which enters with force into the plate, a little out from the centre of the arbor of the screw a hole is made for the pivot of the anchor A. In making this screw turn, the pivot of the arbor of the anchor is made to go farther or nearer the centre, and consequently the anchor itself, so that the points of the pallets take more or less in, according as is required with the teeth of the 'scapement wheel. A, Fig. 2. is the cock of the 'scapement, it carries the silk thread or spring, to which the pendulum is suspended. One of the ends of the silk thread is attached to the arbor *c*, which is called *avance* or *retard*, (fast or slow); the other end of this arbor goes through to the dial, and is squared, to receive a small key. By this means, we can turn the arbor *c* to any side, so as to lengthen or shorten the silk thread, which serves to suspend the pendulum, whose length is changed by this method.

The anchor A, Fig. 1. is fixed on an arbor similar to that for a seconds pendulum. This arbor carries the fork T, which gives motion to the pendulum. The pivot which this arbor carries at the end where the fork is, enters into a hole made in the cock A, Fig. 2.

Fig. 4.

Fig. 4. represents in perspective the wheel D, whose revolution is performed in an hour; it is the arbor of it that carries the wheel *m* of Fig. 3. This wheel *m* is seen in perspective in Fig. 5. whose cannon serves to carry the minute hand. Fig. 6. represents in perspective the wheel S of Fig. 3. It is the arbor of this wheel prolonged, which passing to the motion work, carries the quarter snail *h*. Fig. 2. The pinion of this wheel S, pitches into the hour wheel, seen in perspective in Fig. 7; and it is on the socket of this wheel, that the hour hand is adjusted or fixed.

Fig. 5.
Fig. 6.
Fig. 7.

It will be seen from the preceding description, that the pieces of the repeating motion work are here placed on the back of the pillar plate. Placing them on the fore plate will make no difference.

We shall now proceed to describe a repeating watch with a horizontal or cylindrical 'scapement of Graham's.

Repeating watch with Graham's horizontal 'scapement.

What has been said concerning the repetitions in pendulum clocks, and the simple or plain watch, being once well understood, the reader will have no difficulty in comprehending the mechanism of a repeating watch, which is only on a small scale what the clock is on a great scale.

Plate CCCVI. Fig. 1.

Fig. 1. of Plate CCCVI. represents the wheel-work of the movement and of the repetition, and all the pieces which are put within the frame-plates. There is a distinction here between the wheels,—those of the movement, or which serve to measure the time, as the wheels B, C, D, E, F, and those of the repetition, which serve to regulate the interval between the blows of the hammer: such are the wheels *a, b, c, d, e, f*, whose assemblage is called the little wheel work, or runners.

The spring of the movement is contained in the barrel A; B is the great or fusee wheel; C the centre or second wheel, whose arbor prolonged carries the cannon pinion on which the minute hand is fitted and adjusted; D is the third wheel; E the fourth wheel; and F the cylinder, 'scapement, or balance wheel. The fusee I is adjusted on the great wheel B, a spring-tight collet and pin keeping the wheel to its place on the fusee; the chain is wound round on the fusee, and holds likewise of the barrel. The hook O of the fusee serves to stop the hand, on the watch being full wound up, by the hook stopping against the end of the guard de gut stop (the name it got before the chain was put to the fusee; the modern name of it is the fusee stop,) C (Fig. 2.) attached to the other plate; its effect is the same as in the plain watch. Fig. 3. of Plate CCCII. represents the cylinder 'scapement, of which a description has already been given in p. 127.

Figs. 2, 3.

B is the balance fixed on the cylinder; F is the cylinder wheel, which is represented as tending to act on the cylinder, and cause vibrations to be made by the balance. None of the pieces are drawn here, such as the cock, slide, curb, and pendulum or spiral spring, as they would have rather made the 'scapement part obscure. The wheel work, or runners of the repetition, is composed of five wheels, *a, b, c, d, e*, and of the pinion *f*, and of four other pinions. The effect of this wheel work is to regulate the interval between each blow of the hammer; so that if the first wheel *a* is made to have 42 teeth, the second *b* 36, the third *c* 33, the fourth *d* 30, and the fifth *e* 25; and moreover, if all the pinions into which these wheels pitch have six leaves or teeth; then in the time that the first wheel *a* makes a turn, the pinion *f* will make 4812½ revolutions; but the ratchet R, which the first wheel *a* carries, is commonly divided into 24 parts, the half of which are afterwards taken away, in order that there may remain only 12 to strike 12 blows for the 12 hours. If, then, we divide 4812 by 24, we shall have the number of turns that the fifth pinion makes for each blow of the hammer, which gives 200½ turns of the pinion *f* for one tooth of the ratchet R.

The first wheel *a*, or great wheel of the striking part, carries a click and a spring, on which act a small ratchet, put under the ratchet wheel R, which forms click and ratchet work, like what has been seen in the first wheel of the repetition (Plate CCCV. Fig. 1.), which has the same use; that is to say, when we push the pendant or pusher, the ratchet R retrogrades, without the wheel *a* turning; and the spring which is in the barrel B (Fig. 2.) bringing back the ratchet R, on whose arbor *g*, the inner end of the spring is hooked; the small ratchet comes butt against the click, and turns the wheel *a*; and the ratchet R makes the hammer M to strike, whose arm *m* is engaged with the teeth of this ratchet.

The spring *r* attached to the plate (Fig. 2.) acts on the small part *n* of the arm *m* (Fig. 1.) The effect of this spring is to press the arm *m* against the teeth of the ratchet; so that when we make the watch to repeat, the ratchet R retrogrades, and the spring *r* brings always back the arm *m*, in order that the teeth of the ratchet may make the hammer to strike.—Let us now pass on to the description of the motion work.

Fig. 3.

Plate CCCVI. Fig. 3. represents that part of a repeat-

PLATE CCCVI. Fig. 3.

or which is called the dial or motion work. It is seen in the instant where the button or pendant is just pushed home to make it repeat. In first taking off the hands, and then the screw which fixes the dial of repeating watches, we will see the same mechanism that this Figure presents. This is the kind of repeating motion work most generally adopted; it is solid, and of easy execution. P is the ring or bow to which the pendant shank or pusher is attached, and this enters into the socket O of the watch case, and moves within it its whole length, in tending towards the centre. It carries the piece *p*, which is of steel, and fixed in the pendant shank, both composing the pusher; the under side is filed flat. A plate of steel fixed to the case inside, prevents it from turning round about, and permits it to move lengthwise only. The end part of the steel in the pusher is formed so that it cannot come out of the case socket, this being also prevented by the small steel plate.

The end of the piece *p* acts on the heel *t* of the rack CC, whose centre of motion is at *y*, and at whose extremity *c*, is fixed one end of the chain *s s*. The other end keeps hold of the circumference of a pulley A, put by a square on the prolonged arbor of the first wheel of the runners. This chain passes over a second pulley B.

Fig. 4.

If, then, we push the pusher P, the end *c* of the rack will describe a certain space, and, by means of the chain *s s*, will cause the pullies A, B to turn. The ratchet R (Fig. 4.) will also retrograde, until the arm *b* of the rack comes upon the snail L; then the main spring of the repetition bringing back the ratchet, and the pieces which it carries, the arm *m* will present itself to the teeth of the ratchet, and the hammer M will strike the hours, of which the quantity depends on the step of the snail, which is presented to the arm *b*.

In order to have a better idea of the effect and disposition of this repetition, it is only necessary to look at Fig. 4. where the rack *y c* is seen in perspective; the hour snail L, and the star wheel E; the pullies A and B, the ratchet R, the wheel *a*, the part of raising *m n* of the hour hammer; and these are the principal parts of a repetition, which are drawn as if they were in action.

The snail L is fixed to the star E by means of two screws; they both turn on the pivot formed from the screw V, carried by the all or nothing piece TR, moveable on its centre T; the all or nothing piece forms with the plate a sort of frame, in which the star and hour snail turn.—Let us now see how the quarters are repeated.

Besides the hour hammer M, there is another N, (Plate CCCVI. Fig. 1.), whose arbor or pivot comes up within the motion work, and carries the piece 5, 6 (Plate CCCVI. Figs. 3, 4.) The prolonged pivot of the hour or great hammer passes also within the motion work, and carries the small arm *q*: these pieces 5, 6 and *q* serve to make the quarters strike by double blows. This is the effect of the quarter rack Q, which has teeth at the ends F and G, that act on the pieces *q*, 6, and cause the hammers to strike. This piece or rack Q is carried about by the arm *k*, which the arbor of the ratchet R has on it, by a square above the pulley A, in such a manner, that when the hours are repeated the arm *k* acts on the pin G fixed in the quarter rack, and obliges it to turn and raise the arms *q* and 6, and consequently the hammers.

The number of quarters which the hammers must strike, is determined by the quarter snail N, according to the depth of the steps *h*, 1, 2, or 3 which it presents: the quarter rack Q, pressed by the spring D, retrogrades; and the teeth of the rack engage more or less with the arms *q*, 6, which get also a retrograde motion, and are brought back by the springs 10 and 9: The arm *k* bringing back the quarter rack, its arm *m* acts on the extremity R of the all or nothing TR, the opening of which at *x*, traversing against a stud fixed to the plate, allows R to describe a small space: the arm *m*, coming to the extremity of R, this last pressed by the spring *i x*, is made to return into its place, so that the arm *m* rests on the end R, and by this the quarter rack cannot fall or retrograde, unless the all or nothing piece is pushed aside. The arm *u*, carried by the quarter rack, serves to overturn or set aside the raising piece *m*, (Fig. 4.) (which is moveable on the arbor of the hour hammer,) whose pin 1, comes up within the motion work; so that when even the hours and quarters are repeated, the quarter rack still continues to move a little way, and the arm *u* turns aside the raising piece *m*, by means of the pin 1, which comes within the motion work, and by this it is put from having any holding with the ratchet R, so long as the all or nothing TR does not allow the quarter rack to retrograde or fall; which can only happen in the case when, having pushed home the pendant against the snail, the arm *b* of the rack CC presses the snail, and makes it describe a small space, at the extremity R of the all or nothing: then the quarter rack will fall and disengage the becs or lifting pieces, and the hammers will strike the hours and quarters, given by the snails L and N.

PLATE CCCVI. Figs. 3, 4.

The great hammer carries a pin 3, Fig. 4. which comes up to the motion work through an opening marked 3, Fig. 3.: the spring *r* acts on this pin, and causes the great hammer to strike: this hammer carries another pin 2, which passes also through to the motion work by an opening 2, Fig. 3.; it is upon this that the small tail of the raising piece *q* acts, to make it give blows for the quarters: the small hammer has also a pin which passes through to the motion work by the opening 4; it is upon this pin that the spring 7 presses, to cause the quarter hammer to strike. The spring S is the spring jumper, which acts on the star wheel, E.

Fig. 6.

Figure 6. represents the cannon pinion and the quarter snail N, seen in perspective. The quarter snail N is rivetted on the cannon pinion *c*, the end of which D carries the minute hand; this snail N carries the surprise S, the effect of which is the same as that for the repeating clock; that is to say, when the pin O of the surprise shifts the place, or causes the star to advance, and the jumper having done turning it, one of the teeth of the star comes to touch the pin O which is carried by the surprise, and causes the part of the surprise Z, Fig. 3. to advance, so that when the arm Q of the quarter rack falls on this part Z, and prevents it from falling on the step 3 of the snail; by this the piece repeats only the hour. The changing from one hour to another is by this way made in an instant, and the watch strikes the hour exactly as marked by the hands. The socket or cannon of the cannon pinion *c* D, Fig. 6. is slit, in order that it may move spring tight on the arbor of the second wheel, on which it enters with a degree of stiffness or friction, slight enough to be able to turn easily the minute hand to either side, by setting it back or forward according as it may be required, which sets also the hour hand to the hours.

It is proper here to undeceive those who think that they injure their watches in setting the minute hand backward. In order to convince one's self that there is nothing in this, it is sufficient to remark the position which the pieces must have in a repeating motion work, when it has to repeat the hour, when the pendant or

Plate CCCVI. Fig. 6.

pusher has brought back and set aside all the pieces which communicate with the snails L, N; for at this time there is no communication or connection between the pieces of the movement and those of the motion work, but that of the pin O of the snail or surprise, with the teeth of the star wheel E, which nothing can prevent from retrograding. If then the minute hand is made to make a complete turn backward, the pin O will also make one of the teeth of the star to retrograde; and if the watch is made afterwards to repeat, it will strike always the hours and quarters as marked by the hands. But it must be observed, that if the hands were turned in the same instant that the watch is made to repeat, they would then be prevented: it is necessary then, before touching the hands of a repeating clock or watch, to wait till it has repeated the hour, so that all the pieces shall have taken their natural situations.

It is easy to conclude from this, that since with a repeating watch, we can set backward or forward the minute hand, according as it may be required, we may with much greater reason do this in a plain watch, where no obstacle is opposed to it.

As to the hour hand of a repeating watch, it ought never to be turned without that being done by the minute hand alone; except in that case where the repeater does not strike the hour marked by the hour hand, when it would be necessary to put it to the hour which the repeater strikes.

When the repeater gets of itself deranged, by the hour hand not according with the hour which the watch strikes, this is a proof that the jumper S, or the pin O of the snail, do not produce well the effect they ought to have.

Fig. 7, 8.

The returning or minute wheel, Fig. 6. is placed, and turns on the stud 12, Fig. 1.: this wheel pitches into the cannon pinion N, which has twelve teeth; the wheel, Fig. 6. has thirty-six; the cannon pinion then makes three turns whilst it makes one; this carries a pinion of ten teeth, which pitches or leads the hour wheel, Fig. 7. which has forty; the wheel, Fig. 8. makes then four turns for one of the hour wheel; the cannon pinion consequently makes twelve turns for one of the hour wheel, and the cannon pinion makes one turn in an hour; the hour wheel takes then twelve hours to make one revolution; it is the socket of the hour wheel which carries the hour hand. The raising or lifting piece *m, n*, Fig. 2. can only describe a small arc, which permits the ratchet R to retrograde; and so soon as the mover brings it back, the arm 1 of the raising piece draws the hammer M.

Fig. 9.

Figure 5. represents the under side of the all or nothing, with the two studs; one *u* as a centre on which it moves, and the other *x* on which the star and snail turn, Fig. 9.: the hole *e* of this piece allows the square of the fusee of the movement to come through, and lastly passing through the dial, serves for winding up the watch. W, Fig. 3. is the locking spring and bolt, this is what prevents the movement from opening out of the case.

Y is a small cock or bridge which keeps the rack to its place, and prevents it from getting away from the plate, permitting it to turn only on its own centre.

All the parts of the repetition or motion work, which has been described, are placed on the back of the pillar plate, and are covered by the dial; so that between the plate (Fig. 3.) and the dial there must be an interval, to allow sufficient play for the motion-work: It is for this purpose that a piece is destined, which is not represented here, and which is called the brass edge. This is a sort of circle, or ring, into which the circumference, or edge of the pillar plate, is sunk a little way, with which it is kept fast by means of keys, or griffs 13. and 14. The brass edge is covered by the dial, fixed after that of the brass edge, by means of a screw.

A repeater is made to strike the hour which it indicates the moment we press in the pendant; so that the machine must be contrived in such a way, that it may be easy to push in the pendant, and that the blows of the hammers may be the strongest possible. With respect to the first, that depends on two things; the given force of the spring, and the length of the pusher; that is to say, the space described, and the manner of making the pusher act on the rack. With regard to the last, the rack must be placed in such a manner, that the point of contact of the pusher follows the arc described by the rack, in such a way that the force shall not be decomposed, so that the action of the hand on the pusher shall act wholly upon the rack.

With regard to the pusher, its length depends on the point where it acts on the rack; that is to say, according as it acts farther or nearer the centre of motion. It is obvious, that if it acts near the centre, more force is required, and it will describe a less space, and *vice versa*. As to the force of the blow of the hammer, it is limited by the force of the repeating mainspring, and by the force that the runners require to move or keep them in motion; for it is clear, that it is only the excess of the force of the spring over the resistance of these wheels, that can be employed to raise the hammer. The number of blows of the hammer, for one revolution of the ratchet, determines again the force of the blow.

CHAP. IX.

On Compensation Pendulums.

Compensation pendulums.

Compensation Pendulums are those which are constructed to counteract the effect of heat and cold, in lengthening or shortening a pendulum rod.

Godfroi Wendelinus, canon of Condé in Flanders, who published a dissertation, in 1626, on the obliquity of the ecliptic, seems so have been the first who observed that, by change of temperature, metals changed their lengths.

First suggested by Graham in 1715.

Graham was the first person who thought of making a pendulum rod that should counteract the effects of heat and cold on it, by a combination of rods or wires of different metals, such as brass, silver, steel, &c.; but he never put it in execution, from the opinion that it would not be effectual enough in its operations. It occurred to him at the same time, that mercury, from its great expansion by heat, would be more adapted to the end he was in pursuit of. Having made a pendulum on this principle, it was applied to a clock, and set a-going. It is described in the *Philosophical Transactions*, No. 392, in a paper which was given into the Society in 1726. He says, "the clock was kept continually going, without having either the pendulum or the hands altered, from the 9th June 1722 to the 14th November 1725, being three years and four months." Some time previous to 1726, Harrison being then at Barrow in Lincolnshire, was engaged in making experiments on brass and steel rods with the same view, and produced what is now called the Gridiron Pendulum." See *Description of two Methods, &c.* by John Ellicott, F. R. S. London, 1753.

Errors of simple pendulums.

Some estimate may be formed of the advantages of a compensation pendulum, by comparing the going of a clock which had one, with that which had a simple pendulum, as shewn in a letter from Mr Bliss, at Oxford, dated 12th July 1752, to Mr Short, in London. "I find, upon examining my book, that the greatest difference in the going of the clock, between the coldest weather of the two last winters, and the hottest weather of the two last summers, is no more than one second per day; and this was occasioned by the levers being made too short, of which I advised Mr Ellicott above a year since: Whereas a clock with a simple pendulum and brass rod, made by Mr Graham, and which belongs to Dr Bradley, in the coldest weather lost above fifteen seconds per day, and in the warmest gained above thirteen seconds per day, and went very near the equal time in temperate weather." It is plain that Mr Bliss must have meant, *gained* in the coldest weather, and *lost* in the hottest, otherwise there would be no analogy with the effect of the temperature in summer and winter on the brass pendulum rod. See Ellicott's pamphlet, already quoted.

Graham's Mercurial Pendulum.

Graham's mercurial pendulum.

The mercurial pendulum, invented by Graham, having been the first that was applied to a clock for the purpose of compensation, we shall begin with the description of it, taking the others nearly in the order of their invention. This pendulum consists of a pendulum rod, which carries a large glass jar filled with mercury, so that the expansion or contraction of the rod may be counteracted by the opposite expansion or contraction of the mercury. To make this pendulum in the way which has hitherto been adopted, is attended with considerable trouble. From the nature of the material, the construction of such a pendulum must always be troublesome, because any filling in, or taking out of the mercury from the cylinder or glass jar, to bring about the compensation, will cause a change of place in the index point on the graduated arch or index plate, if such a thing is used. A pendulum which will remedy this evil will be afterwards described, so that we shall now proceed to give a description of one made in the common way.

Dimensions of a mercurial pendulum.

The length of the pendulum over all, from the bottom of the sole to the upper end of the pendulum spring, was 43.95 inches; the inside bottom of the jar, .6 of an inch from the bottom of the sole; and the height of the column of mercury in the jar, about 7.47 inches. From the upper end of the spring, take a length of 39.2 inches on the pendulum downwards, then 43.95 inches — 39.2 + 6, will give that part of the column of mercury below the centre of oscillation equal to 4.15 inches, and that above the centre 3.32 inches. The height of the jar outside, was 7.8 inches; a wire put down inside, measured 7.6 inches; mean diameter inside, 2.018 inches; weight, 7.5 ounces. Although it would be still better to have it of a less weight, yet it is doubtful if it would be then strong enough to support such a column of quicksilver. The weight of the stirrup or cylinder frame was 1 lb. 6 ounces, and was reduced 6 ounces; that is, from the sole was taken 2.55 ounces, and from the top 3.45 ounces, both equal to 6 ounces. When the clock was set agoing after this alteration, with the pendulum the same length as before, it went slow at the rate of 46 seconds in 24 hours, and when shortened by touching up the regulating nut, it was found to be about .15 of an inch less than the former length.

The length of the stirrup bars outside, including sole and part of the top, was 8.125 inches; the breadth of the frame from outside of the bars, 3.25 inches; the thickness of the pendulum rod and bars, 0.136 inch; breadth of ditto, 0.384 inch; thickness of sole outside, 0.515 of an inch; distance from bottom of the sole to upper side of the jar cover, 8.187 inches; jar sunk into the sole about or near to 0.25 inch; distance from upper side of jar cover to under side of stirrup top, 1.25 inch; height of stirrup top for flat of pendulum rod, 1.75 inch; thickness of the flat, 0.220 inch; diameter of the regulating screw, 0.218 inch; ditto of the nut, 1.150 inch. The screw had 36.25 turns in an inch; and the nut was divided into 30 prime divisions, each being equal to a second in a day. The prime divisions were subdivided into four.

Dimensions of a mercurial-pendulum.

	Inches.
Length of stirrup bars inside	8.05
Thickness of sole outside	0.515
Length of stirrup top	1.75
From the stirrup top to the upper end of the pendulum spring	33.485
Length of the pendulum over all	43.800

		Inch.
Length of pendulum spring		.625
Breadth of the double laminæ, including the space between them, each lamina being	164 .168	.500
Thickness of ditto		.007

	lb.	oz.	drams
Weight of quicksilver in the jar	11	12	5.35
Ditto of stirrup frame	1	0	0
Pendulum rod and spring, regulating nut, Jar cover, &c.	0	13	0
Jar	0	7	8
Total weight of Pendulum	14	0	13.35

Before the pendulum was altered, the rate of the clock shewed that the compensation was not sufficiently effective, although the height of the column of mercury was 7.5 inches nearly, and the jar being full, allowed no more to be put in: By reducing the weight of the jar frame or stirrup, the rod required to be shortened, as has been stated, .15 of an inch; whether or not this will be enough, remains to be determined. The daily rate for a month or six weeks was 0″.1 slow, when the temperature was from 36° to 40° of Fahrenheit's thermometer, and got gradually slower as the height of the thermometer increased. When between 60° and 66°, the daily loss was from 0″.37 to 0″.45; for about two weeks, when the weather was extremely cold, the thermometer at the freezing point and under, the clock showed a tendency of rather gaining.

Of late years, the mercurial pendulum has been adopted in some astronomical clocks; and it seems upon the whole to answer very well. The author of the *Elements of Clock and Watch-work* thought, that it was not fit for this purpose, being too quick in its operations of expansion and contraction; but if the cover is well fitted to the top of the jar, we can venture to say, from the resistance made by the glass to any change of temperature, that the operations will be too slow; and for this reason, it is proposed to make such a pendulum with a thicker rod and stirrup bars, that they may not take heat and cold too hastily. A steel jar would perhaps answer the end as well as any other contrivance; but some would object to this, on account of the danger of magnetism. But even a jar of this kind, from its being made thin, (for it would be heavy were it as thick as the glass one,) would be easily affected by the changes of temperature; and mercury being still more susceptible of these changes, the operations of counteracting the effects of them might be too sudden.

It is of great importance, that a pendulum rod should, with the smallest quantity of matter, be as stiff and inflexible as possible; and although it was proposed to have thicker bars and rods, let us suppose the same quantity of matter is taken as before, but under a circular in place of a rectangular surface. It must in this form require more time to get heated and cooled, which is the end we now attempt to gain. The sides of the parallelogram were .384 and .136 of an inch, the sum of which, being doubled, will give 1.040 inch for the circumference of the bar. To find the diameter of a cylindrical rod containing the same quantity of matter as the parallelogram, say, as 355 is to 113, so is 1.040 to the diameter of the rod required, which will be found to be .33104 of an inch.

Mercurial pendulum improved by Reid.

Let the improved jar frame, or stirrup, therefore, be composed of two round steel rods, .331 of an inch in diameter, and 8.85 inches in length, from shoulder to shoulder, at each of which pivots are formed. Those for the upper ends should be a quarter of an inch long, and of the same diameter, tapped so as to screw firm into the upper cross piece. The distance from the centres of the tapped holes, in the traverse or cross piece, requires to be 2.8 inches, in order to give freedom for the jar between the rods, the length of the cross piece over all should be 3.3 inches, and its breadth at the place where the rods are screwed in .450 of an inch. At the middle a circular part is formed, .5 of an inch in diameter, in the centre of which a hole is tapped, by which the regulating screw may raise or lower the jar, without changing the place of the index point. The cross piece may either be brass or steel, though the latter is perhaps preferable. The pivots on the lower end of the rods may be of the same diameter as those on the upper end, but a little longer, and tapped a little way in on the ends; when well fitted into the lugs of the brass sole, on which the jar rests, and sunk a little way down into it, nuts are screwed on to the ends of the pivots, and sunk in the lower side of the brass sole. Care must be taken to have the distance between the centres of the holes in the sole the same as in the cross piece, so as to make the rods stand parallel to each other. To go outside of the frame now described, another is made, to which is attached the pendulum rod, the regulating nut, and lower sole, in which is fixed the small steel index, which cannot change its place, after being once made for it. The upper cross piece for this may be of the same thickness as the former, and in length not less than 4 inches. A hole is tapped near to each of the ends, and their centres are distant from one another 3.56 inches nearly, and are wide enough to allow a round steel rod of .25 of an inch in diameter to pass freely through; the length of these rods, from the lower side of the cross piece, to the upper side of the lower sole, is nearly 10.6 inches. The lower sole may be a brass wheel, crossed into four arms, the centre part being large enough to have a hole tapped, so as to fix the steel index in it. The diameter of the wheel is the same as the length of the upper cross piece, which is 4 inches; and the thickness .25 of an inch, or a little more. This sole, in which the index is fixed, serves also as a resting part for the pendulum, when it happens to be taken from its place. The upper ends of the rods is formed into a sort of double shouldered screw; the tapped part is a little more than a quarter of an inch long, and as much in diameter; the length of the plain and tapped part of the screw is about .7 of an inch, and when screwed into the upper cross-piece, it binds to it the lower end of the pendulum rod, which is formed into a shape something like a compressed λ, having lugs or soles, through which the screws for fixing it passes. The regulating screw has an untapped or plain part, which turns freely in a hole in the middle of this upper cross piece, formed in the same way as the upper cross piece for the jar frame; the nut or head of the regulating screw is shaped so as to lie under the hollow of the λ, at the lower end of the pendulum rod, and on the upper side of the cross piece; the lower ends of the rods of the outside frame are gently tapered, and fitted into holes in the brass wheel, through the edge of which are put pins to fix them and the wheel together; this outside frame has no part in the compensation. The brass cover for the jar, has the lugs hollowed out a very little, so as to come in on the rods of the jar frame; the ends of the upper traverse, of which, as well as the lugs of the jar sole, are hollowed, and take in with a part of the rods of the outside frame, along which the jar frame is moved up and down. The height of the glass jar, outside, is about eight inches; and its weight and other dimensions nearly the same as those stated for the former pendulum; and the diameter of the rod and λ part is .331 of an inch. A view of the improved mercurial pendulum is given in Plate CCCVII. Fig. 1.

PLATE CCCVII. Fig. 1.

Philosophers seem not to be agreed respecting the expansion of mercury relative to that of other metals; some making it 15 times, others above 16 times that of iron. In regard to the column of mercury for a mercurial pendulum, something depends on its diameter as well as its height. Suppose the length of steel to be 43 inches, and the column of mercury 7.5 inches in height, and 2 inches in diameter, which were the dimensions used in a pendulum brought nearly to its state of compensation, we may then find how many times the expansion of this column is contained in the 43 inches. Say, as 43 inches is to 74, the expansive ratio of steel, so is 7.5 inches of mercury, to its expansion for compensating the steel.

Length of steel 43 inches	Log. 1.6334685
Ratio 74	Log. 1.8692317
	3.5027002

Height of column of mercury 7.5 inches	Log. 0.8750613
Ratio 424.26	Log. 2.6276389
	3.5027002

By this process, it appears that the expansion of the mercury is not quite 5.75 times that of the steel. A pendulum, whose vibrations are three or four degrees on each side of the point of rest, will require a column less in height than that which vibrates only one degree. Hence it is a very nice matter, to give precise rules for making a mercurial pendulum, that shall at once be perfect in its compensation.

Method of compensation. Fig. 1.

If the steel rod *a b* and stirrup *b c* of a mercurial pendulum is lengthened by heat, the jar *d e* containing the mercury will, from this cause, be let lower down, and the centre of oscillation be carried farther from the point of suspension *a*; but the heat which lengthens the rod and stirrup at the same time expands the mercury upward, and by this means the centre of oscillation is kept always at the same distance from the point of suspension. When the rod and stirrup are contracted or shortened by cold, the mercury will also be contracted by it; and hence the lengthening or shortening of the pendulum rod by heat or cold, is compensated by equal and opposite expansions or contractions in the mercury.

Gridiron Pendulum.

Gridiron pendulum. PLATE CCCVII. Fig. 2.

The gridiron pendulum invented by Harrison, is composed of nine round rods, five of which are made of steel, and four of brass; and is represented in Fig. 2. where the steel rods are distinguished from the brass ones by a darker shade. As it somewhat resembles the common gridiron in appearance, it hence probably received its present name. Not many years after this was produced, the French artists contrived a variety of compensation pendulums, but the gridiron seems to be the one now generally adopted by them. The first pendulum of this kind which we made was nearly thirty years ago; and knowing that Mr Cumming had some practice in this way, he was applied to, and very obligingly sent a drawing, and the different lengths for the brass and steel rods, which, on being tried some years afterwards, by means of a transit instrument, was found, on the whole, to be tolerably correct, but yet not quite so accurate in the compensation as could have been wished. From an abstract of the going of a clock with this pendulum, it appeared, that, during the temperature from 46 to 48 degrees of Fahrenheit's thermometer, it kept mean time. A temperature 10 degrees lower, made it gain at the rate of nearly half a second in a day, and 10 degrees higher made it lose about as much.

Dimensions of the gridiron pendulum.

The lengths of the rods were, outside steel rods from pin to pin 29.5 inches; centre steel rod from upper end of the pendulum spring to the pin at the lower end, 31.5 inches; inside rods, from pin to pin, 24.25 inches; from the pinning of the lower end of the outside rods to the centre of the ball, 5 inches; making in all 90.25 inches of steel, to be compensated by the brass. Outside brass rods, from pin to pin, 26.87 inches; inside ditto, 22.25 inches, being in all 49.12 inches of brass. The length which the brass ought to have may thus be found by the inverse rule of proportion. As 90.25 inches is to 74, the number for the expansion of steel according to Berthoud, so is 121, that of the expansion for brass, to the length of brass required; that is, $90.25 \times 74 \div 121 = 49.4$ inches, the length required. Although the deficiency of brass here is very little, yet to remedy the compensation, a greater number of inches, both of steel and brass, must be taken, before this pendulum can be made complete. A description of such a one shall now be given.

The length of the outside steel rods, from pin to pin in the uppermost and lowermost traverses or brass cross pieces *a b*, *c d*, is 36 inches; the next or innermost steel rods, from their pinning in the second uppermost traverse *m*, to that in the second lowermost *n*, is 35 inches; the steel centre rod, from the pinning of it, in the third lowermost traverse *o*, to the upper end of the pendulum spring, is 37 inches and ⅝ of an inch, or nearly 37.628 inches; the centre C of the ball below the pinning of the outside steel rods and index rod, is 3.94 inches; the outermost brass rods, from their pinning, in the uppermost traverse to that in the second lowermost, is the smallest quantity possible less than 35.5 inches; the innermost brass rods from their pinning in the second uppermost traverse to the third lowest one, is 34.5 inches. The whole length of the steel is then 112.568 inches, and that of the brass 70 inches. The diameter of the rods is a quarter of an inch each. The distance from the centres of the two outside steel rods, is 2.5 inches. The rods are placed equidistant from one another, only there is a little more space left between the two brass rods nearest the centre and the steel centre rod, in order to give room for the fork to come in and clip the centre rod. The two outside steel rods are prolonged below their pinning in the lowest traverse, as seen below *c d*, about five or six inches within the ball, in order to keep it properly flat in the plane in which the pendulum should swing. In the centre of the lowest traverse *c d* is pinned a steel rod *e f*, somewhat more than a quarter of an inch in diameter, and about nine inches long. This rod goes through the centre of the ball, the index point *f* being on the lower end of it, and it is tapped for an inch in length at that part which lies near to the centre of the ball. A cross piece of brass is fixed to the inside of the ball before casting it, the lowest side of which is in a line across the centre horizontally. The ends of the two outer steel rods, and the centre or index rod, come easily through this cross piece of brass. A hollow tube comes up within the ball, as far as the underside of the inside cross piece, on the end of which, where the cross piece and ball rest, is fixed within it a tapped nut, which screws on the tapped part of the index rod. On the lower end of the tube is soldered a sort of flat conical head or nut *h*, nerrelled on the edge outside, and whose diameter may be an inch or an inch and a quarter. On the upper surface of this nut are traced two circles, in order to put divisions between them, and figures so as to correspond with the turns of the screw in an inch. A small steel index *i* is screwed on to the lower part of the ball, to point at these divisions. The lower end of the tube is a very little below the edge of the ball, that it may rest freely on the upper end. The total length, from the upper end *g* of the pendulum spring to the index point *f*, is 47.75 inches, a length of radius which will require the length of a degree on the index plate to be .833142 of an inch. The distance from the upper end of the pendulum spring to the centre of the ball, is 42.5 inches very nearly, so that the centre of the ball is about 3.3 inches below the centre of oscillation. The lowermost traverse *c d* may be about half an inch thick, and its length and breadth such, as to give it sufficient strength to receive the outside steel rods, and the centre or index rod: The uppermost traverse *a b* is nearly of the same dimensions. The second lowermost traverse *n*, and the second uppermost *m*, are nearly of the same size, and almost equal to that of the uppermost and lowermost; only they are a little shorter, having in their ends a sort of half hole, through which, in the second lowermost traverse, the outer steel rods pass easily; and through these, in the second uppermost traverse, the outside brass rods freely pass. This traverse is, of course, a little shorter than the second lowermost. In the second lowermost traverse is pinned the ends of the outermost brass rods, and in the second uppermost traverse are pinned those of the innermost steel and brass rods. In the third lowest traverse is pinned the innermost brass rods and the centre steel rod: The dimensions of this are nearly the same as the second uppermost and lowermost, only shorter, having a half hole at the ends, through which the inner steel rods pass freely. There is a hole in the middle of each of the two uppermost traverses, through which the centre rod can pass freely. Towards the lower ends of the centre steel rod, and those of the innermost brass rods, are two sets of holes, by which the third or lowermost traverse can be moved or shifted up either three or six

Method of adjusting the compe sation.

Gridiron pendulum. PLATE CCCVII. Fig. 2.

inches, should the compensation be found in excess. It would be convenient, when shifting, to have a piece similar to the third lowest traverse, and three spare pins. This piece being like a half of the traverse, it may then be applied to the three rods, and pinned, but not to the place where the shifting is to be made. This piece will prevent the rods shifting away from one another, and will allow the traverse to be moved and fixed to the intended place. Two thin pieces of brass *p q*, *r s*, must be provided, having nine holes in them, so that all the rods can move easily through them, the two outermost holes being kept rather a little tighter than the others. These pieces are intended to prevent any tremulous motion in the rods or pendulum, and are put at the same distance from the upper and lower traverses, as shewn in the Figure. The pendulum ball is composed of two frustums of equal cones; the greater diameter is seven inches, the lesser four inches, and the height half an inch, giving, by calculation, 24.3474 cubic inches, the weight of which in lead is 9.997 lb. The ball, when filled with lead, together with the shells and inside cross piece, weighed 10 lb. 8 oz.: The weight of the brass and steel rods, traverse pieces, pendulum spring, and top piece, &c. was 5 lb. 13 oz.; in all, 16 lb. 5 oz. The clock to which this pendulum was applied was a month one, and was kept going by a weight of 7 lb. 7 oz. We cannot help thinking, that this pendulum is fitted up in a much better style than either Cumming's or Berthoud's.

The third lowest traverse being shifted up three inches, there will then be this quantity less for lengths of brass and steel than has been stated. The steel will be 36 + 35 + 37.628 + 3.94 — 3 = 109.568 inches, and the longest brass rods may be taken at 35.49 + 34.5 — 3 = 66.99. Their lengths and expansive ratios may be given thus:

Steel 109.568 inches . .	Log. 2.0396838
Ratio 74	Log. 1.8692317
	3.9089155

Brass 66.99 inches . . .	Log. 1.8260100
Ratio 121	Log. 2.0827854
	3.9087954

The difference in excess of compensation is here extremely small, and is on the side of the steel rods, being scarcely an inch too much. In taking into account the lengths of the rods, those on one side along with the centre rods are only taken; those on the other side serve as a kind of counterpoise, for giving an appearance of uniformity to the pendulum, and for preventing the weight of the pendulum ball from bending the rods, which it would do were they all on one side. A considerable time after the gridiron pendulum was produced, some adopted zinc rods in place of brass; and, from their greater expansibility, fewer were requisite, three of steel and two of zinc being sufficient for the compensation; but such of them as we have seen, appeared to have the zinc rods of a greater length than they should have been, according to the comparative expansions of zinc and steel. There was also a large cavity in the upper part of the ball, for lodging the lower traverse, which took away much of its force; and the holes for shifting, to adjust the compensation, being at the upper ends of the rods, rendered it very inconvenient.

Dimensions of a zinc and steel gridiron pendulum.

The following dimensions should answer very well for a pendulum of this sort. The length from pin to pin in the upper and lower traverses of the two outside steel rods should be 27 inches, and 5 or 6 inches more beyond the lower traverse, to go within the ball, for the same purpose that was mentioned in one having the brass rods; from the pin, in the lower end of the centre steel rod, which is in a traverse just above the lower one, to the upper end of the pendulum spring, should be 36.75 inches; from the pin in the lower end of the centre rod to the centre of the ball, 4.75 inches, being in all 68.5 inches of steel. The diameter of the steel rods should be .25 of an inch. In the upper traverse is a hole, through which the centre rod must pass freely. The length of the zinc rods, from the pin in the upper traverse to that in the upper of the lower traverses, is 25.34 inches, and their diameter .27 of an inch. There may be holes in the lower ends of the centre and zinc rods, for adjusting the compensation, as in the case of the brass rods. The ends of the upper and lower traverses must have half holes, taking in with the outside steel rods; pieces for tremulous motion, and manner of fitting up the pendulum ball, and regulating nut, &c. as has been already described.

The lengths and expansive ratios may be put thus:

Steel 68.5 inches	Log. 1.8356906
Smeaton's rptio for steel 138 inches	Log. 2.1398791
	3.9755697

Zinc 25.34 inches	Log. 1.4038609
Do. for zinc 373 inches	Log. 2.5717088
	3.9755697

The zinc which is used in these pendulums must always be understood to be that which is hammered half an inch per foot, which seems to have even more expansion than Smeaton has stated; but whether it expands as much as Ward makes it, still remains to be determined.

Method of compensation.

In taking into account, by this process, the comparative expansion of the brass and steel rods, it must be observed that the steel rods have their expansion downwards, while the brass rods expand upwards; so that when heat expands the steel rods downwards, the brass rods acting in a contrary direction upwards, tend always to keep the centre of oscillation at an equal distance from the point of suspension, and hence the length of the pendulum is constantly the same. In like manner, if cold contracts the steel rods, it will also contract the brass rods, so as still to keep the pendulum at as invariable a length as can possibly be attained by any method that human ingenuity can propose. The comparative lengths of the brass and steel rods may be computed by any other expansive ratio than those of Berthoud's, which we have used; such as those of Smeaton, or of that ingenious artist Troughton. Their differences will vary a little from Berthoud's; but it will be very trifling. It will require long experience to know which are the best founded; as the going of astronomical clocks may be affected by other causes which have no connection with the compensation of the pendulum rod.

Ellicott's Pendulum.

Ellicott's compensation pendulum.

Not many years after Harrison's pendulum was known, Mr Ellicott, and some of the French artists, Compensation Pendulums.

contrived compensation pendulums in different ways, most of them having the ball adjustable by levers, which can never be equal to those in which the expansion and contraction act by contact in the direct line of the pendulum rod. Mr Ellicott was a very ingenious artist of the old school, as appears from several of his works, and his pendulum evinces great ingenuity in its construction.

Ellicot's pendulum. PLATE CCCVII. Fig. 3.

Cumming's improvement upon it.

Ellicott's pendulum, shewn in Plate CCCVII. Fig. 3. consisted of two bars, one of which *a b* was of brass, and the other of iron or steel. Mr Cumming conceived, that where there were two bars only, a flexure and unequal bearing would take place, and therefore an exact compensation could not be effected. To remedy this, he constructed the pendulum with two steel bars, and one bar of brass, as shewn in Fig. 4. No. 3. Into the lower end of the brass bar *a b*, Fig. 4. was let one half of the diameter of a small steel roller *r*, the other half being let into a moveable brass piece having two short arms 1, 2. These arms, by the levers *m o* 2, *n o* 1, moving round *o, o* as fulcra, make the roller press equally on the lower end of the brass bar. The steel roller marked *r*, has a fillet raised up on each end, for the purpose of keeping this part of the brass bar at an equal distance from the steel bars. The length of the brass bar *a b* should be 39.25 inches from the upper end which is square, to the lower end which is rounded, its breadth three quarters of an inch, and its thickness at least one-eighth of an inch. The steel bars are in length from the upper square ends to the centre of the ball, nearly where the short arms of the levers act on the moveable brass piece, about 39.75 inches; and the bars are left broader here, so as to be about one inch and a quarter; and this breadth is prolonged below the end of the brass bar three quarters of an inch or more. The thickness of the steel bars is one-tenth of an inch, and their breadth three quarters. The back steel bar has no opening in it; but the front bar has one which is represented in the drawing at A, Fig. 4. No. 2. In order to see the action of the levers on both arms of the moveable brass piece, a cavity *s s* Fig. 3. is left for this purpose in the ball. A piece of glass is inserted in the opening, so as to prevent dust from getting into this part of the pendulum. This broad part of the steel bars serves as a kind of frame, on which are screwed two pieces of brass of the same figure as the steel bars, to connect them with that steel part of the lower end of the pendulum rod which goes through the ball, on which is a nut and screw, and a strong double spring *m n* in Fig. 4. for the purpose of taking off somewhat of the weight of the ball, according as it bears too much or too little on the short arms of the levers. The levers are shewn at No. 2, 3; the screws, and lower end of the pendulum rod in Fig. 4; the nut N, and double spring SS, in Fig. 3. The use of the nut and screw is to adjust the strength of the spring, as they have nothing to do in the regulation of the pendulum for time to the clock, which is done by an apparatus for this purpose at top connected with the pendulum spring. In the brass pieces which are screwed on to the broad part of the steel bars, the pivots of the levers *a, a* turn. There is a piece of brass put on at top, formed so as to interpose a little way down between the brass bar and the steel ones, keeping them at a proper distance from one another. The sides near to the square ends of the bars and this piece of brass are firmly pinned or screwed together. It is in this piece of brass that the lower end of the pendulum spring is fixed; the upper end being fixed to a piece, which is moveable up and down in a fixed frame by a nut and screw. The pendulum is lengthened or shortened, according as the pendulum spring is let out or brought within that part of the frame through which the spring passes.

Compensation Pendulums.

Ellicott's pendulum improved by Cumming.

The bars of the pendulum are connected by four or five screws, equal spaces being taken for their places between the centre of the ball and the square or upper ends of the bars. The back bar is tapped to receive the screws, which go through holes made in the front steel bar, to let them easily pass. On the shank or body of the screws, are fitted hollow cylinders either of brass or steel, and of such a length, that when the screws are put home there shall be no pinching of the front steel bar by the head of the screws. Rectangular openings are made in the brass bar, for the hollow cylinders to come through, whose length may be about equal to twice the diameter of the cylinders, and so that the brass bar may easily move on them, by any small motion they may have in contracting or expanding. On each of these cylinders is put two loose brass collets or washers, one between each steel bar and the brass bar to keep them free of each other. Their thickness should be at least .04 of an inch, so as to allow the air to pass freely between the bars. The small hollow cylinders through which the screws pass when connecting the bars, should go easily into the front steel bar, the lower base bearing on the inside of the back steel bar. The upper base should be above the surface of the front bar fully more than the thickness of strong writing paper, so that when the screw is put home the shoulder of it may not pinch the bar. The edges of all the bars should be chamfered off from each side, so as to form an angle in the middle plane of their thickness, for the purpose of giving them a lighter appearance, and making them less susceptible of the resistance of the air. The diameter of the pendulum ball may be seven inches and a half, and its thickness at the centre about two inches and a quarter. In the edges, and in the line of the diameter horizontally across, are placed two long and stout screws, *g g*, Fig. 3. whose heads have graduated circles on them, and are near the edge of the ball, and an index *i, i* to each. The inner ends of the screws shewn at *s, s*, are turned of such a shape, so as to apply by one point only on the long arms of the levers *m, n*, as seen in Fig. 3. The front shell of the pendulum ball is fixed on by four screws. It has been objected by some, that, from the weight of the ball, the brass rods in a compensation pendulum are compressed, and the steel rods stretched; a matter of no moment whatever in our opinion. This may, however, in some degree, be remedied in Ellicott's pendulum, by making the brass bar of such a length, as to come through and below the lower edge of the ball, in place of the steel part, which was common to both steel bars, as has just now been described. This part of the brass bar is tapped, having on it the nut and strong double spring, which takes off a part of the weight, as has been noticed. A certain portion of the weight of the ball will in this case bear on the brass bar; supposing it one-third of the weight, the remaining two-thirds will be carried jointly by the steel bars. Although the brass bar is here carried through the ball, it is easy to put a piece to it, moveable on a pivot in the middle of the bar, having two lugs applying to the edges of the bar, on which the short arms of the levers *a, a* may act, as was the case in the other by the moveable brass piece.

Method of compensation. Fig. 3.

Things being in this situation, let us suppose that the bars composing the pendulum rod are lengthened by heat, and that the brass lengthens more than the same length of steel does; then the brass bar *a b*, by its excess of expansion, will press down the short ends of the levers, *m, n* at *b*, and consequently raise up the ball, which,

PLATE CCCVII. Fig. 3, 4.

by the screws *s, s*, rest on the long arms *m, n* of the levers; and provided the ends of the screws press on the levers at a proper distance from the centres *o, o*, the ball will be always kept at the same distance from the point of suspension, notwithstanding any alteration the rod of the pendulum may experience from heat or cold. What this distance ought to be may very nearly be determined, if the difference of the expansion between brass and steel is known; for the proportion which the shorter arms of the levers ought to bear to the longer ones, will always be as the excess of the expansion is to the whole expansion of the steel. Instead of the brass heads of the screws being placed near the outer edge of the ball, they may be more advantageously placed within the ball, at the distance of about an inch and a quarter from the edge, as shewn in Fig. 3.

See *Phil. Trans.* 1751, p. 479. and a pamphlet which Mr Ellicott published in London in 1753. For an account of the improvement made upon it by Mr A. Cumming, see his *Elements of Clock and Watchmaking*, p. 107.

Smeaton's Pendulum.

Smeaton's compensation pendulum.

Fig. 5.

Mr Smeaton's compensation pendulum consists of a glass rod AB, half an inch or more in diameter, and 45.5 inches long. To the upper end is fixed the pendulum spring; to the lower a screw *s* and regulating nut *n*. A brass tube or ring *m*, Fig. 5. of an inch or so in length, is put to move easily on the lower end of the rod, having a fillet at each end, one bearing on the regulating nut, the other supporting the zinc, iron, and lead tubes, which compose what may be called the pendulum ball. The zinc cylinder or tube is 12¼ inches in length, ¼th of an inch thick, and fits easily on the glass rod, the lower end resting on the upper fillet of the brass ring. On the zinc tube is put another of iron, 12 inches long, and ¼th of an inch thick, easily moveable on the zinc tube, with a kind of bottom to it, in which is a hole for the glass rod to go freely through. The bottom is uppermost, and rests on the upper end of the zinc tube. The lower end of the iron tube has a fillet on its outside, on which rests a leaden tube of 12 inches long, and ¼th of an inch thick, and which goes easily over on the iron tube. The outside diameter of the leaden tube will be nearly two inches. Although this pendulum will not be thought elegant in appearance, yet it is said to have answered the purpose of compensation very well. A section of the rod is shewn in Fig. A.

Method of compensation.

As glass does not suffer much expansion or contraction from heat or cold, it will be the more easily compensated. The glass rod AB of this pendulum being supposed to lengthen in a small degree by heat, is compensated by a zinc tube of twelve inches and a quarter long, whose lower end resting on the lower end of the glass rod, would be carried down by the lengthening of the glass rod, but the same cause which produces this, will make the zinc tube expand upwards, which will carry up the iron and leaden tubes. The iron tube has in this case its expansion downwards, and the leaden tube compensates this by having its expansion upwards.

Reid's Pendulum.

Mr Thomas Reid's compensation pendulum with a zinc tube and steel rods, Fig. 6.

Mr Thomas Reid's compensation pendulum is composed of a zinc tube AB, and three steel rods, *ab, cd, ef*. In order to obtain a proper tube, the zinc must be very gently fused into a bar about an inch square, and 24.25 inches long, and the mould into which it is poured should be upright, or nearly so. Let this be very carefully hammered to half an inch per foot, meanwhile keeping it pretty warm, to prevent cracking or breaking. After this operation, a hole is pierced straight through the bar, from end to end, and opened up by means of a clean cutting broach, until it is .450 of an inch, or so, in diameter. The outside may be turned down till it is .7 of an inch, or less. The length should be 25.34 inches, the same as the zinc rods were taken at. The steel rods must be a quarter of an inch in diameter; the length, from pin to pin, in the upper and lower traverses of the two outside steel rods *cd, ef*, 27 inches, five or six inches more being prolonged to go within the ball. In the middle of the lower traverse *m n*, is pinned a steel rod *g h*, somewhat more than a quarter of an inch in diameter, and nine inches long, which comes through the centre of the ball, which is fitted up in the same way in every respect as was described for the gridiron pendulum. The steel centre rod *a b*, goes up inside of the zinc tube, from the pin which is in the lower end of it, which is in a traverse a very little above the lower one, to the upper end of the pendulum spring, 36.75 inches; from the pin in the lower end of the centre rod, to the centre of the ball, 4.75 inches. A hole in the upper traverse *o p* allows the centre rod to pass freely through. The lower end of the tube rests on the traverse *g r*, in which the centre rod is pinned. The upper traverse bears on the upper end, both traverses having a part turned from them, about one-tenth of an inch in height, and of such a diameter as to go into the ends of the tube, for the purpose of keeping it to its proper place. The distance from the centre of the holes in the upper and lower traverses, about 1.25 inch, which will be enough to make the two outside steel rods stand clear of the zinc tube. A thin piece of brass, with three holes in it for the outside steel rods and tube, might be put half way between the ends of the tube, to prevent any bending, or tremulous motion, a thing, however, not likely to take place. It would be proper to have a few holes in the tube, for the purpose of admitting air more freely to the centre rod.

Method of compensation.

The centre steel rod *a b*, when lengthened by heat, will make the lower end B of the zinc tube, (which is supported by the lower end *b* of the steel rod *a b*,) descend with it, but the same cause which lengthens the steel rod *a b* downwards will expand the zinc tube AB upwards, and this will carry up the two outside steel rods with which the ball of the pendulum is connected; their expansion downwards, as well as that of the centre rod, is compensated by the upward expansion of the zinc tube. The length of the steel rods and of the zinc tube, has been shewn to be in proportion to their expansive ratios.

It is about fifteen years since we contrived and made this kind of compensation pendulum, which seems to do very well. The following is of another kind, but we never had it put in execution, although there is no doubt but it would serve the purpose extremely well, notwithstanding the risk arising from the brittleness of the glass.

Mr Thomas Reid's compensation pendulum with a glass tube.

Provide a white glass tube, whose outside diameter is ⅝ths of an inch, its inside diameter ⅜ths, and its length 54 inches: Such a tube may be supposed equal in strength to a solid glass rod, and will be considerably lighter. Make a zinc tube from a square bar, hammered, &c. in the same way as has just now been directed, its length being 16.3 inches, and its inside diameter ⅝ths of an inch, or as much more as will allow it to move freely up and down on the outside of the glass tube. If the thickness of the zinc tube is ⅛th of an inch, it ought to answer very well; if it is some-

Compensation Pendulums.

Mr Thomas Reid's compensation pendulum with a glass tube.

Plate CCCVII. Fig. 7.

what greater, it may answer better. There must be a core of brass fitted to each end of the glass tube, ground gently into the glass, and fixed in by some of the lime cements. To make the fixing more secure, a hole might be bored through the tube and core, about half an inch from each end of the tube, and a copper pin put through them. The core in the lower end must have a small cylindrical piece, or wire formed from it of .3 or .4 of an inch in diameter, stretching 1.5 inch beyond the end of the glass tube, and tapped for the nut inside of the zinc tube to work upon. The regulating nut should be under the pendulum ball, yet a little free of it, as it would be difficult to get at it, were it placed near the lower end of the rod. The core at the upper end has also a part of the brass, a little way above the end of the tube, for the purpose of fixing in the pendulum spring. The zinc tube goes up to the centre of the ball, which rests on the end of it; the lower end, having the tapped nut in it, bears on the regulating screw. The nut may be either soldered into the tube or not, provided it is fast there. As both the glass rod and zinc tube are round, and go through the ball, it will be requisite to have something to keep the ball to its proper swinging position. For this purpose, let a brass tube of an inch and a half in length, be fitted strongly spring tight on the glass rod, and put on above the upper edge of the ball. To the lower end of the brass tube or socket is fixed a traverse piece, into which are fixed two steel rods, a quarter of an inch in diameter, and 6 inches long. These go within the ball, in the same manner as the lower ends of the outside steel rods in the gridiron pendulum. The distance between the holes in the traverse should be 3 inches, that is, each rod should be distant outside 1.5 inch from the centre of the glass tube. When the traverse with the spring tube is once set, so that the ball may have its proper position, it cannot be easily altered. The length taken for the zinc tube is rather in excess for the compensation of the glass rod, and should it be found so, the tube can readily be shortened. As the glass rod is not very fit for the pendulum fork to work on, the following apparatus is proposed, and has been found in other cases to answer the end as well as could be wished. See Plate CCCVII. Fig. 8.

Fig. 8.

AA is a hollow cylinder of brass 1.5 inch long, which fits the glass rod rather more than spring tight. It is made a little thin near the ends, and at the middle it is left thick, having the appearance of a brass ring *a, a, a, a*, formed on the cylinder, into which are fixed two pivots *p, p*, a piece of brass not very thick, .3 of an inch broad, being bent up nearly in a bow form, as at B, B, having a small hole at each end, *b, b*, to receive the pivots *p, p*. One of the ends must be screwed on, in order to get the pivots more conveniently into their holes. At the end or middle of the bow, is a solid or round knob of brass C, in which is a hole tapped to receive the screw D, the head of which is nerrelled on the edge, and sunk on the outside, to receive the round flat piece of brass E, which snaps easily in like a barrel cover, and is not left so tight, but that it may be easily turned round in its place, without any risk of coming out, and supposed to have no shake outwards. Into the piece E is fixed a piece of brass, having a hole in it to receive the pin of the crutch. Two views of this piece are seen at F F. When these pieces are all combined to act in their places, it can easily be seen, that by turning the nerrelled head of the screw D, holding the piece F in its front view position, the crutch pin will be made to move out or in, according as the screw D is turned, by which the clock will be set in beat, to a degree of nicety which is not easily obtained by bending the fork or crutch shank.

There are other modes of putting a clock in beat, but they generally consist of an apparatus for that purpose, carried by the crutch or fork, which is a load on the cock pivot. The one which has been described, has the advantage of being supported by the pendulum rod.

Method of compensation.

The glass tube having a length of 54 inches, will, when expanded by heat, carry down with it the zinc tube, whose lower end rests on that of the glass tube. The centre of the ball of the pendulum resting on the upper end of the zinc tube, will expand upwards from the same cause which lengthens the glass tube, and by this means carry the ball of the pendulum up, and keep the centre of oscillation always to the same distance from the point of suspension. The length of the glass tube rod, and its expansive ratio, will be found to be in just proportion to the length of the zinc tube and its expansive ratio.

Troughton's Tubular Pendulum.

Troughton's tubular pendulum.

Mr Edward Troughton's tubular pendulum, is a very neat and ingenious one, and is in every respect worthy of that celebrated artist, to whom science is so much indebted for the great perfection to which he has brought the division of astronomical instruments.

Plate CCCVII. Fig. 9.

"Fig. 9. Plate CCCVII. says Mr Troughton, drawn to a scale of one-eighth of the real dimensions, exhibits the shape of the whole instrument, in which the parts of action being completely concealed from view, it appears, excepting the usual suspension spring, to be made of solid brass. This figure gives a front view of the pendulum. This form of the bob is used more on account of its being easy to make, and sightly, than from any other considerations; it is made of one piece of brass, about 7 inches diameter, 2.5 thick at the centre, and weighs about 15 lbs. avoirdupoise: the front and back surfaces are spherical, with a thick edge or cylindrical part between them. The apparent rod is a tube of brass, reaching from the bob nearly to the top. This contains another tube and five wires in its belly, so disposed as to produce altogether (like the nine-bar gridiron of Harrison) three expansions of steel downwards, and two of brass upwards; whose lengths being inversely proportioned to their dilatation, when properly combined, destroy the whole effect that either metal would have singly. The small visible part of the rod near the top, is a brass tube, whose use is to cover the upper end of the middle wire, which is here single, and otherwise unsupported.

Reckoning from the top, the first action is downwards, and consists of the spring, a short wire 0.2 diameter, and a long wire 0.1 diameter; these all of steel, firmly connected, reach down within an inch of the centre of the bob, and occupy the middle line of the whole apparatus. To the lower end of the middle branch is fastened the lower end of the interior brass tube, 0.6 in diameter, which terminates a little short of the top of the exterior tube, and produces the first dilatation upwards. From the top of the interior tube depend two wires 0.1 diameter, whose situation is in a line at right angles to the swing of the pendulum, and reach somewhat lower than the attached tube itself, which they pass through without touching, and effect the second expansion downwards. The second action upwards is gained by the exterior tube, whose internal diameter just allows the interior tube to pass freely through it: its bottom is connected with the lower ends of the last descri-

Troughton's tubular pendulum.

bed wires. To complete the correction, a second pair of wires of the same diameter as the former, and occupying a position at right angles to them, act downwards, reaching a little below the exterior tube, having also passed through the interior one without touching either. The lower ends of those wires are fastened to a short cylindrical piece of brass, of the same diameter as the exterior tube, to which the bob is suspended by its centre.

Plate CCCVII. Fig 9. No. 1.

Fig. 9. No 1. is a full size section of the rod, in which the three concentric circles are designed to represent the two tubes; and the rectangular position of the two pair of wires round the middle one, are shewn by the five small circles. By copying this arrangement, from the elegant construction of your own half seconds pendulum, (*Phil. Journal* for August 1799.) I avoided much trouble, which must have occurred to me, unless, indeed, I had been impelled on the same idea, by the difficulty of contriving the five wires to act all in a row, with sufficient freedom and in so small a space.

Fig. 9. No. 3.

Fig. 9. No. 3. explains the part which closes the upper end of the interior tube: the two small circles are the two wires which depend from it, and the three large circles shew the holes in it, through which the middle and other pair of wires pass.

Fig. 9. No. 4.

Fig. 9. No. 4. is designed to explain the part which stops up the bottom of the interior tube; the small circle in the centre is where the middle wire is fastened to it; the others the holes for the other four wires to pass through.

Fig. 9. No. 5.

Fig. 9. No. 5. is the part which closes the upper end of the external tube; the large circle in the centre is the place where the brass covering for the upper part of the middle wire is inserted; and the two small circles denote the fastening for the wires of the last expansion.

Fig. 9. No. 6.

Fig. 9. No. 6. represents the bottom of the exterior tube, in which the small circles shew the fastening places for the wires of the second expansion; and the larger ones the holes for the other pair of wires to pass through.

Fig. 9. No. 7.

Fig. 9. No. 7. is a cylindrical piece of brass, which shews how the lower ends of the wires of the last expansion are fastened to it, and the hole in the middle is that whereby it is pinned to the centre of the bob. The fastening of the upper ends of the two pair of wires is done by screwing them into the pieces which stop up the ends of the tubes; but at the lower ends they are all fixed, as represented by No. 7. I have only to add to this description, that the pieces represented in Fig. 9. have each a jointed motion, by means of which the fellow wires of each pair would be equally stretched, although they were not exactly of the same length.

In the apparatus thus connected, the middle wire will be stretched by the weight of the whole; the interior tube will support at its top the whole except the middle wire; the second pair of wires will be stretched by all except the middle wire and interior tube; the exterior tube supports at its top the weight of the second pair of wires and the bob, and the second pair of wires are stretched by the weight of the bob only.

The first pendulum which I made of the tubular kind, had only three steel wires, and one tube above the bob; that is, two expansions down and one up; and the quantity which one of brass falls short to correct two of steel, was compensated for, by extending those branches of the rod below the bob, and bringing up an external tube to which the bob was affixed. There is an awkwardness in this construction, owing to the rod reaching about 13 inches below the lower edge of the bob, otherwise it is not inferior to the one first described."

Ward's Pendulum.

Ward's pendulum.

Plate CCCVII. Fig. 10. No. 2—6.

The rod of this pendulum consists of two flat bars of steel, and one of zinc, connected together by three screws, as shewn in Plate CCCVII. Fig. 10. No. 2. which is a side view of the pendulum rod when the bars are together; "*h h*, *i i*," says Mr Ward, "are two flat rods or bars of iron about an eighth of an inch thick; *k k* is a bar of zinc interposed between them, and is nearly a quarter of an inch thick. The corners of the iron bars are bevelled off, that they may meet with less resistance from the air; and it likewise gives them a much lighter appearance. These bars are kept together by three screws *l*, *l*, *l*, which pass through oblong holes in *h h* and *k k*, and screw into *i i*. The bar *h h* is connected to the one *k k* by the screw *m*; which is called the adjusting screw. This screw is tapped into *h h*, and passes barely through *k k*; but that part of the screw which enters *k k* has its threads turned off. The bar *i i* has a shoulder at its upper end, turned at right angles, and bears at the top of the zinc bar *k k*, and is supported by it. It is necessary to have several holes for the screw *m*, in order to adjust the compensation. No. 3, 4, 5, are a side view of each bar separately. No. 6. shews the flat side of the zinc bar.

Fig. 10. No. 1.

Fig. 10. No. 1. is a front view of the pendulum rod when screwed together. The letters have the same reference to the different figures."

Method of compensation.

The front steel bar being lengthened by heat, and having its expansion downwards, will carry along with it the zinc bar, whose lower end is supported by a screw in the front bar; the zinc bar in this case will have its expansion upwards, and carry up the back steel bar, whose upper end rests by means of a knee on the upper end of the zinc bar. The pendulum ball hangs to the lower part of the back steel bar which has its expansion downwards; but the two expansions downwards of the steel bars, are compensated by the upward expansion of the zinc bar.

Mr Ward's pendulum must be allowed to be a very excellent one, as it possesses the advantage of permitting the compensation to be readily and easily altered. The description which has been given of it, in the Transactions of the Society for the Encouragement of Arts, &c. for the year 1807, and in the pamphlet which Mr Ward published at Blandford in 1808, contain sufficient details to enable any common clockmaker to copy it. We have only to add, that there should be a spare screw, for shifting the compensation; and that the screws connecting the two steel bars and the zinc one should never on any account be moved. It will be found of great advantage to have a spare screw, which may be put into that place which is supposed requisite to correct the compensation; and then release the one supposed to be, where the compensation is thought to be too much or too little. Our experience with it soon led us to this contrivance. Having made one of these pendulums, we shall now give an account of its dimensions, &c. The distance from the upper part of the pendulum spring to the centre of the ball, is 40.75 inches; and to the lower end of the front steel bar, 2 feet 11.5 inches. From the upper end of the zinc bar, where the back bar of steel rests or hangs on, to the centre of the ball, it is 2 feet 6.25 inches. The steel bars are forged from cast steel, and annealed; their breadth is three quarters of an inch, and their thickness about one-tenth of an inch. The length of the zinc bar is 24.8 inches; and its thickness a little more than two-tenths

Ward's pendulum.

of an inch. The centre of the ball hangs on the end of the tube of the regulating nut, where it was tapped, to work on its corresponding screw, made near the lower part of the back bar, formed here into a round rod, the lower end of which is a point, or index, to a graduated plate fixed to the back of the case, and 5.25 inches below the centre of the ball. The weight of the ball is 13 lb. 2 oz.; that of the zinc and steel bars, nut, pendulum spring, and connecting screws, 2 lb. 13½ oz.; weighing in all nearly 16 lb. In making up steel bars or rods for any compensation pendulum, it is proper to heat or blue them after they are finished, which will dispel whatever magnetism they may have acquired in working them up. The zinc bar of this pendulum, when brought near to the length of compensation, was about 21 inches. Taking the length of steel to be compensated by this at 61.75 inches, we may find what the compensation of the zinc should be, if the steel is rightly taken at 138.

Steel in inches 61.75, ...	Log. 1.7906370
Ratio 138	Log. 2.1398791
	3.9305161

Zinc in inches 21.	Log. 1.3222193
Ratio 405.7	Log. 2.6082968
	3.9305161

The expansive ratio here is greater than 373, as given by Mr Smeaton; but is not equal to 420, as given by Mr Ward, from trials made with his pendulum.

Remarks on zinc pendulums.

The three zinc pendulums which have been described, have each their peculiar properties. The zinc rods of the gridiron one are very troublesome to make; but they are more exposed to the air, or to changes of temperature, and are adjustable by means of the shortest traverse, and the sets of holes which are in them and the centre rod. When this pendulum is well executed, it is perhaps the best of the three. The one with the zinc tube is the strongest, the bearing on it being more firm and direct than in either of the other two; only it has no means for adjusting the compensation, unless by shortening the tube from time to time. According as the excess of its compensation is shown, something might be contrived to adjust it, without taking it from its place, but this would be too complicated; so that the shortening of the tube by degrees is rather the better way. Ward's is much more easily made than the other two. Those who use gridiron pendulums should have a half traverse, with three pins on it, similar to the shortest one in the pendulum, which will be found very convenient, when it is necessary, to shift for compensation. The half traverse and pins should be put into the holes, where the traverse in shifting is not to come. This will keep the pendulum rods in their places, and serve in the same way as the spare screw proposed for Ward's pendulum.

CHAP. XI.

On the Wooden Pendulum Rod.

Wooden pendulum rods.

The wooden pendulum rod does not come under the class of those which have just now been described; nor can it be supposed equal to any metallic compensation one. Having a good opinion of it, however, we put to trial one of them made of a very fine piece of straight-grained deal, that, for the purpose of seasoning, had been kept for five years near a parlour fire, which was almost constantly lighted throughout the whole year. The rod, when dressed up and fitted to the ball, and the pendulum spring put to it, was well varnished, so as to exclude any possibility of its being affected by damp. It was then applied to the clock, which, when regulated, went for about sixty days, during the months of June and July, without any apparent deviation from time; the very dry weather made the fixings for the clock case shrink a little. When these were again made more secure, the clock, during a trial of many months, could not be brought to give the same satisfaction. Whether this was owing to the wooden rod, or to what cause, we shall not at present pretend to determine. On this pendulum being taken away from the clock, a mercurial one was put in its place, having the same pendulum spring which was at the wooden rod, and every thing else being in the same state as before. The difference in the good going of the clock after this became truly astonishing, and may be considered as a striking proof of the great superiority of the one pendulum over the other.

It must here be observed, that, although the comparative trial by the same clock with the mercurial and wooden rod pendulums was in favour of the former, yet this clock and another were fixed on two planks, exactly the same as those described in the next Chapter, and strongly fixed to a stone wall, opposite the brick wall where the other two clocks were, which gave rise to the discovery of their pendulums affecting each others motions. Not being aware of this at the time of trial, the errors of the going of the clock, while the wooden rod pendulum was used, and the good going of it when the mercurial pendulum was applied, may have arisen from various causes, such as the elasticity of the upper plank, or the pendulums being of unequal length and weight. This much may positively be affirmed, that they were not going under such circumstances as to have a fair trial. We propose however to repeat the experiment with the wooden rod pendulum, applied to another clock, placed in a more insulated situation. An eminent American philosopher says that deal has little or no longitudinal expansion, making it less than glass, as may be seen in the Table under the article Expansion in this work.

Ludlam's wooden pendulum rod.

In the Astronomical Observations published at Cambridge in 1769, by the late Reverend William Ludlam, Professor of Mathematics in that university, he has described a very neat and ingenious method of fitting up a pendulum with a wooden rod, constructed for the purpose of preventing any gyratory motion from taking place, as well as to have some resistance from the air. This was effected by having the pendulum ball of an equal mass round the centre of a round wooden rod, and by a thin flat hard steel crutch, to give impulse on the hardened ends of two screws put through the rod, which screws were to keep the flat crutch as near as possible in the plane or line of the diameter of the pendulum rod, or at right angles to the middle plane of the pendulum ball. This ball was nearly of the form of a cheese, or the middle frustum of a globe. For a more particular description of it, see Ludlam's *Observations*, page 81, Plate v.

From the description given of this pendulum by Mr Ludlam, it appears to be a very complete one, and several persons were on that account led to adopt it; but, from our experience, it was found to be much inferior to what might have been expected, and to possess, ra-

Wooden Pendulum Rods.

ther in a great degree, the very defect which Mr Ludlam wanted to avoid. The lateral coming and going of the pendulum rod by heat and moisture, causes the screws to come and go from the crutch, sometimes to clip it hard, and at other times to allow it to have more freedom between the ends or points of the screws than is proper. Finding that it had a strong tendency to gyratory motion when the clock was set agoing, (which however diminished some time after,) arising from the mass of the ball being carried out from the centre towards the edge, and from a thick rod passing through the centre, we thought of the following pendulum, which was afterwards put in execution, where the greater part of the mass of the ball is kept at the centre, and where the least quantity possible is towards the edge. A drawing of this pendulum, is given in Plate CCCVII. Fig. 11. No. 1. and 2. The ball is of a lenticular form, 7 inches in diameter, thickness at the centre 2.5 inches, as seen at AA, AA, having a round wooden rod of about .6 of an inch in diameter, or thereabouts. The rod may be either round, flat, rectangular, or elliptical. This last is perhaps the best form; the transverse diameter being 1.5 inch, and the conjugate 0.5 of an inch. *a a*, *a a*, No. 1. are two small round steel wires, whose diameter is less than .2 of an inch, or say .175 of an inch, the length from pin to pin about 8.5 inches. They might be kept shorter if care were taken to regulate the length of the pendulum by the going of the clock before fixing their length; in which case, they need not project more than .2 of an inch beyond the diameter of the ball. The centres of these wires are one inch apart, each passing through the ball at half an inch from the centre; *b* 1, *b* 2, Nos. 1. and 2. are two pieces of brass, into which the ends of the steel wires are fitted and pinned fast, their shape is represented in the drawing. In one of them *b* 1 is a socket in which the lower end of the rod is fixed; and in the lower one *b* 2, the regulating screw *d* passes freely through: *x*, *x* are two brass nerrelled nuts, tapped to receive the screw *d*, which has also a conical nerrelled head fixed on it; the lower end of the screw serving as an index for the arcs of the pendulum's vibrations. On the upper end of the screw, the lower edge of the pendulum ball rests; and when moved up or down by the screw, the nuts *x*, *x* are screwed against the brass piece *b* 2, in order to keep all fast.

Mr Reid's pendulum with a wooden rod. PLATE CCCVII. Fig. 11.

The advantages which this pendulum possesses, are very obvious. The whole of the momentum of the ball is so near the centre, that it maintains a very steady motion; and should any lengthening or shortening of the rod and steel wires take place, this will in some degree be compensated by the ball. Should they lengthen, the same cause will make the centre of the ball get upwards, the edge meanwhile resting on the end of the regulating screw, and *vice versa*. A piece of flat brass is fitted and pinned into the upper part of the rod CC, as seen in the drawing. Behind the rectangular hole made in this piece of brass to receive the crutch pin, a part of the wood is taken away, in order that the crutch with its pin may get as near as may be to the piece of brass. The piece of brass in which the lower end of the pendulum spring is, is fitted to the top of the rod, having two pins through it, to make it fast there. The upper end is fixed to a piece of brass, which goes on a steel arbor, having pivots to rest on a cock, and turn freely on it, so that the pendulum may take its plumb-line when hung on.

It has been observed by some cabinet-makers, that from drawers, whose sides and bottom were of cedar, there issued effluviæ, that inspissated the oil at the locks, and thickened it so much, that the locks became of no use till they were taken off and cleaned.

Wooden Pendulum Rods.

Pendulum rods of cedar wood.

Pendulum rods have sometimes been made of cedar wood, and are objectionable on this account, as the oil at the pivot holes of the clock becomes thickened by it. Perhaps if pendulum rods of cedar were strongly varnished, this might deprive the wood of this inspissating quality.

Method of fixing pendulums.

It is of the utmost importance to have the pendulums of clocks well fixed at the point of their suspension; and the cock to which they are suspended should, at the same time, be strong and firmly fixed to the wall of the place where the clock stands. This requires to be particularly attended to in turret clocks, and still more so in clocks intended for astronomical purposes. These last ought to be placed upon an iron bracket, strongly fixed to as massy a stone pier as can possibly be got into the place where the clock is to stand. We have had an instance of a pendulum which was so well fixed up, that there did not appear a possibility of its being made any firmer, or that the motion of the pendulum could in the least affect the cock and suspension, yet the arc of its vibration was a little increased, after having made considerable exertions to put farther home the screws, &c. concerned with the fixtures of the cock and the suspension of the pendulum. The arc of vibration did not exceed two degrees on each side of the point of rest, so that its motion, or centrifugal force, could not be very great at the point of suspension; yet small as this force was, it is clear that it was sufficiently great to affect the cock there, as this cause made the arc of vibration of less extent than when the suspension was afterwards more firmly fixed. We have suspended the pendulum on a strong brass cock, which was either rivetted or screwed to an iron plate. This iron plate was screwed firmly to the wall, the clock case being between the plate and the wall, and sometimes a notch was left in the pillar plate to receive the end of the brass cock, by which means the clock frame and the pendulum suspension were made to keep together as nearly as possible; and when every thing here was so far adjusted, a strong screw with a square head was put through the cock, binding it and the pendulum top-piece firmly together. Another way is, to have two brass supports screwed on to a very strong seat board. These supports may be about one inch broad and half an inch thick, and in height about six inches, more or less, according to the height of the bending of the pendulum spring above the seat board. Each support has a strong and broad sole, and these soles have a stout steady pin to go into the seat board, which is screwed, from underneath the seat board, by a strong iron or steel screw fast to the upper side. The supports at the top incline a little towards each other, and a thick and broad piece of plate brass is screwed to them behind, so as to connect them firmly together. The upper ends of the supports are made level, and parallel with the soles and seat board. Across these ends is made a triangular notch, to receive the pivots of a piece of steel, to which the pendulum is suspended. By means of these pivots the pendulum turns, so as to hang freely in a vertical position. The distance between the ends of the brass supports at the top need not be more than two inches, while at the bottom the distance may be four inches, or not quite so much, the inclination being about ten degrees or so from the perpendicular. The piece of steel should not be less than half an inch thick at the middle, where it should be circular, and about three quarters of an inch broad. In the middle is a hole of about three-tenths of an inch in diameter: the two conical arbors are formed from the circular part, so as to be in a line with the diameter of the hole. The pivots of these arbors, which turn in the triangular notches, may be about three-twentieths of an inch thick. In the hole, which is three-tenths of an inch wide, is fitted a steel pivot, having a shoulder on the under side, which comes so far beyond the upper side as to admit a stout brass collet to be pinned on it, and against the upper flat side of the circular part, besides a sort of screw head on the end, with a slit in it, by which a screw-driver can turn it about, so that the pendulum ball may be made to stand in the plane in which it ought to swing. From the shoulder, below the circular part of the steel piece, to the lower end, may be an inch long. To this the pendulum spring is fixed. This, in some respects, is a very convenient mode of suspension, but we do not think it so strong and so firm as the other.

Effect of the weight when opposite to the pendulum.

When the astronomical clock, formerly mentioned, which goes six weeks without winding up, was planned, care was taken to have the weight kept at as great a distance as possible from the pendulum ball, as we conceived that the attraction of the weight would disturb the vibrations of the pendulum. This idea, which appeared to us new, had occurred, we have been told, long before to several very able artists and amateurs, such as Graham, Harrison, Lord Macclesfield, Sir George Shuckburgh, Troughton, and others. In the course of our trials with the clock, the arc of the vibrations of the pendulum, when the weight came as far down as the ball, was observed to suffer a sensible diminution, and this was imputed to their mutual attraction. Upon mentioning this afterwards to one or two persons, supposed to be competent to judge in an affair of this kind, they entertained some doubts respecting this explanation of the fact, and thought it might probably arise from some motion communicated to the air by the swinging of the pendulum. Without making any experiments in order to examine the action of the air on the motion of the pendulum, an account of the fact, which was ascribed solely to attraction, was published in Nicholson's *Phil. Jour.* October 1812, vol. xxxiii. octavo series. Soon after this, Mr Ezekiel Walker of Lynn, in a paper published in the same Journal, endeavoured to shew, that the cause of this disturbance of the pendulum, (which he says had been known to him 30 years before,) arose from the motion of the air communicated by the weight to the pendulum, which it certainly did, as we soon afterwards found from one or two experiments, which did not occupy much time. In a paper of Mr Walker's in Nicholson's *Phil. Jour.* for May 1802, vol. ii. octavo series, p. 76. entitled, "Methods for diminishing the irregularities of Time-pieces, arising from differences in the arc of vibration of the Pendulum," he has assigned several causes for the changes that take place in the arcs of vibration, and proposed different methods to prevent them. But no notice whatever is taken of the motion communicated to the air by the pendulum. M. Berthoud mentions, in the first volume of his *Essai*, published in 1763, No. 642, that the air put in motion by the vibrations of the pendulum, acts against the weight of the clock, so as to set it in motion, and that this will in its turn gradually diminish the motion of the pendulum until it stops it altogether. This takes place more readily when the weight hangs by a single ball than when it is suspended upon a pulley. This fact, it must be confessed, had either been overlooked by us, or had entirely escaped our memory. Month clocks, from stopping frequently, have long been very troublesome to clockmakers, who no doubt assigned for it a different cause from the true one. In the old month clocks, the weights are very large and heavy, and the momentum of the pendulum very small, so that they were extremely liable to be stopped. But in clocks where the pendulum has even a considerable momentum, this agitation of the air will be sufficient to stop them altogether.

Having been called upon to examine a good astronomical regulator of Graham's, which had stopped, and which belonged to a nobleman in the neighbourhood of Edinburgh, we informed the man who was sent to put it in order, that he would find the weight opposite to the pendulum, which was actually found to be the case.

CHAP. XII.

On the Sympathy or Mutual Action of the Pendulums of Clocks.

Sympathy of clocks.

It is now nearly a century since it was known that when two clocks are set agoing on the same shelf, they will disturb each other;—that the pendulum of the one will stop that of the other; and that the pendulum which was stopped will, after a while, resume its vibrations, and in its turn stop that of the other clock, as was observed by the late Mr John Ellicott. When two clocks are placed near one another, in cases very slightly fixed, or when they stand on the thin boards of a floor, it has been long known that they will affect a little the motions of each other's pendulum. Mr Ellicott observed, that two clocks resting against the same rail, which agreed to a second for several days, varied 1′ 36″ in 24 hours when separated. The slower having a longer pendulum, set the other in motion in $16\frac{1}{3}$ minutes, and stopped itself in $36\frac{2}{3}$ minutes. It never could have been supposed, however, that when very strong fixtures were made, it was possible for any thing of this kind to take place. About three years ago, in a room where astronomical clocks were placed under trial, two strong deal planks were firmly nailed to a tolerably stout brick wall or partition, the ends of the planks being jambed between the adjoining partitions. The planks were 6 feet long, 6 inches bread, and $1\frac{5}{8}$ths of an inch thick. One of them was placed behind the suspension, and the other behind the balls of the pendulums. The pendulums were suspended on strong massy cocks, partly of brass, and partly of iron, and, with the back of the cases, (one of which was of very hard oak,) were firmly screwed to the upper plank, and also to the lower one, the bottom of the cases being free and independent of the floor. Two clocks, whose pendulums were nearly of equal length and weight, and whose suspensions were distant from each other about two feet, kept so unaccountably close together for the greater part of twelve months, as to become a matter of considerable surprise. When the cold weather commenced in November, they made a small deviation from one another for a few days, and then resumed the same uniformity which they had before. An account of this was published in Mr Tilloch's Philosophical Magazine, where the observations of M. de Luc, which seem to have been a very near approach to the cause, were inserted by way of reply. The pendulum which was at one of the clocks, was of Ward's kind. On its being taken away, a gridiron one was put in its place; but with this, which was longer than Ward's, the clocks could never be brought to the same time as before. Their arcs of vibration continually varied, and no satisfactory going could be obtained from them, although we were well aware that they were competent to have given a very different performance. The gridiron pendulum clock was one of the best possible in its execution, and had one of the best recoiling 'scapements we have ever seen or made. The clock was taken from its case, to have a 'scapement of a different kind put in. In the meanwhile, the pendulum being left hanging in its place, was observed to be in motion, which was at first imputed to some shaking of the house. On being stopped, it got again into motion, and upon observing it narrowly, it was found not to be in such a direction as any shaking of the house could produce, swinging quite in time with the pendulum of the going clock, the two pendulums mutually receding and approaching each other. The cure was instantly obvious; and after the upper plank was sawed through between the clocks, the pendulum became in a little while dead and still. The arc in which it vibrated was about twelve minutes of a degree on each side of the point of rest, which was nearly about the greatest extent of variation in the arcs of the two pendulums. It would be impossible to make two clocks go closely together, in any other situation than the one which has been mentioned.

After the plank was cut through, the going clock was observed to be losing nearly at the rate of a second and a half a day; and if the clock which kept so long in unison with it had been tried under the same circumstances, it is probable that the rate would have been found to be fast. The rate they had for a period of eight or nine months or more, when they went close together, did not exceed two-tenths of a second fast a day, and this may have been a mean of the natural rate of each pendulum, if it may be so expressed; that is, suppose one clock was going slow 1.5 second per day, the other fast 1.7 second, there will be two-tenths of a second left for the acceleration of both, which seems to be the only way of explaining this phenomenon.

CHAP. XIII.

On Turret Clocks.

Turret clocks.

We have frequently seen turret clocks put up in places where no advantage was taken of the length of fall for the weights, which either did not descend through the whole height, or if they did, the ropes had a second rewinding, as it were, on the barrel. Hindley, who was certainly a man of genius, and whose turret clocks were perhaps unequalled in regard to their execution, though defective from no advantage being taken of the fall, made them all with barrels of a small diameter, and of such a length as to admit almost any number of turns, so that they could be placed in any situation, whether with propriety or not. We shall therefore lay down such rules, that a clockmaker may fit up a turret clock suited to any given fall for the weights.

Suppose that the height of fall for the weights is 25 feet, and that the clock is required to go eight days without being wound up, and with a single line to the weight, that is, with no pulley for the weight to hang on. We may allow 12 inches for what the weight will take. This reduces the length of fall to 24 feet; allowing 16 turns of the barrel to give 8 days going, and dividing the 24 feet of fall by 16, we shall have during the length of the rope 18 inches for one turn of the barrel. To find the diameter of the barrel, we say, as 355 for the circumference is to a diameter of 113, so is the circumference 18 inches of the barrel to its required diameter, which will be found to be 5.73 inches nearly. But this diameter would be too large, since the diameter of the rope must be taken into account; for the true diameter, or that which is necessary to run out the fall, must be taken at the centre of the rope when wound round the barrel. Allowing the diameter of the rope to be half an inch, then taking this from 5.73 inches, we shall have for the proper diameter of the barrel 5.23 inches. Having now obtained the diameter of the barrel, its length between the ends may easily be found. Sixteen turns of the barrel, the number wanted to produce eight days going, and a rope of half an inch in diameter, will require eight inches; but as the coils of the rope cannot lie quite close to each other, we may allow, for freedom, one inch and a quarter, consequently if the barrel is made 9.25 inches in length between the ends, it will be sufficiently long. For the striking part, a rope of half an inch in diameter will be strong enough, and as one of a considerably smaller diameter, even one-half, would suit the going part, the going barrel may be made shorter. If the clock should be made to go by a double line and pulley, then the diameter of the barrels will require to be the double of 5.23 inches, or 10.46 inches. Or if the fall is only 13 or 14 feet, then the barrels of 5.23 inches in diameter would do, by means of a pulley. The diameter of the pulley will in part lessen the length of the fall, and in place of 12 inches we may now deduct 16 inches, or so, from the fall, on account of the length taken up by the weight and pulley; but this trifling circumstance requires little accommodation on the part of the clockmaker. Taking then the diameter of the barrel at 10.46 inches, in order to ascertain what diameter the barrel ends and the great wheel ought to have, the rope being half an inch in diameter, twice this added to the barrel's diameter will make it 11.46 inches, but, for the sake of even numbers, let it be taken at 11 inches and a half for the diameter of the plain barrel end; an additional inch, or 12.5 inches in diameter for the barrel ratchet end ought to do, unless when the barrel ratchet is put on the barrel end, and within its diameter, as is sometimes done, in order to have the great wheel of a less diameter than it otherwise would be, when the barrel ratchet end is done in the usual way. The centre of motion of the ratchet end click need not be more distant from the top of the ratchet than half an inch, or at most .6 of an inch, and .75 of an inch more than this for the breadth of the wheel rim, including the teeth. The semidiameter of the barrel ratchet end is 6.25 inches; to this being added .6 of an inch, and .75 of an inch, we shall have for the semidiameter of the great wheel 7.6 inches, or its diameter 15.2 inches. The diameter of the great wheel being thus obtained, we may get the circumference by saying, as 113 is to 355, so is 15.2 to the circumference required, which is found to be 47.75 inches; this divided by 240, the double of the number of the teeth proposed to be put into the great wheel of the going part, we have for the breadth of each tooth and each space 0.199 of an inch, or nearly .2 of an inch. It is perhaps advisable to have the space a very small degree less than what is here given; the teeth will then be somewhat more than .2 of an inch in breadth. Taking small temporary seg-

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ments of thin brass, having the same radius as the wheel, and cutting them from the proposed number on the cutting engine, will lead us to form an idea of the strength that the teeth may have. Indeed this, and calculation together, ought to go hand in hand, and is the way that any ingenious clockmaker ought to adopt, if his object is to have the best possible contrivance in the construction of any piece of work in which he may be engaged.

If it is proposed to have the pendulum of such a length as to swing 30 beats in a minute, the swing-wheel having 30 teeth, and the pinions 10 each; then the numbers for the teeth of the second and third wheels will be 60 and 50, and the length of the pendulum 156.8 inches; where twenty feet or upwards, for length of fall and strength of clock can be obtained, a shorter pendulum than this should never be adopted. The diameter of the second wheel may be made half of that of the great wheel, or even a little less; however, we may safely take it at the half, viz. 7.6 inches, as it is to be cut into half the number of teeth, and being considerably thinner than the great wheel, the teeth will, notwithstanding this, be sufficiently strong for the force exerted on them. The third wheel having 50 teeth, and the force exerted on them being considerably less than that on the second wheel, we may obtain the diameter of the third wheel, by first taking the proportion of 60 to 50, and then making the diameter somewhat less than the first proportion would give, because, were the teeth cut on this diameter as given, they would be as strong as those of the second wheel. We then say, as 60 teeth is to its diameter of 7.6 inches, so is 50 teeth to the diameter required, which is found to be six inches. Taking six inches in the compasses, and applying them to the legs of any sector that has a line of equal parts, both legs of the sector being extended till the points of the compasses fall exactly on 50, set the compasses to the number 45, which will give a distance equal to the diameter of the third wheel. This will be found to be 5.5 inches nearly, and if the swing wheel is made five inches in diameter, it will do very well.

The barrels both in the going and striking parts being made equal in diameter, and each performing a revolution in 12 hours, we now proceed to make out proper numbers for the striking part and diameters for the great wheel, the pin wheel, and the tumbler wheel; this last we shall also make use of as a fly wheel. The diameter of the barrels being equal, the great wheels may also be equal, and the diameter of the striking great wheel will be 15.2 inches. The number of blows which the hammer must make in 12 hours, can be obtained by a very simple rule. The first blow 1 being added to the last blow 12, will make 13, and 13 multiplied by 6, half of the number 12, will give 78 for the number of blows required during one revolution of the great wheel and barrel. The great wheel of the striking part will require to have rather stronger teeth than that of the great wheel of the going part, because there is a stronger rope and a heavier weight applied against them, in order to raise as much weight of hammer as may be, so as to bring a sufficient sound from the clock bell. The pin wheel pinion being 10, and the wheel 64, having eight lifting pins in it for the hammer tail, the number of teeth in the great wheel which will be necessary, so that one turn of it may produce 78 blows, may be either 98 or 100.

Suppose we take 98 for the number of teeth, 98 divided by 10, the number in the pin wheel pinion, the quotient will be 9.8, which, multiplied by 8, the number of pins in the pin wheel, will give 78.4 for the number of blows for one revolution of the great wheel. If the great wheel should have 100 teeth, this, divided by 10, will give 10, and this again multiplied by 8, will give 80 for the number of blows during one turn of the barrel; either of these numbers for the teeth of the striking great wheel would do very well. If we take 98, and as the pin wheel is to have 64 teeth, we may find a proper diameter for it, so that the teeth may be nearly about the same size as those of the great wheel. Say as 98, the number of teeth in the great wheel, is to 15.2 inches, its diameter, so is 64, the number of teeth required in the pin wheel, to a diameter required for it, which will be found to be 9.9 inches.

The pin wheel, having 64 teeth, and 8 lifting pins in it, the tumbler wheel pinion, which makes one revolution for every blow of the hammer, must have 8 teeth or leaves in it. The diameter of the tumbler wheel must be considerably smaller than that of the pin wheel, and this will depend on the number of teeth it ought to have, on the number of leaves in the fly pinion, and on the number of the revolutions which the fly pinion is to make for every blow of the hammer. The less the number of revolutions given to the fly pinion during one blow of the hammer, the less will the striking part be under the influence of oil. But few turns in the fly require it to be considerably extended in the wings or vanes, and this demands some ingenuity and address in the clockmaker to carry them out, so that they shall be conveniently clear of every part of the clock. When the arms of the fly are extended, the wings or vanes can be considerably diminished in surface; and a little weight may be given them, so that when once the fly is set in motion it will not easily stop. The construction of the fly, and fly pinion, has hitherto been injudicious. The flies commonly applied to turret clocks were too heavy, the wings or vanes were too broad, they made too many revolutions, and the fly pinion was not so properly sized as it might be: for it must be considered that it acts not merely as being driven, but it must sometimes act as a leader. For although the tumbler wheel, or fly wheel, which turns the fly pinion, acts as a driver, yet, from the nature and application of the fly pinion, and fly to regulate the velocity of the striking, the fly pinion, from the acceleration which it will acquire, must sometimes act as a leader, so that the size of the fly pinion ought to be a mean between the size of a leader and that of being driven. If the pinion is made too large, or the size of a leader, the wheel teeth in driving it would be apt to butt on the pinion, and if made too nicely, as it were, to be driven, it could hardly ever act as a leader, as here the pinion would butt on the wheel teeth; this then is the reason of keeping it to the mean size of the two, which will be found to have a good effect. The arms of the fly may be about twenty-six inches.

The number of the revolutions of the fly pinion for one blow of the hammer is arbitrary; in some clocks the fly may make twenty revolutions, in some more and in some less. When the revolutions are few, and the acceleration of the fly fit to carry forward in a small degree the striking, it may appear to strike faster towards the end of a long hour, but it will require a nice ear to perceive it. We have made the fly pinion to have only four turns for one blow of the hammer, which answered extremely well, so that the tumbler wheel will require 40 teeth, supposing the fly pinion to have

10. If we take the ratio of the pin wheel of 64 to its diameter 9.9 inches, then the tumbler wheel of 40 would have its diameter 6.25 inches, the teeth would then be of the same size or strength with those of the pin wheel; but this is not requisite, as they will bear to be considerably diminished in size, and if the diameter of the tumbler wheel is nearly 5.5 inches, the teeth will be sufficiently strong. In this striking part there is no fly wheel and pinion.

The locking of the striking part of turret clocks requires safe and good mechanism. That which Hindley used is very ingenious, and was adopted in the clock made for St Andrew's Church in Edinburgh; yet, from foulness of oil or dirt, it is liable to misgive, and in attempting to rectify it, the ignorance or carelessness of workmen is apt to increase the evil. The nicety of this locking lies in the pins of the count-wheel, whose office is to raise up the locking-lifter, and pass it at the same time. The locking which is here proposed, is by means of two pins or detents on the fly pinion arbor, one of which is for locking *on*, and the other is a detainer while the striking is on warning. In this motion work, we have a rack, having teeth on the inside as well as on the outside; the tumbler raises the rack by means of the inside teeth, the rack-catch acts by those on the outside, and is concentric with the hour lifting arm, or that which discharges the striking; but both move freely and independently of each other. When the rack is on the lifting of the last tooth by the tumbler, a pin which is in the rack carries forward the end of a lever or arm. Concentric with this arm, and fixed with it, another arm presents itself (at the same instant when the pin in the rack has carried the arm forward) to a pin or detent on the fly pinion arbor, and here the striking is locked. The pin in the minute wheel, on raising up the hour lifting arm, raises at the same time the rack catch, and consequently allows the rack to fall, and the pin from the fly pinion arbor, which before this was locked, gets disengaged; and here the striking would go improperly on, but another arm, which is connected with the hour-lifting arm, presents itself to the other detent on the fly pinion arbor, and detains it till such time as the lifting arm drops off from the pin in the minute wheel, and then the striking being at liberty goes on, and is again locked when the pin in the rack is made to move one of the locking arms forward. This locking is sure and safe, and very easily executed.

The pins of the pin-wheel ought to be pretty stout, and one half of their diameters should be cut away, so as to allow the hammer tail to drop off freely, causing as little loss as possible of the force of the weight. Some have made very slender pins, and strengthened them by their opposite ends being fixed in a small circular rim or ring over them; but small pins are apt to tear and wear away the acting part of the hammer tail. The hammer tail may be so constructed that it begins to raise the hammer head when the lever by which it acts is at its maximum length, the head having then a more horizontal position than when it is afterwards raised up. The principle laid down here of the striking, &c. was adopted and put in execution in the two turret clocks which were made by Mr Reid for the royal burgh of Annan, and which are not equalled by any turret clocks in the island. The frame of these clocks is so constructed, and the wheels so disposed, that any wheel can be separately lifted out of the frame, without either taking it to pieces, or removing any of the other wheels.

The diameters of the wheels and the length of the barrels being determined, we may thence fix upon the length and breadth of the clock frame, which is proposed to be rectangular, and the wheels lying all nearly in a horizontal position, making it of such dimensions as not to pinch any part of the work, nor yet to have a superabundance of room. Beginning, then, with the going part:—The great wheel being 15.2 inches in diameter, and having 120 teeth, and the pinion which it drives 10, we know that the distance of their centres will be 8.081, or 8.1 inches nearly. We also know, that in the case of the second wheel of 7.6 inches in diameter, and 60 teeth, driving the third wheel pinion of 10, the distance of their centres must be 4.273 inches. In like manner, we get the distance of the centres of the third wheel, and swing-wheel. The diameter of the third wheel is 5.500 inches; the swing-wheel pinion being 10, we have for the distance of their centres, 3.158 inches. By taking these distances, and adding them together, with the semi-diameters of the great and swing-wheels, we shall have the space that would be required to contain the going part.

	Inches.
From the centre of the great wheel to that of the second wheel, ...	8.081
From the centre of the second wheel to that of the third wheel, ...	4.273
From the centre of the third wheel to that of the swing-wheel, ...	3.158
The semi-diameter of the swing-wheel, . .	2.5
The semi-diameter of the great wheel, . .	7.6
Inches,	25.612

So that it requires 2 feet, 1 inch, 6 tenths, and a very little more, to contain the going part.

By proceeding in the same manner, we shall find the distance of the centres of the wheels in the striking parts to be as follows:

	Inches.
From the centre of the great wheel to that of the pin wheel, ...	8.1875
From the centre of the pin wheel to that of the tumbler wheel, ...	5.6815
From the centre of the tumbler wheel to that of the fly pinion, ...	3.2544
Semi-diameter of tumbler wheel, ...	2.75
Ditto of the great wheel, ...	7.6
	27.4734
To which add the space required for the going part, ...	25.612
Gives for inches,	53.0854

The length, then, required to contain the going and striking parts is about 4 feet 5 inches, being the inside length of the frame.

The width inside of the frame, depends on the length of the barrels, the thickness of the ends, and of the great wheels, &c. The striking barrel being the longest, we must take the length given for it, which was determined to be 9.25 inches between the ends. Allow one quarter of an inch or so for the thickness of the plain end, and half an inch for that of the ratchet end, and about 3-4ths of an inch or so for the thickness of the great wheel, these being 1.5 inch, which, added to the length of the barrel, makes 10.75 inches. The pin wheel is supposed to run behind the great wheel, having a proper freedom between them, the pins for lifting the hammer tail being on the opposite side of the pin wheel, and the plain barrel end having a sufficient

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freedom of the front bar of the clock frame. We shall call this freedom about .3 of an inch, and as much for the freedom of pin wheel and great wheel; the thickness of the pin wheel about .4 of an inch, or a very little more; the height of the pins from the surface of the pin wheel about .6 or .7 of an inch.

	Inches.
The length of the barrel, with its additions, was,	10.75
Freedom of plain barrel end,	.3
Ditto of great and pin wheels,	.3
Thickness of pin wheel,	.45
Height of pin wheel pins,	.7
And take the distance of their tops from the side bar of the frame at	1.25
Inches,	19.75

By this it appears that the distance between the bars of the frame inside, will require to be 13.75 inches. The side bars, one on each side of the frame, are of forged iron, about four inches in breadth, and .4 of an inch thick, having at the ends a sort of thickness left there, so as to form a shoulder, and beyond the shoulders are tenons, not quite so thick nor so broad as the bars themselves; these tenons about 4.5 or 5 inches long, are fitted into a rectangular hole, in the cast iron part of the frame, which compose the ends of it. The ends of the tenons are sometimes formed into two screws, each having nuts to bind them against the shoulders, and with the cast iron ends: or having sometimes slits in them to receive a strong iron wedge to bind the shoulders; either of them will do very well. The length from shoulder to shoulder of the side bars need not be quite so much as that which has been allowed for containing the going and striking wheels. If this length is 4 feet 4 inches, it will be sufficient; the space given by the cast-iron frame ends will more than compensate what has been deducted from the calculated length. The cast-iron ends are composed of two sorts of pillars, connected by a rectangular bar, near 5 inches broad, and about half an inch thick; the length of the rectangular bar such as to allow the side bars, when the tenons are into the square part of the pillars, and in the rectangular hole which is made there to receive the tenons, that the inside of the side bars shall be only distant from one another 13.75 inches. The middle part of the pillars is a square of about 3 inches, and 6 inches long; the upper and lower ends of the pillars are turned into such a figure or shape, as the taste or fancy of the artist may suggest. The middle of the rectangular hole which receives the tenons, may be distant from the lower end of the pillar about 12 inches; the top of the upper end may be equally distant. This frame, if constructed in the manner which has been directed, will be found to be strong, firm, and stiff, and very handy and convenient, while going about the making of the clock. Should it be thought that the side bars from their length may yield a little, a foot can easily be attached to each, near to the middle of the bar, or any other convenient place.

Nothing about a turret clock requires more skill and ingenuity, than to construct properly the wheel work for setting off and carrying the hands to the different dials, more especially if there are more than two. The wheels for this purpose should be as few in number as possible, having the least allowable shake between the teeth, and a sufficiency of freedom in the end shakes of the arbors, and in the conducting rods.

Turret Clocks.

Turret clocks with four dials and hour and minute hands to each were formerly but very seldom made. The town clock of Edinburgh has four dials, with hour and minute hands to each, which we put to it in the year 1795. It is an excellent specimen of this sort of mechanism. Hooke's joint has been found very useful in the conducting rods for the dial work; but where any oblique direction is given to the rods, Hooke's joint will make the hand rather to go irregular, making the hand more forward at one part, and more behind at another than it ought to be. In large turret clocks which have minute and hour hands, the wind and weather give a very severe trial to the dial-work and wheels, and such clocks are in general very much exposed to such trials. In the clock which we have been planning, the second wheel pinion making one revolution in an hour, is that which must conduct the dial work. Let that pivot of it which comes through the fore side bar be left pretty thick, and prolonged three or four inches beyond the bar outside. Two ways have been adopted to prevent the hands from changing their place by any force or violence, arising from winds or any other cause. One of them consisted of a pretty stiff or strong circular spring, keyed on behind the minute wheel; the other consisted in putting on the minute wheel arbor, a wheel with square or unrounded off teeth, into which teeth a click from the conducting wheel passed into the space or spaces. We propose to adopt the first of these two methods at present. On the thick pivot of the second wheel pinion, outside of the front bar, let a square be made of .3 of an inch long; on this let the square socket of the circular spring be well fitted, and the side or angle marked to correspond, so as to know at all times that which it has been originally fitted to: this spring may either be of steel or brass, and the diameter equal to that of the minute wheel less by the teeth. From the square part of the pivot let this arbor be turned down, but hardly more than what is necessary to form an arbor nearly cylindrical; the square sides must not be completely turned out, otherwise this might render the arbor too small. The diameter of the minute wheel may be about 4.5 inches, and cut into 40 teeth; on the same socket with the minute wheel, let there be a bevelled wheel of 5.5 inches in diameter, and having 50 teeth, the distance of the back of the bevelled wheel from the nearest side of the minute wheel being about half an inch, or .6 of an inch. This space is to allow the hour lifting arm to come in between them, so that the lifting pin in the minute wheel may freely get hold of it; the whole length or height of the socket may be about 3, or 3.5 inches, and turns on the cylindrical part, or arbor of the prolonged pivot. Two other bevelled wheels of the same number and diameter as the other are cocked on the front bar, so as to pitch with the first; their arbors are disposed horizontally, and at right angles to the socket of the first bevelled wheel, so that they may be connected with the dial wheels on the two opposite dials, whose wheel and minute hands they will conduct. Over the first bevelled wheel, and pretty near the inside of it, is placed a round brass dial, having minute divisions and figures on it. A minute hand on the socket, having a collet against them pinned by the end of the arbor, will keep the minute wheel tight on the arbor by means of the spring behind it. When there are four dials, then in place of the two wheels, with their arbors horizontally placed, let there be one arbor placed perpendicularly, on which are fixed two bevelled wheels, the upper one of which pitches with the first bevelled wheel; the lower one, whose lower pivot or arbor may be connected with that of another, which carries a bevelled wheel, turning four others, all of them in the same frame: The four wheels, if properly placed, will turn the four minute arbors at the dials all in their proper course or direction. This frame will require to be placed a little below that of the main frame of the clock. It is seldom that four dials are wanted, and in most instances the two opposite generally suffice. To lead the snail wheel, or what is generally though improperly called the hour wheel, let another flat minute wheel of the same number of teeth and diameter as the first be pitched with it, and whose arbor goes through the main frame; and near the edge of the going great wheel, a little below, on the left hand side, a cock on the fore bar receives the wheel pivot, and the arbor is free on the fore bar: The other pivot, which is left pretty thick, turns in the back bar; on the end of this pivot, which is prolonged a little way beyond the bar, is formed a lanthorn pinion of 4 or 6, or such a number as may suit the number of teeth in the snail wheel; or a pinion of a proper number having a prong to it, may be twisted in a hole made in the arbor to fit and receive it. A lanthorn pinion of four will lead about the snail wheel and snail, having a common socket; the wheel having 48 teeth and 7 inches in diameter, and turning on a stud in the back bar; the rack is also on a stud here. The pivot required to have a lanthorn pinion formed on the end of it, for a wheel of 48 teeth, and 7 inches diameter, would be rather too thick; so that by keeping the pivot of a moderate size, or sufficiently thick to have a hole in it to receive the prong of a pinion of 6, and the snail wheel 72, may be a better way than that which we first proposed. The hour lifting arm and the detaining one may be formed or not from one and the same piece, and fixed on an arbor which lies above the great wheel, whose pivots must run in cocks attached to the main frame; cocks are also required for the hammer, the verge, and the pendulum. The length of the pendulum which we have proposed for this clock, may be thought by some rather inconveniently long, which is a matter that can very easily be got the better of, by assuming any other lengths, say 6, 7, or 8 feet: either of these lengths will have perhaps dominion enough over the clock; but these will require other sets of numbers for the second and third wheels, allowing the pinions to remain 10 each, and the swing wheel to have 30 teeth. The second wheel having 75 teeth, the third wheel 60, the pinions 10 each, and the swing wheel 30, the vibrations in a minute are 45, and length of pendulum required is 5 feet 9.7 inches. If the third wheel of this set is made 70, all others remaining the same, the vibrations in a minute will be 42, and the length of the pendulum 6 feet 8 inches: 40 vibrations in a minute would require the wheels to be too disproportionate in numbers, unless we were to make one of the pinions 12 in place of 10; the wheels in this case would be 75 and 64. In the other they would have been 80 and 50. The length of pendulum is 7 feet 4.2 inches; the vibrations in a minute 38; the pinions 10 each, and the swing wheel 30. The wheels are 75 and 64, the length of pendulum 8 feet, 1.75 inches. Wheels 80, 72, and 30, and pinions of 12, will give 40 vibrations in a minute.

It is certainly not requisite to give any more examples of constructing turret clocks. The one which has been given is sufficient to enable any intelligent artist to proceed in this way, whether with clocks going eight days, or with those which require daily winding up. There are often great objections made against the trouble of daily winding up a turret clock, but when this trouble can be submitted to, a clock of this sort is decidedly preferable to those which go eight days. Turret clocks which strike quarters are sometimes made, some of which are done by a quarter rack and snail, and others by a count wheel. For the description of a thirty hour clock of this kind, put up in the town-house of Paris in the year 1782, we refer to Berthoud's *Histoire de la Mesure du Temps par les Horloges*. This is perhaps one of the finest public clocks in Europe. It was constructed with much care and expense, and is the only one which has enamelled dials, one of which is above 9 feet in diameter.

Although not in its proper place, we may here remark, that where four sets of dials and dial work are required, it would hardly be safe to trust them to a young tight collet behind the minute wheel. We would therefore propose, that the pivot of the second wheel pinion be squared down, and a little longer beyond the fore bar than what was proposed for the square of the spring; this is for the particular reason of getting easily at a bolt pin when at any time setting the hands. On this square of the pinion let the squared socket of a plain wheel be very well fitted. This wheel is about 3.6 inches in diameter, and in thickness about one-fourth of an inch. The minute wheel must have a sink in it, so as to receive the plain wheel, but the sink must be more extended in diameter, to admit a skeleton sort of a rim of a wheel with forty teeth cut inside of it. This rim must fit well the inside of the sink in the minute wheel, and be fixed to it, either by soft solder, or some other means. The minute wheel, in this case of the sink in it, will require to be thicker than in the case of the spring collet. A bolt may be lodged under a dovetail slit made in the plain wheel; in this slit, and lying close to the sink, the bolt can be made to move out or in to the inside teeth on the minute wheel; on the end opposite that of the locking end of the bolt, is fixed a stout round pin or knob, for the finger to pull out when occasionally setting the hands; this pin serves also for a stout spring to push the bolt into its place between the inside teeth.

In fitting up the dial work immediately behind the dials, it may be recommended to adopt that which was contrived and put in practice in the different dial-works of St Andrew's church clock; on the minute arbor, just by the lower end of the hour wheel socket, is a loose steel washer, which lies close to the fore-plate of the dial work frame; and should the wind press the hour hand and hour wheel socket down, it affects no other part, but only presses the washer against the plate. Inside of the dial-work frame, and on the minute arbor, are washers to prevent any binding on the ends of the hour-wheel socket.

In the town clock at Paris, the revolutions of the fly striking the hour, are eight for every blow of the hammer; the fly of the quarter part makes four revolutions for every quarter hammer blow, there being ten lifting pins on each side of the great wheel, making 20 lifts, the amount of the quarter blows in an hour. The wings or vanes of the flies in this clock are pretty broad and long, and can be set to take more or less hold of the air. The fly of Hindley's clock in the Orphan Hospital makes 4.57 turns for every blow of the hammer; but, from the imperfect construction of the clock no adequate weight of hammer can be raised, and hence a sufficiency of sound cannot be obtained from the bell. It has been said that the weight of the hammer for this purpose should be 5 pounds weight forevery 100 pounds in the bell. Turret clocks in general must either have their bells too large for this proportion, or the clocks have not been made to raise a heavy enough hammer. The arm of the hammer when at rest, should hardly make an angle of elevation above 20 degrees, or 24 at most; and in order to get as much mass of matter in the hammer head, the tail by which it is raised should be pretty long, and give a rise from the bell as little as possible. But this distance of rise from the bell must depend, among other things, on the length of the arm, and on the angle or length raised by the pin wheel and hammer tail.

It was formerly proposed to fix on the fore bar the small dial, to which the minute hand is set at, when setting those of the principal dials; but it matters not whether a dial is fixed and the minute hand is moveable, or the minute hand is fixed and the dial moveable. Suppose that, by means of three small and short brass pillars, fixed inside of the bevelled wheel, we now screw on the tops of them a light round dial, having the minute divisions and figures on it, and the minute index fixed to the fore bar, we can here make the bevelled wheel be turned about, till the minute index points to the proper minute. This mode will, besides, allow us to have more conveniently three sets of dial work, that is, two by the bevelled wheels, whose arbors are laid horizontal, and the third by connecting it with the socket of the first or front bevelled wheel.

Where turret clocks are of a large size, and have very heavy weights applied to the barrels, they require much force and strength to wind them up. In order to remedy this, an apparatus of much the same nature as that which is commonly applied to cranes has been used. This consists of a wheel, with rather strong and coarse teeth, fixed on the barrel end, opposite to that where the great wheel is. A pinion of any number, on whose arbor is a square to receive the winding up key, is attached to the clock frame, by means of a cock, &c. so as to pitch with the wheel on the barrel end; and by this means, a considerable weight can be raised with ease, requiring much less exertion, but more time than when the winding up was performed by the barrel arbor. The clock in the town-house of Paris is wound up in this manner, which is represented in the drawing of Vick's clock, Plate CCC. Fig. 1. The size of the wheels and strength of teeth, may be regulated according to the weight to be wound up. The weight of the going part is in all cases light, when compared with that which is necessary for the striking part, in most of these clocks. Besides the advantage of winding up a heavy weight with ease, this method has another, which is, that the barrel arbor pivots can be used, either in conducting the hands, discharging the quarter and striking parts, or turning count wheels, &c. The old way of the division of the hours striking by the count wheels and locking plate, and locking on the hoop wheel, does not yield in ingenuity to any thing which has been since introduced in its place by modern clockmakers. The only great objection to the old way, was the trouble of making the clock strike a round of eleven hours, when the striking of the hour corresponding with the hands, took place from any accidental discharge. It may not be out of its place to observe here, that the application of the cord or rope for the weight should be on that side of the barrel which lies next to the pinion into which the great wheel acts, especially in turret clocks, as this relieves the barrel pivots of a great degree of friction, which they would otherwise undergo were the course of the rope and weight on the opposite side.

CHAP. XIV.

On the Method of fitting up Astronomical Clocks.

On fitting up astronomical clocks.

Although the example of calculation which we have given for the different parts of a turret clock, is applicable to any clock; yet, in order to make the calculation more familiar and easy, we shall apply it to an astronomical clock, intended to go 32 days without winding up, performing the computation in the most rigid manner, as these clocks ought to be made as perfect as possible in all their parts.

From the inside bottom of the intended case to the under side of the seat board, is supposed to be 4 feet 10.7 inches, the seat board one inch thick, and the distance from the upper side of it to the centre of the dial 3.125 inches, or 3$\frac{1}{8}$ inches. From these, to obtain a proper diameter for the barrel, which is to have sixteen turns on it, we propose that the length taken up by the pulley and weight shall not exceed 6 inches, and that the weight shall be about 10lb. or perhaps even less. Four feet 10.7 inches diminished by 6 inches, will be 4 feet 4.7 inches, and this doubled will be 8 feet 9.4 inches; which divided by 16, the number of turns proposed for the barrel, we shall have 1054 tenths of inches, which divided by 16, will give 65.875 tenths for one turn round the barrel. From this, to find the diameter of the barrel, say as 355 is to 113, so is 65.875 to the diameter required, which will be found to be 2.0968 inches. The diameter given here for the barrel must be lessened by a diameter of the gut. The diameter of the gut, which we had 24 years at a month clock, and which carried a weight of 24lbs. was .045 of an inch; it might have even supported it much longer, but a different weight was afterwards hung on. It is very thick gut at .080 of an inch, and .060 of an inch is about the diameter of common sized gut, which we shall take for our estimate in the diameter of the barrel; then 2.0968 inches *minus* .060 of an inch, will give for the true diameter of the barrel 2.0368 inches. The diameter might be kept even a little larger than this, since the cutting of the screw upon the barrel for the gut to ride in will lessen it a little. The depth of the screw cannot be much more or less than .020 of an inch, at which we shall take it; 2.0368 + .020 will then make the diameter of the barrel 2.0568 inches. It is more than 40 years ago since we proposed that the trade in general should adopt for all their work gages, inches and the lowest subdivisions of an inch. Had this been done, it would have made all the communications between the different branches of the art extremely simple and easy; and yet however simple this may appear, it has never been done. It must be observed, that every branch, such as movement-maker, enameller, glass-maker, spring-maker, verge-maker, &c. have all their own gages, no one of which corresponds with that of his neighbour's, and all these gages have numbers applied to them. On what these numbers are founded, it would puzzle very much both the makers and owners of the gages to tell.

To get the length of the barrel between the ends, let us take the diameter of the gut at .080 of an inch, in order to allow freedom between the turns on winding round the barrel. This .060 multiplied by 16, the number of turns proposed, will give 1.28 inch, or very near 1 inch and $\frac{1}{10}$ths of an inch for the length of the barrel between the ends. The barrel, or great wheel, making a revolution in 48 hours, we must see what the number of teeth for it, and the second wheel pinion which it drives, ought to be, and likewise the number of teeth for the second wheel, and that of the centre pinion, so that this last shall make 48 turns for one of the great wheel. Let us assume 24 for the number of the second wheel pinion, and 20 for that of the centre pinion. If we take 6 times 24 for the number of the great wheel teeth, and 8 times 20 for the number of teeth in the second wheel, then the centre pinion will be turned 48 times round for once of the great wheel, as $6 \times 8 = 48$. Having assumed the pinions to be 24 and 20, these multiplied into one another, and the product multiplied by 48, the last product will be such a number, as when divided by a number for one wheel, the quotient will be a number for another wheel, $24 \times 20 = 480 \times 48 = 23040$, which divided by 144, the number for one wheel, the quotient will be 160 for the number of teeth of the other wheel. Or if we take 25 for the number of the second wheel pinion, and 20 for the other, these multiplied together, and the product again by 48, will give such a number, as when divided by 150, the number for one wheel, the quotient will be 160 for the number of the other wheel, $25 \times 20 = 500 \times 48 = 24000 \div 150 = 160$. The numbers for the teeth of these wheels may be obtained in the same way which we make use of to find the numbers of the teeth of the wheels for clock and watch movements. If we take 26 for the second wheel pinion, and 20 for the centre pinion, and multiply them into one another, and if the product is again multiplied by 48, the number of turns of the centre pinion for one of the great wheel, we shall have a number, which being subdivided till there is no remainder, its multiples will form such sets of numbers as may be given for the teeth of the two wheels. Thus $26 \times 20 = 520 \times 48 = 24960$, the multiples of which will be seven 2's, one 3, one 5, and 13, which give the numbers 156 and 160 for the wheels. For the subject of our astronomical clock, we shall adopt the number 144 for the great wheel, and 160 for the second wheel, and its pinion 24, and 20 for the centre wheel. The object is to have as high numbered wheels and pinions as can be conveniently got in. The diameter of the great wheel is assumed to be such, as will allow the teeth proposed for it to have strength enough to bear the exertion put upon them, which we shall take at 3.520, and for that of the second wheel 3.300. In other words, these are 3.5 inches, and .020 parts more of an inch, and 3.3 inches for the other. The pinions for the third and swing wheels are to be 16 each, the number of teeth for the centre wheel 128, and for the third wheel 120. For the sake of saving trouble to those who may be inclined to make such a clock, we shall give the diameters of the wheels and pinions, and the distance of their centres.

	Teeth.	Diameter.	Distance of Centre.	Pinion.	Diameter.
The great wheel .	144	3520	2021.7	24	614
Second wheel . .	160	3300	1830	20	437.2
Centre wheel . . .	128	2600	1437.2	16	349.3
Third wheel . . .	120	2800	1280	16	329
Swing wheel . . .	30	2000			

	Teeth.	Diameter.	Distance of Centre.
Wheel concentric with the second ditto	20	743.6	1322
Wheel carrying the hour hand	60	2032.5	

The wheel of 20 is concentric with the second wheel, which making three revolutions in 24 hours, carries the hourhand-wheel of 60 once round in that time. The hour circle will have the 24 hours marked on it, that is, from 1 to 24, being intended for a sidereal time clock. There is no other dial-work than the wheels of 20 and 60, which will require to have the hour-hand turned about by itself,* when at any time the clock is set by the minute hand. From the centre of the dial to the centre of the hours and seconds circles, is 2.5 inches to each. The centre of the great wheel is on a line below the centre of the dial about 1 inch, and to the left of the perpendicular line, in the centre of the dial, 2.9 inches. The centre of the third wheel is also to the left of this line, a little more than half an inch, say .519 of an inch. The 'scapement we would propose to be the same as those which we have made to astronomical clocks, after the principle of that of Mudge's time-keepers; only the pallets might be made longer, and the springs of course a little stronger. The angle of 'scapement might be reduced to 15 minutes on each side of the point of rest, and yet the pendulum may be made to vibrate about 1.5 degrees on each side. The unlocking here would be as near the lowest point as possible, or when the pendulum had its maximum force.

CHAP. XV.

On Chimes and Bells.

On chimes and bells.

CHIME, in its general meaning, is applied to the sounding of bells, such as change-ringing by church bells, or the striking quarters of the hour by a clock on two or more bells, or to tunes played by a clock on a series of nine, twelve, or sixteen bells, tuned to their respective notes on the scale. Clocks that play tunes on bells are called musical clocks; when hour quarters are chimed or struck by the clock itself, for example, on six or on eight bells in octave, it is called a quarter clock, and sometimes a chime clock; and when the quarters are struck by a string being pulled, it is called a pull quarter or a repeating clock, whether the quarters are struck on six or eight bells, or whether they are given by a double blow on the hour-bell, as in the repeating watch. A time piece, or going part, and having no hour striking part, but having a repeating part, is by some called a silent pull.

Method of pricking tunes on the music barrels of clocks.

Various ways may be adopted for pricking tunes on the music barrels of clocks. The earlier mode of doing this was by taking a piece of writing paper of such a size as to cover exactly the surface of the barrel, and in a direction perpendicular to the axis of the barrel, to draw as many lines parallel to one another as there were notes in the tune to be laid down on the barrel, the lines being equidistant, and corresponding perfectly with the hammer tails as they stood in the hammer frame. They were marked at each end

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* This cannot be considered as inconvenient by those who wish to have the most perfect mechanism for the dial-work.

with the letters or notes they were to represent in the gamut or scale of music; and, according to the number of bars in the tune, as many spaces were made by lines drawn equidistant and parallel to each other, intersecting the others at right angles. The junction of the ends of the paper, when applied round the barrel, represented one of these bar lines. The length or breadth of the spaces (which might be either squares or parallelograms) contained between the bar and note lines, was again divided on the note lines into as many parts or spaces as the number of crotchets in a bar, and for notes of lesser value a less space was taken. While the paper was lying on a table, the notes in the tune proposed to be laid on the barrel were marked by a black ink dot on their respective lines, and in the same order as the bars of the music lay. After this was done, the paper was pasted on the barrel; the note lines now appeared like so many circles traced round the circumference of the barrel, while the bar lines lay longitudinally on the surface of it. By this means the black ink dots were transferred and marked on the barrel by a punch or finger drill. This mode might answer very well where large barrels were used, and only one tune laid on; but in smaller work, and where several tunes were to be put on the same barrel, it is neither sufficiently neat nor accurate.

New methods of transferring tunes to music clock barrels.

We are not acquainted with the method adopted by those workmen in London who practise the pricking of music on clock barrels; but having had occasion to construct some musical clocks above thirty years ago, and having no opportunity of getting the music pricked on the barrels by any professional person, it became necessary to contrive some method for this purpose. One way consisted in applying the barrel concentric with the arbor of a wheel cutting engine, whose dividing part consisted of an endless screw and wheel; and having fixed other apparatus on the engine for this purpose, different numbers of turns of the endless screw were taken for the longer or shorter notes, and the tunes were as accurately put on the barrel as could be wished. Another way consisted in placing the barrel and its train of wheel work and regulating fly in the frame. A force was applied to turn the barrel, wheel work, and fly round in the order of lifting the music hammer tails, and an apparatus was used to mark the dots on the barrel. The fly made 360 revolutions for one turn of the barrel; or should this be thought too quick a train, it might be made by altering the numbers of the wheel teeth to make 250 or 260 revolutions for one turn of the barrel; the train or revolutions of the fly being fixed, was made use of in the same way as the endless screw in the former way, by taking a greater or a smaller number of turns of the fly for the longer and the shorter notes. Knowing the number of bars in the tune, and the crotchets in a bar, by calculation, the number of turns of the fly was obtained (and parts of a turn if necessary) that a crotchet required, so that the tune might go round the barrel, leaving a small space for locking and running; this was all that was required to be known: quavers and semiquavers came to have their proportion according to the value of the crotchet. Although the process of putting tunes on barrels answered very well by both these methods, yet it was rather tedious, and attended with some trouble and embarrassment in the operation; and a more simple and easier method of doing this was afterwards contrived and adopted, by which we could lay on a tune with the greatest accuracy and expedition in nearly ten minutes.

Although bell music is not of a favourite kind, yet, for the benefit of such clockmakers as may be disposed to construct music clocks, and have not the opportunity of getting the music pricked on the barrel by those whose profession it is to do this sort of work, we shall give a description of the tool and its apparatus, which will be found very well adapted for this purpose, and also of the manner of using it.

Having a good strong turn-bench, such as those used by clock-makers for their larger sort of work, to the standards or heads of it let there be attached supports on each side; to the supports on the side nearest the workman, let there be fixed a straight cylindrical rod AB, about ten or twelve inches long, and in diameter a quarter of an inch, or even three-tenths of an inch. A spring socket CD must be made for this rod to slide easily and steadily along it, somewhat like the socket which slides on the upright stalk or rod of a watch-maker's glass stand. In the thick and strong part of this socket E is fixed a steel arm EFG, bent into a curve, which lies over and above the music barrel when in the turn-bench, as shown in Fig. 2. at EFG. The steel rod AB may at pleasure be placed at any distance from the barrel, about an inch or rather more, and should stand parallel to the barrel arbor MN, and nearly in the same plane with it, but rather a little above this than otherwise. On the outer end of the curved arm is fixed a flat piece of steel G, a little more than half an inch long, in breadth not quite so much, and about one-tenth of an inch thick. The lower and front edges of this flat piece of steel should be neatly and smoothly rounded off, so as to allow it to come easily and freely into the notches *a*, *b*, *c*, &c. which are on the edge of a thin brass scale, whose use will come afterwards to be explained. To the supports attached to the turn-bench heads, and on the opposite side to that where the round steel rod is placed, let there be fixed a slip of brass XY, about ten or twelve inches long, an inch and a half broad, and nearly a tenth of an inch thick, the inner edge of which must be made to stand parallel with the barrel, and the flat side to stand nearly in a plane between the upper surface of the barrel and its centre, the edge being placed so as to stand clear of the tops of the teeth of a high numbered wheel WW screwed on to the end of the barrel. Near the ends of this slip of brass slits are made, through which screws *s*, *s*, pass that screw it to the upper side of the supports; the slits serving to allow it to be moved a little occasionally lengthwise when required. On the upper side of the slip of brass is fixed another, but not quite so thick, the length being about that of the barrel, and breadth one inch and three quarters. On the inner edge of this are made as many notches *a*, *b*, *c*, &c. as there are hammers, bells, or notes to be used in the tune or tunes to be marked on the barrel. These notches are equidistant, and the middle of them should correspond to the middle or line of the hammer tails; their width being such as to admit the flat steel piece G on the end of the curved arm EFG; the depth of them cut on the edge of the brass should be about one quarter of an inch. The edge of this piece of brass, or music scale as it may be called, must also stand parallel with the barrel, and at a little distance from it, not nearer than three-tenths of an inch, so that the flat steel piece on the end of the curved arm may have room to get in a little way, and to pass through at the same time to a certain degree of depth. On the upper side of this brass slip the letters of the

Plate CCCVIII. Fig. 2.

Plate CCCVIII. Fig. 3.
Fig. 2.

scale of music or gamut are marked to those notches which correspond with the hammer tails, and hammers intended to strike on the bells the notes so marked; but in an inverted order to the usual way in which they are marked in the scales of music, the lower notes being on the right hand side, and as they rise going to the left. This is done to suit the way in which the bells are commonly, though not necessarily, placed in music clocks, (See Fig. 3.); for a clock-maker of any ingenuity might contrive the barrel to turn any way he thought proper, and place the bells to stand in the order of the music scale if there was any advantage to be derived from it. In the curved arm EFG, Fig. 2. is fixed a punch *f*, having a very fine and sharp conical point, at the distance of four inches or so from the centre of the sliding socket, and not quite an inch from the outer end of the flat steel piece; the punch when applied to the barrel should stand upright, and directly over the centre of it. This apparatus being all adjusted as we have directed, it is evident that when the curved arm is raised up a little way, the socket can then be made to slide easily along the steel rod, and by this means bring the outer end of the flat steel piece very readily into any notch required, and the point of the punch is brought at the same time with the greatest precision to the place of the note on the barrel, leaving the flat steel piece for the time in the notch: The point of the punch touching or resting on the barrel, a stroke from a very small hammer on the top of it will cause the point to make a pretty deep mark or conical hole on the surface of the barrel.

Fig. 5.

It now remains to be shewn how the time or the lengths of the different notes are determined. Long or slow, short or quick notes, such as the minim and demi-semi-quaver, are not well suited to bell-music, and, of course, are seldom introduced into tunes chosen for it; the crotchet, quaver, and semiquaver, forming the greatest part of the composition: the minim and demi-semi-quaver may, however, be brought in at some parts. It may be unnecessary to state, what is pretty generally known, the proportional value of the notes to one another; suffice it to say, that a minim is equal to two crotchets, a crotchet to two quavers, a quaver to two semi-quavers, and a semi-quaver to two demi-semi-quavers. The time in which the barrel turns, after striking or lifting a hammer-tail, to strike any note on a bell, must be in the same proportion with the notes, according to their respective character. Let a wheel of 250 teeth, for example, be fixed on the end of the barrel, and let both be placed in the turn-bench, with the apparatus which has been described: To the turn bench is now attached a steel or brass spring, having a knee or bending at one end, so that it may fall into the spaces of the wheel-teeth. The tune of the Jolly Young Waterman (See Plate CCCVIII. Fig. 5.) being proposed to be laid on the barrel, will, by inspection, be seen to contain 20 bars of three crotchets each, being 60 crotchets: if 250, the number of the wheel is divided by 60, the number of the crotchets, we shall have four for the quotient, and ten for the remainder; shewing that we may take four teeth or spaces for every crotchet, ten the remaining part of it, serving as a run for locking, and the other part for a run at unlocking for a tune to be played. Now as a crotchet is equal to four spaces, a quaver must be equal to two, and a semi-quaver equal to one. In the tune proposed, the first note is F ♯; the curved arm is brought to the left hand, and the flat steel piece put into that notch; the punch is then made to mark the barrel; and this being a semi-quaver, or the fourth part of a crotchet, the spring index is shifted into the next space of the wheel teeth, and the curved arm moved to the next note, which is G, on the left hand, and the flat steel piece being put into the notch corresponding to G, the punch is made to mark it on the barrel. This being a semi-quaver also; the spring is shifted into the next space, and the curved arm moved to note A on the left; the steel piece is put into the corresponding notch, and the punch marks this on the barrel. A is here equal to a quaver and a half; therefore the spring index must be moved over three, or into the third space, and the curved arm moved to the next note, being B, on the left hand; the steel piece being put into this notch, the note is marked on the barrel; and as it is a semi-quaver, one space is taken for it, and the arm moved to G. This being marked, and as it is a quaver, two spaces are taken, and so on. When crotchets are marked, four spaces are taken after marking them. In the tune which we have used, nine bells or notes are all that is required; and three more, or a dozen, would give such a compass as to take in almost any tune that might be required. In place of the spring index, it would be better to have a single threaded endless screw to work into the wheel teeth, one turn of which would be equal to a tooth or space. The arbor of the screw being squared on one end, and a small handle for turning it being put on, there would be less danger of making mistakes with the screw than with the index. On the arbor of the screw there might also be put a hand or index to point to a circular space or dial of eight or ten divisions. This would give room to make parts of a turn, where great nicety is required. After one tune is laid on the barrel, either it or the music scale must be shifted a short space when the next one is to be put on. To shift the music scale is perhaps the preferable way of the two; and the spaces for shifting should be marked on the top of one of the supports, and close by one end of the long slip of brass; or they might be marked on a short line drawn longitudinally on the surface of the barrel at or towards one of the ends of it; or by taking both methods, the one would serve as a check on the other. The length of shifting depends on the distance between the hammer tails, and the number of tunes to be put upon the barrel. For example, if the distance between the hammer tails is four-tenths of an inch, and it is proposed to put eight tunes on the barrel, then if we divide four-tenths by eight, we shall have half a tenth for the length, or space to shift for each tune; and this is taking advantage of the whole space between the hammer tails, a circumstance which is frequently overlooked; for where the shifts have been confined to a less space for shifting than might have been got, so much room is lost. The distance between the hammer tails depends on their number, and on the length of the barrel. We have made the distance a quarter of an inch, where the number of hammers were eleven, and the length of barrel about three inches and a quarter, the number of tunes put on the barrel seven, the spaces for shifting were three hundred parts of an inch or thereabouts, and where the clock of itself shifted the tune. When the hammer tails are thin, a number of tunes could be made to have their shifts in a very short distance between the tails; the diameter of the lifting pins must also be taken into account, being of some consideration where the spaces for shifting are extremely limited. Although we have taken the number of the wheel teeth for dividing the notes at 250, yet either a greater or a less number may be assumed; all that is required is to proportion the number of turns of the endless screw, and parts of a turn, to the number of bars in the tune, and to the notes in each bar, and to have the tunes to go nearly round the barrel, so that a small part of a revolution of it after the tune is played over, may be left for what is called locking and running. If the dividing wheel was taken at 128 teeth, and the tune being supposed to have 20 bars, each bar having three crotchets, as in the former example, 128 teeth divided by 60, the number of crotchets, the quotient would be two, and the remainder would be eight; so that each crotchet would require two teeth or turns of the endless screw, a quaver one turn, and a semiquaver half a turn, and the remaining eight teeth would serve for locking and running. When the tunes are all marked on the barrel, each mark must be drilled to obtain holes for the lifting pins to be driven into them. Great care should be taken to have a stiff and excellent drill, so as to run no risk of breaking, which would occasion a great deal of trouble; and it should be of such a temper, and well and judiciously whetted up, so that it may drill all the holes without requiring to be once sharpened up: the object here is to have all the holes of the same width, so that the lifting pins may be all of the same diameter. The holes being drilled, and the barrel polished, a number of pins should be prepared into lengths of half an inch or so each, and a very little tapered at one end. The stronger and harder the brass wire for the pins is, so much the better; some of the best kind of pins used in the female dress are very fit for this purpose. In placing the pins in the holes, if they should be found too long for knocking in by the hammer, they should be shortened by the cutting plyers before the hammer is applied, which will prevent bending, and allow the pins to have a more secure hold of the barrel rim. After all the pins are put in, they must now be shortened to an equal and proper length or height. For this purpose prepare a hard cylindrical steel collet, having a hole in its centre sufficiently wide to allow it to be put readily on the pins; the lower end of it hollowed, the upper end rounded, and the height of the collet about one-twentieth of an inch or a little more; the height depending on the size of the barrel and the diameter of the pins. The collet being placed on a pin, the cutting plyers are applied to cut the pin just over by the rounded end; a small touch of a file takes away the burr made by cutting, and as the hardness of the collet prevents the file from taking any more away from the height of one pin than from another, they must be all of an equal height. This operation being finished, the small burrs made on the top of the pins by the file must be taken off; this is done by a piece of steel wire, about six or seven inches long. The end where it is twirled about by the fore finger and thumb, should, for the length of an inch or so, be made into an octangular form, for the more readily turning it round back and forward. On the face or point of the other end, two notches are made across each other, which may be either angular or round at bottom; the latter may be the better of the two, if rightly executed, and should be made with the round edge of a flat file, whose thickness should not be more than the diameter of the pins. The point where the notches are cut should be hardened, and the inside and bottom of the notches polished, so that a sharpness may be given to take away the burrs easily from the top of the pins.

Plate CCCVIII. Fig. 3.

The shape of the hammer tail is such as is represented at Plate CCCVIII. Fig. 3, a form which makes the hammer easy enough to be drawn, and the tail takes little or no room when falling; and should two pins or notes succeed each other rather rapidly, the nib or point of the hammer tail will not be interrupted by the succeeding pin. In the first musical clocks, and even in those made long afterwards, the bells were all placed on one strong iron bell stud, the opposite end of which was supported by what may be called an auxiliary stud, which occasioned a crampness that prevented the bells, when they were struck by the hammers, from vibrating, or giving out that full tone which they might have otherwise been made to produce; and the improvement made on this, as well as on the quarter bell studs afterwards, was effected by placing each bell separately on its own bell stud, which was made of well hammered brass, having some degree of elasticity. The sweetness given to the tone of the bells by this method was truly surprizing. The bells in this kind of music may be sounding at the time that a succeeding note is struck out and sounding too, which may not be so pleasant to a very nice ear. This can be prevented by having a double set of hammers, and having every tune pinned twice over on the barrel, one set of the hammers having the heads of buff leather, or having a brass head with a piece of cloth sewed over it. These, when they strike the bell, will damp the sound of the note which is last struck. The buff hammer should fall on the bell to be damped, at the same instant that the brass hammer strikes the succeeding note on its bell. This improvement, however, must greatly increase the expence on such a clock; but the effect of buff or cloth hammers is so striking, that the additional price ought not to be grudged.

Plate CCCVIII. Fig. 3.

In Plate CCCVIII. Fig. 3, AA is a circle representing an end view of a clock music barrel, and a few of the lifting pins. The dart shews the direction in which it turns. The letters *a, a, a, a, a,* represents a section or end view of a brass piece thus shaped. The length depends on that of the barrel, and the number of hammers to be let into this brass piece, which is called the hammer frame, the length of it being sometimes three or four inches, sometimes ten or twelve. The flat part of the hammer tails fills up the thick part of the hammer frame, into which slits are made to receive the hammers. Near to the outer and lower angular part at *a* of the frame, a hole *h* is made through the whole length of it, not drilled, but ploughed as the workmen call it, and this is done before any slits are made in it for the hammers. A wire is put through this hole, and through corresponding holes in the flat part of the hammer tails. This wire is their centre of motion, and the holes in them are made so as to have freedom on it, and the flat part of the hammer tails are also made to have freedom in the slits made to receive them. On the under side of the hammer frame at *b*, the hammer springs *c, c* are screwed, one for each hammer, acting on that part of the hammer tail just where it comes out of the thick part of the hammer frame. When the pins in the barrel raise up any hammer by the nib, and carrying it away from the bell, at the instant the pin quits the nib, the spring *c,c*, by its returning force, makes the hammer head give a blow on the bell to elicit the sound. To prevent any jarring in the bell by the hammer head resting or touching it after having given the blow, each hammer has a counter-spring acting near the lower end of the shank, and inside of it. All the counter-springs are made to project from one slip of well-hammered brass, and screwed on the top of three kneed brass cocks, fixed to the upper side of the brass frame. *d d* is a view of the side of one of the cocks;

and *e e* an edge view of one of the counter-springs. *f f* is a side view of one of the bell studs, which are also screwed on the upper side of the hammer frame: an edge view is seen at *f f*, Fig. 4. *g, g, g, g* are edge views of the bells. *g, g*, Fig. 4, is a side view of one of them as fixed to its stud. In some musical clocks, in place of the barrel being made to shift for change of tune, the hammer frame is made to shift, carrying with it all the hammers and bells. The change or shifts of the barrel, is either done by hand or by the clock itself. The mechanism for this commonly consists of a wheel fixed on a steel arbor, on the square of which a band is put, which points to the name or number of the tune marked on a small dial, at which the barrel for the moment stands. The diameter of this wheel is about one inch and a half, and sometimes more or less. The rim is a strong and thick hoop or contrate form, having as many steps on it as there are tunes set on the barrel, the height of the steps being equal to the space from one tune to another. On these steps rest the kneed end of a double lever about four inches long, whose centre of motion is in the middle, and is either upon strong pivots run into a kind of frame, or upon a stout pin, which goes through the lever and the brass stud in which the lever moves. The other end of the lever bears on the end of one of the pivots of the music barrel, which is pressed against it by means of a pretty smart steel spring, acting against the end of the opposite pivot. Concentric with the hoop-wheel, and fixed on the same arbor, is a star-wheel of a number according with the steps on the hoop-wheel, a jumper with a pretty strong spring works into the star wheel, by which means the barrel is kept always to its place, by the lever bearing at one place on every step. Although the Figures which have been given to represent the hammer frame, hammers, springs, and counter-springs, bell studs, and bells of music striking, are not exactly like those which are commonly made to strike quarters in clocks, yet they are equally well calculated for the purpose; only the nibs of the hammer tails need not be so far from their centre of motion, being less confined by the pins in the quarter barrel, which are fewer in number than those on a music barrel. A quarter barrel need not be much in diameter, if five quarters are only to be put on it. If ten is intended to be put on, then the diameter should be double that of the other.

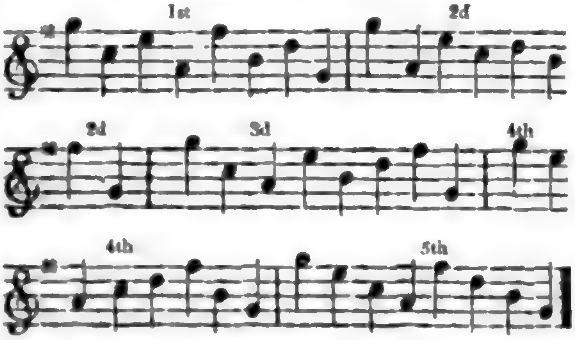
PLATE CCCVIII. Fig. 4.

After having described the method of laying down the tunes on a music clock barrel, it may be thought unnecessary to explain the method of putting on the quarters of a clock quarter or chime barrel. But, simple as it is, we conceive it will be both interesting to the general reader, and acceptable to workmen who may not be in the habit of contriving for themselves, or who may not have had an opportunity of seeing it executed by others.

Method of putting on the quarters on a clock quarter barrel.

Quarters are commonly struck on a set of eight bells, from G to G in octave, or they may be numbered 1, 2, 3, &c. on to 8. The quarter barrel may have eight circles faintly turned on it, so as to correspond to the quarter hammer tails. Five, and sometimes ten quarters are put on the barrel; we shall, however, in this instance only lay five on the barrel. Take a wheel cut into 50 teeth not rounded off, and screwed temporarily on the end of the barrel; provide an index, and a piece of brass bent so as to apply to the barrel when in the turn bench, in the manner of a straight edge, and the index spring tight in the teeth; take a point, and make a slight trace across the circle, which corresponds to high G or No. 1, then move the index a tooth, in the direction the quarter barrel turns when moved by the wheel work; make a trace across the circle intended for the second hammer, and so on. When the eighth circle has been marked, move the index two teeth for the first hammer of the succeeding quarter, and so on till the whole is completed; the barrel may then be drilled and pinned accordingly. Should the intervals between the quarters be thought too little for locking, the wheel, in place of 50, may be cut 55, and this will allow three teeth in place of two for the intervals. G, A, B, C, D, E, F, G, may also be represented by the figures 1, 2, 3, 4, 5, 6, 7, and 8. No. 1. being the high G, and 8. the low G. The changes given in the following set of chimes or quarters, will exhibit how to proceed in putting them on the barrel, after what has been already said.

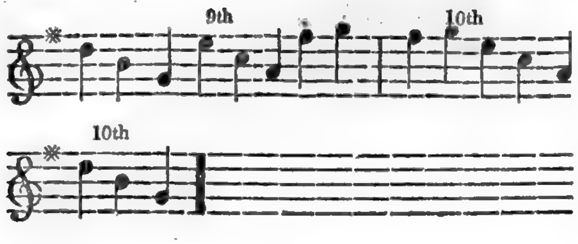
A set of Chimes for Clock Quarters; the barrel making two revolutions in the hour.



Chimes for clock quarters.

With the number of 8 bells and hammers for the quarters of a chime or quarter clock, a great variety may be produced; and where it may be preferred to have the chime or quarter barrel to make one revolution for the ten quarters which are given in the course of every hour, we shall give a specimen of a set of chimes which may be put on such a barrel.

A set of Chimes for Clock Quarter Barrels, which make one revolution in an hour.



On Bells.

Bells.

It is still a point undetermined whether the common shape of the bell, or that which is called the dish-form, and used chiefly in house clocks, is the best. The great expence which attends experiments on bell founding, will probably keep this point long undecided. Being in possession of a manuscript, containing some of Professor Ludlam's remarks on the subject of bell founding,* which we conceive to be very valuable, we shall lay them before our readers. "I saw a great deal of the art of bell founding," says Mr Ludlam, "in the time of the late Mr Thomas Eayre of Kettering, a man who had a true taste for it, and spared no expence to make improvements. Much of tone depends on minute circumstances in the shape; and Mr Eayre had crooks or forms cut on thin boards, carefully taken from the inside and outside of all the good bells he could find. This county (Cambridge) and Northampton abounds with the best bells I ever heard, cast by Hugh Watts of Leicester, between 1630 and 1640. Ringers in general, who are commonly constituted the judges of bells, (and as such are feed by the bell founder) regard neither tune nor tone. The hanging of the bell is all they regard, that they may show their dexterity in change-ringing. That shape of a bell that is best for tone, (a short one) is not the best for hanging, so tone is utterly disregarded; to please the ringers, and to get money, is all. In my opinion, the thinner the bell and deeper the tone the better, provided it is not shelly, that is, like a thin shell, with such a tone as the fragments of a broken Florence-flask will give. A deep tone always suggests the idea of a great bell, is more grave, and better suited to the slow strokes of a church clock, and is heard farther. The clock in St Clement Dane's church in the Strand, London, strikes the hour twice—once on the great bell in peal, and again on its octave or 12th, I know not which; listen to them, and you will perceive which is most agreeable and best heard. The son of Mr Thomas Eayre, who was a good bell founder, cast a dish-bell of five or six hundred weight, for the church clock at Boston, in Lincolnshire, the tone of which was very deep and wild. Mr Thomas Eayre, very early in life, made a curious chime for Sir T. Wentworth, afterwards Lord Malton, and father of the Marquis of Rockingham, which had thirteen dish-bells, the biggest about two hundred weight. This is at Harrowden, near Kettering. Thomas Eayre, his son, and his brother Joseph, being all dead, to their bell-founding business one Arnold succeeded, who had worked with Joseph Eayre, and is now at St Neot's, Huntingdonshire. Arnold I believe to be a much better bell founder than the White Chapel bell founders, though by no means equal to old Thomas Eayre. Romilly always would confound Thomas Eayre with Joseph Eayre, and so imputed the faults of the one to the other. Romilly was so conceited when at Leicester, where there is undoubtedly the best peal of bells in the kingdom, (partly old Watt's and partly Thomas Eayre's) that he would not so much as deign to hear them. I cannot help thinking that a bell of five or six hundred weight, of the dish form, might be cast far fitter for your purpose, than one of the church form. But who will do it? Who has had any experience of bells of this form? It must also be observed, that small differences, in the form, in the shape or thickness of the sound-bole of a church bell, will make great differences in the tone. All I can say is, it is not the weight of metal, but something resulting from the shape of the bell, that gives both freedom and depth of tone, as I can prove by many instances. What that shape is that makes a bell so willing to speak, is a question which a good bell founder ought to be able to answer. It is a known and undoubted fact, that a bell speaks much better, when both the clapper and the bell is hammer hardened, and when they are worked in to touch each other in many points. I now recollect, [that above 40 years ago, Thomas Eayre made a large turret clock, with quarters, for Lady E. Germain, (now Lord G. Germain's) at Drayton, near Thrapton, Northamptonshire, all the bells of which are *Dish-Bells* of a large size. I know not their weight exactly, but suppose the biggest four hundred weight—they are heard a great way."—"There is an instrument brought from China, called a gon or gong, made of hammered brass, or of some sort of a metallic composition, about 16 inches over. The drawing is a section of it.

Ludlam's observations on bell founding.

What I call the sides AA are about four inches deep, and seem to supply the office of the sides of a drum, while the flat part BB answers to the stretched parchment; only there is a round part in the middle to stiffen it. On this raised part you beat with a ball of packthread of four or five inches diameter, fastened to the end of a stick. The metal, at a mean, is about one-eighth of an inch thick, but unequal, the whole form being manifestly raised out of a flat plate by the hammer. The tone is amazingly deep, clear, and sonorous. The note of that I saw, and had some time in my possession, was F, an octave below the F fa ut cliff in the bass." See our article GONG.

Construction of organ clocks.

That music which is produced by clocks with organ barrels must be greatly preferable to that of bells, and the apparatus for marking the tunes on clock barrels is equally suited to do the same on barrels intended by machinery to work or to sound the pipes of an organ; the difference consisting in marking off on the barrel the spaces of the longer and shorter notes, as in place of pins they have staples or bridges of various lengths, according to the length of the note, or the time which the pipe should be allowed to sound it. The very short notes are by pins of different thicknesses. When an organ part is put to a clock, considerable power or force of weight or spring is required; small as the organ may be, or its wind-chest, some force is required to work the bellows, so as to keep the wind-chest full and no more. To work the bellows, that is, to move the lower board of them up and down, on the inside of which is an air valve that opens on the board being moved downwards, and on the motion upwards

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* These remarks are contained in a series of unpublished letters written by that eminent Professor, and copies of which are in the possession of the writer of this article. See p. 123. col. 2. of this article.

it shuts, and the air being then compressed, it is forced into the wind-chest by a communication between them for that purpose, and is ready to give sound to any of the organ pipes the moment when any of their valves should open. This operation with the bellows, though of a different shape, is just the same as with the common bellows when blowing up a fire. The bellows is worked by means of a short crank fixed on one end of the arbor of an endless screw, which works into a trundle of a high numbered pinion, which is on the end of the organ barrel, and nearly of the same diameter with it. On the other end of the endless screw arbor is fixed a small jagged pulley, over which is put an endless silken cord, which being continued, goes round another jagged pulley on the end of a pinion arbor of one of the quick running or fly wheels in the organ train. These wheels are regulated by a fly, by which the velocity of the organ barrel in turning is brought to keep the time required for the music. The wheels, on being impelled by the moving power, which is considerable, (being greater than that used in bell music), communicates their motion by means of the endless cord, and turns the organ barrel. The pins, bridges, or staples, on the barrel turning, act on the tails of levers nearly similar in form to the hammer tails of the bell musical clock, only they are a little longer, and equally moveable on a centre or wire. The other arms of these levers are in an opposite direction, and are about the same length as those which are lifted by the staples on the barrel when turning, and are a little broad and flattish towards the end, where the under side (on the opposite ends rising) press down on the upper ends of the slender rods, whose lower ends then by this means open the valves of the organ pipes, and the sound is prolonged according as the lift is pins or bridges. What has been described constitutes the chief machinery in an organ clock. Many ways may be contrived to set the organ barrel in motion, and at the same time while playing, and at the end of a tune, to make the clock of itself shift the barrel from one tune to another.

Music from steel springs.

Within these two or three years a new species of music by steel springs has been invented at Geneva. From the smallness of the machinery which plays the music, it is very surprising and curious, as it has been put into rings, seals, watches, and snuff boxes. Two ways are used to lift the ends of the springs which give the different notes; one is by a very small barrel, the other by a plate wheel. The last being more adapted to take up little room, is chiefly used in watches. The space for the springs falling, after being bent up, is short. A double set of springs for giving the same notes is made, without which the beauty of the music could not be produced. The number of springs varies, for the most part, from sixteen to twenty-four, or upwards. Those springs which are lifted by the barrel pins are straight, while those which are lifted by the pins in the plate wheel have a sort of part projecting from the end at one side; and this side edge of the spring lying over the top of the pins is taken away so as to clear them. The projecting part at the end of each spring corresponds with its own lifting pin. As the pins are on both sides of the plate-wheel, this allows a greater variety of notes than the barrel can perhaps admit. The springs on the upper and under sides of the plate wheel are sometimes sixteen or seventeen on each side. On the plate-wheel are traced 16 or 17 concentric circles, for the pins to meet their corresponding notes in the springs whose ends come each to their corresponding circle both above and under the plate-wheel. An apparatus on a small scale being made like that which has been described, will serve to put or mark the places for the notes both on the barrel and the plate-wheel; the only difference is, that the barrel will require to be marked by a curved arm sliding on a steel rod. The concentric circles on the plate-wheel, must have short and faint traces across them: This is regulated by a thin straight edge laid in an oblique direction across the circles, and the intersections are afterwards marked by a point. The springs may be easily tuned to their respective notes, as the least thinning or shortening them will make a very sensible alteration on the tone. The tongue of a steel trump, or Jew's harp, shews, in some degree, what may be done in this way by steel springs. The train which regulates this very minute musical machinery, as may very easily be conceived, must be composed of a few very small wheels, the motive force being proportionably small. It must be a great effort of patience and ingenuity to make them play two or more tunes. However beautiful and ingenious the machinery of these small contrivances is, they can only be considered as toys for amusing children.

For further information on subjects connected with HOROLOGY, see LONGITUDE, ORGAN, PENDULUM, TIMEKEEPER, and WATCHES.

HORSE. See MAMMALIA.

HORSES, DISEASES OF. See VETERINARY MEDICINE.

HORSEMANSHIP. See MANEGE.

HORSLEY, SAMUEL, one of the most eminent theologians in modern times, was born in October 1732, and was the eldest son of the Rev. Mr Horsley, minister of St Martins in the Fields. He received the classical part of his education at Westminster School, from which he was removed to the University of Cambridge, where he applied himself principally to mathematical studies. After having taken his degree as master of arts, he went to Oxford in the capacity of private tutor to the Earl of Aylesford, where he received the degree of doctor of laws. On leaving this university, he came to London, where he was elected a fellow of the Royal Society, of which he was chosen secretary in 1773. He published several valuable papers in the Transactions of that learned body, and continued to discharge the duties of his office in a very distinguished manner, till the resignation of the president Sir John Pringle in 1778. Soon after his having settled in London, he accepted the office of chaplain to Bishop Lowth, one of his greatest patrons, who presented him to the rectories of St Mary Newington and Albury in the county of Surrey; appointed him Archdeacon of St Albans in 1778; and, in 1782, conferred upon him the valuable living of South Weald in Essex. In 1788, he was raised to the bishopric of St David's by the interest of Lord Thurlow; and, in 1794, was translated to the see of Rochester, holding at the same time the deanery of Westminster. In 1802, he was promoted to the see of St Asaph; and is generally understood to have had his Majesty's promise of the Archbishopric of York. He died at Brighton on the 4th of October 1806.

These numerous promotions and high prospects as a dignitary in the English Church were fairly earned by the eminent services which he rendered to the cause of sound principles and sacred literature. In 1769, while residing at Oxford, he published a valuable edition of Apollonius; and discovered his thorough qualifications for illustrating the works of the ancient geometers. In 1779, he produced an edition of Newton's Works in five volumes 4to, with commentaries and separate dissertations; an undertaking in which he is generally allowed to have done more than could reasonably have been expected from one whose acquirements on other subjects were so diversified and distinguished; but, at the same time, to have failed in that full illustration of his author, which the improved methods of calculation and analysis might have accomplished. In 1778, he published a sermon on the consistency of the doctrine of divine Providence with the free agency of man, in which he combats the necessitarian tenets with great ability. In 1789, he collected and printed in one volume the tracts which he had written during the preceding six years, in his celebrated controversy with Dr Priestley on the Unitarian system; a discussion in which he is now generally acknowledged to have had a decided superiority, both in learning and argument, and in which his productions must always be read as standard works, and admired as models of clear and powerful reasoning. In 1790, he published a pamphlet without his name, entitled, "A Review of the Case of the Protestant Dissenters," in which he vindicates in a highly nervous style the high church principles on the subject of the test laws. In 1796, appeared from his pen a very learned dissertation on the Latin and Greek Prosodies; in 1800, a critical disquisition on the 18th chapter of Isaiah, in a letter to Lord King; in 1802, a new Translation of the Prophet Hosea, with critical and explanatory notes. Besides many smaller pieces, he was the author of an Elementary Treatise on the fundamental principles of Practical Mathematics, which appeared in three volumes in 1801 and 1803, and of a Critical Essay on Virgil's Two Seasons of Honey, and his Season of Sowing Wheat, with a new and compendious method of investigating the Rising and Setting of the Fixed Stars. There have been published, since his death, three volumes of his Sermons, a volume of his Charges, a volume of his Speeches in Parliament, and a Translation of the Book of Psalms with notes. He has also left in manuscript, a Treatise on the Pentateuch, and on the Historical Books of the Old Testament; and a Treatise on the Prophets, containing Notes on Isaiah, Jeremiah, Ezekiel, Joel, Amos, and Obadiah; which are announced to be in a state ready for the press, and which it is to be hoped, will not be suffered to be lost to the Christian world by any want of encouragement on the part of the public. His son, the Rev. Heneage Horsley, proposes to publish an uniform edition of all his father's works, with a biographical account of the author.

The name of Bishop Horsley stands unquestionably in the first rank of the scholars and divines of the present age. His intellectual powers were of the highest order, and of so versatile a nature, that wherever he applied his attention, he was generally sure to take precedence. He possessed an almost inexhaustible activity of mind united with an ardent spirit of research, and a capability of constant exertion, which, had his pursuits been less various, might have raised him to a still higher point of eminence. In the mathematical and physical sciences, he held a respectable station. In metaphysical acuteness and research, he had few superiors. In classical attainments, and particularly in a critical knowledge of the sacred languages, he occupied the very foremost rank of excellence. In the most recondite theological erudition, he was not surpassed by any of his contemporaries. And, in the church of which he was so distinguished an ornament and support, he was pre-eminent for his consistency and decision, as the champion of a sound and scriptural creed. In public speaking, his voice was sonorous and commanding, and his whole elocution distinct and impressive. In the duties of his Episcopal office, he was eminently exemplary; and, in the see of St David's particularly, he strenuously exerted himself to accomplish a regular system of improvement in the qualifications and condition of its clergy. He examined in person the candidates for holy orders, and inspected carefully the titles which they produced. He treated them, at the same time, with paternal kindness, encouraging them to visit him, assisting them with his advice, and ministering, with a bountiful hand, to their temporal necessities. In his progress through his diocese, he preached frequently in the parish churches, and bestowed liberal donations on the poor. In the House of Peers, he supported the character of an enlightened and eloquent senator; and took a part in most of the important discussions of his time. In his political and ecclesiastical sentiments, he must be classed, and readily classed himself, among high churchmen (a term, which we profess to use not as vituperative, but merely as descriptive); but it has never been doubted, that his zeal was conscientiously sincere; and it is certain, that, on many occasions, he discovered a greater degree of genuine liberality and practical toleration than many who were louder in their pretensions. He was a systematic opponent of the slave trade; and is understood, on good authority, to have been anxious to enter into a parliamentary enquiry into the claims of the Irish Catholics, with a view to grant them whatever privileges might have appeared compatible with the security of the Protestant succession and the Protestant establishment. He was an earnest advocate for mutual forbearance between the two most respectable parties in the Church of England; and the decision of his comprehensive mind on the points in dispute deserves to be emblazoned in every vestry of the English and Irish establishments. "The Calvinists contradict not the avowed dogmata of the church; nor has the church in her dogmata explicitly condemned or contradicted them." He has been charged with harshness and dogmatism in his character and manner, especially as a controversialist, and it would not be easy to exculpate him wholly; but much of this intolerance, often more apparent than real, evidently arose from his zeal for the truth which he defended, and his high sense of its importance. His language, at the same time, however strong, was always dignified; and his works in general rather display an undisturbed liberality of judgment and expression towards the advocates of conflicting opinions. Even his sternest polemical tracts contain many expressions of the most magnanimous candour, of which the following conclusion of one of his letters to Priestley may be given as a striking specimen. "The probability, however, seems to be, that, ere those times arrive, (if they arrive at all, which we trust they will not) my antagonist and I shall both be gone to those unseen abodes, where the din of controversy and the din of war are equally unheard. There we shall rest together, till the last trumpet summon us to stand before our God and King. That whatever of intemperate wrath and carnal anger hath mixed itself, on either side, with the zeal with which we have pursued our fierce contention, may then be forgiven to us both, is a prayer which I breathe from the bottom of my soul, and to which my antagonist, if he hath any part in the spirit of a Christian, upon his bended knees will say, Amen." See *Preface to Horsley's Sermons*; *Monthly Magazine*, 1806, vol. xxii. p. 401.; *Gent. Magazine*, 1806, vol. lxxvi. p. 987, &c. Montucla, *Hist. des Mathematiques*, tom. iii. p. 13. edit. 1803; *Phil. Trans.* vol. lvii.—lxvi.; and *Public Characters* for 1807. (*q*)

HORTICULTURE.

1. By the term Horticulture, is to be understood the whole management of a garden, whether intended for the production of fruit, of culinary vegetables, or of flowers. The formation of a garden may be included also, to a certain extent, under this subject: draining, inclosing, and the forming of screen plantations and hedges, may be considered as parts of horticulture; while the general situation of the fruit and the flower gardens in regard to the mansion-house, and the position of some of their principal component parts, as shrubberies, hot-houses, parterres, and walks, belong more properly to Landscape-*Gardening;* which see.

It is evident, that the horticulture of every country must vary in its nature and objects according to the climate. The great end of this article will be, to exhibit as correctly as possible the present state of gardening in Britain, noticing particularly the improvements which have recently been introduced, especially since the close of the 18th century. After a general prefatory account of the rise and progress of horticulture in this country, we purpose to give a short view of the different kinds of gardens now existing; and then to treat of some general matters, such as situation, soil, manures, enclosure-walls, &c. After this, the fruit garden will be particularly attended to; the various kinds of fruit-bearing plants will be mentioned, and the most esteemed varieties of each; and here the different kinds of forcing-houses will claim attention. The kitchen garden will fall next to be discussed, in the same minute way. After which, the flower garden will be considered; but here abridgment must be studied; for to speak of *all* the ornamental plants cultivated, would be an endless task: the delicacies of Flora will not, however, be neglected, and the sorts called "florists flowers" will be enlarged upon. A few remarks on the diseases of plants, and on their prevention or cure, will conclude the whole.

Without detaining the reader with trite remarks on the antiquity of gardening, or discussions concerning the celebrated groves of the Hesperides, the hanging terraces of Babylon, or other gardens of remote ages, we shall at once proceed to give some short account of the rise and progress of modern horticulture. In doing this, it will be necessary to confine our attention almost exclusively to our own country. To discourse of the progress of the art in other countries, would not only swell this part of the article to an improper size, but would be an unprofitable undertaking. Nothing can be more evident than the fact already hinted at,—that the practice of gardening in one country cannot be applied to any other, unless that other greatly resemble the former in climate. Useful hints may no doubt be occasionally drawn, from observing the modes in other countries. But it is scarcely necessary to remark, that in warm climates the practice must differ very widely from that which obtains in the temperate or the cold. In the former, the plants which require to be fostered in our stoves, either grow spontaneously, or are cultivated in the open fields; while the greater part of our common pot-herbs * refuse to flourish in sultry regions. Again, the far northern countries of Europe, Sweden, Norway, and Russia, possess peculiarities of climate: snow covers the soil throughout the winter, and the summers are uninterruptedly bright and warm. Even in Britain, such is the difference of climate between the favoured counties of the south-west of England, and that part of the island which lies to the north of the Cheviot Hills, that the same rules cannot be applied to both, without very considerable modification. The horticulture of the north of France, of Belgium, Holland, and Denmark, may in general be considered as approaching to that of South Britain; and these countries may frequently afford mutual lessons to each other, each availing itself of the other's discoveries, and adopting its improvements.

Rise and progress of British horticulture.

2. The origin of British horticulture is completely involved in obscurity. It may in general be asserted, that most of our best fruits, particularly apples and pears, were brought into the island by ecclesiastics in the days of monastic splendour and luxury, during the 12th, 13th, 14th, and 15th centuries. Gardens and orchards ("orti et pomaria") are frequently mentioned in the earliest chartularies extant; and of the orchards many traces still remain, in different parts of the country, in the form not only of enclosure-walls and prepared fruit-tree-borders, but of venerable pear-trees, some of them still abundantly fruitful, and others in the last stage of decay. Of the state of horticulture previous to the beginning of the 16th century, however, no distinct record exists. Till then, it is generally said, that some of our most common pot-herbs, such as cabbages, were chiefly imported from the Netherlands, their culture not being properly understood in this country; but of this, there is no distinct evidence, and the thing seems unlikely. From the "Itinerary" of Leland it appears, that even greenhouses were not then unknown in England.

Fitzherbert.

3. During the reign of Henry VIII. rapid steps of improvement were made in horticulture. According to some authors, apricots and musk-melons were introduced by that monarch's gardener; and different kinds of salad herbs and esculent roots were, about the same time, first brought into the country from Flanders. Henry had a fine garden at his favourite palace of Nonsuch, in the parish of Cheam in Surrey. Here Kentish cherries were first cultivated in England. The garden wall was fourteen feet high; the wilderness occupied ten acres; "lelacke trees which beare no fruite, but only a plesaunte flowre," are mentioned among the rarities contained in it; as are also yew and lime trees. In the year 1534, Fitzherbert, the father of horticultural writers, published his "Booke of Husbandrye."

4. Queen Elizabeth was both a horticulturist and a florist, if we may believe a poet celebrating majesty:

> *Cultor herbarum, memor atque florum.* †

Mountain.
Hyll.
Mascall.

During her reign, Dydimus Mountain published the "Gardener's Labyrinth;" Hyll, the "Profitable Arte of Gardening;" and Leonard Mascall, (the introducer of several good pippins,) the "Arte and Manner how to plant and graffe all sorts of trees," &c.: While Barnabe Googe, Esq. translated the "Foure Bookes of Husbandrie of Conradus Heresbachius." All of these works are printed in black letter, and have become extremely

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* By the term *pot-herbs*, gardeners and green-grocers frequently understand only aromatic plants used for seasonings: we use it, correctly, to signify the *olera* in general.

† *Archæologia*, vol. vii.

Gerarde.

Sir Hugh Platt.

rare. With the exception of the first mentioned, they are, generally speaking, little more than compilations from Varro, Columella, Palladius, Cornelius Agrippa, Cardanus, and some old French and Italian writers. In Elizabeth's days, carnations were, it is said, first cultivated by the Flemings at Norwich, and nearly at the same time tulip roots were brought from Vienna to England. Orange and lemon trees now became known. The "Herball, or Historie of Plants," by John Gerarde, first appeared in 1597; and a second edition, enlarged and improved by Johnston, came out about forty years afterwards. It may, in passing, be remarked as somewhat curious, that so distinguished a writer as Gerarde, and a piece so well known and frequently quoted as his "Herball," should not be mentioned by Professor Martyn, in his chronological list of authors and books on gardening. Towards the close of the 16th century, Sir Hugh Platt published "The Jewel-House of Arte and Nature," a little book not destitute of merit; and early in the following century appeared a posthumous work of his, called "The Garden of Eden."

5. A fine garden was formed at Theobald's, near Waltham Abbey, by James VI. (I. of England). In the year 1640, about thirty years after the formation of this garden, it was described by Mandelslo * as a large square, surrounded with fruit-tree walls, containing also espalier trees on some sort of trellises, and ornamental arches of trees; besides a parterre for flowers.

Parkinson.

6. His son Charles I. seems to have patronized gardening. He appointed the celebrated Parkinson his herbarist. In 1629, appeared the first edition of this man's great work in folio, entitled, "*Paradisi in sole Paradisus terrestris*; or a Garden of all sortes of pleasant Flowers, with a Kitchen Garden of all manner of Herbs and Roots, and an Orchard of all sort of Fruit-bearing Trees," &c. This may be considered as the first general book of English gardening possessing the character of originality. From his lists of flowers, shrubs, and fruits, the state of our gardens at that period may be pretty accurately guessed. The laurel or bay-cherry was then very rare, and considered as a tender plant, being defended "from the bitterness of the winter, by casting a blanket over the top thereof;" and the larch tree was only nursed up as a curiosity. For the culture of melons, he recommends an open hot-bed on a sloping bank, covering the melons occasionally with straw,—the method practised in the north of France at this day. Cauliflowers, celery, and finochio, were then great rarities. Virginia potatoes (our common sort) were then rare; but Canada potatoes (our Jerusalem artichoke) were in common use. The variety of fruits described, or at least mentioned, appears very great. Of apples there are 58 sorts; of pears, 64; plums, 61; peaches, 21; nectarines, 5; apricots, 6; cherries, no fewer than 36; grape vines, 23; figs, 3; with quinces, medlars, almonds, walnuts, filberds, and the common small fruits. The number of approved apples, pears, plums, and cherries, at the present day, is not nearly so large. Of florists flowers, he mentions about 50 varieties of hyacinth; above 60 anemonies; but only 20 ranunculuses.

Blith.

Austen.

7. In the time of the Commonwealth, Walter Blith produced rather an ingenious work, with the quaint title of "English Improver improved, or the Survey of Husbandry surveyed;" and Ralph Austen published a "Treatise of Fruit Trees," also a book of merit.

8. After the Restoration, Charles II. brought over Le Nôtre, the favourite gardener of Louis XIV. and designer of the gardens of Versailles, to lay out and plant St James's and Greenwich Parks, which still remain very creditable monuments of his taste. Rose, who was gardener to Charles, had studied the art in France. It is remarked by the Honourable Daines Barrington, that at the installation dinner at Windsor, 23d April 1667, cherries, strawberries, and ice-creams were produced, shewing that the king possessed both hot-houses and ice-houses, and that his gardener was an adept at forcing, for strawberries require considerable nicety of management.

Evelyn.

9. From about the middle to the end of the 17th century, the well known John Evelyn, Esq. was the chief promoter of almost all horticultural improvements, forming an era in the history of British planting and gardening. Soon after returning from his travels on the continent, he translated "*Le Jardinier François*, instructing how to cultivate all sorts of fruit-trees and herbs for the garden." In 1664 appeared his celebrated "Sylva, or a Discourse of Forest Trees; with Pomona, an appendix concerning fruit-trees; Acetaria, a discussion of sallets," &c. His "*Calendarium Hortense*, or Gardener's Almanack, directing what he is to do monthly throughout the year," was also at first added to the Sylva, but was soon afterwards published separately, and went through many editions. This useful manual, laid the foundation of the successive *Gardener's Calendars* which have been published by Miller, Abercrombie, and Nicol. In 1693, his translation of Quintinye's "Complete Gardener" made its appearance, in folio; and, six years afterwards, he ushered into the world an octavo edition, "abridged and improved by George London and Henry Wise," two of the most distinguished gardeners and nurserymen of their day, and whose names have been consecrated by Addison in his paper on gardening in the "Spectator," (No. 477.) They had both been apprentices of old Rose, and succeeded him in the office of royal gardener. They converted an old gravel-pit in Kensington Gardens into a picturesque hollow of foliage, producing an effect in gardening which the critic compares to the sublime in epic poetry, and exclaims, "Wise and London are our heroic poets!" It is curious, that while the labours of Evelyn justly placed him at the head of the improvers of his time, he should have missed an opportunity, fairly placed within his reach, of handing down his name as the greatest horticultural benefactor of Britain. In March 1662, it was proposed to the Royal Society to recommend the cultivating of potatoes with the view of preventing the recurrence of famine; Evelyn was particularly consulted, and was requested to mention the proposal at the end of his Sylva, then announced for publication. He does not seem to have complied with this request, nor to have paid any attention to the culture of the plant: he merely mentions it in his Acetaria, and dismisses it with apparent indifference. This American plant, however, has proved a treasure to this country, "compared with which the mines of Potosi are worthless."

Le Gendre.

10. During the period of which we are speaking, several books on gardening came out, some of them countenanced by Evelyn, and others in which he took no share. One of the earliest of these was the translation of an essay on the management of fruit-trees, by the Sieur Le Gendre, curate of Henonville, "wherein is treated of nurseries, wall-fruits, hedges of fruit-trees, dwarf-trees, high standers," &c. He wrote from the experience of a long life, the leisure of which had been

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* Travels by John Albert de Mandelslo, near the end. In the English translation, the account of King James's garden, &c. is omitted, as uninteresting!

Sherrock. Rea. Worlidge. Meager. Sir William Temple.

spent in the "ordering of fruit-trees." He was one of the first who attended to the proper training and pruning of wall trees; he boldly condemns the absurd taste, then prevalent, of cutting fruit-trees into the shape of lions or pyramids, but he was not able to divest himself of the doctrine of the moon's influence, and the necessity of planting and pruning only at certain periods of her waxing and waning. About the same time, Dr Robert Sherrock published, "The History of the propagation and improvement of vegetables by the concurrence of art and nature;" a work containing a reasonable portion of information, disguised with a good deal of pedantry. Soon after, John Rea, gent. published his "Flora, or a complete Florilege," folio; in three parts: "1. Flora, treating of the choicest plants, flowers and fruits that will endure our winters; 2. Ceres, containing such plants or flowers as are yearly, or every other year, raised from seeds; 3. Pomona, treating of the best garden fruits, of evergreens, and flowering shrubs." This was followed, first, by a "*Systema Agriculturæ*," and then by a "*Systema Horticulturæ*," by J. W. (John Worlidge) gent.; and by the publication of the "English Gardener," by Leonard Meager, "above thirty years a practitioner in the art of gardening." This last contains a good deal of useful information: it is divided into three parts; 1. Of planting stocks, fruit-trees, and shrubs; 2. Kitchen garden; and, 3. Garden of pleasure.—The second volume of Sir William Temple's Miscellaneous Works, it may be mentioned, contains a curious account of the state of gardening in England in the close of the 17th century.

11. King William and Queen Mary appointed Dr Plukenet, a man distinguished for botanical knowledge, and author of a Phytographia and other works, to be their herbarist; and, under his directions, collectors were dispatched to the Indies in search of ornamental plants.

Lawrence. Bradley. Switzer.

12. Early in the 18th century, Lawrence published "The clergyman's Recreation, shewing the pleasure and profit of the art of gardening." But Richard Bradley, F. R. S. and Professor of Botany at Cambridge, soon eclipsed all other writers of this period, both for the number and the influence of his horticultural publications. They exceeded twenty in number, and were generally written in a popular style: several of them, as might be expected, are mere compilations, and others are avowed translations. The writings of Switzer, however, about the same time, also acquired a share of celebrity. They extend to six volumes in octavo, embracing, besides "*Ichnographia rustica*," a "Practical fruit gardener," and a "Practical kitchen gardener."

Miller.

13. In 1724, appeared in two octavo volumes, the first edition of the "Gardener's Dictionary," by Philip Miller, of the Botanic Garden at Chelsea. He professes to collect and digest the labours of his predecessors; but the book partakes largely of the character of an original work, and it soon attracted general notice. He asserts that gardening never arrived to any considerable pitch in England till within thirty years last past, *i. e.* from 1690 downwards. Seven years after the publication of the octavo edition, which is now very scarce, the first folio edition came out. In the preface he gives some account of ancient gardens, and also of English gardens in the time of Charles the Second and William and Mary. The descriptions of numerous plants introduced into England, chiefly from America, during the first half of the 18th century, with details of horticultural improvements of different kinds, gradually swelled the work to two volumes in folio. In each successive edition (as observed by Dr Pulteney *) it received such improvements and augmentations, as have rendered it in the end the most complete body of gardening extant. In evidence of the estimation in which it is held on the Continent, it is enough to mention that there are French, German and Dutch translations of it, and that some of the continental writers bestow on the author the title of *hortulanorum princeps*. Till the seventh edition, the system of Tournefort was followed. In this the names and system of Linnæus were adopted. In the eighth edition, being the last published by Miller himself, he informs us, that the plants then cultivated in England (1768), were more than double the number known when the first folio edition appeared (1731.) In this edition the plants were first distinguished by the short *trivial* names, invented by Linnæus to supersede the tedious *specific* denominations previously in use. The Gardener's Dictionary, it may here be added, has since been enlarged and improved by the late Professor Martyn of Cambridge, and brought before the public in four volumes folio, forming, as he very modestly styles it, "a digest of what was known in gardening and botany at the end of the 18th century." This great undertaking occupied the learned and laborious professor for nearly twenty years; but it is a work which will long maintain the horticultural reign of the name of Miller, and which is calculated at the same time to establish his own fame.

Hitt.

14. In the early part of Miller's time, Batty, Langley, and Ellis, published various horticultural works of some merit. In 1755 Thomas Hitt produced his "Treatise on Fruit-Trees;" and in it he proposed an improved mode of training wall-trees, by regular horizontal branches, with upright bearers. This is a work well deserving of attention; and the author has not, it is believed, received all the praise to which he is entitled. While practical works such as those now mentioned, engaged the attention of horticulturists in general, some philosophical pieces also appeared, and justly acquired celebrity for their authors; particularly, "Vegetable Statics" by Hales, and the "Principles of Agriculture and Vegetation" by Dr Francis Home, father of the present distinguished professor of Materia Medica in the University of Edinburgh.

Abercrombie.

15. From the middle to the end of the 18th century, one of the most popular and useful writers on horticultural subjects was John Abercrombie, who, either from diffidence or some other motive, at first published his writings under the borrowed name of *Thomas Mawe*. It is said he was patronized and encouraged by the celebrated Dr Oliver Goldsmith. He was the son of a market-gardener near Edinburgh, and had gone into England when a young man, and after acting as a workman for some years at Kew Gardens, had been enabled to begin business as a nurseryman at Hackney. The work entitled "Every Man his own Gardener" has passed through at least twenty editions. This is formed on the plan of a calendar, containing practical instructions under detached monthly heads. Before his death, which happened in 1806, he had prepared another work, entitled "The Practical Gardener," in which the systematic method is adopted, of connecting under one article every thing relative to the culture of the same plant. This last has been published in the form of a thick duodecimo volume. He wrote also,

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* Sketches of Botany in England, Vol. II.

"The British Fruit Gardener," "The Complete Forcing Gardener," and "The Complete Kitchen Gardener and Hot-bed Forcer," and still other books of similar import. It is perhaps to be regretted that he was induced by booksellers to multiply his publications so much, this circumstance having tended to bring upon him the imputation of book-making, and to excite some degree of prejudice against him. In point of fact, however, he understood the business of gardening extremely well, and his writings altogether afford a very complete view of horticultural operations.

Marshall.

16. Another deservedly popular work on horticulture remains to be noticed. It is written by the Rev. Charles Marshall, a clergyman of the church of England, who is evidently a very zealous amateur gardener. The title is, "An Introduction to the Knowledge and Practice of Gardening." A great deal of correct information is here condensed into little space, and conveyed in perspicuous and unaffected language. There is subjoined to it a compendious *calendar*, better calculated, we think, to be useful as a remembrancer, than any one published since the time of Evelyn.

Speechly. Forsyth.

17. The "Dictionary of Gardening," bearing to be written by *Alexander Macdonald, gardener*, in two volumes 4to, is an expensive work which has not acquired much reputation. It appears to be little more than a compilation, and is certainly not the work of a practical gardener; but it necessarily includes a great deal of useful information. Of late years, the culture of the vine and of the pine-apple has been very well treated by Speechly, in separate works. Forsyth's "Treatise on Fruit-trees and their diseases, with a particular method of cure," first appeared in 1791, in 4to. The royal patronage, kindly bestowed on an old and meritorious servant, secured to this work a considerable degree of attention, and even procured for the author the extraordinary distinction of a parliamentary reward. Many excellent remarks are to be found in the book. In 1802, it was republished with improvements in an octavo form.

Botanical Magazine. Maddock. Cushing.

18. Curtis's "Botanical Magazine" was begun in 1787; and it has been continued in monthly numbers, with little intermission, ever since; Dr Sims having edited the work since Mr Curtis's death. Important hints are frequently thrown out as to the habits, mode of cultivation, and uses, of the plants described and figured. Maddock's "Florist's Directory," appeared in 1792; and it is still the standard book of instructions for the cultivation of the hyacinth, tulip, ranunculus, anemone, auricula, carnation, pink, and polyanthus, the favourites of the *florist*, strictly so called. The "Exotic Gardener," by J. Cushing, foreman to Messrs Lee and Kennedy of Hammersmith, is the latest and best treatise on the management of the hot-house, greenhouse, and conservatory; and on the soils suitable to tender exotics in general.

Knight.

19. In the Philosophical Transactions for 1795, the first of Mr Thomas Andrew Knight's horticultural papers made its appearance: it is entitled, Observations on the grafting of trees. In the Transactions for 1799, 1801, and 1803, are contained his ingenious papers on the fecundation of fruits, and on the sap of trees. His excellent little "Treatise on the culture of the Apple and Pear," was published in 1797. He has presented several interesting communications to the Horticultural Society of London, which are published in the Transactions of that Society, to be afterwards noticed.

In the hasty sketch which has now been given of horticultural writers in England, many have been passed over, some of whom would deserve notice, and perhaps commendation, in a more detailed account.

Reid. Justice. Gibson. Gordon.

20. Scotland has been more distinguished for producing excellent practical gardeners than good publications on the art of gardening. There does not appear to have existed any Scottish system of gardening, as a separate book, till the beginning of the 18th century, when "The Scots Gard'ner" was published by John Reid, gardener to Sir George Mackenzie of Rosehaugh. The work is divided into two parts; the first treating of contriving and planting of gardens, orchards, avenues, and groves; the second, of the propagation and improvement of forest and fruit trees, kitchen herbs, roots and fruits; with a gardener's calendar; the whole adapted to the climate of Scotland. The style is very inaccurate; but the matter evinces not only an acquaintance with previous horticultural works, but a practical knowledge of the subject. About thirty years after the publication of Reid's book, there appeared "The Scots Gardener's Director, by James Justice, F. R. S. and one of the principal clerks of Session," (*i.e.* of the Court of Session or supreme civil court of Scotland.) This is characterized by Professor Martyn, as "an original and truly valuable work, founded upon reflection and experience." Nearly at the same time Dr Gibson published an anonymous octavo volume on fruit-trees, containing many useful remarks, and some curious notices concerning the history of the most esteemed apples and pears of Scottish origin, or which are generally supposed to be of Scottish origin. In 1774, there appeared a small octavo volume entitled, "The Planter's, Florist's and Gardener's Pocket Dictionary, by James Gordon, nurseryman at Fountainbridge near Edinburgh." It is avowedly a compilation; but the author being a practical gardener, occasionally gives his own opinions and practice. It has already been seen, that several of the Scottish gardeners who have settled in England, have attained distinction as authors. We allude, in particular, to Abercrombie, the voluminous writer lately spoken of, and to Forsyth, the author of the Treatise on Fruit-trees.

Nicol.

21. Among the recent Scottish writers on gardening, one remains to be mentioned, who will long hold a distinguished place,—the late Mr Walter Nicol. He was the son of the gardener who planned and executed the extensive pleasure-grounds of Raith in Fifeshire; and here he received his horticultural education. He afterwards acted for some time as gardener to the Marquis of Townsend at Reinhamhall in the county of Norfolk; but he left England in order to take charge of the fine gardens and grounds of General Wemyss of Wemyss-Castle in Fife, the improvements there having been conducted under the directions of his father. Here he observed a praiseworthy practice now too much neglected by head-gardeners,—that of instructing his young men or assistants, not only in botany, but in writing, arithmetic, geometry and mensuration. He used to remark, that he thus not only improved his scholars, but taught himself, and made his knowledge so familiar, that he could apply it in the daily business of life. In this way he gradually became qualified to communicate his information to the public. In 1797 the first of his works appeared, under the title of "The Scots forcing Gardener," in one volume octavo. About this time he changed his mode of life, and dedicated his whole attention to the planning and improving of ornamental grounds. In 1803 he published the "Practical Planter," a book which both increased his reputation as a writer, and extended his employment as an improver. In 1809, appeared the "Villa Garden Di-

rectory," a little book which soon acquired the high character which it still retains. The "Gardener's Calendar," in one large volume octavo, came out in 1810; and forms at this day one of the best books on horticulture in our language. In the same year he undertook an extensive journey through England, visiting all the principal seats and plantations in that country; and on his return he made some progress in composing a "Planter's Calendar." But after a few weeks illness he died, on the 5th March 1811. His last work just mentioned, has since been completed and published by his friend Mr Edward Sang, nurseryman at Kirkcaldy in Fife.

Horticultural Society of London.

22. In 1805, a Horticultural Society was instituted at London, under the patronage of Earls Dartmouth and Powis, Sir Joseph Banks, and other distinguished characters. The first volume of its Transactions appeared, in 4to, in 1812, containing several useful and scientific communications, by Mr T. A. Knight, Mr R. A. Salisbury, and other ingenious horticulturists. In 1809, the Caledonian Horticultural Society was established at Edinburgh by the individual exertions of that venerable physician and excellent amateur gardener Dr Andrew Duncan senior, Professor of the Institutes of Medicine in the University there. The Society has been fostered by several of the Scottish nobility and gentry, particularly the Duke of Buccleuch, the Earl of Wemyss and March, the Earl of Leven, Sir James Hall, Sir George Stewart Mackenzie, Sir George Buchan Hepburn, and others. It publishes Memoirs, in the octavo size, in detached parts or numbers, two parts generally appearing in the course of the year; and some important enough papers have in this way been brought before the public. A desire of improving their knowledge of gardening has thus been excited among gentlemen; and the intelligence and zeal of practical cultivators is thus, in the most unassuming way, made known to the world.

Caledonian Horticultural Society.

Importance of employing a good gardener.

23. Perhaps no fitter place may occur for warning gentlemen of the value of the services of an experienced gardener, and of the propriety of employing only one who has made himself acquainted with all the parts of his business; as well as for inculcating on gardeners themselves the necessity of their diligently and practically studying every branch of their profession. A well informed and judicious gardener, instructed by experience, is a treasure which every gentleman should prize. Numerous as are the books on gardening, and excellent as some of them undoubtedly are, there are many parts of the gardener's duty for which no general rules can possibly be laid down: like the physician, he has to deal with the living principle, and his treatment, of his trees especially, must vary, according to a thousand nameless circumstances. Much must depend at all times on his own sagacity and observation; but very much is to be learned by a young gardener, from practising under the eye of an experienced master. A gardener ought to have some knowledge of chemistry, particularly of the doctrines of heat, of the nature of water, and of vegetable physiology. All good practical gardeners, indeed, become chemists to a certain extent without knowing it.

Botanical gardener.

Fruit-gardener.

Kitchen gardener.

The profession contains different departments. The cultivator of rare plants, or the botanical gardener, may excel in his own department, and yet be very little acquainted with the proper management of fruit-trees. The fruit-gardener generally possesses a knowledge of the culture of kitchen-vegetables: but a great proportion of the common order of workmen who have acquired a competent knowledge of the last-mentioned branch of horticulture, are extremely ill informed concerning the treatment of fruit-trees. 1. The business of the botanical gardener implies, as already remarked, the cultivation of all sorts of rare plants, either in the open border, in frames, in the green-house, the conservatory, or the stove; the adapting of the soil and artificial climate, to the respective kinds of plants; a discriminating eye, and an acquaintance more or less familiar with the characters and names of the genera and species of plants as described by Willdenow, at least of such as are contained in the Hortus Kewensis, or the Cambridge Catalogue. To these qualifications must be added, general taste in the disposing of plants in borders, and in the forming and keeping of ornamental grounds. 2. The fruit-gardener should have a correct knowledge of the different kinds of fruit-trees, and the principal *varieties* of each kind; he must be familiarly acquainted with the method of training and pruning suited to each sort, and must at the same time possess judgment and experience to enable him to adapt the degree of pruning or mode of training to the peculiar circumstances of the individual tree. He must understand the formation of fruit-tree borders, the operations of grafting and budding, and the preserving of blossom. The peach-house, the vinery, and the pine-stove, belong to his department, as well as the melon frames, and some other subordinate matters. Much may be learned from authors; from Miller, Forsyth, Hitt, Speechly, and others; but an intimate acquaintance with the proper training, and the proper pruning and disbudding of wall trees, is to be acquired only by observation and practice, as they vary continually, according to the soil, aspect, luxuriant or weakly state of the tree, and even according to the season. 3. The kitchen-gardener's duty is generally thought to be very simple and easy; but he who can perform it neatly and with success, may be accounted a good general gardener. The rearing of several culinary articles requires particular attention; such as asparagus, celery, sea-cale, mushrooms, and above all, melons and cucumbers. Great assistance may be derived from books,—from Abercrombie's Practical Gardener and Nicol's Calendar; but a person who has never witnessed nor practised any of the nicer parts of the kitchen-gardener's duty, will be but ill qualified to attempt them.

The public nurseries are useful seminaries to young gardeners. The overseers of these establishments are generally well-informed persons, and dexterous workmen, having been selected on account of possessing these qualities. Many very useful parts of the profession may here be acquired; such as the level-digging of ground, and neat finishing off of beds or borders,—apparently simple matters, in which, however, many gardeners are extremely deficient. In some nurseries extensive collections of hardy and green-house plants are kept, and a knowledge of the culture of these may thus be acquired. Nor is the knowledge of the modes of raising from the seed and rearing in nursery-beds, of the various forest-trees, an inconsiderable matter: in many places, indeed, the head-gardener is required to maintain a nursery of seedling forest-trees, for the use of his master's estate. In the public nurseries a knowledge of the processes of grafting and budding may be acquired; but the gardener who has studied only in this school, will afterwards discover how much he has to learn as to the proper wood to be used for grafts, as well as to the size and quality of the stocks. Under any of the first rate market-gardeners a young man may learn many parts of his profession with great advantage, particularly the raising of all sorts of pot-herbs and salads, and the forcing of many of them. But here too he will labour under disadvantages; for in few such gardens can he acquire any knowledge of the management of fruit-trees, particularly peaches, apricots, and the finer sorts of pears.

A young gardener who has spent his time in places where the proper management of fruit-trees was not attended to, or where no opportunity of attending to it existed, may possibly be willing to accept lower wages, in order to compensate for the defect of his education. But the proprietor of the garden will soon find himself a loser by the injudicious economy of employing him: and if it were a general rule steadily followed by gentlemen, not to employ as their gardeners persons who had not duly sought opportunities of gaining an acquaintance with the different branches of their profession, young men of merit would, instead of grasping at the situation of head-gardener immediately upon the expiry of their apprenticeship, be convinced of the necessity of *practically* studying every department of their "multifarious and numerous employment," as Evelyn happily styles it. In Germany, it may be remarked, a gardener has not only to serve a long apprenticeship, but to pass certain examinations, before he can be recommended to a situation as head-gardener. In this country there is no such regulation; and the greater necessity, therefore, for the employer being able to judge of his gardener's qualifications.

Scottish gardeners.

24. Scotland has long been distinguished for producing gardeners in greater numbers than any other country of Europe; and several of them have risen to the highest eminence in their profession. At the present day many of the nobility and gentry of England employ Scottish head-gardeners; while the numbers of those of an inferior order, to be found in every county south of the Tweed, is quite surprising. Some of the causes of the very great number, and of the real excellence, of the Scottish gardeners, have been assigned in the 9th chapter of the "General Report of Scotland." One is to be found in the early education secured to the children of the labouring class in that country, by the ancient and most laudable institution of parish schools: another, in the hardy mode of life and sober disposition of the young men, which have very generally gained them the esteem of *English* masters; and a third, in the tendency which struggling with a very variable climate at home, has to call into action all the powers of the mind, and to create a habit of unceasing attention to the duties of the station. It may here be mentioned as a striking and very honourable trait in the character of the Scottish master-gardeners of the last age, (already mentioned, § 21.) that it was a common practice among them to spend a part of the evening in instructing their apprentices in different branches of education, particularly arithmetic, mensuration, drawing of plans, and botany. Even at this day, there are still in some places of Scotland to be found the remains of this praiseworthy custom. A turn for reading and study was thus created among young operative gardeners; and to this, their rise in life might in many instances be traced. The taste for reading was perhaps never more prevalent among gardeners than at this day. Nor do they entirely neglect geometry, though it must be admitted that this kind of knowledge is on the decline among them. It is not, indeed, now nearly so necessary as formerly to the professional gardener, grounds being no longer planned into regular mathematical figures, and topiary work being altogether exploded.

Classification of gardens.

25. We have little fear of being accused of partiality when we give a favourable report of the character of Scottish gardeners, the justness of their claim of merit being universally recognized: but, without enlarging farther on the topic, we proceed to give some very general account of the different kinds of gardens now existing in Britain. All of them, we think, may be arranged under one or other of the following divisions. a. Royal gardens, and public botanic gardens. b. The gardens of noblemen and gentlemen of great opulence. c. Villa gardens. d. Cottage gardens. e. The public nurseries, which, especially near London, may without impropriety be ranked as gardens. f. Market gardens. On each of these heads, a few examples and observations seem necessary for illustration, and at the same time they may prove not unentertaining.

Royal Gardens.

Royal gardens. Kew.

26. The Royal Gardens at Kew, on the banks of the Thames near London, are perhaps the first in the world for variety of plants. They were originally planned by that distinguished character Frederick Prince of Wales, father of King George III. The extent is about 120 acres. The surface is flat; but owing to the tasteful disposition of trees and shrubs, the grounds exhibit a considerable variety of scenery. They are nearly surrounded by wood, amidst which rises a pagoda, or Chinese temple, to the height of 160 feet: this was designed by Sir William Chambers, who afterwards published a description of the gardens and palace of Kew, in folio. The exotic garden was established about the year 1760, after the Prince's death, chiefly by the influence of the Marquis of Bute, a great encourager of botany and gardening. He placed it under the care of Mr William Aiton, who had long been assistant to the famous Philip Miller at Chelsea. The principal green-house and orangery is 145 feet long, 25 high, and 30 broad. About 1794, a large green-house, 110 feet long, was erected, for the reception of African and Cape plants only. There are twelve other hot-houses of various descriptions. Adding together the lengths of all the hot-houses, the garden contains no fewer than 839 feet in length of glass; and besides this, about one-half of the houses have covered borders in front, for the protection of different kinds of bulbs, and alpine plants, during winter. One of the hot-houses is appropriated to the palm and fern tribe, displaying the gigantic species of warm climates almost in their native luxuriance and beauty. Another is devoted to the plants of New Holland, which have a character of foliage peculiar to themselves, so that the botanical visitor finds himself suddenly carried, as it were, into a new world. A third contains chiefly the plants of China, and of these the collection is very rich, a magnificent assortment having some years ago been procured from Canton, accompanied by a Chinese gardener to take care of them. A catalogue of the plants of the garden, entitled "Hortus Kewensis," was first published in 1768 by Dr Hill. A more scientific work, under the same title, was given to the public in 1789, by Mr Aiton the superintendant, assisted by Dr Solander; this extended to three volumes, octavo. Between 1810 and 1813, an improved and enlarged edition, in five volumes, octavo, was published by Mr William Townsend Aiton, who had succeeded his father: he was assisted in the first three volumes by the late Mr Dryander, and, after the death of that botanist, in the remaining two volumes, by Mr Robert Brown, author of the "Prodromus Floræ Novæ Hollandiæ," and justly considered as one of the very first botanists of the age.

Hampton court.

The Royal Gardens at Hampton Court were laid out by London and Wise, already mentioned as nurserymen and gardeners of eminence in the reign of King William. A labyrinth in the wilderness quarter, and some other remains of the old style, are here still to be seen, having in some strange way or other escaped during the revolutions of taste, and the desolating improvements of Kent and Brown. The winding walks of the labyrinth are about half a mile in length, although the entire space occupied by it does not exceed a quarter of an acre. In a grape-house on the south side of the palace, is a Black Hamburgh vine, which has been much spoken of: the stem is more than a foot in circumference; one principal branch, trained back, measures 114 feet in length; and the plant has produced, in one season, 2200 bunches, weighing on an average 1lb. each.

Kensington.

The gardens at Kensington have long been celebrated. They were greatly improved by the late Mr Forsyth, who certainly succeeded in renovating the fruit-trees, and rendering them productive of excellent fruit. Too much was probably ascribed to the composition, now generally known by the name of *Forsyth's plaster*, and it was no doubt injudicious to bring such a matter before the British parliament. The effect of the pre-eminent degree of patronage bestowed seems unluckily to have been to excite an undue prejudice against the practices recommended in the Treatise on Fruit-trees.

Frogmore.

The gardens at Frogmore near Windsor have been formed chiefly under the direction of Charlotte Queen of George III. and of Princess Elizabeth, one of their daughters. The gardens display much taste, and are kept in excellent order. They are the private property of her Majesty.

Botanic Gardens.

Botanic Gardens, Chelsea.

27. The Botanic Garden at Chelsea is supported by the Worshipful Company of Apothecaries of London. The ground was granted to them in the end of the 17th century by Sir Hans Sloane, on condition of their presenting to the Royal Society, annually, fifty new plants, till the number should amount to 2000. In the middle of the garden there is a marble statue of Sir Hans, by Rysbrack. On the north side of the garden is a large greenhouse, and close by it a stove, also of considerable dimensions. Over the greenhouse is a botanical library. On the south side of the garden, near the Thames, are two wide spreading cedars of Lebanon, planted so long ago as 1683; at present (1816) the circumference of one of them, three feet from the ground, is somewhat more than thirteen feet, and of the other almost thirteen feet. The laborious and well informed Philip Miller was superintendant of this garden for many years, and here his admirable *Gardener's Dictionary* was composed. Since the death of Miller, the garden has been rather on the decline, the soil being much exhausted, and the hot-houses having fallen into disrepair. Of late, however, the Company has, at much expence, restored every thing to a state of more than former excellence, the improvements having been conducted by Mr William Anderson, an eminent practical gardener and botanist. Botanical instructions are here given during the summer months by a demonstrator appointed by the Company of Apothecaries.

Oxford.

The botanic garden at Oxford is of considerable antiquity: but the collection of plants is not extensive; and in that famed city of theological and classical learning, no great encouragement seems to be given to the votaries of Flora or Pomona.

Cambridge.

The botanic garden at Cambridge, has long had a higher character in the botanical world. The collection, however, cannot be accounted very extensive. The many editions of the *Hortus Cantabrigiensis*, published by the late Mr James Donn, the curator, tended greatly to spread its fame. Not that it is to be imagined that *all* the plants enumerated in the Cambridge catalogue are to be found, at any one time, in a living state in the garden; if they were ever cultivated there, it is enough. The catalogue was printed in the shape of a pocket volume, and formed a convenient companion to the garden or greenhouse: in fact, it long regulated the nomenclature of plants in this country. Now, however, many give the preference to the *Hortus Kewensis*, as a more accurate performance; and an abridged pocket edition of this has also been published.

Liverpool.

The botanic garden at Liverpool was established by subscription, under the auspices of the patriotic Mr Roscoe. The suite of hot-houses is perhaps the finest in Britain, and the whole establishment is highly creditable to that opulent commercial city. The collection of plants is great; and the many opportunities of procuring seeds from ships, constantly arriving from every quarter of the world, are eagerly embraced by an active and intelligent superintendant, Mr William Shepherd. Here Sir James Edward Smith, the celebrated author of the *Flora Britannica*, and President of the Linnean Society, has occasionally delivered a course of lectures on botany.

Hull.

A public botanic garden has recently been set on foot at Hull; it is on an extensive scale, and can already boast of a very ample collection of plants. For it the public are in a great measure indebted to William Spence, Esq. well known not only as a naturalist, but as a writer on some questions of political economy.

Dublin.

28. At Dublin, there are now two botanic gardens; one belonging to the Dublin Society, and another to Trinity College.

The former was established about the year 1798. It contains twenty-four acres (Irish). The collection of plants is very extensive. The general arrangement of the hardy herbaceous kinds, is according to the system of Linnæus; each Linnean class standing separate in a large grass lawn, and an alley leading from one class to another. Aquatics are necessarily placed by themselves; and near the Aquarium, there is a piece of marshy ground for bog plants. Shrubs form another division, and trees a third. The collections in all of these departments are very extensive. In one part of the garden there is an arrangement, on a small scale, according to the natural method of Jussieu. Plants indigenous to Ireland are brought together, so as to exhibit the Flora of the country at one view; but they occur likewise in their places in the general arrangement. They have in this garden what are termed *cattle gardens*, containing plants which different animals are supposed to eat or to refuse. There is a piece of ground set apart for making experiments on the different gramina, and also on what are called artificial grasses, such as clovers, trefoils, saintfoin, lucern: this department, if properly attended to, is evidently calculated to be very useful. The stoves and greenhouses are extensive, and contain a numerous collection.

The College botanic garden was established only in 1806. It occupies no more than three acres and a half. It is enclosed by a wall twelve feet high, the south-east aspect of which is faced with brick, and on this the more delicate of the hardy climbing shrubs and others which require shelter are trained. Here, for instance, Metrosideros lanceolata flowers every year, and here may be seen the finest specimen in the three kingdoms, perhaps, of Ligustrum lucidum, or the wax-tree of China, and which escaped unhurt in this situation, during the severe winter of 1813, when the original plant from which it was taken perished in England. There is in the garden a general arrangement of herbaceous, perennial, and biennial plants; the annual plants and the gramina being each kept separate. Although the space is small, there is not only a Fruticetum, but an Arboretum; and, with equal taste and judgment, the principal part of this last is so contrived as to serve for a screen to give shelter to the rest of the garden. There is an extensive collection of the hardy medicinal plants, arranged according to Jussieu's method. There is only one stove and one greenhouse; but the exotics cultivated in these are curious and numerous. Upon the whole, this small botanic garden contains a richer and more varied collection than is perhaps to be found any where else in Europe within the same compass. It does honour to the liberality and public spirit of the heads of the College; and they seem to have been peculiarly fortunate in their gardener, (Mr James Townsend Mackay, originally from the Botanic Garden at Edinburgh), who has here proved, that, to a thorough knowledge of practical horticulture, and extensive acquisitions in botany, he adds an acquaintance with the principles of landscape gardening.

Edinburgh.

29. The Royal Botanic Garden of Edinburgh was planned, in 1767, by Dr John Hope, then professor of botany. The collection of plants, both hardy and tender, formed by Dr Hope, was uncommonly great; and some of the rarer trees and shrubs planted by him now afford admirable full grown specimens: the Constantinople hazel, (*Corylus colurna,*) for example, now appears as a fine and lofty tree. The assafœtida plant was here first cultivated, by the Doctor, in the open air in this country. The quarter where it grew was sheltered by a yew hedge, and saw-dust was generally laid over the root of the plant during winter. There are two hot-houses, a dry stove, and a large greenhouse; all of them at present in a state of decay; but likely soon to be rebuilt in a magnificent style, and on an extensive scale. Dr Hope was a zealous disciple of Linnæus, and on the death of that illustrious botanist, he placed in the garden a square monument, surmounted by an urn, with the simple inscription, "Linnæo posuit Jo. Hope, 1779." It deserves to be recorded, that in the dry stove a dragon's-blood tree (*Dracæna draco*) planted by the Doctor, attained the height of thirty feet, exactly double that of the largest specimen of the plant at Kew; but this invaluable plant, which ought to have been the pride and boast of the Scottish capital, absolutely perished, owing to the want of funds for raising the glass-roof of the house! In this garden lectures are delivered by Dr Daniel Rutherford, Professor of botany in the University of Edinburgh. The herbarium of the late Dr Hope is kept at the garden. The present superintendant is Mr William Macnab, who was bred at Kew Gardens, and who is at once an excellent cultivator of plants and an acute botanist. Under his management the collection of hardy herbaceous plants has been so greatly enlarged, that it is now excelled only by that at Kew Gardens.

Private Gardens.

Gardens of nobility and gentry.

30. Many of the private gardens in this country are, it is believed, superior in some respects to those of any other. They are maintained in a more liberal style; and the products are not only plentiful, but every kind of fruit and culinary vegetable is of the first quality of its kind. It may be affirmed, that in Britain a gentleman may derive from his own garden, with the aid of glass and of fire-heat, a more varied and richer dessert, throughout the year, than is to be met with on the most luxurious table in any other country. To prove this assertion, it will be enough to run over the fruits successively afforded throughout the year, by a well-conducted British garden. Strawberries, planted in pots and forced in a hot-house, produce their fruit about the middle of April, and forced cherries are ready at the same time. These are followed by early melons, about the beginning of May. In June the first forced grapes and peaches are ready for the table, with the luscious pine-apple: may-duke cherries on good exposures now ripen, and different kinds of strawberries in the open ground are abundant. These, with early melons, grapes, peaches, nectarines, and pine-apples, continue plentiful till August, when the currant and gooseberry come in. By the middle of August the early pears are ready, and the later houses of peaches, nectarines, and grapes are in perfection, with melons; and by September, the open wall crops of peaches, apricots, and nectarines, greengage plums, and jargonelle pears, with the late preserved gooseberries and currants, and the early jenneting and oslin apples, swell the dessert. In October, late crops of melons and grapes, with peaches, nectarines, and figs, join themselves with the ripening apples and pears; till, towards the end of it, the careful horticulturist gathers and stores the remaining fruits of his labours, that he may possess a supply during the winter season. The autumn pears, such as the beurré and the crassane, are in season till the new year; when the colmart, St Germain, and chaumontel, still prolong the succession of pears: then many varieties of keeping apples present themselves, till the season revolve, when *early* strawberries, cherries, and melons may again be procured. Several fruits not generally cultivated, such as oranges and shaddocks, have not here been enumerated; and our nuts, such as filberds and walnuts, are intentionally omitted.

Variety of fruits produced in Britain.

The general extent of the walled garden is from two to five acres. It is to be observed, that a walled garden of three or four acres at the present day, affords as much space for the production of fruits and kitchen vegetables, as did a garden of perhaps five or six acres at the end of the 17th or beginning of the 18th century, when the garden was invariably connected with the mansion-house; so that the portion next the house was naturally laid out as a parterre, and large spaces were occupied by arbours, fountains, and grass-plats for statues or obelisks. A very few only of our modern fine gardens can here be particularized. In all of them, fruits and vegetables are cultivated with great care, and with remarkable success. In most of those to be now specified, besides these more ordinary productions, there are rich collections of curious and ornamental plants.

31. To begin with England. The gardens at Chiswick House, the seat of the Duke of Devonshire, near Kew Bridge, are very extensive, and remarkable for containing a most magnificent range of hot-houses. At White Knights, near Reading, the Marquis of Blandford has a very complete garden, distinguished more especially for a choice collection of ornamental plants.—Spring-Grove, near Blackheath, the seat of the illustrious President of the Royal Society Sir Joseph Banks, affords a very fair example of a well kept English garden. Here, in the open air, grows a noble specimen of

the Chili pine, (*Araucaria imbricata,*) the most admirable, perhaps, of the many plants discovered and brought home by Mr Archibald Menzies: of this Spring Grove specimen the venerable owner is justly proud. Wormly Bury, the seat of Sir Abraham Hume, near Enfield, may also be noticed; it is particularly remarkable for its hot-houses being stored with fine specimens of the rarest tender exotics. Other gardens well deserve notice, such as Lord Tankerville's near Walton; the Duke of Northumberland's at Syon House, Brentford; and Earl Mansfield's at Caen Wood, Hampstead.

32. Scotland can boast of some first-rate gardens. The Duke of Buccleuch's at Dalkeith contains, within and without the walls, 13 acres. Every thing here is in a princely style: the gravel walks of the place are about fifty miles in extent. Though the soil of the garden was originally bad, and the subsoil is still unpropitious, the whole has been brought to a most productive state by the ingenuity and judgment of his Grace's gardener, Mr James Macdonald, as will afterwards be more particularly mentioned. The Earl of Eglinton's garden at Eglinton Castle, Ayrshire; the Duke of Montrose's at Buchanan, in Dunbartonshire; the Earl of Mansfield's at Scone, in Perthshire; and Mr Ferguson's of Raith in Fifeshire, may also be named.

33. In Ireland there are many excellent private gardens. In the vicinity of Dublin, the Lord Lieutenant's deserves notice, as well as the Chief Secretary's, Lord Castlecoote's, and the Lord Chief-Justice Downe's. The garden of the latter at Merville, two miles south of Dublin, besides producing fruit and kitchen vegetables in perfection, is distinguished for abounding with rare flowers of every description, collected with great taste and assiduity. There is here a separate collection of American natives. At Collon, in the county of Lowth, the Right Hon. John Foster has the richest and most varied plantations of trees and shrubs of every kind, to be seen in Ireland, and probably among the best in Britain. Mr Latouche's garden at Bellevue, in the county of Wicklow, likewise deserves to be mentioned as of the first rank, both for fruit and for a general collection of plants. At Castle Forbes, too, in the county of Longford, the Countess of Granard has a fine collection of flowers. Scottish head-gardeners, it may be remarked, are equally prevalent in Ireland as in England. Three out of the four principal gardens in the vicinity of Dublin, above specified, are under the management of Scotsmen.

Villa Gardens.

Villa gardens.

34. These are innumerable; some of them are kept in the highest style of excellence. They are generally about an acre in extent; but many are nearly twice that size. Under this head, are included all the gardens attached to the country houses of those in the middle ranks of life: a few also, belonging to opulent individuals, who devote their leisure to the study of botany and the cultivation of curious plants, must be ranked under this class, though in some respects far excelling the most extensive gardens. Such is the Count de Vande's garden at Bayswater, on the Uxbridge road, remarkable for a very rich collection of plants; and Mr Kent's, at Clapton, near Hackney, where aquatics, both hardy and tender, are grown in great perfection. The tender aquatics are kept in a stove during winter; but, in the summer season, the vessels containing them are placed on slight hot-beds under glass frames, where linings of horse-litter can be added at pleasure; it being found, that in this way they flower more freely. Mr Vere, at his villa at Knightsbridge, possesses a very ample collection of rare exotics.

Cottage Gardens.

Cottage gardens.

35. Under the title of cottage gardens, must be included all gardens of an inferior sort, such as those common about villages and towns. Cottage-gardens, properly so called, are in some places numerous and well kept, affording not only an agreeable relaxation to the occupiers, but contributing very much to the comforts of their family. In South Britain, however, they are neither so useful, nor so well managed, as in some parts of Scotland. While in the former the vine may sometimes be seen extending its shoots over the cottage-roof, indicating a mild climate and a fertile soil, the really useful produce of the ground seems much neglected. In Scotland, on the contrary, too little attention is doubtless paid to ornament; but the healthy kale and cabbage plants, and other useful pot-herbs, with well-earthed rows of early potatoes, shew that the inhabitants understand the management of their little spots, and how to draw from them the most effectual assistance to their families.

Public Nurseries.

Public nurseries.

36. The *public nurseries*, especially near London, are of the first order. These, besides being remarkable for general collections of plants, are usually distinguished for excelling in some particular department. Thus at Lee and Kennedy's at Hammersmith there is not only a most extensive general collection, but more particularly a complete assortment of heaths and other Cape of Good Hope plants. Loddige's at Hackney is distinguished for stove plants; Whitley, Brames and Milne, at Fulham, have a general collection; as have also Malcolm at Kensington, and Jenkins & Gwyther near Paddington. At Thomson's at Mile-End, besides a rich collection of young plants, are many fine old American trees of the rarer kinds, and a very large gingko tree of Japan, (*Salisburia adiantifolia*): at Colville's, on the King's Road, there is a great extent of glass for the growing of showy plants for the London market; Davy's, in that neighbourhood, is famed for a fine collection of tulips, certainly the first in Britain: Milliken at Walworth excels in auriculas, ranunculuses and anemones; and Chandler, near Vauxhall, in camellias; Gray and Wear at Brompton Park (formerly the nursery grounds of London and Wise) have a great collection of fruit-trees. Mr Joseph Kirke, also at Brompton, has but a small nursery, but it is rich in the newly introduced fruits, particularly those raised by Mr Knight, and those recommended by the Horticultural Society of London. Ronalds at Brentford, and Wilmot and Lewisham at Deptford, may also be mentioned as excelling in the culture and training of young fruit-trees. At what is called the Botanic Garden at Sloane Street, kept by Mr William Salisbury, the partner and successor of Curtis, there is a considerable collection of curious shrubs and plants in general. Several of the nurserymen pay much attention to the production of seeds for the market, either of culinary plants, or of ornamental flowers. Of the principal kinds of the former, such as cabbages, turnips, and peas, they annually raise a small quantity of the different varieties, in their own nursery grounds and under their eye, taking care however that each variety be as far separated as possible from any similar crop; they examine the plants when in flower, and reject such as are spurious. The whole seed thus procured is kept till next season; it is then sent to some seed-farmer in

their employment, perhaps in a remote part of the country, and grown by him. In this way there is yearly procured a large stock for sale, and which in general is not only better saved, but more genuine than what can easily be got in a private garden.

Throughout the kingdom there are public nurseries near all the principal towns. At Edinburgh there are several, which it may confidently be affirmed are kept in a state of greater order and neatness than any in the south; they are particularly distinguished for the excellence of their seedling forest-trees. The number and the flourishing state of the public nurseries may be adduced as a strong proof of the general attention paid to horticultural improvements throughout the country. Towards this they afford great facilities, furnishing, when wanted, every possible variety of plants, at prices comparatively low. In one important article we believe all of them are deficient,—fruit trees. These, indeed, they contain in sufficient numbers; but their quality is often doubtful. This is particularly the case with apples and pears. The grafts for these are often collected from the nursery lines, instead of being taken, as they ought to be, from *bearing branches of fruitful trees.* Sometimes, no doubt, they are selected from fruit-bearing trees in gentlemen's gardens in different parts of the country; but it is frequently impossible for nurserymen to procure grafts of the desired kinds in this way. If any judicious nurseryman, therefore, would form a collection of fruit-trees of his own, to be maintained in a fruit-bearing state, he would thus not only be certain as to the kind which he propagated, but have at his command yearly a moderate quantity of proper grafts from the fruitful boughs of bearing trees. He would thus, no doubt, be limited in the number of his grafts, and might find it necessary to ask a higher price for his plants; but this would most cheerfully be given by judicious purchasers. A nursery orchard of this kind could only, with propriety, be formed on ground the property of the nurseryman, or of which he held a very long lease. Till some such establishment take place, gentlemen who wish to avoid disappointment, must, in general, be content to graft their own fruit-trees.

Market Gardens.

Market gardens.

37. The *market gardens* near the metropolis are wonderful in extent, and managed in general in the best style. High rents are paid for the ground, so that as many crops as possible must be taken, and those must be of the most productive sorts. At the same time, such is the competition in Covent Garden market, that unless the produce be excellent of its kind, it will be rejected. The accumulated heaps of kitchen vegetables to be seen very early in a summer morning in this place, are quite surprising, and would confound many who have frequently passed through the market in the day time, after vast quantities have been sold, and carried off by retailers, and other quantities have been placed out of sight. If from an inspection of Covent Garden green-stalls, one may judge of the general state of horticulture in Britain, it may be said to approach perfection. It cannot however be denied, that although the kitchen vegetables exhibited for sale in this market excel in size, they are inferior in flavour, and perhaps in wholesomeness, to those raised at a distance from London. Much of the land here occupied as market-gardens has been heavily cropped every year for perhaps a century past, and the soil has been annually replenished with manure from the city. It thus acquires a grossness calculated to give size certainly at the expence of delicacy of taste. The vegetables of the London markets, however, ought not to be judged of from specimens to be met with in taverns: these are often kept steeping in water for a day, or perhaps two or three days, as if it were intended to extract all flavour, or otherwise sweating in a heaped basket in the cellar, the alliaceous and strong-smelling plants tainting the others. Every one possessed of a garden is well aware of the superiority of pot-herbs when recently gathered; but those sent to the London market are gathered and packed on one day; they are carried, by the indefatigably industrious gardeners, during night, either in waggons, or by boats on the Thames, so as to reach the market very early the next morning. Even in this way, a complete day and night must elapse before the inhabitant of London can set on his table the freshest vegetables to be procured in the markets. But as the gardeners come to town only three times a-week, on Tuesdays, Thursdays, and Saturdays, pot-herbs must very frequently be two or three days kept before they be used. They must therefore unavoidably suffer some deterioration; and the wonder is, to see an enormously overgrown city so amply and regularly supplied, and with articles so excellent in their kind.

38. Fuller, in his "Worthies," fixes the date of the establishment of a market for pot-herbs at London, to be 1590; but Lyson properly remarks, that entries occur in dinner bills of fare, detailed in the account of Queen Elizabeth's progresses, which shew, that "parsley, sorrel, and strong herbs, with peason," were to be *purchased* at least twenty years before that period. *Rathripe* or early peas were then accounted a dainty for a queen; and they still continue to be a dainty, selling, when they first come in, at a crown or even half a guinea a pottle (less than a quart.) Other articles, when produced early, give prices high in proportion; asparagus, 6s. or 7s. a hundred; and early potatoes, 3s. 6d. a pound. These and several other culinary plants are therefore extensively *forced* by the London market-gardeners; that is, they are forwarded by the artificial heat either of a hot-bed or of a flued pit. Some idea may be formed of the encouragement given to horticulture by the demand of the metropolis, from considering the extent of ground occupied in the production of kitchen vegetables and fruit within 12 miles of London. Mr Lyson, above named, author of the "Account of the Environs of London," and who, in the course of his minute investigations and inquiries, had a good opportunity of forming an accurate calculation, estimates that at least 5000 acres are employed, within that circuit, in raising kitchen roots and pot-herbs, exclusive altogether of late potatoes, and of vegetables raised for cow-feeders. He states that 800 acres are cropped with fruit, including apples, pears, gooseberries, currants, raspberries, and strawberries. Not fewer than 1700 acres are planted with potatoes for the market; and 1200 with cabbages, turnips, and parsnips, for the feeding of milch cows. The raisers of these articles are properly *farming gardeners*: they manure very highly, and raise garden crops, and then refresh their land by sowing with corn. They abound near Camberwell and Deptford. The production of medicinal herbs employs about 300 acres; and from 400 to 500 are in the hands of nurserymen. In this way, the employment of about 9500 acres of the richest and most highly manured lands in the vicinity of London is accounted for. At Hoxton is a very extensive and well conducted market garden, Mr Grange's; and this may

be considered as a fair example of all the others. But the garden ground is chiefly situated near the Thames, both above and below the city, for the conveniency of water carriage in conveying the produce to market, and the not less important advantage of bringing back stable dung, for the construction of hot-beds and the manuring of the ground.

The districts of Brentford and Twickenham are famous for strawberries; and in the last alone, there are about 400 acres in fruit-trees, the produce of which is chiefly sent to London. Fruit arrives from every part of the surrounding country at the same emporium, and yet it is believed the demand is seldom satisfied. It may here be remarked, that the production of fruit, and the supplying of the market with it, should by every possible means be encouraged. It is a just observation of an eminent horticulturist, (Mr Knight,) that the palate which relishes fruit is seldom pleased with strong fermented liquors, and that as feeble causes continually acting ultimately produce extensive effects, the supplying the public with fruits at a cheap rate would have a tendency to operate favourably both on the physical and moral health of the people. Isleworth parish is remarkable for producing great quantities of raspberries, which are sent partly to Covent Garden market, but chiefly sold to distillers, or makers of sweets.

In Fulham parish, there are nearly 1000 acres under crops of esculent vegetables, intended either for market or for cow-feeders. In Mortlake parish there are generally about 80 acres under asparagus; one asparagus grower here, Mr Biggs, has sometimes had forty acres under this crop at one time. Near Deptford also much asparagus is raised; and one grower here, Mr Edmonds, has, we are informed, at this time, no fewer than eighty acres covered with asparagus beds, —a thing which must appear almost incredible to those who have not witnessed the loads of this article daily heaped on the green-stalls of the metropolis, for the space nearly of three months. About twenty acres in the neighbourhood of Deptford are employed in the raising of onion-*seed*, this article of Deptford produce having acquired reputation all over the country. What are called the *physic gardens* are chiefly near Mitcham, nine or ten miles from Westminster Bridge: in these are raised chamomile, lavender, liquorice, rhubarb, wormwood, and above all peppermint, not only for supplying the essential oil to apothecaries, but for the manufacturing of a favourite cordial.

We have now explained, perhaps at too great length, the classification of gardens above given: but without going into some little detail, no idea could have been conveyed of the general state of the country in regard to horticulture. We now hasten to make some remarks on the subjects which naturally present themselves as important when a new garden is projected. Most of them are applicable to several classes of gardens; but when not otherwise stated, a garden of the first character is to be understood as in view.

Situation, &c. of a Garden.

Situation.

39. The consideration of the position of the garden with respect to the mansion-house properly belongs to the subject of Landscape *Gardening*. It may only here be remarked, that of late it has become fashionable to place the fruit and kitchen garden at perhaps half a mile's distance, or more, from the house. In many cases this has been found inconvenient; and it can seldom happen that the garden walls may not be effectually concealed, by means of shrubs and low growing trees, so as not to be seen, at least from the windows of the public rooms, and the garden yet be situated much nearer to the house. It is scarcely necessary to observe, that an access for carts and wheel barrows, without touching the principal approach, is indispensable. Some of the circumstances which are considered as constituting the best kind of situation may here be mentioned, and these, it may be remarked, ought never to be altogether sacrificed to effect.

Shelter.

Shelter is, in our climate, a primary consideration. This may in part be derived from the natural shape and situation of the ground. Gentle declivities at the bases of the south or south-west sides of hills, or the sloping banks of winding rivers with a similar exposure, are therefore very desirable. If plantations exist in the neighbourhood of the house, or of the site intended for the house, the planner of a garden naturally looks to them for his principal shelter; taking care, however, to keep at a reasonable distance from them, so as to guard against the evil of being shaded. If the plantations be young, and contain beech, elm, oak, and other tall-growing trees, allowance is, of course, made for the future progress of the trees in height. It is a rule, that there should be no tall trees on the south side of a garden, to a very considerable distance; for during winter and early spring, they fling their lengthened shadow into the garden, at a time when every sun-beam is valuable. On the east also they must be sufficiently removed to admit the early morning rays. The advantage of this is conspicuous in the spring months, when hoar-frost often rests on the tender buds and flowers: if this be gradually dissolved, no harm ensues; but if the blossom be all at once exposed to the powerful rays of the advancing sun when he overtops the trees, the sudden transition from cold to heat often proves destructive. On the west, and particularly on the north, trees may approach nearer, perhaps within less than a hundred feet, and be more crowded, as from these directions the most violent and the coldest winds assail us. If forest trees do not previously exist on the territory, screen plantations must be reared as fast as possible. The sycamore (or plane-tree of Scotland), is of the most rapid growth, making about six feet in a season; next to it may be ranked the larch, which gains about four feet; and then follow the spruce and balm-of-Gilead firs, which grow between three and four feet in the year. Excellent instructions for the formation of screen-plantations, as well as for the regulation of forest-trees in general, may be found in "The Planter's Calendar," already mentioned, § 21. Walls and quick hedges are subordinate means of shelter, to be spoken of by and by. The best general *exposure* for a garden must evidently be towards the south; and a gentle declivity in that direction, equal perhaps to a fall of one foot in thirty, is deemed very desirable; effectual draining being in this case easily accomplished.

Water.

Water is not to be forgotten. If a streamlet can be brought to flow through the garden, it may be rendered conducive both to convenience and amenity: where this cannot be accomplished, the situation should be such that water may be conveyed by pipes from some neighbouring stream; soft or river water being greatly preferable, for the purposes of the horticulturist, to that of springs or wells. Where running water cannot be commanded, recourse is had to a lake or pond, it being known that water freely exposed to the air and sunshine for some time, becomes comparatively soft, and fit for the nourishment of plants.

In selecting ground for a garden, the plants growing naturally on the surface should be noted, as from these a pretty correct opinion may be formed of the qualities of the *soil*. The *subsoil* should also be examined. If this be radically bad, such as an iron-till mixed with gravel, no draining, trenching, or manuring will ever prove an effectual remedy; if, on the contrary, the subsoil be tolerably good, the surface may be greatly meliorated by these means. In every garden, two varieties of soil are wanted, a strong and a light one, or, in other words, a clayey loam and a sandy loam, different plants requiring these respective kinds. For the general soil, a loam of middling quality, but partaking rather of the sandy than the clayey, is accounted the best.

Enclosure Walls.

Walls.

40. When the situation is fixed on, the next consideration is the enclosing with walls. Supposing a garden to be about an acre in extent, and the ground sloping gently to the south, the rule is, that the north wall may be 14 feet high; the south wall, 10; and the other walls, about 12. In a larger garden, containing perhaps four acres, the north wall is sometimes raised 18 feet high; the side walls, or those on the east and west, 15; and the south wall, not more than 12. On a dead level the north wall is generally made 16 feet high; the east and west walls 13½; and the south wall, 11. It may be observed, that walls higher than 12, or at most 14 feet, are necessary only for pear-trees; peach, nectarines, apricot and plum-trees seldom requiring more than 12 feet. It may also be right to notice, that the terms north and south wall are here used to denote the north and south sides of a square or parallelogram; but that, in speaking of wall fruit, if it be said that peach or fig trees require a south wall, this must be understood to mean a wall with a south aspect, or what is in reality the north wall of the garden. There are two motives therefore for raising this wall some feet higher than the others; first, sheltering the garden from the northern blast; and, in the next place, the procuring of ample space for training the finer kinds of fruit-trees on the south side of the wall, or best aspect of the garden. Under the denomination of finer kinds of fruit-trees are to be understood not only peaches, nectarines, apricots and plums, but some of the French pears, such as the chaumontel, colmart, and crassane. Many gardeners are of opinion that the best aspect for a fruit wall in this country is about one point to the eastward of south; such walls enjoying the benefit of the morning sun, and being turned a little from the violent west and south-west winds. South-east is, for the same reasons, accounted by many a better aspect than south-west. The south-west and west walls are assigned to fruits which do not require so much heat to ripen them as is necessary to those above mentioned; such are cherries, many kinds of pears, and apples. The north walls are appropriated to apples and pears for baking, plums and morella cherries for preserving; and a few may-duke cherry, white currant and gooseberry trees, are trained against these walls with the view of their affording a late crop.

Bricks, it is generally allowed, are the best material of which to construct the walls. The foundation and basement are often made of common building sandstone, while the superstructure is brick; and sometimes the back part of the wall is of sandstone, and the front only of brick. Sandstone which rises in flags is the best substitute for bricks. Both kinds of materials admit of the branches of the trees being nailed-in regularly, and without difficulty. Where the walls are of common rubble building, a trellis of spars is sometimes placed against them, and to this trellis the branches are tied with osier-twigs or rope-yarn. This is regarded as a very good plan; but the expence is considerable, as, to prevent the lodging of insects, the trellis must be smooth and painted. The trees thus enjoy the shelter and reflected heat of the wall, without being injured by its dampness in rainy weather; and as the wall is not injured by the driving and drawing of nails, there are fewer lurking-places for the woodlouse and the snail. The rails of the trellis are made closer or wider according to the nature of the tree to be trained against it. In a few instances in Scotland, walls have been built of different kinds of *whinstone*, chiefly greenstone and basalt. These minerals, on account of their almost black colour, are calculated to absorb and retain more heat than stones of a light hue: but it is to be considered that it is not the heat retained by the wall which benefits the tree, so much as the heat reflected from the wall. The proposal of painting walls black, is, on the same principle, not admissible. It may here be of some importance to remark, particularly as applicable to Scotland, that in building brick walls, *bricklayers* only should be employed; stone-masons working as awkwardly and clumsily with bricks, as bricklayers would do with masses of whinstone.

As the walls of a garden form one of the principal sources of expence, it is proper, before proceeding to build, to ascertain correctly the average level of the borders, if the ground be unequal, so as to suit the depth of the foundation to it. If the inequalities be considerable, both walls and borders are made to sink and rise, so as to humour them. Declivities in a garden are not unpleasing; and when they happen to slope to the south or east, they afford the earliest crop of different legumes, such as peas or beans. Some improvers have constructed a series of low flat arches as the basement of the wall, these arches having their tops on a level with the surface of the borders; the piers left are from two to four feet broad, according as the foundation is firm or otherwise. The advantage consists not merely in saving much building, but in permitting the roots of the wall-trees, which are planted opposite to the arches, to extend themselves in every direction, and draw nourishment from the soil on both sides of the wall. In some places projecting stone buttresses are set at intervals in the walls, in order to strengthen them, and to break the force of the winds when sweeping along. But to this latter purpose they contribute little: temporary screens of reed, projecting at right-angles from the wall, and removed after the blossoming season, when the chief danger is over, are thought better: and if any sort of strengthening columns or piers be necessary, they can be built so as to project only on the outside of the wall. In this country, walls are generally made of the thickness only of three bricks laid side by side, or somewhat more than a foot; and to such walls in exposed situations, buttresses may be very proper. When the walls are intended to be high, indeed, they are commonly made sixteen inches thick for a few feet above the basement, and then gradually reduced to twelve or thirteen. The basement, whether of brick or stone, is always about six inches thicker than the lower part of the wall.

Walls have sometimes been built with curves; and in perfectly calm weather, the trees in these curves must receive more heat than on a straight wall; but it is found that in windy weather they suffer much more; and that even when there is only a slight air of wind, a draught is produced around the trees, rendering their situation colder than if they were at a distance from the wall. Curved or semicircular walls are therefore no longer constructed. The inclining of walls to the horizon, in order to their receiving the sun's rays more directly, is excellent in theory, but not adapted to practice. Trellises may be so inclined, or close wooden palings: such indeed have been successfully employed in some gardens, as at Brechin Castle, the seat of Mr Maule of Panmure; where curved walls may also be seen. A stone or brick wall, however, could not be sufficiently inclined without the support of a bank of earth, and this would inevitably keep the wall continually damp and cold. A coping is necessary to preserve the wall, not only by preventing the rain from sinking into it at top, but to throw it off from the sides, where its trickling down would do much damage. The best coping is formed of long pieces of freestone, neatly hewn from four inches thick in the centre to two at the plinth; the edges being made to project beyond the wall about two or three inches, and a groove being run underneath the plinth, to collect and throw off the drops.

What is commonly called the *kitchen-garden* has, in in modern times, become almost the only walled enclosure. It is likewise the *fruit-garden*, the walls being chiefly intended for the protecting and training of fruit-trees. These, it is to be understood, are planted on both sides of the wall; the exterior fruit-border being defended generally by a sunk fence and an evergreen hedge, with a wire fence for the exclusion of hares. If, after all, the enclosing walls afford too little room for training, a cross wall is built in the middle of the garden; or, where the establishment is large, and where fruit is much in demand, two cross walls are reared. These cross walls are not placed nearer to each other than a hundred feet; if they be two hundred feet separate, it is perhaps better. They can scarcely be said to disfigure the garden; on the contrary, they might be defended as tending rather to enliven its effect, by presenting new scenes as the successive central doors are opened. They seldom need to be high; being generally destined for peaches, nectarines, or plums, nine or ten feet are sufficient.

Hot Walls.

Hot Walls. 41. It may be proper in this place to say a few words of flued walls, as by much the best time for their construction is at the original enclosing of the garden. Hot walls are of two kinds; such as are intended to have sloping glass-frames attached to them, thus to a certain extent forcing the fruit; and such as are not calculated for having this appendage, but merely to have screens over the blossoms in the spring. Both are generally built about ten or twelve feet high.

In the first kind of hot wall, a ground plate or low parapet, a foot high, and at the distance of perhaps five feet from the wall, is, in some places, formed for the glass frames to rest upon, these being heavy and strong; the trees are trained on a trellis within a few inches of the wall; and along the border in front of the trees, early crops of peas, kidney-beans, or strawberries are raised. In other places, the frames are of very slight construction, and easily manageable: they are about two feet shorter than the height of the wall; and this deficiency is supplied by a boarded parapet, on which rest the rafters for supporting the sashes: the space between the bottom of these and the wall, seldom exceeds three feet. One furnace is reckoned sufficient for 45 or 50 feet of such frame-work. When the new wood of the tree is sufficiently ripened, the whole is taken down and carried under cover. When there is a considerable extent of hot wall, adapted for the reception of glass frames, perhaps 250 or 300 feet, particular trees may be forced or omitted, and an opportunity is thus afforded of restoring trees, by allowing them a year's rest. For these hot walls, fire heat is required only for about four months, from the end of February to the end of May, and again for two or three weeks, when the new wood is ripening.

Flued walls, with an apparatus for temporary coverings of canvas, oiled paper, or woollen nets, are necessary for the perfect production of the finer sorts of peaches and nectarines in all parts of Britain north of Yorkshire. Without the aid of artificial heat, the young wood of these trees is seldom sufficiently ripened, in ordinary seasons, to ensure a supply of good flower-buds for the following year, and unless the buds be strong and plump, the chance of a crop the ensuing season is proportionally lessened; and frequently, after a sufficient quantity of fruit has been brought to full size, unless heat be supplied artificially, in autumn, maturation is not effected. In the northern parts of the island, therefore, it is always proper to construct a portion of the garden walls with flues: the additional expence of forming the flues, particularly where the inside facing only is of brick, is but trifling; and little consideration should be attached to the expence of the small quantity of fuel that may be necessary for promoting the *setting* of the fruit, and for ripening off the young wood in autumn, the time when it is chiefly wanted.

The flues are commonly eighteen or twenty inches deep, and nine inches wide, inside measure, and they make as many turns as the height of the wall will permit. Formerly they made only three turns; but it has been found, that the oftener the flues are returned, provided they draw well, the less heat escapes by the chimney, and consequently the more is evolved from the surface of the wall. The sole of the flue to the length of the first turn, is generally a foot above the level of the border. The front wall of the flue is 4½ inches thick, or a brick on bed, without any inside plastering. In some places a wooden trellis covers the wall; but in general, the trellis does not extend higher than the first range of the flue, the heat above this not injuring the trees: where neatness is much studied, the trellis rods are sunk into a small recess purposely left in the wall, thus preventing the appearance of bulging, which is otherwise unavoidable.

Soils.

42. The improvement of the soil naturally becomes an object of great importance at the first formation of a garden; and its subsequent management, or "keeping in heart," as gardeners term it, is a matter of equal interest. Soils.

The various soils distinguished by gardeners and horticulturists consist of the simple earths (as they used to be called) of the chemists, particularly argil, silex and lime, mixed in different proportions. It is well known, that some of the principal offices of the soil are merely mechanical; such are, the giving proper support to the vegetable by means of its roots, and the supplying these with water in a slow and convenient manner, the superfluous moisture draining off. A mixture of clay and sand is called *loam*; and according as the one or other of these earths predominates, the soil is denominated a

Soils.

clayey or a sandy loam. In the same way, in some counties of England chalky loams are common; and in other districts, gravelly loams are not unfrequent. When oxide of iron prevails, and renders the clay hard and of a dark brown or red colour, the soil is called ferruginous loam, or more commonly *till*. Boggy or heathy soil consists of ligneous particles, or the decayed roots, stems and leaves of various carices, heaths and sphagna, and the coaly matter derived from these, generally with a slight mixture of argillaceous earth and sand. While the nomenclature of soils remains so imperfect and unsettled as it now is, there seems no propriety in enlarging further on the different varieties. Some judicious remarks on these, and on the principles on which they should be distinguished and named, may be found in the Agricultural Report of Ross and Cromarty, drawn up by Sir George Mackenzie, Bart.

Carbonaceous matter, and certain salts, in small proportion, are likewise ingredients in a good soil; plants deriving not only support from the soil, and nourishment from the water and from the decomposition of the water, supplied by the soil to their roots, but also other peculiar sorts of food from the carbon and salts alluded to.

43. Any substance added to a soil, either to supply a deficiency or to rectify what is amiss, is called a *manure*. The use of manures is, of course, very various. They may be destined to render soil less retentive of moisture, or to make it more retentive; or they may be calculated to communicate carbonaceous matters or salts. With the former view, clay or argillaceous marl form a suitable manure for a sandy soil, and sand or lime for one that is clayey; while dungs and composts of every kind yield the other requisite materials to the soil. For opening clayey soils in gardens, marls are excellent, particularly gravelly marl. Where marls cannot be had, shelly sand, coal-ashes, or wood-ashes mixed with chips of wood, may be resorted to. For binding sandy soils, argillaceous marls or calcareous loams are proper; and the scourings of ditches are often, for this purpose, valuable.

The improvement of cold or sour clay is sometimes effected by scorifying it, or *burning* it, as it is commonly termed. The sward, with two or three inches of the clay adhering to it, is collected in heaps, and brought into a state of red heat, by means of furze, peat or coals, taking care to add clay on the exterior so as to confine the fire. Acids and vegetable matters of noxious tendency seem thus to be driven off, and a soil fit for garden culture produced. This is an old practice which has been lately revived. In Hitt's Treatise on Fruit-trees, published in 1758, there is a chapter "Of the burning of clay for the improvement of land."

44. The soil of a garden should never be less than two feet and a half deep; the best gardeners prefer having it fully three feet. The natural soil, therefore, however good, is seldom of sufficient depth. If it be not two feet, a quantity of earth from the fields is carried in. The cleanings of roads and grass-turf of any kind, form valuable additions to garden soil. In the course of trenching, a portion of the subsoil is brought to the surface, and gradually meliorated; but to bring up much of it at once, is very injurious. Soil of the usual depth may be trenched two spit (spadeful) deep; and if this be done every third year, it is evident that the surface which has produced three crops, will rest for the next three years; thus giving a much better chance of constantly producing healthy and luxuriant crops, and with one half the manure that would otherwise be requisite. Nicol insists for the deeper soil, and recommends that, after taking three crops, the ground should be trenched *three* spit, by which the bottom and top are reversed; three crops are again to be taken, and the ground trenched *two* spit, by which the soil which formed the top goes to the middle, and that which lay in the middle goes to the surface. After other three crops, the trenching is to be again three spit deep. By thus alternately trenching two spit and three, after intervals of three years, the surface soil is regularly changed, resting six years and producing three; and an approach is thus made to the desirable object of having always a *new* soil.

It is agreed on all hands, that nothing contributes more to the preserving of the soil of a garden in good condition, than exposing it as often as possible to the action of the sun and air. It is a rule, therefore, that garden ground, when not in crop, should regularly be dug *rough*, or if possible *ridged up*, and left in that state to the influence of the atmosphere. If it be allowed both a winter and a summer fallow, the oftener a new surface is exposed the better; after it has lain ridged up during winter, therefore, repeated diggings are given in the spring and summer months. Whether some noxious matter be exhaled, or some fertilizing substance be imbibed, or what may be the precise nature of the operation that goes on, we do not here inquire. The fact is certain, that *aëration*, as it is sometimes called, is of the greatest advantage to garden soils.

Mould.

45. It has been already remarked, that it is desirable to have soils of different quality in the garden. One of the most generally desired is what is called *mould*, by which is meant a soil in which vegetable earth predominates. Such as is of a bright chesnut colour is preferred: it is usually styled by gardeners, hazelly mould, or hazelly loam, from being of the colour of the hazel nut. The characters of the best mould, according to Miller, is, that "it cuts like butter, does not stick obstinately, but is short, tolerably light, breaking into small clods, is sweet, well tempered, without crusting or chapping in dry weather, or turning to mortar in wet." It should be so open, as not to stick to the spade or the fingers after a shower of rain. Dark grey and russet-coloured moulds are likewise considered good; ash-coloured are commonly bad; yellowish red still worse. Good moulds after being broke up by the spade, or after rain, if the surface have been recently dug or hoed, emit rather a pleasant smell. What are called brick moulds or loams, are much esteemed both by the gardener and the florist, as auxiliaries to mix with other soils.

For some purposes a sandy soil is wanted. In this case, either the *surface* sand, from a sandy pasture, is alone used, as it contains a considerable portion of vegetable matter, or if pure sea or river sand be employed, light rich mould, nearly in the proportion of one-half, is mixed along with it. For a very great number of plants, particularly in the flower garden, an excellent soil is to be found in the turf of old pastures, and the earth which adheres to the turf to the depth of six or eight inches, mixed with a portion of cow and horse dung in a rotten state, laid together in a heap for at least a year, and frequently turned over. This is a *compost*, and naturally leads us to speak more particularly on the subject of manures.

Manures.

Manures.

46. Many authors have treated of manures, and given theories of their beneficial action; Fordyce, Hunter, Cullen, Ingenhousz, Senebier, and others. The learned

Manures.

Kirwan wrote a separate essay on this subject. In this work of Mr Kirwan, and in the more recent publication of Sir Humphry Davy, may be found all the information on the matter that is to be obtained by reading. To enter fully on an account of manures, or the theory of their action, would here be out of place. Besides, manures in general have already been treated of in a former part of this work, (See vol. i. art. AGRICULTURE, p. 270, *et seq.*); and the remarks here made, shall be confined to manures considered as particularly applicable to gardens.

Composts.

47. It is now an established fact in practical gardening, that for the greater number of culinary plants, and for all fruit-trees and flowers, composts or compound manures are far preferable to simple dungs, and that till the latter be completely rotted, they should not in any case be suffered to touch the roots of the plants. Even composts should not be too rich. Trees especially are very apt to be injured by the injudicious and excessive use of manure. A very rich compost will stimulate them for a few years to preternatural exertion; but, as remarked by Mr Knight, will in all probability become the source of disease and of early decay. A very good practical gardener, Mr David Weighton, recommends for cold clayey land a compost made up in the following proportions: three parts light mould; one part rotten stable dung; one part sharp sand; one part coal ashes; half a part lime, with a small proportion, perhaps an eighth part, of pigeons' or sheeps' dung. For a light sandy soil, the following are the ingredients and proportions: to two parts of the natural soil, three parts of pond earth, or the scourings of ditches, and three of strong loamy earth; one part of clay, or rather clay-marl if it can be got; and two parts of stable or cow-house dung.

In the opinion of some gardeners, the best mode of applying compost manures, is to trench deep, and put compost in the bottom, to the thickness perhaps of eight inches; then to lay on the old garden soil, and to cover the whole with compost to the depth of some inches. In this way, the old or worn out soil is placed in the middle, and is exposed to the effluvia which may arise from the lower stratum, and at the same time is incorporated, by digging, with the upper.

48. In the neighbourhood of the coast, sea-weed is often used; and if dug in soon after being collected, its fertilizing powers are considerable; for artichokes, asparagus, seacale, and cabbage, indeed, there cannot be a better manure. The careful gardener pays great attention to the preservation of the dung of the stable and cow-house. The essence of these kinds of dung is often in some measure lost, by the drainings being allowed to escape. These should be collected in cisterns, and poured occasionally over the dunghil or the compost-heap. Indeed it appears evident, that every large garden, and every well-regulated farm, should be furnished with a close shed as a dung-store, for *dungs*, properly so called, should be as little exposed to the influences of the weather as possible. It is two centuries since this was pointed out by Sir Hugh Platt, who recommends the building of a brick receptacle, and covering it over, so as to prevent the access of rain, and exclude air to a certain degree.

49. Mr Knight has proved, that vegetable matter in its recent and organised state may be employed as a manure with more advantage than when it has been decomposed. It is evident, that no inconsiderable proportion of its component parts must be dissipated and lost during the progress of the putrefactive fermentation; and it is no less evident, that if this process be made to go on beneath the surface of the soil, the exhaled particles must first be applied to the roots of the plants, before they can escape.

Fruit-tree Borders.

Fruit-tree Borders.

Fruit-tree borders.

50. The proper forming and managing of borders for fruit-trees is a matter of great consequence, especially when peaches and nectarines, vines, and the best sorts of plums and pears, are cultivated. In many old gardens the borders are only five or six feet broad, and are crowded with perennial flowering plants. Such borders are too narrow, and such plants must greatly rob the trees of their nourishment. The border, according to a gardener's common rule, should not be less in breadth than the wall is in height; but the general breadth is only from 8 to 12 feet. If care be taken to make the soil good below the walk, such a border may prove sufficient. If the bottom be not dry, it is made so by means of drains. Many are of opinion, that it should at the same time be rendered impervious to the roots of the trees, by means of lime-rubbish, or clay and gravel rolled hard, or by complete paving: this precaution is particularly necessary where the subsoil is a cold wet till.

The monastic cultivators of fruit-trees in the 13th and 14th centuries were well aware of the importance of this matter, and seem to have been unsparing either of labour or expence. When Mr Ferguson of Pitfour was laying out a new orchard in Aberdeenshire, he found, in clearing out the remains of the garden of the ancient Abbey of Deer, which is included within the precincts of the orchard, a border which had been prepared for fruit-trees in the following laborious and expensive manner: "First, rich soil above three feet deep; secondly, a well-paved causeway; thirdly, a bed of pure sand, a foot deep; fourthly, another causeway; and beneath the whole, a considerable depth of rich earth."

Gardeners always wish the soil of their borders to be more than two feet deep; for pear-trees it should be three feet at least. In many cases, no part of the natural soil is retained; but the entire border is formed, partly of good loam brought from the neighbouring fields, or prepared by rotting some old pasture turf, and partly of such compost moulds as have been already described. When the natural soil is to some extent retained, if it be a strong clay, it is opened by adding sea sand, or coal-ashes that have been kept dry. Sometimes in place of these, a small proportion of quicklime is used; but this is seldom advisable. If, on the other hand, the natural soil be loose and sandy, the clayey matter to be found in ditches and open drains in ploughed land is resorted to, and laid about six inches thick at the bottom of the border. Many cultivators are particular in adapting the quality of the soil or compost to the nature of the trees to be planted. For apricot and apple trees, the compost usually preferred, consists of three-fourths light earth, and one fourth strong loam, well mixed and incorporated with some thoroughly rotten cow dung. For peach, plum, and pear trees, a stronger soil is prepared, and the proportions are reversed, the loam constituting three-fourths, and the light soil one-fourth. Cherry-trees, too, like rather a cool bottom; and equal parts of light earth and of loam form for them a suitable soil.

In forming a new garden, it is very advantageous to have the borders prepared a whole season before planting the trees, and that, equally, whether these consist mainly of travelled soil, or of the natural soil enriched by some composts. If the ground be repeatedly turned and ridged up, it is found ultimately to be in a much better condition for receiving the plants.

The soil of the borders is at first made higher by some inches above the walks, than that of the quarters in the interior of the garden: the reason is, that the quarters annually receive a large accession of manure, whereas the fruit-tree borders are afterwards to receive comparatively little that can add to their depth. Some judicious gardeners contend, that such borders are to be manured only with composts, rendered as homogeneous as possible by frequent turning and intermixing. Others do not hesitate to use well-rotted dung: this is dug in with a three-pronged fork, so as to avoid injuring the roots of the trees; and it is generally applied in the month of November, after the winter dressing of the trees.

51. The borders, particularly those next to south walls, are in most places cropped with early peas, or turnips, or some other plant which does not extend its roots deep into the earth; avoiding therefore cauliflowers and beans. But many gardeners disapprove of this, especially in the case of peach and nectarine borders; and certainly if a crop be taken, it should be of the lightest kind, such as salad herbs, and perhaps a few scattered patches of ornamental annuals next the walk. In order to avoid using the fruit-tree borders, therefore, it is a custom, in some well ordered gardens, to have low reed hedges or palings run across some of the quarters; to these the earliest peas or beans are closely attached, as they advance in growth, so as to enable them to escape the frosts of March and April more effectually, even than in front of a south wall. It need scarcely be remarked, that fruit-tree borders are kept carefully clear of weeds, and that frequent stirrings with the hoe, or the three-pronged fork, and frequent rakings are practised, the maintaining of the surface in a fresh and porous state being found of singular advantage. When the season proves very dry, they are watered perhaps three times in the week, after sunset.

52. In many situations and circumstances, it is found impossible to form a soil for fruit trees, with the care, and at the unavoidable expence, which have here been supposed. In these cases it is necessary to adapt the kind of trees to the soil. On soils naturally very light, gravelly, and sandy, peach and nectarine trees do little good: it is better to plant apricots, figs, or vines, which agree with such soils, and, when trained against a wall having a good aspect, will, in the southern parts of the island, afford excellent crops of fruit. On such soils, even espalier and dwarf-standard apple trees are short-lived, subject to blight, and produce only stunted fruit. Next to renewing the soil, the best remedy is to engraft and re-engraft frequently, on the best wood of the trees, giving the preference to grafts of those kinds which experience has shewn to be most productive and healthy in that particular place. In shallow soils some have been in the practice of making troughs or hollows, and filling them with rich earth, for the reception of the trees: but this is not to be approved of; the roots of the tree will probably be confined to the trough, and it is possible that water may be retained in it. In thin soils, therefore, it is more proper to raise the surface into little hillocks than to dig hollows. If a tree be planted on the general surface, and have earth heaped around it, it will spread its roots in every direction, and to a great distance, in the shallow soil; and some subsoils, such as decomposed trap-rock, or chalk, are themselves calculated to afford much nourishment.

Division of the Garden, &c.

Division of the garden.

53. It is, of course, understood, that the wall-tree borders extend all around the margin of the garden. It naturally follows that a gravel walk should run parallel with them. On the other side of this walk, in very many gardens, there is a row of espalier-trees, (or, to speak more correctly, counter-espalier trees), fixed to trellis-rails. If the enclosure be tolerably extensive, the centre is traversed by a broad walk. If it be of the largest dimensions, and possess a cross wall, or cross walls, the arrangement of the walks falls to be altered accordingly; a main walk proceeding directly to the doors in the centre of the cross walls. The rest of the garden is divided into compartments, and most of these compartments, in some of our best gardens, are laid out in beds four feet wide, with narrow alleys. So many alleys, no doubt, occupy a good deal of room; but the advantages of conveniency and neatness in enabling the workmen to clean and gather the crop without trampling the ground, seem to compensate the sacrifice of space. For currant, gooseberry, and raspberry bushes, the quarters are of course, reserved undivided; and narrow beds are unnecessary in the case of large perennial plants, such as artichokes or rhubarb. Border-edgings are not in use, excepting for the walks next the walls, and the cross walks in very large gardens; for these, dwarf box is almost universally employed. In the interior quarters, however, parsley may sometimes be observed forming an edging; and thyme, winter savory, or hyssop, are occasionally employed in the same way, and harmonize very well with the culinary crops around.

Hot-houses.

54. Hitherto nothing has been said of the situation of the range of hot-houses. In many gardens, these occupy a very considerable part of the south wall, that is the wall on the north side of the garden. In the area behind them, are sheds for tanners bark, rich mould, and other requisites; while there is a cart access to the doors of the furnaces, and these, with all the rubbish necessarily attending the operations of forcing, are completely hid from view. In some places all the forcing-houses form a continuous range; but generally the pine stove and succession pit, being of different dimensions, are placed separately. In some elegant gardens, as at Raith-House and Wemyss-Castle in Fife, the hot-houses have a flower-garden in front of them, while every thing offensive is excluded from view, as in the former case. In other places the hot-houses are disposed in a different manner: the several kinds of houses stand detached from one another, each being set down as it were in a separate grass lawn; the back part, where the furnaces are situated, is concealed by shrubs, so that the houses seem to stand in little thickets, and thus form an agreeable variety with clumps and patches of trees in the park. Donibristle, the seat of the Earl of Moray in Fife, may be mentioned as an example of this sort of arrangement.

Flower ga den.

55. In many instances, the flower garden is separated from the fruit and kitchen garden merely by a wall, perhaps by a quick hedge. But in modern *places*, (as gardeners speak) this garden is removed from the other by a considerable distance. To it belongs the greenhouse and the orangery; there is often connected with it a conservatory; and sometimes, where the owner has a taste for the culture of rare plants, a stove merely for the keeping of tender exotics.

Slip.

Where the interior of the walled garden does not afford space enough for raising a sufficient supply of culinary vegetables for the family, a piece of ground is fenced off on the outside of the walls, on one or more sides, and is called the *slip*. If the melon and cucumber ground be not situated at the back of the principal suite of hot-houses, it may very conveniently be placed in the slip.

Hedges.

Hedges.

56. For tall hedges, to afford additional shelter to particular quarters, or to screen objects from view, various evergreen plants are employed. Holly answers admirably, for height, strength and thickness; but it is of very slow growth, and flourishes only in clayey ground. Yew is also excellent, and much used. Several deciduous trees are likewise employed, such as lime, beech, and horn-beam. English elm is occasionally used; and in wet places alder is justly preferred. In very large gardens a hedge of holly or beach running from north to south, is of incalculable advantage, especially if the garden be in the form of a parallelogram, and much exposed to high winds. Small ornamental divisions in gardens are formed of many different kinds of plants, according to the taste of the owner, and the size of the hedge wished for. Laurel, laurustinus, phillyrea, and evergreen oak, are suited to this purpose; as well as pyracantha, sea-purslane, rosemary, and French tamarisk; the last two, however, will not form hedges unless in our southern counties, where the myrtle can withstand the cold of ordinary winters. But of all shrubs used for such division hedges, evergreen privet seems the best; and it is the plant now most frequently employed for that purpose. Some persons are fond of flowering hedges: they are composed of different kinds of rose-bushes, sweet-briars, and honeysuckles; the lately introduced Rosa Indica, making here a conspicuous appearance, being equally covered with flowers early and late in the year. Garden hedges of any kind are now much less frequently planted than they used to be. In our climate the fruit-garden must be surrounded with brick or stone walls: these serve not merely for protecting the trees fixed against them, but supersede the necessity of tall hedges for the purpose of shelter. The flower-garden, however, is still chiefly sheltered by evergreen hedges, with rows of tall deciduous shrubs, or low-growing trees behind. In some places these are situated on the declivity or talus of a bank, forming a highly ornamental screen, analogous to the *brise-vent* of the French. From the interior of this garden, however, hedges have been nearly banished, by the change of taste, and dislike of every thing formal.

In this country, as formerly remarked, the Fruit-garden and the Kitchen-garden are locally blended together, both being inclosed by the same walls: the objects of each, however, are quite distinct, and may conveniently be treated of separately. The general disposition of the departments of the garden has been already spoken of, and likewise the forming of fruit-tree borders. Other matters particularly connected with the *fruit-garden* shall now be considered.

FRUIT-GARDEN.

FRUIT-GARDEN.

57. The kinds of fruits usually cultivated within the walled garden, but in the open air, are eighteen in number; and of these ten are considered as indigenous to the country, and eight are exotics. The native fruits are the apple and pear (*Pyrus*); plum and cherry (*Prunus*); the medlar (*Mespilus*); the red and the black currant, and the gooseberry (*Ribes*); the raspberry (*Rubus*); and the strawberry (*Fragaria*). The exotic fruits are, the peach, nectarine, and almond (*Amygdalus*); the apricot (*Prunus*); the grape (*Vitis*); the fig (*Ficus*); the quince (*Pyrus*); and the mulberry (*Morus*). The apples and pears, plums and cherries, found native in our woods, however, differ so completely in appearance and taste from those of our gardens, that none but a botanist could easily be persuaded to consider them as of the same original species. The chestnut (*Fagus*); hazel-nut (*Corylus*); sorb (*Sorbus*); elder-berry (*Sambucus*); and berberry (*Berberis*), are likewise natives: these are also cultivated, but generally in the pleasure-grounds exterior to the walled garden. The walnut (*Juglans*) is a foreign tree, planted chiefly in lawns, or on the outside of the orchard. The pine-apple (*Bromelia*) and the melon (*Cucumis*), constantly require artificial heat. Oranges, lemons, and shaddocks (*Citrus*) must at least spend the winter under glass. The pomegranate (*Punica*) is sufficiently hardy to live in the open air in our climate; but it does not generally produce its fruit. This, with some other fruits occasionally cultivated, shall be noticed after speaking of the more common.

Before treating of each of the fruits in detail, it will be proper to explain the operations of grafting and budding, training and transplanting, all of which must afterwards be frequently referred to.

Stocks for Grafting.

Stocks for grafting.

58. When a cion, or part of a cion, is taken from a fruit-tree, and inserted either on a young stem, or on the bough of a full grown tree, it is called *grafting*. But in the former case a new or additional tree is procured; and in this way, chiefly, apples and pears are propagated; and sometimes plums and cherries. A good cion may generally be cut into two or three pieces, which are called *grafts*; the stems on which they are placed being named *stocks*. The raising of stocks, and the propagation of fruit-trees, will properly fall under the article NURSERIES: a few explanatory observations in this place may therefore suffice. The subject is not without interest; for every one who wishes to keep his garden and orchard well supplied with fruit-trees, should establish a small private nursery, in which, upon stocks of different kinds, according to the end in view, he may graft or bud the kinds of fruit which experience shews to be best suited to the soil and climate of the place, and which best meet his own views.

59. It is necessary that the stock should be a member of the same genus or natural family with the graft or bud to be inserted on it. The principal kinds of stocks employed, are the following:

For *apples*,
  Common apple, from the kernels, for full standards.
  Crab apple, from the kernels, for half standards.
  Codlin, from layers or cuttings,
  Paradise, from layers,
  Creeper, from layers, all for dwarf trees.

For *pears*,
  Common pear, or wilding, from the kernels, for full standards.
  Quince, from the kernels, or by layers, for dwarf and espalier trees.

Fruit-Garden.

Stocks for grafting.

For *plums, apricots, peaches, nectarines,* and *almonds,*
  Red-wheat plum, either from stones, or layers, or suckers.
  Black muscle plum, the same.
  Greengage plum, the same.
  Bullace-plum, a common native species, which has received its trivial name *P. insititia,* from being used for stocks.
For *cherries,*
  Small black cherry of the woods, *Prunus cerasus;* and,
  Wild red cherry of the woods, *P. avium.*

60. It may here be remarked, that seedling stocks which have a natural tendency to attain the full height of the species to be grafted on them, are by horticulturists universally denominated *free-stocks.* If the seeds of different varieties of apples and pears be sown, free-stocks suited for the grafting of apples and pears, are, generally speaking, produced. When very great numbers of such stocks are wanted, the seeds are procured from the manufacturers of cider and perry; but where a private gentleman wishes only to have a few hundreds of stocks, it seems much better to employ only select seeds, that is, the kernels from good specimens of hardy and healthy kinds of choice fruits, when in a ripe state. Crab stocks are very much used: the seeds are to be procured in quantity only where verjuice is made from the fruit. The paradise apple is of no estimation as a fruit; but the tree being naturally dwarf, grafting on it tends to dwarf the engrafted tree. The creeper apple has got its name, from its tendency to throw up suckers, which are easily detached with roots: it is sometimes called the Dutch paradise. Pear-trees, as already said, are grafted either on free-stocks from the seeds, or on quince stocks from layers or suckers. The latter are employed chiefly for dwarfing the trees, and throwing them more early into bearing; but with the view also (whether well or ill-founded is not the question) of imparting some degree of hardness and sharpness to the melting sugary pears, the hard and breaking pears, on the other hand, being placed on free stocks. For, all practical gardeners, it may be observed, concur in stating, that the nature of the fruit is, to a certain extent, affected by the nature of the stock. Miller says decidedly, that crab stocks cause apples to be firmer, to keep longer, and to have a sharper flavour; and he is equally confident, that if the breaking pears be grafted on quince stocks, the fruit is rendered gritty or stony, while the melting pears are much improved by such stocks. This is scarcely to be considered as inconsistent with Lord Bacon's doctrine, that "the cion overruleth the graft quite, the stock being passive only;" which, as a general proposition, remains true; it being evident that the graft or the bud is endowed with the power of drawing from the stock that peculiar kind of nourishment which is adapted to its nature, and that the specific characters of the engrafted plant remain unchanged, although its qualities may be partially affected. Quince stocks, it may be added, are also proper where the soil of the garden is naturally moist, the quince agreeing with such a soil. Peaches and nectarines are, in this country (as noticed in the tabular view) generally budded on plum stocks, particularly the black muscle: but the more tender sorts are placed on seedling stocks of their own kind, raised from peach-stones; or perhaps on apricot stocks. In France, almond stocks are much used; and for this reason the French peach trees seldom last good more than twenty years, while the English endure twice that period. Apricots also are chiefly budded on plum stocks, the red wheat plum being preferred for them.

61. In the second volume of the London Horticultural Transactions, Mr Knight has given a few remarks on the effects of different kinds of stocks in grafting,—well deserving of attention, as being the result of more than thirty years experience. He is of opinion, that a stock of a species or genus different from that of the fruit to be grafted upon it, can rarely be used with advantage, unless where the object of the planter is to restrain or debilitate. If, therefore, extensive growth and durability be required, the peach, nectarine, or apricot, should not be grafted on the plum; but if it is intended to diminish the vigour and growth of the tree, and if durability be not thought an important quality, the plum stock is proper. The same remark is applicable to the grafting of pears on quince stocks. The finer sorts of peaches and nectarines are often budded on apricot stocks. Of this Mr Knight approves; but he adds, that, if lasting and vigorous trees be wished for, the bud cannot be placed too near the ground.

62. The seeds for stocks are commonly sown in March, in four-feet beds. The germination of some kinds is promoted by placing them in moist sand, in a greenhouse or cellar, for some time previously. Next season, the seedlings are transplanted into nursery rows. Here they remain till they reach the size wished for, in order to the forming of wall or espalier dwarfs, or dwarf standards, half standards, or full standards,—the characters of which will be immediately explained. For the first three kinds, they are generally ready after two seasons: for the last, not sooner than after three or four. The finer kinds of plums are budded or grafted on plum stocks, raised from the stones. The common kinds of plums, and the almond, are propagated chiefly by suckers; figs, mulberries, and quinces, principally by layers; gooseberries and currants by cuttings. Several varieties of apple, as the original or bur-knot, the brown apple of Burntisland, and some others, grow by cuttings; and many kinds, indeed all those sorts of fruit trees that have small buds, may be propagated by laying down branches, having a ligature of leather or wire passed firmly around them, either above or below a bud, in the part buried in the earth. At the place of binding, the circulation of the sap being interrupted, a swelling ensues, and roots break forth. The layer is separated the following year, and planted where it is intended to remain. This mode of propagating fruit trees is well known and often practised on the continent, though little attended to in this country; by it, in the course of three years, bearing trees are produced, without the trouble of grafting. Stocks for cherry trees, raised either from the native black cherry or guigne, or the wild red cherry, are considered as less apt to prove gummy or diseased, than those raised from the stones of garden cherries, and they are at the same time accounted more durable.

Nursery Training.

Nursery training.

63. Fruit trees are trained as *standards,* of different kinds; as *wall trees,* or as *espalier trees.* For these, stocks of different ages or sizes are requisite. Standards are subdivided into three kinds, full standards, half standards, and dwarf standards.

Full standards.

Full standards are less used in Scotland than in England, where stems six or seven feet in height before the branches set out, are indispensable in orchards to which cattle are frequently admitted. Apples and pears are very commonly trained as full standards, and also cherries and plums.

Half standards.

Half standards have shorter stems, perhaps from three to five feet. These are particularly well calculated for standards in small gardens.

Dwarf standards.

Dwarf standards have low stems, from one foot to two feet high; they are grafted on the most dwarfing stocks of their respective kinds, (apples on paradise stocks, and pears on quinces), to make them produce low heads, suited to small compartments or borders; they come soon into bearing, produce large fruit, and in considerable abundance; while so humble is the tree, that the fruit may often be reached by the hand. Apples, pears, plums, cherries, and filberds, are very often trained as dwarf standards; and sometimes apricots, peaches, and figs. The French frequently train them to a cylindrical or somewhat pyramidal shape (*en quenouille*): in this way their appearance is improved, and the ground is less shaded; but in general, the giving this shape must prove detrimental to the fruitfulness of the tree. In this country, they are usually trained like bushes (*en buisson*); from which, it is presumed, Mr Nicol denominates them *buzzlers*.

For dwarf *wall trees*, stems five or six inches in length are sufficient; these, it will be observed, are the trees which are ultimately destined to cover the garden wall, being named *dwarfs* only from the humble stocks on which they grow.

Riders are wall trees grafted or budded on tall stocks, and are generally meant for the temporary purpose of filling the wall till the dwarfs get forward. The term *riders* is of Scottish origin, English gardeners having no appropriate name for wall trees trained in this manner, but merely calling them standards.

Espalier trees are intended for being trained against low treillages or latticed work or rails which consist of simple upright posts; stems or stocks six or eight inches in height, are therefore sufficient. To those who may look into French horticultural books, it may be useful to observe, that *en espalier* is their term for what we call wall training, and that our espalier training is by them denominated *en contre-espalier*.

The management of these different kinds of trees, from the time of their being grafted till they be fit for transplanting, belongs, equally as the raising of stocks, to the nursery department. The operations of grafting and budding, however, being of general importance, and among the nicest operations in horticulture, must here be described.

Grafting.

Grafting.

64. *Grafting* may be performed in several different ways. The most important points are, to apply the inner bark of the stock and of the graft precisely to each other, and to bind them firmly in that situation. M. Thouin of Paris, in his laboured but excellent papers in the *Memoires du Museum d'Histoire Naturelle*, has made many minute distinctions, enumerating and describing no fewer than forty modes of grafting, independent altogether of several modes of grafting by approach, and of budding. We shall content ourselves, however, with explaining only the principal kinds practised by our own gardeners. These, as well as several other sorts of grafting, are very distinctly described, and illustrated by figures, by the late Mr Curtis, in his "Lectures," vol. iii.

Tongue grafting.

65. The mode of grafting most commonly adopted in forming young fruit-trees is called *tongue grafting*. Here it is desirable that the top of the stock, and the extremity of the graft, should be nearly of equal diameter. Both are cut off obliquely, at corresponding angles, as nearly as the eye can guess; and the tip of the stock is cut off horizontally. A slip (or very narrow angular opening made by cutting out a thin piece) is then made in the centre of the stock downwards, and a similar slip in the graft upwards. (Plate CCCIX. Fig. 1.) A very sharp and narrow bladed knife is necessary. The thin point of the upper half of the sloping end of the graft is then inserted into the slip in the stock; this is sometimes called *lipping*. The barks of stock and graft are brought closely to unite, at least on the right hand side, so as not to be displaced in tying, which is always done from left to right, or in the course of the sun. Strands of fresh bass-matting, steeped for a little time in water to render them more pliant, and to prevent the knot from slipping, are generally used for ties. A quantity of clay is worked fine, and mixed with some hay chopped small, or horse droppings, and sometimes with a little salt. It is found better to have it prepared a day or two beforehand, and to beat it up with a little water as needed. The tying is then covered with this clay, in the form of a collar, or ball tapering at both ends, the upper end being applied closely to the graft, and the under to the stock. These balls are not removed till after midsummer. A neat substitute for clay is mentioned by Abercrombie: a composition of turpentine, bees wax, and rozin, at first melted together, and afterwards heated as wanted; care being taken not to apply it too hot. A coating, laid on with a brush, to the depth of a quarter of an inch, is said to be less liable to crack than clay; and, it is added, that when the full heat of summer arrives, the composition melts away of its own accord. It may be remarked, that the *whip grafting* mentioned in old horticultural books, is merely the kind now described, wanting the important improvement of the tongues or lips.

Cleft grafting.

66. When the stocks to be grafted upon are strong, or perhaps branches of large trees, *cleft grafting* is often resorted to. The head of the stock or branch, (which we may suppose to be two or three inches in diameter,) is first cut off obliquely, and then the sloped part is cut over horizontally near the middle of the slope; a cleft, nearly two inches long, is made with a stout knife or thin chisel in the crown downwards, at right angles to the sloped part, taking care not to divide the pith. This cleft is kept open with the knife. (Plate CCCIX. Fig. 2. *a*.) The graft has its extremity for about an inch and a half cut into the form of a wedge, (Fig. 2. *b*.); it is left about the eighth of an inch thick on the outer or bark side, and is brought to a fine edge on the inside. It is then inserted into the opening prepared for it; and the knife being withdrawn, the stock closes firmly upon it. A circular incision is now made in the bark of the stock at the base of the wedge, to the extent of three parts of the circumference of the stock; by this means a shoulder can be formed on each side of the cleft.

Crown grafting.

67. Old stocks are sometimes grafted in another way, called *grafting in the bark* or *rind*, or *crown grafting*. The head of the stock or thick branch is cut off horizontally; a perpendicular slit is made as in budding, (to be presently described); a narrow ivory folder, or a silver fruit-knife, is thrust down between the wood and the bark, at the places where the grafts are

to be inserted. The graft is cut, at the distance of an inch and a half from its extremity, circularly through the bark, not deeper than the bark on one side, but fully half way through, or beyond the pith, on the other. The cut portion is then sliced away; the end of the graft is pointed, being sloped a little to the point on the outside, but left straight on the inside. A shoulder is likewise left, to rest on the bark of the stock. The grafts are then inserted into the openings made by the ivory folder; and either three or four grafts are inserted on a crown, according to its size. This mode cannot be practised till the sap be in full motion, perhaps in the end of March, as till then the bark cannot easily be raised from the wood. When the grafts are placed on old trunks, they are apt to be drawn from their places by violent winds; it is proper, therefore, to bind them to stakes for the space of perhaps two years, when they will have acquired a sufficient hold of the stock.

Saddle grafting.

68. *Saddle grafting* consists in cutting the top of the stock into a wedge-like form, and in making a corresponding angular notch in the bottom of the graft, to fit the wedge like a saddle. It is a mode sometimes adopted in the grafting of orange trees.

Side grafting.

69. *Side grafting* is merely tongue grafting, performed in the side of a branch, or in the body of a stock, without heading down. The bark, and a little of the wood, are sloped off for the space of an inch and a half, or two inches; a slit is then made downwards, and the graft is cut to fit the part, with a tongue for the slit, (Plate CCCIX. Fig. 3.); the parts being properly joined, are tied close, and clayed over. This mode is sometimes employed for supplying vacancies on the lower parts of full grown fruit trees. It cannot properly be performed till the sap is in action, or till about the middle of March.

Inarching.

70. *Grafting by approach*, *inarching*, or *ablactation* as the older horticulturists termed it, is practised on some kinds of fruit trees, chiefly tender, such as oranges, lemons, pomegranates, and mulberries, and on several ornamental trees which do not readily succeed by the ordinary means, such as myrtles, jasmines, andrachnes, and some rare species of oaks, firs, and pines. Walnut trees are sometimes also increased in this way. The principle is, that the graft shall continue to have a degree of attachment to the parent plant sufficient to keep it alive, until such time as its bark shall have become united to the bark of the stock which is approached to it. The stock is often planted in a pot (Plate CCCIX. Fig. 4. *a.*) at least a year before, and is brought close to the tree or shrub to be grafted on it, (Fig. 4. *b.*); if too low, it is raised on a slight stage to the required height. Where the tree is strong, the pot is sometimes fixed upon one of the branches of the tree. The operation of inarching is seldom performed before the middle of April, or the beginning of May. When it can be accomplished, tongue grafting is even in this way advisable. In four or five months the inarched graft is generally found to be fairly united to the stock; the head of the stock is then cut off; but the graft is not separated from the parent plant till nearly a year have elapsed. Sometimes, for sake of curiosity, branches of contiguous trees are joined by approach-grafting. To make this experiment succeed, it is necessary to fix the branches to poles, to prevent wind-waving; and indeed this caution is in general necessary in all kinds of inarching practised in the open air.

Root grafting.

71. Recourse is sometimes had to *root-grafting*, either for curiosity, or on account of seedling stocks being scarce. A piece of the root of a tree of the same genus, well furnished with fibres, is selected, and a graft placed on it, tied and clayed in the ordinary way. Thus united, they are set with care in a trench in the ground, the joining being covered, but the top of the graft being left two inches above ground. Some gardeners have thought that in this way the plant must preserve a nearer resemblance to the parent tree; but Abercrombie remarks, that though it is an expeditious way of obtaining a new plant, such a graft cannot be materially different from a cutting or layer.

Shoulder grafting.

72. What is called *shoulder* or *cheek grafting*, was formerly much more frequently employed than it is now. The head of the stock being first cut off horizontally, one side of it is then sloped. The graft is sloped in the same manner, and a shoulder left at the point where the sloping begins. This shoulder is applied to the horizontal head of the stock, and the bark is brought to join at each edge if possible. Another old method of grafting was called *terebration* or *peg-grafting*: the head of the stock was cut off horizontally, and a hole was bored in the centre of it; the graft was selected of equal bole with the stock; within an inch and a half of the lower end of the graft, a circular incision was made, and the bark and a great part of the wood were removed, leaving only a peg to fit the hole bored in the stock.

Cions for Grafts.

Cions for grafts.

73. The *cions* are gathered a good many weeks before the season for grafting arrives: the reason is, that experience has shewn, that grafting may most successfully be performed, by allowing the stock to have some advantage over the graft in forwardness of vegetation. It is desirable that the sap of the stock should be in brisk motion at the time of grafting; but by this time, the buds of the cion, if left on the parent tree, would be equally advanced; whereas the cions, being gathered early, the buds are kept back, and ready only to swell out when the graft is placed on the stock. Cions of pears, plums, and cherries, are collected in the end of January or beginning of February. They are kept at full length, sunk in dry earth, and out of the reach of frost, till wanted, which is some time from the middle of February to the middle of March. Cions of apples are collected any time in February, and put on from the middle to the end of March. The selecting of proper cions is a matter of the greatest importance, if we wish to enjoy the full advantage which may be derived from grafting. They should be taken from a healthy tree in full bearing, and from the outer side of the horizontal branches of such a tree, where the wood has freely enjoyed the benefit of sun and air. It is however the observation of a judicious practical gardener, Mr James Smith at Hopetoun House, that particular notice should be taken, whether the tree to be grafted from be in a luxuriant or in a debilitated state. If the former be its condition, the grafts are very properly taken from the extremities of bearing branches; but if it be in the latter predicament, the most healthy shoots in the centre of the tree should be resorted to; and if no proper shoots exist, the amputation of some central branches will quickly tend to produce them. The least reflection must convince every one, how extremely improper it must be to take cions from young trees in the nursery lines, as is too often done. It may be remarked, that the middle of the cion generally affords the best graft.

Budding.

Budding.

74. Budding, or inoculating, as it is sometimes, though not very correctly called, depends on the same principle as grafting, the only difference between a bud and a graft being, that a bud is a shoot in embryo. On this account, grafted trees usually produce fruit two seasons earlier than budded trees: but those kinds of trees that are apt to throw out gum, are not grafted without difficulty, while they are readily propagated by budding; such are the peach and nectarine, the apricot, the cherry, and the plum; the cherry, however, being occasionally grafted, and the plum not unfrequently. In the case of both these sorts of fruit trees, there is another reason for preferring budding,—that gum is apt to exude at the places necessarily cut in performing the process of grafting. Budding is performed any time from the beginning of July to the middle of August, at which period the buds for next year are completely formed in the axilla of the leaf of the present year, and they are known to be ready by their easily parting from the wood. The buds preferred are the shortest observed on the middle of a young shoot, on the outside of a healthy and fruitful tree; on no account should an immature tree, or a bad bearer, be resorted to for buds. For gathering the shoots containing the buds, a cloudy day, or an early or late hour, are chosen, it being thought that shoots gathered in full sunshine perspire so much as to drain the moisture from the buds. The buds should be used as soon after being gathered as possible, and the whole operation should be quickly performed.

In taking off the bud, the knife is inserted about half an inch above it, and a thin slice of the bark and wood along with it taken off, bringing out the knife about an inch and a half below the bud. (Plate CCCIX. Fig. 5. *a.*) This lower part is afterwards shortened and dressed; and the leaf is cut off, the stalk being left about half an inch long. (Fig. 5. *b.*) Perhaps it is better to insert the knife three quarters of an inch *below* the bud, and to cut upwards; at least this mode is practised in the Scottish nurseries. The portion of wood is then taken out, by raising it from the bark, and pulling it downwards or upwards, according as the cut has been made from above or below. If the extraction of the wood occasion a hole at the bud, that bud is spoilt, and another must be prepared in its stead; as gardeners speak, the *root* of the bud has gone with the wood instead of remaining with the bark. It is to be noticed, that the bud, and the portion of bark above and below it, receive together from gardeners, simply the name of a *bud*.

On a smooth part of the bark of the stock, a transverse section is now made, through the bark down to the wood: from this is made a longitudinal cut downward, about an inch and a half long, so that the incision may somewhat resemble a Roman T; by means of the flat ivory haft of the budding-knife, the bark is raised a little on each side of the longitudinal incision, so as to receive the bud. (Plate CCCIX. Fig. 5. *c.*) The prepared bud is placed in the upper part of the incision so made, and drawn downwards: the upper part is then cut off transversely, and the bud pushed upwards till the bark of the bud and of the stock join together. (Fig. 5. *d.*) It is retained in this situation by means of tying with strands of moistened bass-matting.

In about a month after the operation, the tying is slackened: buds that have *taken* appear swelled, and the footstalk of the old leaf falls off on being slightly touched. All shoots that spring below the budded part are carefully cut off. The head of the stock is not removed till the following March: after this, the bud grows vigorously, and in the course of the summer makes a considerable shoot. Against the next spring, the shoot is headed down, in the manner of young grafted trees.

Production of New Varieties of Fruits.

Production of new varieties of fruits.

75. From the well-known facts, that some of the favourite cider apples of the 17th century have become extinct, and that others are fast verging to decay, the conclusion has been drawn, that our varieties of fruit are but of limited duration. Each variety springs from an individual at first; and this individual has been extended by means of grafting and budding. Dr Darwin, indeed, in his *Phytologia*, has contended, that each bud is a separate plant, the viviparous offspring of a bud of the preceding year, and deriving nourishment from the soil by means of a set of lengthened radicles peculiar to itself. This opinion cannot be supported. Mr Knight's view is more rational, and more consistent with observation. All the extensions by means of grafts and buds, must naturally partake of the qualities of the original; where the original is old, there must be inherent in the derivatives, the tendency to decay incident to old age. Some popular writers, such as Southey, have represented this doctrine as on a par with that of the hamadryads, or as equivalent to saying that a graft could not survive the trunk from which it was taken: but these authors are more lively than accurate; for such an absurdity was never taught by any horticulturist. It may be assumed as a fact, that a *variety* or *kind* of fruit, such as the golden pippin or the ribston, is equivalent only to an *individual*. By careful management, the health and life of this individual may be prolonged; and grafts placed on vigorous stocks, and nursed in favourable situations, may long survive the parent plant, or original ungrafted tree. Still there is a progress to extinction; and the only renewal of an individual, the only true reproduction, is by seed. This doctrine seems to be true, at least, as to fruit-trees, and more particularly as to varieties of these, produced by cultivation: whether it can safely be extended to plants in general, may admit of some doubt.

76. As the production of new varieties of fruit from the seed, is a subject which now very much occupies the attention of horticulturists, it may be proper here to state the precautions adopted by Mr Knight and others in conducting their trials. It is, in the first place, a rule to take the seeds of the finest kinds of fruit, and from the ripest, largest, and best flavoured specimens of that fruit. When Mr Knight wished to procure some of the old apples in a healthy and renovated state, he adopted the following method: he prepared stocks of the best kinds of apple that could be propagated by cuttings, and planted them against a south wall in very rich soil; these were next year grafted with the stire, golden pippen, or some other fine old kind. In the course of the following winter, the young trees were dug up, and the roots being retrenched, they were replanted in the same place. By this mode of treatment they were thrown into bearing at two years old. Only one or two apples were allowed to remain on each tree; these consequently attained a large size, and more perfect maturity. The seeds from these fruits Mr Knight then sowed, in the hopes of procuring seedlings possessed of good or of promising qualities; and these hopes have not been disappointed.

Production of new varieties of fruits.

It may here be mentioned, that in order to produce a hybrid variety, possessing perhaps a union of the good properties of two known kinds, Mr Knight had recourse to the nice operation of dusting the pollen of one variety upon the pistils of another: He opened the unexpanded blossom, and cut away, with a pair of fine-pointed scissars, all the stamina, taking great care to leave the styles and stigmata uninjured. The fruits which resulted from this artificial impregnation were the most promising of any; and the seeds of these he did not fail to sow. Mr Knight has generally observed in the progeny a strong prevalence of the constitution and habits of the female parent: in preparing seed for raising new pears, therefore, he would employ the pollen only of such delicate pears as the chaumontel, crassane, and St Germain, upon the flowers (deprived of stamina) of the swan-egg, longueville, muirfowl-egg, auchan, or green yair, which are hardy.

Every seed, though taken from the same individual fruit, furnishes a distinct variety: these varieties, as might be anticipated, prove of very various merit; but to form a general opinion of their value, it is not necessary to wait till they produce fruit: an estimate may be formed even during the first summer, by the resemblance the leaves bear to those of the highly cultivated or approved trees or to those of the wild kinds; the more they approach to the former, the better is the prospect: the leaves of good kinds improve in character, becoming thicker, rounder, and more downy every season. The plants whose buds in the annual wood are full and prominent, are usually more productive than those whose buds are small, and shrunk into the bark. But their future character, as remarked by Mr Knight, must depend very much on the power the blossoms possess of bearing cold, and this power is observed to vary in the different varieties, and can only be ascertained by experience. Those which produce their leaves and blossoms early, are preferable; because, although more exposed to injury from frosts, they are less liable to the attacks of caterpillars. It is also to be observed, that even after a seedling tree has begun to produce fruit, the quality of this has a tendency to improve, as the tree itself becomes stronger and approaches maturity; so that if a fruit possess any promising qualities at first, great improvement may be expected in succeeding years.

Mr Knight has of late brought into public notice several new varieties of apples, pears, and cherries. Some of these seem likely to maintain a high character of excellence: they will be noticed in their proper places. He has, at his seat at Downton in Herefordshire, many hundreds of promising seedlings coming on, some of them annually improving in character.

77. From this digression we return to the young grafted or budded fruit trees. When they have been trained one year, they are called *maiden plants*; and these, especially in the apple and pear, are considered as forming the best plants. But trees of two, three or four years growth, or even more, succeed very well, provided due care be taken in transplanting.

Transplanting.

Transplanting.

78. Here it may be enough to observe in general, that in raising young fruit-trees from the nursery lines, or in transplanting them from one part of the garden to another, much more care should be bestowed than is often given, particularly in public nurseries. The surface earth should be removed, and the horizontal roots carefully traced, and raised at full length if possible: should this be inconvenient or thought unnecessary, the roots should be cut with a sharp knife, not hacked with a blunt spade. A tap root, or one which penetrates straight down, should not be left more than a foot long at most. If the trees are only to be carried a short way, the roots should be as little cut as possible. When they are to be carried to a distance, it is thought best to prune off the small and soft fibres, which are apt to rot and injure the whole root. If the tree be several years old, and have a large head, it is proper to dig a trench all round, and to scoop out the earth from under the root. In this way a ball of earth rises with the tree, and its success is ensured. A bass-matting is sometimes introduced as far as possible beneath the tree on one side; and when it comes to be turned over on the other side, the root and ball of earth are completely included in the matting; but this is seldom necessary. As it unavoidably happens that some roots are destroyed at the time of transplanting, and the means of drawing nourishment are thus lessened, many consider it proper to prune the tops of the trees to a certain extent, that the demand on the roots may be diminished. This however must be done cautiously, and by an experienced gardener; to lay down rules for it, is impossible.

Transplanting.

It may here be observed, that when the plants are of considerable size, they are prepared for transplanting, by cutting the roots a year beforehand, or in some sorts even two years before lifting. In this way the remaining short roots are induced to set out many radicles or fibres, and the entire roots of the tree are contained within a small compass. If the trees be young, this abridgment of the roots may be effected by a downright cut with a sharp spade all around, at a short distance from the stem; passing the spade entirely under the plant on one side, if it be wished to cut off the tap root.

It may scarcely be necessary to remark, that an essential preliminary to transplanting, is the preparing of the ground to receive the trees, by digging it over. The distances should likewise be fixed, and even the holes dug. Some gardeners make a point of digging the holes for the trees perhaps a fortnight before planting: in this way the soil into which the fibres are likely soon to penetrate, is softened and meliorated by the action of the air; but this practice is more applicable to orchard planting. In putting in wall-trees, it is not uncommon not only to have the border well prepared generally, but to have a quantity of very good friable mould for each tree in particular, into which it may strike young fibres freely: this mould however should not be screened or made fine, but should be of the ordinary degree of roughness natural to garden soil. When the trees have been brought from a very great distance, so as to have been several days on their journey, Miller recommends the placing the roots in water for eight or ten hours before planting.

It may be considered as a safe general rule, to plant shallow, more especially for dwarf standards and half standards, the soil for which is not particularly prepared. Whether the general soil be cold and moist, or thin and gravelly, it is found better to place the roots of the young trees almost on the surface, and rather to heap earth over them in the form of a hillock than to sink them into the soil. Suppose the subsoil be a mouldering rock, and a hole be dug in it, it is evident that the tree will be placed in a sort of well, which will at once retain water, and hinder the spread of the roots. If the tree be placed on the surface, it will insinuate its roots into and draw nourishment from many invisible crevices. Since shallow planting has been recommended, it follows as a necessary consequence that stakes are indispensable for dwarf standard and half standard trees.

Mulching.

From about the end of October, or after the shedding of the leaf, till the end of November, is considered as the best time for the planting of fruit-trees in this country, particularly in light soils. The weather is then mild, and the earth has time to settle about the roots during winter, before the first approaches of genial spring. But trees may be transplanted, in open weather, any time from the end of October till the beginning of March; and for heavy or wet land, planting in this latter month is accounted preferable. Young wall trees are planted about six or eight inches from the wall, and the part that has been cut at the time of grafting is placed next to the wall. The tree is planted at the same depth at which it formerly stood; but the roots are not the better for being deeply covered; if they be saved from the frost, they can scarcely be too near the surface. At the time of planting, the mould should be moderately dry, so as readily to crumble down. If, however, very dry weather occur, the ground is *mulched* at some distance around the roots, so as to prevent the bad effects of drought. *Mulching*, it may here be explained, consists in rendering a portion of the ground thoroughly moist by adding water, and working it like mortar. To increase the retentiveness of moisture, some short stable dung, or other litter, is added. When the roots are covered, the tree is gently raised and shaken, so as to cause the earth to apply closely to the roots. The soil is at the same time slightly pressed down. Wall-trees are not nailed up till the following spring. In this way they settle or subside along with the loose earth of the border. Were they nailed to the wall, they would run the risk of being suspended.

Garden Training.

Garden training.

79. Towards the end of March, young trees that have been planted out since October of the former year are headed down, or have their shoots shortened back to three, five, or six buds, according to their strength, and the purpose for which they are intended. When the trees have stood two, three, or more years in the nursery after grafting or budding, the heading down is of course confined to the last year's shoots, and its extent, as well as the thinning out of superfluous shoots, must be left to the judgment of the experienced gardener, it being impossible to lay down rules where the circumstances must be perpetually varying.

Wall-trees.

80. The two principal methods of training wall-trees which are followed in this country, are called the *fan* and the *horizontal* modes. In the former, the branches are arranged like the spokes of a fan, or like the hand opened and the fingers spread. In the other way, a principal stem is carried upright, and branches are led from it horizontally on either side. The Dutch style consists in taking a young tree with two branches, and leading these horizontally to the right and left, to the extent perhaps of twelve feet each way, and in then training the shoots from these perfectly upright to the top of the wall. This is now seldom practised here, excepting perhaps with fig-trees, or white currants. In some places, a few of the wall-trees are trained in a stellate form, the stem being led upright for about six feet, and then some branches trained downwards, others laterally, and others upwards. When walls exceed seven feet in height, the best gardeners seem to concur in giving the preference to the fan training, variously modified: in this way they find that a tree can much sooner be brought to fill its allotted space, and the loss of a branch can much more easily be supplied at any time. For lower walls, the horizontal method is preferred; and the same plan is adopted almost universally on espalier rails. Mr Hitt strongly recommends this mode for most sorts of wall-trees; and for pears he adopts what is called the *screw* stem, or training the stem in a serpentine manner, the branches going off horizontally as in the ordinary straight stem.

Wall-trees.

In the first volume of the Transactions of the London Horticultural Society, Mr Knight has made some ingenious and excellent remarks on the training and pruning of fruit-trees. His year old plants are headed down as usual, early in the spring, and two shoots only are trained from each stem in opposite directions, and in an elevation of about 5°. (Plate CCCIX. Fig. 6.) To procure the shoots to be of equal lengths, the stronger is depressed, or the weaker elevated. All lateral shoots are destroyed. Thus far it may be remarked, Mr Knight's method agrees very much with Hitt's, described in his Treatise on Fruit-trees. This shape, Mr Knight observes, ought to be given to young trees in the nursery, and is perhaps the only one that can be given to them without the risk of subsequent injury. Next season, as many branches are suffered to spring from each plant as can be conveniently trained, without shading each other; and by selecting the strongest and earliest buds towards the points of the year-old branches, to be trained lowest, and the weakest and latest near their bases, to be trained inclining upwards, each annual shoot will be nearly equal in vigour. (Fig. 7.) In the following winter, the shoots are alternately shortened, and left at full length. In the course of the third year, (Fig. 8.) if the tree be a peach, the central part consists of bearing wood: And, upon the whole, the size and general health of the trees trained in this way, afford evidence of a more regular distribution of the sap than Mr Knight has witnessed in any other mode.

The distance at which the branches are laid in, in all the different modes, varies from eight to ten inches, according to the nature of the tree, or the size of its foliage or fruit. While fan-trained trees are still in progress, a few more shoots are preserved at the summer pruning, than are likely to be ultimately laid in: this is for fear of accidents. Trees that have filled the spaces allotted to them, are disbudded of most of the wood-buds that appear. Wood-buds on old spurs are always displaced. Trees which are in training for the horizontal method, require different management. The leading stem is constantly to be attended to; all the buds that appear on it are carefully preserved, till enough be procured to lay right and left, and form the tree. All wood-buds on the horizontal branches, excepting the leading one, are displaced. The fan-training is considered as best for apricots, cherries, and plums, placed against walls, even though the walls be low. None of these kinds of fruit answer well for espaliers; cherries or plums succeed better as half standards or dwarf standards.

81. The wall-trees which have now been spoken of are called *dwarfs* by the gardeners. It is a very common practice to train high standards on the intermediate spaces between the dwarf trees; such trees are in Scotland termed *riders*, (§ 63). Plants four or five years old are preferred, because they are but temporary, and the object is to get fruit as soon as possible. Some good judges have condemned this plan of temporary trees as hurtful; being calculated to deprive the permanent trees of a proportion of the nourishment which

they would otherwise draw from the border: but if the border be tolerably rich, and be only slightly cropped with herbaceous plants, it does not seem likely that the temporary trees can do much injury.

Espalier trees.

82. In popular language, the term *Espalier* is somewhat equivocal: it means either rows of fruit-trees planted like hedges, or the individual trees composing the rows; or lastly, it means the stakes or rails to which the branches of the trees are tied. By using the terms espalier-*tree* and espalier-*rail*, ambiguity may always be avoided. Of late years, some have proposed to banish espalier-trees altogether, alleging that they injure the kitchen-garden quarters, by depriving them of sun and air. But in point of fact, they exist in the greater number of kitchen-gardens, and are not likely soon to be laid aside. If they are sometimes injurious by depriving the plants of air, they are at other times very useful, acting as a hedge in protecting the young crops from the violence of strong winds. Espalier trees generally produce excellent fruit, the sun and air having access to both sides of the tree; they commonly afford abundant crops, and the fruit is not apt to be shaken by high winds. Further, they tend to hide the crops of culinary vegetables from the eye, and to render the walk of the kitchen garden as pleasant as an avenue in the shrubbery.

Apples and pears are the fruits best suited for espaliers. The apples are generally grafted on crab stocks, to keep them of moderate size; or, if the tree be wished still smaller, on Dutch paradise stocks. The distance allowed between the former is from 30 to 40 feet; between the latter, 25 is found sufficient. These may seem large spaces at first; and, to take away the naked appearance, a small cherry-tree, or white currant bush, is sometimes planted in each interval. It is to be studied that, in the same line of rail, trees of similar growth be planted: so that the whole may be nearly equally filled. The trees, when planted, should be of one year's growth, or at most of two years. If the rail be not previously erected, so that the branches can be tied to it, a stake is necessary, to prevent wind-waving. Very often, the permanent rails are not put up till the trees have been two or three years trained on temporary stakes. Simple ash-poles firmly stuck in the ground, and either charred or smeared with tar at the bottom, to retard rotting, form a very efficient substitute for a rail; for it is to be observed, that during summer, when the leaves are expanded, they equally hide the roughest poles, or the most finished rail. Mr Nicol, however, recommends sinking hewn stones in the earth, and fixing a wooden rail in them: and a writer, in the Scottish Horticultural Memoirs, vol. i. has described a kind of cast iron espalier-rail, which of course must be highly durable, and, what is remarkable, is cheaper at the first than a wooden one. Some gardeners shorten the head of the tree in the usual way; others preserve the original branches at full length, never cutting a branch unless where there is a real deficiency of wood for filling the rail. The pruning is chiefly done by disbudding in the summer season. The distance at which the branches are laid in depends on the size of the fruit and leaves; when these are large, seven or eight inches are required; when small, four or five may be sufficient.

Dwarf-standards.

83. Dwarf trees were formerly much in vogue; and, strange as it may appear, the prospect of fruit was generally sacrificed to a fine shape. It was thought necessary that the lower branches should spread horizontally near the ground, and should decrease in width upwards, so that the tree should have a conical form. Now, it is well known that the fruit-buds of pears and apples in general, and of many sorts of plums and cherries, are produced at the end of the former year's shoots, which therefore should remain at full length; yet these were necessarily shortened, in order to preserve the desired shape, and it may easily be conceived that trees so dressed could not prove fruitful. For these reasons, the training to espalier-rails has generally been preferred. A few dwarf trees, however, prove ornamental, and they sometimes afford a great deal of fruit. The kinds of dwarf fruit-trees now in request are chiefly pears and apples. The pears must be of the summer and autumn sorts, the later fruits requiring a wall in our climate. Dwarf pears are chiefly budded on quince stocks. The trees are planted out, at two or three years old, where they are to remain, and they are placed from 20 to 25 feet asunder. A few stakes are driven into the ground, and, by means of tying down, the lower branches may soon be made to acquire a horizontal direction. No branches must cross each other, and no central upright shoots are permitted. The only other particular to be attended to is, when the trees are to be trained in a concave form, that, in shortening the shoots, the uppermost eye or bud is to be left *outwards*, as in this way the hollowness in the middle of the tree is better preserved. Sometimes the branches are trained round a hoop, which is supported by three or four small poles. Dwarf-standard apple trees on paradise stocks may be planted very closely, as they occupy but little room: they do not require more than 10 or 15 feet; on crab stocks they need at least 25. Plums are now seldom planted as dwarf-standards; cherries more frequently; apricots scarcely ever.

Preserving of Blossom.

Preserving of blossom.

84. In this country, particularly on the east coast and in the northern division of the island, it is an important part of the gardener's duty, to preserve the blossoms of apricots, nectarines, peaches, and the finer sorts of plums, from being destroyed by spring frosts, and especially frosty winds. One of the means first employed is still occasionally resorted to; namely, shading the trees slightly with branches of spruce-fir, yew, or beech: but the branches ought to be so firmly fixed as not easily to be displaced by the winds, or to shake much: if this precaution be neglected, they will be ready to beat off the blossom which they are intended to defend. Strong fronds of the common brake (*Pteris aquilina*) have been used with advantage in this way; being the remains of the former year's growth, they are light and dry, and much less apt to injure the blossom than branches of trees.

The most effectual protection, however, is afforded by canvas-screens, in moveable frames; the fabric of the canvas being made thin enough to admit light, and yet affording sufficient shelter. The stuff called *buntine*, of which ships flags are sometimes formed, is recommended by Nicol; and he adds, that it may be rendered more transparent, and more durable by being oiled. The stuff called *osnaburg*, manufactured in the towns of Dundee, Arbroath, and Montrose, answers equally well, especially if made on purpose, of a wider texture, so as to resemble gauze. These screens are kept clear of the tree, a foot at top, and 18 inches at bottom. If, when not in use, they may be stowed in a dry loft, they last for many years. Sometimes the canvas is used in the form of sheets to hoist up and down; and in some places (as at Dalmeny Park garden, one of the finest in Britain) the contrivance is such, that the covering can be drawn up or let down along the entire stretch of the wall, by two men, in the course of a minute. These screens are employed only at night, or in bad weather; and chiefly from the end of March to the beginning of May. Blossom thus partially protected is perhaps more tender than if no protection whatever had been given. The screens must therefore be continued till all risk of danger be over; perhaps till the leaves of the tree be pretty fully expanded, the blossom of several of our fruit-trees preceding the unfolding of these.

Frames covered with oiled paper have been successfully employed at Grangemuir garden in Fifeshire. The frames are of wood, inch and half square, with cross bars mortised into the sides. To give support to the paper, strong pack-thread is passed over the interstices of the frames, forming meshes about nine inches square. Common printing paper is then pasted on; and when this is quite dry, a coating of boiled linseed oil is laid on both sides of the paper with a painter's brush. These frames are placed in front of the trees, and made moveable, by contrivances which must vary according to circumstances. If the slope from the wall be considerable, a few triangular side frames may be made to fit the spaces. At Grangemuir, the frames are not put up till the blossoms be pretty well expanded; till which time they are not very apt to suffer from spring frosts or hail showers. In this way, it may be remarked, there is much less danger of rendering the blossom delicate by the covering, than if it were applied at an earlier period. The paper frames, if carefully preserved when not in use, will endure for a good many years, with very slight repairs.

At Dalkeith garden, in order to break the force of the winds, screens made of reeds are projected, at right angles with the wall, perhaps to the distance of ten feet, and at intervals of thirty or forty feet from each other; and at the same time nets wrought with straw are placed in front of the trees. These straw nets are very well deserving the attention of gardeners who may find their walls too much exposed to east winds during the spring months. Old fishing-nets, kept at the distance of fifteen or eighteen inches from the tree by means of hooked sticks, are sometimes employed; these may be doubled over, in order to render the interstices closer. But nets made of coarse woollen yarn or carpet-worsted, are preferable to these. At Haddington, in East Lothian, woollen nets for this purpose are manufactured in the loom, and can thus be afforded at much less expence. They are woven very thick, the meshes not being larger than to admit the point of the finger, even when stretched out. The advantage of woollen yarn over flax for this purpose is evident; every small mesh being in effect rendered still smaller, by the bristliness of the material, and its constant tendency to contract; and from its aptitude to attract and concentrate moisture, such as cold dews and hoar-frost, the blossom derives additional security. These nets, and indeed nets of any kind, remain on night and day, till the season be sufficiently advanced.

To guard against the effects of hoar-frosts falling perpendicularly, some make a temporary coping of boards, to project a foot or eighteen inches over the tree at the top of the wall. Hitt recommends, that, in what are called *black frosts*, the borders opposite to the trees should be watered every night, affirming that he perceived advantage from this. So it might be; but he is no doubt wide from the true *rationale* when he ascribes the good effects to some thinning of the glutinous juices, &c. Perhaps the latent caloric evolved in the freezing of the newly moistened surface, may preserve a higher temperature immediately around the plant.

Garden fruits.

85. We now proceed to the consideration of the different species of fruits cultivated within the walled garden, and the principal varieties of each. The order in which these are treated of, seems to be of little moment: the following arrangement is adopted, partly on account of the importance of the fruits, and partly because of natural alliances:

Peach, and Nectarine; Almond,	*Amygdalus.*
Apricot. Plum, Cherry,	*Prunus.*
Apple, Pear, Quince,	*Pyrus.*
Vine,—*Vitis.*	
Fig,—*Ficus.*	
Mulberry,—*Morus.*	
Medlar,—*Mespilus.*	
Red Currant, Black Currant, Gooseberry,	*Ribes.*
Raspberry,—*Rubus.*	
Strawberry, six species,—*Fragaria.*	

Some other hardy fruits and nuts, which are planted exterior to the garden, will afterwards be noticed; as also the pine-apple and the melon, which require a constant high temperature, and the orange, lemon, and shaddock, which are rather inhabitants of the green-house.

All the common fruit trees and fruit-bearing plants, are extremely well known, both here and on the continent; any botanical description of them seems therefore unnecessary. The generic and trivial names given by Linnæus shall merely be mentioned, and at the same time the class and order in his system, and the family in the Natural Method of Jussieu, to which the plant belongs. Occasionally, when it may appear useful, some of the foreign names of the trees or the fruits shall be given.

GARDEN FRUITS.

Peach.

Peach.

86. The *Peach tree* is the *Amygdalus Persica* of Linnæus, belonging to the class and order Icosandria Monogynia; and natural order Rosaceæ of Jussieu. This species is by Linnæus divided into two varieties; 1. With downy fruit, the *peach*; 2. With smooth fruit, the *nectarine*. Peaches and nectarines have sometimes occurred on the same tree; in a few cases, on the same branch; and one instance is on record, of an individual fruit partaking of the nature of both. Yet they are generally considered as distinct kinds of fruit, and they shall here be spoken of separately.

A good peach possesses these qualities: the flesh is firm; the skin is thin, of a deep or bright red colour next the sun, and of a yellowish green next the wall; the pulp is of a yellowish colour, full of high flavoured juice; the fleshy part thick, and the stone small. Those varieties, the flesh of which separates readily both from the skin and the stone, are the proper *pêches* of the French, and are by our gardeners termed *free-stones.* Those with a firm flesh, to which both the skin and the stone adhere, are the *pavies* of the French, by our gardeners named *cling-stones*. The latter require more shelter and better seasons to bring them to perfection than the former. In countries possessing sufficient climate, as in France and the warmer states of North America, the pavies are preferred: in this country, the preference is generally given to the free-stones, pavies being chiefly planted in forcing-houses, where the climate can be made.

87. Parkinson, in his *Paradisus*, enumerates twenty-one kinds of peaches, several of which, particularly the Old Newington, are still cultivated. Miller gives a list of thirty-one, with their characters; but as these are taken only from the fruit, without any notice of the bud, blossom, or leaf, they sometimes prove unsatisfactory. The following are the names:

1. White Nutmeg,
Red Nutmeg,
Early or small Mignone,
Yellow Alberge,
5. White Magdalen,
Early Purple,
Large Mignone,
Belle Chevreuse,
Red Magdalen,
10. Early Newington,
Montauban,
Malta,
Noblesse,
Chancellor,
15. Bellegarde or Galande,
Lisle,
Boudine,
Rossana,
Admirable,
20. Old Newington,
Rambouillet,
Bellis (Belle de Vitry.)
Portugal,
Teton de Venus,
25. Late Purple,
Nivette,
Royal George,
Persique,
Monstrous Pavie,
30. Catherine,
Bloody Peach.

88. The characters of such of these as are chiefly cultivated, and chiefly deserving of attention in this country, may be mentioned.

The *White Magdalen*, or Early Magdalen, is a round fruit, of a middling size, with a deep furrow; of a pale colour, and the flesh white to the stone; melting, juicy, with considerable flavour; ripening in August; the tree sometimes succeeds on the open wall, even in North Britain.

The *Red Magdalen*, however, is altogether a superior fruit; it is large, round, and of a fine red next the sun; the juice very sugary and of exquisite flavour; ripening in the end of August: the tree is a free grower and great bearer: the blossoms are small. Nicol recommends the red magdalen as the "best peach we have, either for the open air or the hot-house." In doing so he is justified by the experience of Scottish gardeners; for the peach commonly known in Scotland by the name of red magdalen ripens well, in ordinary years, even in the northern districts of the country. This we believe to be the same which goes by that name in the south; but we have reason to think that the same name is applied, in some parts of England, to another peach; for English horticulturists sometimes complain that the red magdalen does not succeed well.

The *Large Mignone* is somewhat oblong in shape, and generally swells out on one side; the juice is very sugary, and of high flavour: this, though a free-stone, being rather a tender sort, is generally budded on a peach or apricot stock.

The *Early Newington* or Smith's Newington (supposed to be the *pavie blanc* of Duhamel) is a fruit of middling size, of a fine red next the sun; flesh firm, with a sugary well-flavoured juice; ripening the beginning of September: a clingstone: the tree a good bearer.

The *Noblesse* is a large fruit, red or marbled next the sun; flesh greenish-white and melting, very juicy, and, against a good wall and in a favourable season, the juice becomes rich and well-flavoured; ripens in the beginning of September; and should be eaten *sharp ripe*, as the gardeners term it, the fruit being apt to become mealy if not taken just when it ripens.

The *Boudine*, sometimes called the bourdine, is a large round fruit, of a fine red next the sun; the flesh white, melting, juice vinous and rich; ripens from the beginning to the middle of September: the tree a plentiful bearer, especially when old. In favourable situations in the south of England it has sometimes produced fruit on standards.

The *Old Newington*, already mentioned, is a large round fruit, of a beautiful red next the sun; the flesh white and melting; when ripe, the juice very rich and vinous; a clingstone, and not ready before the beginning of October.

The *Rambouillet*, often called rumbullion, is a fruit of middling size, deeply divided by a furrow; the flesh melting, of a bright yellow colour; juice rich, and of a vinous flavour: ripens about the middle of September: the tree a good bearer.

The *Téton de Venus* is a fruit of middling size and longish shape, of a pale red next the sun; flesh melting, white; juice sugary, and not without flavour; ripens the end of September: the tree is a free bearer, on a warm light soil; but the fruit comes to perfection only in fine seasons.

The *Royal George* is an excellent peach; and in a very good soil and aspect, the fruit becomes large, dark red next the sun, juicy, and high-flavoured. If the soil and aspect be not favourable, the tree proves a shy bearer.

The *Catherine* is a large round fruit, of a dark red next the sun; the flesh white, melting, full of a rich juice; a clingstone; ripens from the beginning to the middle of October, against a good wall and in a favourable season; the fruit, however, is improved by lying two or three days before being used: it is sometimes called the October Peach.

89. To the ample list of Miller, a few others might be added. The *Ann Peach*, sometimes called the Early Ann, is a small round fruit, of a yellowish white colour, faintly tinged with red on the sunny side; ripening about the middle of August. This is said to be of English origin. The *Royal Kensington* is described by Forsyth, and the tree is said to grow freely, and not to be liable to blight. The *Orange Peach* is mentioned by Nicol as the most elegant he was acquainted with, and the best-flavoured of the cling-stones; rather large than otherwise, round, dark red or purple next the sun, and bright orange on the other side; the flesh of a deep orange colour, but purple at the stone; the tree a very great bearer. It is possible this may be the Yellow Alberge, the fourth in the tabular list above given. The *Double-flowering Peach* is sometimes cultivated for curiosity, on standards, being very ornamental while in bloom; the flowers being only semi-double, fruit is generally produced, and in fine seasons abundantly; in most cases, however, it is fit only for preserves.

90. That indefatigable and excellent horticulturist Mr Knight, has produced several new peaches of the most promising qualities, at his seat of Downton in Herefordshire. After due precautions to bring his trees (small ones planted in large pots) to the highest state of health and vigour, he impregnated the pistil of one with the pollen of another: only three peaches

were suffered to remain on each tree: from sowing the stones of these, he obtained his new varieties. The situation of Downton being rather high and late, it may reasonably be presumed that fruits produced there, will succeed in all places not less favourably situated as to climate. Two of these new peaches deserve particular notice; 1. The *Acton Scott Peach;* the fruit ripens early, and uniformly attains perfection; it is juicy and sweet, with a rich flavour; where secluded from the sun's rays, the skin is very white: the tree is an abundant bearer, and not subject to mildew: and Mr Knight considers it as calculated to succeed in many cold and unfavourable situations, where the more delicate varieties would certainly fail. 2. The *Spring Grove Peach* has a firm flesh, but not hard; the exterior colours are bright yellow and dark red; it melts in the mouth, resembling a nectarine in consistence as well as taste, having a remarkably rich, brisk, and vinous flavour; the stone parts readily from the flesh, which is of a greenish cast: it never becomes over-ripe or mealy, but is apt to shrivel a little, and is then most perfect: the tree grows slowly, but the wood is healthy, and acquires maturity early in the season: It succeeds better on an apricot than a plum stock. *

New peaches.

By persevering in the track pointed out by Mr Knight, we may hope, in time, to obtain peach-trees sufficiently hardy to produce their fruit in almost every situation in Britain, perhaps even as standards. In Maryland and Virginia, peach-trees are propagated from the stones, without budding. Every peach orchard contains, of course, numerous varieties. Among these a few are always of superior quality; with the fruit of the rest, pigs are fed. One of these American seedlings possessed of good properties, is now growing in the garden of Mr Braddick at Thames Ditton: it has produced fruit, which is figured in the second volume of the London Horticultural Transactions, under the title of Braddick's American Peach.

In arranging the different varieties of peach-trees in a new garden, the late kinds, especially the pavies, must have the full south aspect; the others may be a point or two to the east. The kinds which ripen nearly at the same time should, as far as possible, be placed together, as this afterwards saves much trouble in collecting for the dessert, especially in a large garden.

91. The fan mode of training is considered as best suited to peach-trees, and is the plan generally adopted. These trees may, to a certain extent, be considered as constantly in a state of training. In pruning them, the great object is, to keep every part of the tree equally furnished with bearing wood, that is, with a succession of new shoots, laid in to the wall every year. This is to be attended to in April, and especially in May: for, the wood and young shoots laid in afterwards, seldom ripen sufficiently to stand the winter. Besides, at that early season, the superfluous shoots can be pinched or rubbed off, without the use of the knife. The blossom-buds, it may be remarked, rise immediately from the eyes of the shoots; they are round, short, and prominent; while the leaf and shoot buds are oblong, narrow and flattish. The winter pruning is performed any time from the end of October till the end of February; but the early part of winter is generally thought best. Where the trees are well managed, there is not a great deal of winter pruning required. In shortening branches, it is a rule to cut behind a wood-bud, which may become a leader, to attract nourishment towards the shoot; for a shoot possessing flower-buds, but having no wood-bud to act as a leader, may blossom, but will produce no perfect fruit. Branches which are considered as too weak to ripen fruit, are commonly cut, as they must tend to rob the other parts of the tree. When the trees have completely filled the spaces allotted to them, the principal shoots are not shortened unless with the view of filling vacancies, or when the extremities of the shoots have remained unripe and been checked by the frost.

Mr Knight has explained the nature of what are called *luxuriant shoots,* and also the right mode of managing them. Most gardeners have directed the shortening of these in summer, or the cutting of them out in the following spring: But Mr Knight has experienced great advantages from leaving them wholly unshortened, but trained with a considerable inclination to the horizon: for, in this way, they have uniformly produced the finest possible bearing wood for the succeeding year; and so far is this practice from tending to render naked the lower or internal parts of the tree, whence these branches spring, that the strongest shoots they afford, invariably issue from the buds near their bases. The laterals from luxuriant shoots, if stopped at the first leaf, often afford very strong blossoms, and fine fruit in the succeeding season.

92. In the milder parts of England, the blossom of the peach-tree scarcely requires protection: in less favoured places, it is protected by some of the means already specified. Dr Noehden, in the second volume of the London Horticultural Transactions, has mentioned rather a singular mode of preventing the bad effects of frost on the blossom or young fruit of the peach-tree. It is this: after a frosty night, the first business of the morning is to sprinkle cold water over the trees by means of the garden engine, taking care that the blossom or young fruit receive their share, and that the operation be performed some time before the rays of the sun strike the trees. Whether the water is useful merely by promoting a gradual thawing, has not been ascertained.

When the fruit has attained the size of large peas, or of small hazel-nuts, it is thinned, to the distance of five or six inches between each fruit. In this way it acquires a larger size, and the tree is not exhausted. The picking off of leaves which overshadow the fruit, as recommended by Nicol and others, is not a good practice; at least it must not be pushed to any considerable extent; for the flower-bud for the succeeding year being lodged in the axilla of the leaf-stalk, must greatly depend on the leaf for its nourishment.

In dry seasons, and especially in soils naturally dry, a hollow bason, about six feet in diameter, is sometimes formed around the root of the tree; this is covered with *mulch* (small dung moistened, mixed with a little loam, and worked together like mortar,) and water is occasionally added according to the state of the weather. This is practised only while the fruit is growing, and the intention is, to keep it always in a state of progress.

Mr Knight seems to think, that in the milder parts of England plentiful crops of fruit might be procured from the hardier sorts of peach-trees trained as espaliers: he suggests that they should be planted in rows in the direction of north and south; that they should

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* These two varieties were sent by Mr Knight in the spring of 1816 to the garden of Sir George Mackenzie at Coul, in Ross-shire, where they are planted against a south wall. If they succeed well in that latitude they will prove a great acquisition to Scotland.

not exceed five feet in height; and that while the blossom is exposed to danger from frost, mats should be thrown over them, so secured as to descend on each side nearly in the angle of an ordinary roof of a house.

On account of the usual mode of training and pruning peach-trees in this country, they do not occupy much space on the wall. Some of the old horticultural writers speak of twelve or fourteen feet as enough: but the trees are now permitted to spread wider, from fifteen to twenty feet being allotted to each tree. Near Paris, a single peach-tree may sometimes be seen covering sixty feet of wall. It is at Montreuil that peaches are cultivated in perfection, peach-gardens being here established for the supply of the capital. Making due allowance for the difference of climate, advantages might probably be derived from copying some of the practices of these French cultivators, whose whole attention is devoted to the management of peach-trees. In 1814, Mr John Mozard, who was bred under the famous gardener Pepin, and is himself one of the principal proprietors of peach-gardens at Montreuil, published a little piece, entitled, "*Principes pratiques sur l'éducation, la culture, la taille, et l'ébourgeonnement des arbres fruitiers, et principalement du pêcher,*" which is well deserving the attention of horticulturists in this country.

Nectarine.

Nectarine.

93. The *Nectarine,* as already observed, is merely a variety of the peach. The English name may be supposed to be derived from the nectareous flavour of the fruit. The skin is smooth, not downy as in the peach; and the flesh is rather more plump than in that fruit. Nectarines, like peaches, are either free-stones or clingstones; the former are called by the French *Pêches lisses,* smooth peaches; the latter, *Brugnons.* Miller enumerates ten varieties:

Fairchild's Early.
Elruge.
Newington.
Scarlet.
5. Brugnon or Italian.
Red Roman.
Murrey.
Golden.
Temple's.
10. Peterborough.

Of these the following are in most esteem.

The *Elruge,* a middle-sized fruit; when ripe, of a dark red or purple next the sun, pale towards the wall; ready in the middle of August: the tree grows freely, and is a sure bearer; indeed it is perhaps the best nectarine for the open air, especially in the less favoured counties.

The *Newington* nectarine is rather a large fruit; of a beautiful red next the sun, and, on the other side, of a bright yellow; flesh melting; juice very rich, racy and high-flavoured; a clingstone, not ripening before September: the tree a good bearer, when in a favourable situation.

The *Red Roman* nectarine is a large fruit; deep red or purple next the sun, and yellowish on the other side; flesh firm and of excellent flavour; when quite ripe, it shrivels; a clingstone, not ready before the middle of September.

The *Murrey* (*i. e.* murrey-coloured) is a middle-sized fruit, of a dirty red colour next the sun; the pulp pretty well flavoured; ripens from the beginning to the middle of September.

Temple's nectarine is a middle-sized fruit, of a light red next the sun, and yellowish-green on the other side; pulp melting, with a fine poignant flavour; the skin shrivelling when the fruit is perfectly ripe, which seldom happens before the end of September: the tree grows freely, and is generally productive.

To these may be added the *Early Violet* nectarine, of middle size, violet purple next the sun, pale yellow on the other side; flesh sugary, juice with a vinous flavour; a clingstone, ripening in the beginning of September: the blossom is very small, but the tree very productive; it requires a good situation, and succeeds only in warm seasons.

The production of a new and early nectarine, suited to the climate of Britain, may be considered as one of the desiderata in our horticulture. It may here be mentioned, that a new variety of white nectarine is described by recent French writers as being remarkably early and of excellent flavour; the foliage of the tree is of a pale or whitish green; it was raised by Mr Noisette, a nurseryman at Brunoy.

The management of the nectarine-tree is in every respect the same as that of the peach. In this country, nectarines require the best exposure in the garden; and to the northward of Yorkshire, they seldom acquire maturity without the aid of a flued wall and artificial heat.

Almond.

Almond

94. The *Almond-tree,* (*Amygdalus communis,* L.) can scarcely be ranked as an effective fruit-tree in this country. In clumps of shrubs on the lawn, it makes a fine appearance in early spring, when covered with its beautiful blossoms. In good seasons, such standards produce some ripe fruit: but ornament is its principal recommendation; and if the fruit be no object, the double-flowered variety is preferable. Trained against a wall, the almond-tree perfects its fruit in our ordinary seasons, when the outer cover opens naturally to give out the stone containing the kernel. They are very sweet and fit for the table when green, and they are sometimes kept in sand till winter.

In France, the almond tree is much cultivated. Bastien enumerates nine varieties; among which is an *amandier pêcher,* or peach-almond tree, supposed to have been derived from an impregnation of the almond by the pollen of the peach. On the same tree, he tells us, two sorts of fruit occur; the one round, fleshy, and divided by a furrow like the peach; the other oblong, not fleshy, and resembling the common almond.

The kinds of almond chiefly cultivated for their fruit are,

The common sweet almond;
Tender shelled;
Hard shelled;
Sweet Jordan; and
Bitter almond.

These different varieties are propagated by budding on plum or peach stocks, or on almond stocks raised from the stones; plum stocks being preferred for strong and moist soils, and peach or almond stocks for such as are light and dry. In this country it often happens that the varieties are little attended to. Almond trees are raised from the stones, and of course are liable to *sport,* as gardeners speak. It may be remarked, that even when they are raised from the stones, budding or working of one new variety upon another, is extremely useful in hastening the production of fruit.

The general management in regard to pruning, &c. is similar to that of the peach tree, only that the bearing twigs are often left six inches long without being nailed to the wall.

Fruit Garden.

Apricot.

Apricot.

95. The *Apricot tree* (*Prunus Armeniaca*, L.; *Icosandria Monogynia*; *Armeniaceæ*, Juss.) is said to be a native of the whole of the Caucasus, the mountains almost to the top being covered with it. It is supposed to have been introduced into this country in the reign of Henry VIII.

96. In 1629, Parkinson describes six varieties. At least ten varieties are now commonly cultivated. Several of these have been known since the days of Parkinson, particularly the Masculine; and others are mentioned by Rea in 1702, such as the Roman and the Orange.

Masculine.
Moorpark apricot.
Orange apricot.
Royal orange.
5. Roman.
Transparent.
Peach apricot.
Breda.
Brussels.
10. Turkey apricot.

The *Masculine* is generally first ripe. It is a small roundish fruit, red next the sun, and, when ripe, of a greenish yellow on the other side. It has a quick high flavour, but in general is rather tartish. The tree is a good bearer.

The *Breda* is a large roundish fruit, becoming of a deep yellow when ripe; the flesh soft and full of juice, and of an orange colour within. It is considered as among the best of the apricots, and the tree is a liberal bearer.

The *Moorpark* is a large fruit, flat shaped, of a deep yellow colour, and very high flavoured. Nicol declares, that one Moorpark is worth three of any other kind of apricot; and it is esteemed by many the richest of the stone-fruit kind. The tree requires a good soil and situation, but deserves them. It is regarded as of English origin, and it receives various names in different parts of the country, such as Lord Dunmore's apricot, the Anson apricot, and the peach apricot. It takes its name from Moorpark in Hertfordshire, a place celebrated by Sir William Temple in his account of English gardens at the close of the 17th century. (Miscellaneous Works, vol. ii.)

97. The stocks commonly preferred for apricots are those of the muscle plum; but Mr Knight has observed, that they succeed better, and are more durable, on stocks of their own kind, that is, on apricot stocks: this he found to be the case, in particular, with the Moorpark apricot. The apricot being an early tree, the budding is performed any time from the end of June to the end of July; the bud is inserted about six or eight inches from the ground. The apricot is sometimes twice budded; that is, one variety is budded on another. The tree is said in this way to be kept more dwarf. When apricot trees are wanted as *riders*, or temporary trees, to fill the wall, they are of course budded on stocks four or five feet high. The best plants for dwarfs are such as have two strong branches, expanding as widely as possible from each other, and inclined at an angle of about 30°. But it very frequently happens, that there is only one main shoot, and this is headed down to six or eight inches, to obtain a supply of lateral wood. October is the best time for planting, and the end of February for heading down. The young shoots are laid in horizontally, or nearly so, and are not shortened till November following.

The fruit being produced partly on spurs, but chiefly on young wood of the former year, during summer care is taken to pick wood-buds from these spurs, and to lay in and protect a sufficiency of new wood for next season. In June, the superfluous and fore-right shoots can be displaced with the finger and thumb; late in the season a knife must be used. The young shoots cut off, it may be mentioned, may be used for dyeing a fine cinnamon colour. Some good fruit, it must be observed, however, is produced from the curzons or spurs upon two-year-old shoots. The shape of the buds indicates those likely to be fruitful, and which of course are to be preserved. The winter pruning is done any time from October to March. Not only all decayed and very old wood is as much as possible removed, but some of the most naked parts of the bearers of the two last years are cut out, so as to make room for a supply of new wood. The retained shoots are commonly shortened a little, and are always cut next a wood-bud, which is to act as a leader. The full grown apricot tree is managed much in the same way as the peach; but its late or autumn shoots do not agree with being shortened; when wanted as bearers therefore, they are laid in at full length to the wall. The small and subordinate, or late shoots of the apricot, are more apt to be destroyed by frost than those of the peach tree. On this account, the pruning is often delayed till the end of January, when it can be seen which shoots are alive, and which have perished.

Fruit Garden.

98. When the fruit is over-crowded, it is thinned, but cautiously, in the early part of summer. In the beginning of July it is finally thinned, and the best of the thinnings may then be used for tarts. Some gardeners recommend thinning the Moorpark to a fruit to every foot square, and the smaller kinds of apricots to a fruit to every eight inches; but, in general, the thinning is not carried so far. As the fruit approaches maturity, it is nailed close in to the wall, in order to its gaining as much reflected heat as possible. In this country, apricots begin to ripen in the end of July, and they continue till peaches be ready. Before the introduction of the new style, they were sometimes ready early in July, and hence received the name of Mala *præcocia*, to which epithet our English name may be traced.

Apricot trees are generally placed against an east or a west wall; the heat of a full south wall being apt to render them mealy before they become ripe. In the northern parts of the island, however, a south-east or south-west aspect answers best. In some of the warmer districts of England, several varieties of the apricot, particularly the Moorpark, transparent, Breda, and Brussels, are frequently planted as espalier trees, the horizontal branches being tied to the rail, but the bearers left loose. Occasionally some of these, especially the Breda and Brussels, are tried in the form of dwarf standards; and in fine seasons, they yield the highest flavoured fruit.

When an apricot tree has been greatly mismanaged, it may be cut down very much, as it sets out stronger branches than a peach tree, and these may soon be trained so as to fill the former space. The strong branches of this tree are very apt to throw out gum at places where any accidental hurt has been received: the usual remedy is to cut out the diseased part, filling up the space with pitch and rosin melted together, or merely with a little tar, or any sort of mild paint.

Apricots are seldom forced, as they do not in general answer expectation in this way. The Moorpark, however, is sometimes seen on the flued wall along with peach trees; and dwarf or espalier plants of the early masculine and Brussels, are occasionally introduced into the border of the cherry-house or the peach-house, with success.

Plum.

Plum.

99. The *Plum-tree*, (*Prunus domestica*, L.) is completely naturalized in this country, but can scarcely be said to be indigenous to Britain: it is however admitted into our Flora by Sir J. E. Smith, and is figured in English Botany, plate 1783. There are many varieties, of which some of the oldest and best marked are *P. præcox*, the primordian; *damascena*, the damask or damson; *juliana*, the St Julian; *pertigona*, the perdrigon; and *cerea*, the magnum bonum. Parkinson enumerates no fewer than sixty sorts. Miller describes only about thirty.

100. The following are the kinds chiefly cultivated at present:

White primordian.
Early damask.
Black damask.
Precoce de Tours.
Maître Claud.
Monsieur's plum.
Imperatrice.
White Perdrigon.
Blue or Violet Perdrigon.
Red Perdrigon.
Queen Claudia, or true green-gage.
White gage.
Blue gage.
Apricot plum.
Mirabelle.
Drap d'or.
White imperial, or magnum bonum.
Red imperial.
St Catherine.
Orleans.
Fotheringham.
Wine-sour.
La Royale.
La Roche-corbon.
Coe's golden drop.

The *White Primordian*, which is also called St Barnaby's plum, and sometimes Jaune-Hâtive, is the earliest plum we have, commonly ripening in the end of July. The fruit is small, of a longish shape, sugary, but without much flavour. One tree on a wall is reckoned enough, the tree being a free bearer.

The *Early Damask*, or Morocco, immediately succeeds the white primordian. The *Precoce de Tours* and *Maître Claud* are well flavoured plums, and the trees grow freely, and bear well as standards.

Monsieur's Plum, or the Wentworth, is a large fruit, somewhat resembling the white magnum: the tree is a copious bearer, and answers very well as a standard: the fruit is much used for tarts and in sweetmeats. The *Imperatrice* is remarkably late, seldom ripening on standards till the end of October.

The *Perdrigons* are melting, sugary, and perfumed fruits; the trees are not very free bearers, but are in many places planted as espalier and dwarf standards.

The *Queen Claudia* of Rouen, or Verte-bonne, seems to be the proper *Green-gage*; "the best (says Mr Nicol,) the most generally known, and most highly esteemed of the plum kind." A few trees of this sort are generally trained to a south-east or south-west wall; but in a sheltered situation, and where the soil is a rich deep loam, with a dry bottom, the fruit acquires a higher flavour when produced on standards. The *white* or yellow gage, and the *blue* or red gage, though inferior to the green, are much cultivated.

The *Drap-d'or*, golden drop, or cloth of gold plum, is a good fruit; but it requires a wall, and the tree is not in general a plentiful bearer.

The *White Imperial*, or white magnum bonum, has also several other names, as yellow magnum, Holland magnum, Mogul plum, and egg plum. It is a very common fruit; of a large size; sweet, but with no great flavour; excellent for tarts and sweetmeats: the tree grows freely, and seldom fails to bear, either on a wall, or as a standard.

The *Red Imperial* is likewise called red magnum bonum; it is also a large fruit, and of fine appearance; but it is principally used for baking and preserving: the tree is a free bearer as a standard. The *St Catherine* has a rich sweet juice, and is fit either for the dessert, or for being used in confectionary.

The *Orleans* is a middling good plum, of which there are several varieties, as the old or red, the new, and white. The tree is a vigorous grower, and great bearer: it succeeds perfectly as a standard, but is sometimes placed against a wall: it is well suited for a market fruit-garden.

The *Fotheringham*, or sheen plum, is a beautiful large red fruit, of considerable flavour; "there is hardly any plum that excels it," says Forsyth: the tree answers equally well for a wall, or as an espalier or standard.

The *Wine-sour* is a plum said to be of Yorkshire extraction; it is not much cultivated, but seems deserving of attention; it is very late, and chiefly used for preserves.

La royale is an excellent plum, of a red colour; the tree however is generally a dull bearer. The *Roche-corbon*, or red diaper plum, is large and of high flavour.

Coe's Golden Drop is a late ripening plum, the merits of which have within these few years been attended to, in consequence of a recommendation by Mr Knight in the first volume of the Horticultural Transactions of London. This gentleman considers it as a new variety, while others allege that it has been known for many years. The tree is distinguished by the great size of its foliage, the leaves being often five inches long and three broad. The flesh of the fruit is of a golden colour when ripe; on the side next the sun, the skin is dotted with violet and crimson. It is beautifully figured in Hooker's *Pomona*, t. 14; and is there announced as superior to any late plum at present in the British gardens. It keeps many weeks: Mr Knight mentions, that he suspended some of the fruit by their stalks in a dry room in October, and that they remained perfectly sound till the middle of December, and were then not inferior, either in richness or flavour, to the green gage, or the drap d'or. This variety requires a wall, but succeds extremely well on a west aspect.

The *Bullace-plum* is the fruit of a distinct species of Prunus, *P. insititia*, which grows naturally in hedges in England. It is often planted in shrubberies or lawns; it is a great bearer, and the fruit is excellent for baking or preserving. There is a variety with wax-coloured fruit, called the White bullace. The *Myrobalans*, or cherry-plum, is by some considered as only a variety of the common plum; but others rank it as a distinct species: Willdenow describes it under the title of *P. cerasifera*.

101. If the wall be high, or above ten feet, a plum-tree is allowed about 24 feet in length; if it be low, perhaps 30 feet, horizontal training being in this case adopted. An east, south-east, or south-west aspect is found to be better than a full south exposure, in which last the fruit is apt to shrivel and become mealy. Several kinds bear well as espalier trees; and many as standards. Even in some parts of the Highlands of Scotland, the yellow magnum and the green-gage trees may be seen thriving luxuriantly, and bearing excellent crops of fruit. The late Mr Hunter of Blackness, a zealous Scottish horticulturist, describing the garden of

Macdonald of Glenco, says, "The magnums were large, well shaped, free from gum, and of a rich yellow colour all over; the gages of the true brownish and green colour, and completely ripened; and these were growing on standards, in the heart of Lochaber, where the snow on the tops of the hills was visible to us from the garden, on the 23d of September." (*Scot. Hort. Mem.* i. 179.) It is to be observed, however, that in such situations, the blossom had probably not expanded till late in the spring, when the danger of frost was over. In the lower and milder parts of the country, plum blossom frequently requires protection as much as that of the apricot or the peach; indeed, the calyx drops sooner, and the blossom is in this respect more tender. In favourable seasons, it may be added, plums are plentiful much farther north; a degree at least.

Plums produce their fruit, partly on the former year's wood, but chiefly on small spurs, rising along the sides, and at the end of the branches, when of two years growth or upwards. These spurs continue long in a fruitful state. There is no necessity, therefore, for securing a supply of new shoots annually, as in peach and nectarine trees. During the summer, fore-right shoots are displaced with the fingers, and side shoots are laid in horizontally, or in a sloping direction, where there is room for them. Useless wood-buds proceeding from spurs are at the same time removed. In this way little winter pruning is required; only some extended spurs, and a few supernumerary shoots, are to be cleared away. The cuts must always be clean, and the knife sharp; plum-trees, like other stone fruits, being very apt to throw out gum and to canker. In regulating mismanaged trees, the lopping off of large branches is, however, sometimes practised; if the air be excluded by some mild paint or other plaster, the wound frequently closes, and new branches set out, which bear fruit in two or three years. For wall plum trees, many gardeners prefer the fan mode of training; but some train in the horizontal manner, being of opinion that this is the best way to check luxuriance of growth, and throw the trees into bearing. When the fruit come in close bunches, some are thinned out, in the beginning of July, when the stoning is over, to allow the rest to acquire full size; and care is taken to lay in the young shoots close to the wall, so that the sun and air may not be intercepted, but may have access to ripen and give flavour to the fruit.

The finer varieties of plums are budded or grafted on plum stocks raised from the stones. Young trees bear transplanting very well, four or even six years after they have been budded or grafted; so that they are often ready to bear the year after being planted. Great pains, however, should be taken, to raise the roots at full length, and to replace them in their new situation without bruising or other injury, and without much exposure to the air.

Cherry.

Cherry.

102. The *Cherry-tree* is the *Prunus cerasus*, L.; *Cerisier* of the French, who make three subdivisions, *Griottier*, *Bigarreautier*, and *Guignier*.—It has been generally said that cherries were introduced into England by the fruiterer of Henry VIII.; but Professor Martyn has shown that they were known much earlier. Lydgate, in his account of the London cries in the middle of the 15th century, mentions that

> "Hyt (supposed white) pescods one began to cry,
> "Straberys ripe, and cherries in the ryse."

Ryse is a word not yet obsolete in Scotland, signifying spray or twigs; and on the stalls of the Edinburgh fruit market, cherries may sometimes be seen "in the ryse," or at least stuck on the thorns of hawthorn sprigs, in order to catch the fancy of children. The white pescod is a kind of plum.

103. Parkinson's list in 1629 contains about thirty varieties of cultivated cherries, several of which are still known, and in esteem, as the mayduke, heart, amber, and morello, but others have entirely disappeared. Miller enumerates only twenty-one; and of these it is not necessary to notice more than one half, being those commonly cultivated.

May-duke.
Archduke.
Harrison's heart.
Hertfordshire heart.
White heart.
Black heart.
Carnation cherry.
Morello.
Lundie guigne.
Black coroun.
Tartarian cherry.
Kentish.

Of the *May-duke* Nicol observes that we have no cherry equal to it, and that the tree thrives in all situations. It does very well as a standard; but against a good wall, and with a southern aspect, the fruit becomes considerably larger, and, contrary to what happens in other fruits, it seems to acquire a higher flavour. It ripens early in June; and before the change of the style, it was often gathered in May: this was particularly the case with a small variety called the Early May.

The *Archduke* is also called the Late duke: it is a good cherry when ripened on a wall; but the tree does not answer well as a standard.

Harrison's heart is a large cherry, of good qualities, and the tree bears freely. The *Hertfordshire* has a firm flesh and excellent flavour: it is a late cherry, not ripening till August. The *Carnation cherry* has received its name from the fruit being variegated red and white: it is a late cherry, and requires a good wall.

Though the taste of the *Morello* cherry, approaching that of the mulberry, is not agreeable to many, yet when ripened on a wall in the full sun, it acquires a size and richness of flavour superior to any other: The tree grows freely, and bears well.

The *Lundie guigne* is of a dark colour, and nearly as large as maydukes which grow on standard trees: it receives its name from Lundie in Fife, the seat of Sir James Erskine, where the original trees still remain. The *black coroun* resembles the black heart; it is an excellent fruit, and the tree is a healthy grower and great bearer. The *black* and the *white Tartarian* cherries are much cultivated at Petersburgh, and were introduced from Russia about 1797: the fruit is of good flavour, and ripens early; and the trees produce plentifully. The *Kentish* cherry is chiefly planted in cherry orchards, and in market gardens: the flowers being late in expanding, they generally escape the spring frosts, and afford a plentiful crop: the fruit, however, is fit only for tarts.

New cherries.

104. That indefatigable and truly meritorious horticulturist Mr Knight has lately added to our list three new cherries raised from seed; they have been called the Elton, the Black Eagle, and the Waterloo.

The *Elton* is the offspring of a blossom of the graffion, or ambrée of Duhamel, fecundated by the pollen of the white heart; it is distinguished by a very deep tinge of crimson in the petals, and by the extraordinary length of its fruit-stalks. The pulp is very juicy, and of delicate flavour. The tree grows vigorously, and is a free bearer.

The *Black Eagle* was from the graffion, with the pollen of the mayduke, and the tree and its fruit resemble the mayduke in a considerable degree.

The *Waterloo* was of the same origin. "It sprang (says Mr Knight) from the largest and finest ambrée cherry that I ever saw; and I imagine it was the best fed; for it stood alone upon a tree which was well capable of bearing at least half a dozen pounds of cherries." The Waterloo is somewhat later than the black eagle. It is nearly as hardy as the mayduke; and it has been observed to acquire tolerable perfection even in cloudy and rainy weather. On approaching maturity, one side presents a dark livid colour; but in ripening, it acquires a rich and deep red colour, nearly black. It is larger than the black eagle, and more conic towards its point.

All of these three varieties possess valuable qualities, and deserve the attention of cultivators in every part of the country. The only plants of these yet brought to Scotland, as far as we know, are in the garden of Sir George Mackenzie, Bart. at Coul in Ross-shire, where, as it is situate far to the northward, their qualities in regard to climate will be put to the proof. They who possess opportunities should also attempt the production of new kinds. The cherry, it is believed, *sports* more extensively in variety when raised from seed than almost any other fruit; and Mr Knight justly remarks, that it is probably capable of acquiring a higher state of perfection than it has yet attained.

105. The finer kinds of cherries are trained against the wall, chiefly in the fan manner: they are placed about twenty-four feet distant from each other, and, at the first planting, a temporary tree is usually put in between each. When favoured with a south aspect, they not only produce early, but large and excellent fruit, highly worthy of a place in the dessert. To prolong the cherry season, some of the duke and heart varieties are generally placed against a west wall. The morello being chiefly wanted for preserves, has frequently a north aspect assigned to it. This variety in so far differs in habit from the others, that it is produced rather on the young wood of the former year than on spurs; it is necessary therefore, at the time of pruning, to have a supply of young wood in view. Cherry-trees are sometimes trained on espalier rails; and in this case, as in wall-trees, it is a great object to keep up a stock of young wood, or at least a quantity of young spurs, or curzons. The branches are generally tied to the rails by means of willow-twigs, or strands of bass-matting. All stone-fruit trees being liable to become gummy at places where they are galled, attention is necessary that the tyings do not injure the bark. Cherries, it may be added, succeed much better as half-standards or dwarf standards than as espalier-trees.

It is a general rule to bud or graft cherries at the height where the head is intended to begin. Some prefer having only two main branches for a wall cherry-tree; but three branches are, in general, found more commodious. Miller suggests, that budding heart cherries on stocks of the birdcherry (*Prunus padus*), might have a similar effect as grafting apples on paradise stocks; that not only might the tree be thus kept in less compass, but rendered more fruitful.

In pruning cherry-trees, the shoots are not shortened, for they produce many fruit-buds at the extremities. It is a common remark of practical gardeners, that cherry-trees dislike the knife. The branches therefore are trained at full length, superfluous fore-right shoots being displaced by the hand in the early part of summer. Much fruit is produced on small side-spurs proceeding from wood two or three years old; these side-spurs are therefore carefully preserved.

When the fruit begins to colour, it is assailed by blackbirds, jays, and other birds. The most effectual remedy is found in hanging a net in front of the tree, or over it, if it be an espalier or dwarf-standard. In gathering the fruit, care should be taken not to break the fruit-spurs, which are very brittle: to avoid the risk of this, some gardeners are at the pains to cut the fruit-stalks with a pair of small scissars.

Apple.

Apple.

106. The *Apple-tree* (*Pyrus Malus, var. sativa*, L.) belongs to the class Icosandria, order Pentagynia, and natural order Rosaceæ of Jussieu. The crab-tree, *P. malus*, is a native of various parts of Britain, and is figured in English Botany, t. 179. Like the wild pear, it is armed with thorns. Many of the cultivated kinds have been imported from the continent at different times; and many others have been raised from the seed in this country. Ray, in the close of the 17th century, described seventy-eight sorts, then accounted good: several of these still retain their character, but many more have either lost it, or have entirely disappeared. The costard-apple, which was then so commonly sold in London that dealers in apples were styled costard-mongers, is not now known. At this time among the favourite cider apples were the redstreak, the golden-pippin, the gennet-moil, the white and red masts or musts, the fox-whelp, and the stire; all of which, as remarked by Mr Knight, are now fast hastening to decay and extinction. Several new apples, however, possessed of excellent qualities, have of late years been brought into notice; and so many amateurs of gardening are now engaged in raising new varieties from seed, that there seems little reason to apprehend a deficiency. This is as it should be; the apple being doubtless the most useful of the fruits freely produced in this country.

107. Forsyth, in his Treatise on Fruit-trees, describes no fewer than 196 varieties, exclusive of many, of which he gives the names only, without descriptions. In this place only a few of the finer apples can be noticed; such as are commonly cultivated in gardens, as wall or espalier trees, or as half and dwarf standards. The other standard apples used for baking or in the manufacture of cider, will be treated of under the article ORCHARDS.

Golden pippin,
Balgone pippin,
Nonpareil,
Scarlet nonpareil,
Ribston pippin,
Oslin pippin,
Hawthorndean,
Margaret,
Jenneting,
Nonsuch,
Margil,
Quince apple,
Aromatic pippin,
Royal Russet,
Codlin; Royal, Kentish, Carlisle, and Keswick.

Newton pippin, and Spitsenberg.

Rennets, grey, golden, and Canadian,
Violet apple.

The *Golden pippin* is a well known excellent fruit, ripening late in autumn; when fully matured it keeps long, and forms, during winter, one of the choicest dessert apples; it is generally small, but beautiful, and the juice is sweet and high flavoured. The tree requires a light but good soil; if the subsoil be wet, it is extremely apt to canker. It is rather of low growth; against a wall, however, it grows freely, and produces abundance of fine fruit. The golden pippin is highly praised by French horticultural writers, under the name of Reinette d'Angleterre. Miller notices the general falling off of this fruit, and the subject has been enlarged upon by Knight: the fact cannot be denied: the former ascribes it to the practice of grafting on free-stocks instead of crab-stocks; the latter, we believe with more reason, to the natural decay of the variety through old age. The *Balgone pippin*, so named from the seat of Sir James Suttie in East Lothian, much resembles the golden pippin, and to all its excellencies adds the advantage of larger size. The tree grows luxuriantly against walls, and appears at present to be in health and vigour. It deserves the attention of the horticulturists of South Britain.

The *Nonpareil* is one of the best apples known, and the chief of the russet tribe: it is rather a flat-shaped fruit, with a sharp, pleasant, high-flavoured juice. It is scarcely ripe till the end of November; but if well ripened, it keeps till May, or later. The tree grows to a large size; and in a good soil, such as a hazelly loam, it bears pretty freely. It is very generally trained against a wall; and in the northern parts of the island, it requires not only a wall, but a good aspect. The *Scarlet nonpareil* ripens more freely than the former; and the fruit becomes larger, and more smooth and plump, being at the same time highly charged with the flavour peculiar to the nonpareil: it is in season in January and February.

The *Ribston pippin* is an excellent apple; when well ripened, it adds to the dessert; for kitchen use it is unrivalled. The tree grows freely in almost every situation, and is a good bearer. The fruit is of a greenish yellow colour, with red or brown streaks on the side next the sun. It keeps very long, remaining quite firm till April or May. Mr Nicol is justly in raptures with it: "It may be called a universal apple for these kingdoms; it will thrive and even ripen at John-o-Groat's, and it deserves a place at Exeter or at Cork." It was long supposed to have been raised at Ribston Hall in Yorkshire; but it is now ascertained to be a Normandy pippin, introduced early in the 18th century.

The *Oslin pippin* is sometimes called the Original, and sometimes the Arbroath pippin: by Forsyth it is named Orzelon. This is a very good apple, excelled in flavour only by the nonpareil, over which it has the advantage of ripening in a worse climate. It does not keep: indeed it should be eaten from the tree, and it is known to be fit for use by its acquiring a fine yellow colour. It is particularly described by Dr Duncan, senior, in the first volume of the Scottish Horticultural Memoirs. The tree grows freely by cuttings, provided each cutting include a knot or bur. The Doctor mentions, that of fifty branches detached early in the spring, more than one half blossomed and produced ripe fruit the same year; they continued fruitful for the next two years, and promised to form permanent fruit-bearing trees. The Oslin has been for time immemorial cultivated at St Andrews and Arbroath, where there were formerly magnificent establishments for monks, by whom it was probably introduced from France.

The *Hawthorndean*, or White Apple of Hawthorndean, derives its name from the romantic seat, in Mid Lothian, of the poet and historian Drummond, at which he was visited by the celebrated Ben Jonson. It is a summer apple, but does not keep long; it is juicy and good, excellent for kitchen use. The tree is a free grower, and bears quickly and plentifully; it is however but short-lived, generally shewing symptoms of decay when twelve or fifteen years old: it is well calculated, therefore, for a temporary tree in any situation, and for this purpose it is much employed.

The *Margaret apple* is also called Magdalene apple; it is an early fruit, of good flavour, but does not keep long. The tree is of middling size; commonly productive.

Jenneting, or Geniton, as Dr Johnson has it, is generally supposed to be a corruption of June-eating. It is a small fruit, but very early ripe; certainly however not in June, nor earlier than August. It is perhaps inferior to the Oslin, Margaret, and one or two other early apples; but no one possessed of a healthy jenneting tree in full bearing would willingly part with it.

The *Nonsuch* is a well known pippin; the tree is rather subject to the canker, but it generally bears more or less every season.

The *Margil* is a very good late apple, fit for the dessert in January; the fruit is much improved when the tree is trained against a wall.

The *Quince apple* is a small fruit, shaped like the quince; the side next the sun of a russet colour, the other side yellowish; it is an excellent apple for about three weeks in September, but does not keep much longer. The tree is of low growth.

The *Aromatic pippin* receives its name from its fine flavour; the side next the sun is of a bright russet colour. It ripens in October, and is fit for use from December to February.

The *Royal russet*, or leathercoat russet, is so named from the deep russet colour of the skin; it is a large fruit, of an oblong figure, broad towards the base: it is an excellent kitchen fruit, and may also appear in the dessert; it keeps till April. The tree grows to a large size, and bears very freely.

The different varieties of *Codlins* are chiefly baking apples, although they may also occasionally be taken to the table: they are early; but none of them are good keeping apples. The trees are great bearers, and make commodious half and dwarf standards in gardens; the latter are frequently trained around hoops to support their branches. An account of the valuable properties of the Carlisle and Keswick codlins is given by the Right Hon. Sir John Sinclair in the first volume of the Scottish Horticultural Memoirs. The codlins are frequently propagated by slips, suckers, or layers, trees thus procured yielding fruit much more quickly than grafted trees.

The *Newton pippin* and *Spitsenberg apple* are two American sorts, which have of late years become favourites in some parts of this country. The former was introduced from Long Island, New York: it is a beautiful and excellent apple; it ripens best on a wall, but in favourable seasons it succeeds on espalier rails, or even on dwarf standards. The Spitsenberg is also a very good fruit, with somewhat of the pine-apple flavour; the tree requires a sheltered situation and a good soil: it is observed to thrive better on a west than on a south wall.

The *Grey rennet*, Reinette grise, is a middle-sized fruit, of a deep grey next the sun, but on the other side intermixed with yellow; a juicy apple, of a quick flavour, yet sugary: it ripens in October, but does not

Apples.

keep long. The *Golden rennet*, Reinette dorée, is a very good apple, ripening in the end of September, fit either for the table or the kitchen, and keeping till February. The *Canadian rennet* is called by the French horticulturists Reinette de Trianon: it is a large fruit, of a yellow colour, with a tinge of red: it keeps till February.

The *Violet apple*, Pomme violette, is a middling large fruit, of a long shape; pale green on one side, but deep red next the sun; flesh delicate, juice sugary, with a slight flavour of the sweet or March violet. The tree grows vigorously, and the fruit ripens in the end of October.

The *Eve apple* is originally from Ireland, but now very generally cultivated in the west of Scotland. The tree is nearly as ample a bearer as the Keswick codling; and it is peculiarly well calculated for forming small standards, to be trained either hollow, or like a cylinder or a cone, the tree growing close and compact, and the fruit-spurs being regularly distributed along every part of the branches. The apple is of a fine colour, and well tasted, fit either for table or kitchen use. It keeps nearly four months. The tree produces fruit the second year after being grafted; and, like the burknot, it may be propagated by cuttings or by layers.

Several excellent and well known garden apples are not included in the list above given, in order to avoid prolixity; such as the summer and the winter Thorle; different varieties of Pearmain; the Wine apple or Queen; the red and the white Calville; Wheeler's Russet; Holland pippin; the Strawberry apple; the Devonshire Quarenden, the Crofton, and the Kerry pippin. It cannot be too often inculcated, that the choice of varieties of fruits, and especially of apples and pears, ultimately to be employed as standards and dwarf standards in gardens, ought to depend very much on *experience*,—on observing which kinds succeed best in the particular soil and situation in question.

New apples.

108. As formerly mentioned, several new apples have of late been brought into notice. Of these, the following have deservedly acquired a good character: The Yellow Ingestrie pippin, the Downton pippin, and the Wormsley pippin.

The *Yellow Ingestrie pippin* was raised a few years ago by Mr Knight, from a flower of the orange pippin dusted with the pollen of the golden pippin. It is similar in form and colour to the latter, which it almost rivals also in richness and flavour: it ripens in October, but does not keep. The tree is very productive.

The *Downton pippin*, named from Mr Knight's seat, had the same origin; and also possesses very good qualities in certain upland situations; but in the low grounds about London it is not good.

The *Wormsley pippin* is another of Mr Knight's apples, a very large fruit, and, in the consistence and juiciness of its pulp, nearly resembling the Newton pippin; it ripens in the end of October, and keeps for some time.

The apple called *Hughes's new golden pippin* possesses the finest qualities; but we suspect it will be found to be, not a new fruit, but a French apple, cultivated in Normandy, and not unfrequently shipped for this country at Charante.

Some varieties are cultivated chiefly by way of curiosity; particularly the *Fig-apple*, which is remarkable for producing no seeds, and indeed for having no proper core; it is said also to shew stamens and pistils only, or to be destitute, or nearly so, of petals. The *Dwarf rennet* is also deserving of notice; when grafted on a paradise stock, the tree scarcely exceeds in size a large plant of gillyflower. It is therefore sometimes kept in pots and forced, and placed in a growing state on the table. The fruit completely resembles the common French rennets. To these may be added, the *Pomme d'Api*, or Apius's apple, a very small fruit, of a yellowish colour, but bright red next the sun; and the *Pomme de deux ans*, or John apple, remarkable for having apples and blossoms on the tree at the same time.

Apple trees.

109. Apple trees intended for full standards are grafted on free stocks, or crab stocks; those for espalier rails or walls, on paradise and codlin stocks. A young grafted apple tree should have three branches; and, if intended for a wall-tree or espalier, the centre branch only is cut down, perhaps to a foot in length, to encourage the setting out of a succession of branches. The fruit of the apple tree is produced on small side and terminal spurs, or short spurs or curzons, from an inch to more than two inches long, proceeding from branches two, three, or four years old, the same wood continuing fruitful for a number of years. The nonpareil, and some other varieties, indeed, yield a few fruit from shoots of the former year; but this is not usual. Espalier and wall trees are pruned twice in the season, in summer and in winter. In May and June, foreright and other superfluous shoots are taken out, a few being laid in, to supply wood where wanted. Any time between December and March a selection of these is made; and unfruitful, decayed, or cankered branches being cut out, new branches are led along in their place. At the same time, old rugged spurs, and useless snags, are taken clean off close by the trunk, applying any mild ointment to the wound. On walls from nine to twelve feet high, the fan-training is preferred; but on walls under nine feet, the horizontal method is often adopted. About twenty-five feet are allowed to each tree. Standard apple-trees receive, and indeed require, but little attention. The ground is dug over, lichens and mosses on the trunks or branches are destroyed, dead branches are cut out, and such as cross each other so as to rub together. When a standard or a dwarf standard is heavily loaded with fruit, several clefted or forked stakes are stuck into the ground, and made to support the drooping branches, which are otherwise apt to break down. Standards in gardens are placed generally thirty feet apart; espalier trees on dwarf stocks, fifteen feet apart; on free stocks, perhaps twenty-five feet.

110. The apple tree grows and thrives on very various soils. It equally dislikes a strong clayey and wet soil, as one that is open, dry, and gravelly; a deep rich cool soil answers best. To lay down more particular rules would be nugatory. It is a fact, that in each particular place, certain kinds of apples are observed to succeed better than other kinds. When therefore the cultivator has discovered the varieties most congenial to the soil and situation, it will be his wisest plan to encourage them, by multiplying grafts of them on his other and less productive trees, or by forming new additional trees of those successful sorts. Where the soil is shallow, and the subsoil bad, it is by following this plan only that large crops of apples can be regularly procured; the new wood of the grafts bearing for a few years, and then giving place to other grafts.

This may be illustrated, by instancing Dalkeith Park garden near Edinburgh, belonging to the Duke of Buccleuch. Formerly few or no apples were here produced, the soil being very shallow, and the subsoil pernicious. But his Grace's gardener Mr James Macdonald, planted many new trees on this plan:—He formed a small hillock of earth about a foot high, and four or five feet in circumference; on this he placed the tree, carefully spreading the roots, and then covering these with six inches of good earth, and fixing the stem to a stake to prevent wind-waving. The roots of the trees so planted, do not appear ever to have penetrated to the bad subsoil. Still, however, finding that all his standard fruit-trees, and particularly apples, would inevitably prove short-lived, Mr Macdonald had recourse to the other plan of constantly putting on new grafts. He inserts regularly from 2000 to 3000 every year, sometimes placing five or six sorts on one tree. The grafts are of such kinds as experience has taught him to be most fruitful in Dalkeith garden. Apples are now produced in this garden in wonderful profusion, the young wood being often bent down with heavy clusters of fruit, which in many cases are to be seen resting on the ground.

Pears.

Pears.

111. The *Pear tree*, (*Pyrus communis*, L.) is naturalized in some parts of England, and is figured in "English Botany," t. 1784, but can scarcely be accounted an original native. The date of the introduction of the earliest cultivated varieties is not known; for most of them we are indebted to France and the Netherlands. Parkinson enumerates sixty-four, many of which have disappeared. Knoop, in his *Pomologie*, describes and figures above a hundred. Miller has selected eighty, which he describes in his Dictionary, as the best then known in England. Not above one half of those contained in this list are now much esteemed or cultivated. Pears are distinguished, according to the season in which they are fit for use, into *summer*, *autumn*, and *winter pears*. Summer pears must be gathered as they ripen, and eaten from the tree, none of them keeping more than a few days: autumn pears do not keep much more than a fortnight; winter pears are gathered before being fully ripe, in dry weather, and kept, some for several weeks, and others for several months, before being used. They are also classed, according to their general qualities, as *desert* or *kitchen* pears; and, according as their flesh is firm and breaks, or is soft and melts, into *breaking* and *melting* pears.

112. The following are the best kinds at present cultivated.

Summer Pears.

Jargonelle.
Cuisse madame.
Red muscadelle.
Green chisel.
5 August muscat.
Little muscat.
Summer bonchretien.
Skinless.
Prince's pear.
10 Summer bergamot.
Musk blanquet.
Longueville.
Green Yair.

Autumn Pears.

Brown beurré.
15 Autumn bergamot.
Gansel's bergamot.
Swiss bergamot.
Verte longue.
Green sugar.
20 Great Mouthwater.
Red orange.
Great russelet.
Red doyenné.
Auchan.
25 Muirfowl egg.

Winter Pears.

Chaumontel.
Colmart.
Crassane.
St Germain.
30 Echassery.
Winter bonchretien.
Virgouleuse.
Holland bergamot.
Easter bergamot.
35 Dry martin.
Louise bonne.
Marquise.
Little lard pear.
Ambrette.
40 Poire d'Auch.
Swan egg.

Summer pears.

113. The *Jargonelle* (meaning the cuisse madame of the French, whose jargonelle, *vice versâ*, is our cuisse madame) is a well-known fruit, the tree being universally cultivated either against walls, or espalier rails, or as dwarf standards. The flesh is breaking, sweet, and has a slightly musky flavour. It ripens in August, and does not keep; but if two or three trees be planted on an east aspect, the jargonelle season may be prolonged till the end of September.

The *Cuisse Madame* (*i. e.* the French jargonelle) is not nearly so good a fruit as the former; but the tree being a great bearer, the kind is liked for the London market.

The *Red Muscadelle*, or *La bellissime*, is a large beautiful fruit, of a yellow colour, with red stripes; the flesh melting and of a rich flavour, when not too ripe.

The *Green Chisel*, or Hasting pear, is of a whitish-green when ripe, has a very thin skin, flesh melting and sugary, but when too ripe, mealy.

The *August Muscat*, Royal Muscat, Hanville, or Poire d'Averat, is a roundish flat pear, shaped like a bergamot, skin smooth, of a whitish-yellow colour; flesh breaking, juice richly sugared and perfumed; characterized by Miller, as "one of the best summer pears yet known." The fruit is produced in clusters, and the tree is a great bearer.

The *Little Muscat* is of a longish shape, of a yellow colour, except next the sun where it is red. On a south or south-east wall it is ripe early in August.

The *Summer bonchretien* is a large oblong fruit, with a smooth and thin skin, of a whitish-green colour, but red next the sun; full of juice, and of a rich perfumed flavour. It succeeds very well on an east or west wall, but as a standard only in good situations, in the milder counties of England.

The *Skinless*, Early russelet, or Flower of Guigne, is a long-shaped reddish coloured fruit, with a very thin skin, the flesh melting, and full of a sugary juice.

Prince's Pear is a small roundish fruit, of a yellow colour, but red next the sun; flesh intermediate between breaking and melting; juice high flavoured. The tree is generally a great bearer, and the fruit will keep for a fortnight.

The *Summer Bergamot*, or Hamden's bergamot, is a round flattish pear, of a fine greenish-yellow colour; the flesh melting, and the juice highly perfumed: the tree is a strong and healthy grower, answering either as an espalier or standard.

The *Musk blanquet*, Little blanquet, or Pearl pear, is of a yellow colour, full of juice and quite melting; the fruit is produced in clusters, and ripe on the wall in the end of August.

The *Longueville* is very generally spread over the northern part of Britain, where aged trees of it exist in the neighbourhood of ancient monasteries: it is not, however, contained in Miller's list; nor is it mentioned by the French writers. In quality it is surpassed by several of those already mentioned; but still it may be accounted a good summer or early autumn fruit. The longueville of Jedburgh, in Roxburghshire, it may be remarked, seems to be a variety, the fruit possessing the quality of keeping for many weeks: the trees at that place are very old, and evidently the remains of orchards or gardens belonging to the rich religious establishment which once flourished there.

The *Green Yair*, or Green Pear of the Yair, is a small green fruit, sweet and juicy, but with little flavour: the tree is a copious bearer, either as a standard or espalier tree. It is supposed to be of Scottish origin, the Yair being an ancient seat on the Border.

Autumn pears.

114. The *Brown Beurré*, or Red beurré, is a large and long fruit, of a brownish-red colour next the sun, melting and full of sharp rich juice, slightly perfumed; indeed it is one of the best autumn pears we have; it must however have every advantage of soil and shelter, and a good aspect on the wall. The fruit varies considerably in colour, the difference seeming to depend on accidental circumstances of soil and vigour.

The *Autumn Bergamot* often gets the name of English Bergamot: it is a smaller fruit than the summer bergamot, but resembles it; the flesh is melting, and the fruit richly perfumed: the tree is a free grower and great bearer.

Gansel's Bergamot is of English origin, having been raised from a seed of the autumn bergamot by the late General Gansel at Donneland Hall near Colchester. It is nearly allied to its parent. In good situations, the tree answers excellently as a standard; and if the fruit be gathered in the middle of October, it is in perfection about the middle of November, and continues a month on the wall: it sometimes attains a large size; we have seen one produced at Torry in Scotland, which measured in circumference 14 inches, and weighed, when taken from the tree, nearly 1lb. 10oz.

The *Swiss bergamot* is a round fruit with a tough skin, of a greenish colour striped with red; flesh melting and full of juice, slightly perfumed: the tree a copious bearer.

The *Verte longue* (long green pear,) or *Muscat-fleuri*, is a handsome fruit, of good qualities: in a dry soil and warm situation, the tree produces great crops.

The *Green Sugar* pear, or Sucré vert, has a very smooth green skin; flesh melting, and the juice sugary, with an agreeable flavour: the tree is a free bearer.

The *Great Mouthwater*, or Grosse mouille-bouche, is a very good pear; and the tree answers equally well for the wall or espalier rail.

The *Red Orange* pear is middle-sized, of a round shape, greenish colour, and purple next the sun; the flesh is melting, and the juice sugary, with a slight perfume.

The *Orange Rouge* was formerly the most common pear in France, but it is now much less cultivated.

The *Great Russelet*, or Gros rousselet, is a large oblong fruit, of a brownish colour, becoming dark red next the sun; the flesh tender and agreeably perfumed.

The *Red Doyenné* or Dean-pear is smaller than the common doyenné; it is usually a little turbinated or top-shaped, sometimes, when the fruit is clustered, almost globular, crowned with the persistent leaflets of the calyx; colour yellow; when ripe, red next the sun; ripens from the end of October to the end of November, and continues in perfection a fortnight or three weeks; the flesh is pale-coloured, melting, and, though not very juicy, agreeably perfumed. The tree is a great bearer even in unfavourable seasons, answering perfectly well either as a standard or espalier. The Dean-pear has been long known in this country, but rather neglected, perhaps on account of Miller's characterizing it generally as "a very indifferent fruit." Mr R. A. Salisbury, however, having recommended the red doyenné in the Memoirs of the Horticultural Society of London, particularly for high and exposed situations, it has risen in estimation.

Autumn pears.

The *Auchan* sometimes receives the epithet of *grey* or *red*: it is an excellent pear, said to be of Scottish origin: in Scotland the tree is often placed against an east or a west wall, but it answers better as an espalier or a standard. It probably deserves more of the attention of English gardeners than it has met with. The tree is a free grower and plentiful bearer, even in light soils. The fruit is sweetish, with a peculiar and rather agreeable flavour. When the name *Auchan* alone is used, this is the kind to be understood: What is called the Summer Auchan is a trifling green fruit not worth cultivating; and the Black or Winter Auchan is a smaller and later variety.

The *Muirfowl egg* is another pear of good qualities, said to be originally Scottish. It ripens in September, and keeps for many weeks. It is often placed against walls in Scotland, but the fruit from standards is much higher flavoured, though not of so large a size.

Winter pears.

115. The finer sorts of winter pears are of French origin; and in this country they require all the aid of a wall with a good aspect, and very considerable attention after they are taken from the tree, several kinds attaining maturity only in the fruit-room.

The *Chaumontel*, or winter beurré, was raised at Chaumontel near Chantilly, where, it is said, the original tree still exists. It is a large rich flavoured melting pear; the skin a little rough; often of a pale green colour, but becoming purplish next the sun; sometimes with a good deal of red. The tree may be considered as in general requiring a wall, and a pretty good aspect: in a few places it succeeds on espalier-rails in good seasons. The fruit is left on the tree till the close approach of winter; it is fit for eating in the end of November and continues till January. The Chaumontel is produced in great perfection in Guernsey and Jersey, and considerable quantities are yearly commissioned from these islands by the London fruiterers.

The *Colmart*, or Manna pear, is large and excellent; the flesh very tender and melting, and the juice greatly sugared; both in shape and quality, it considerably resembles the autumn or English bergamot: it keeps throughout the winter, and till the end of February. The tree requires a large space of good wall, but deserves it.

The *Crassane* (said to derive its name from *crassus* thick,) or Bergamot crassane, is a pear of a large size and round shape, with a long stalk; the skin is roughish, of a greenish-yellow when ripe, with a russety coating; the flesh is very tender and melting, and full of a rich sugary juice. It is fit for use from the middle to the end of November, and is one of the very best pears of the season. The tree requires a good wall.

The *St Germain* is a large long pear, of a yellowish colour when ripe; flesh melting and very full of juice, with considerable flavour. If the tree be planted on a dry soil, in a warm situation, and trained against a good wall, it bears pretty freely: There are two varieties, a spurious, and the true; and it is believed the former is by much the more generally disseminated. The spurious fruit ripens in December, remaining green when ripe, and generally decays by the end of January; unless the soil and season be favourable, it is insipid

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and watery; it is shorter, and its form is subject to more variations than that of the true variety. The true St Germain keeps in perfection till the end of March, and, for sweetness and flavour, ranks among the very best of the winter pears. It is beautifully figured by Hooker, in the *Pomona Londinensis*, Plate 5.

The *Echassery* is a thick oval fruit, shaped like a citron; skin smooth, and yellow when ripe: flesh melting, juice sugared, with a delicate perfume. In season in December and January. The tree requires a good wall; the fruit is produced in clusters.

The *Bonchretien*, or winter bouchretien, requires even in France all the advantages of a south wall and well prepared border. But although Quintinye and Duhamel mention this as the very best late winter-pear, we would be inclined to consider it as greatly inferior to those already named, judging either from the specimens imported into this country, or from those produced in our gardens. With us it attains a large size, but seldom acquires sufficient maturity to bring forth the characters for which the French authors praise it. The French graft the tree on a quince-stock; but Miller gives it as his opinion, that if it were placed on a free stock, and the branches trained at full length on a good wall, the fruit might be much improved in this country. It is to be observed that, even in France, the tree is late of coming into a bearing state, but that it becomes more fruitful as it advances in age. Delaunay mentions that the French use the unripe fruit, in soups, in place of turnips; and it must be confessed, that those generally produced in this country seem much fitter for that purpose than for appearing in a dessert.

The *Virgouleuse*, or ice-pear, is a large and long fruit, of a green colour, inclining to yellow as it ripens; flesh melting, and full of rich juice; for eating in December, and continues till February. The tree is often accounted a bad bearer; but it has been justly remarked by Miller, that this may frequently arise from gardeners not attending to its nature: it produces vigorous shoots, and the blossom comes principally at the ends of these shoots; if therefore the tree be pruned in the ordinary way, much of the blossom must be cut away; if however, it be allowed ample space, and the branches be laid in at full length, the tree produces fair crops. In favourable situations, it succeeds on espalier-rails, but it is commonly trained against a wall.

The *Holland Bergamot* is a good pear, of a greenish-yellow colour; the flesh tender, and high flavoured: it must remain on the tree till the approach of frost: it keeps till May.

The *Easter Bergamot*, Bergamotte de Pâques, or winter bergamot, is a large roundish fruit, of a greyish-green colour with a little red; the flesh between breaking and melting. In this country, the tree must stand on a free stock, and have a good wall, and well prepared border. The fruit is fit for the table in February, and keeps till April.

The *Dry martin* (martin-sec), or winter russelet, is an oblong pear, russety on one side, inclining to red on the other; flesh breaking, juice sugary, with a little perfume; ready in November, and keeps about three months. The tree is generally placed on a free stock; but it succeeds either against a wall or rail, and bears pretty freely.

The *Louise-bonne* resembles the St Germain, and is pretty good when produced against a wall, and from a dry soil; in season in December. The tree generally bears well.

The *Marquise*, or marchioness's pear, is a long pyramidal fruit, of a greenish-yellow colour, with a little brown; the flesh is melting, and the juice rich and sweet. In season in November and December. In this country the tree requires a good wall and favourable aspect.

The *Ambrette* is an oval middle-sized fruit, melting and sugary; when produced from a dry soil and against a south wall, the fruit acquires a flavour resembling the scent of the sweet-sultan or *ambrette* of the French.

The *Poire d'Auch* is described by Forsyth as resembling the colmart, but fuller towards the stalk, and "without exception the best of all the winter pears."

The *Swan-egg* is a very good late pear, for use in November and December. It is egg-shaped, of a green colour, thinly spotted with brown; flesh melting, and abounding with a pleasant juice. On standards or espaliers the fruit acquires a higher flavour than on wall-trees; indeed it is only trained against a wall in high and bleak situations.

116. With the exception of five, all the pears which have now been enumerated and described are of French origin. Of these five, two are considered as of English origin, the Gansel's bergamot and the Swan-egg; and three of Scottish origin, the Muirfowl-egg, Green Yair, and Auchan. Some other Scottish pears, which occur chiefly in country gardens, but are of good quality, may just be named. Such are *Pear-James*, the *Early Carnock*, *Late Carnock* or *Drummond*, *Golden Knap*, *Crawford* or *Lammas*, the *Grey Goodwife*, and the *John Monteith*.

Among English pears little known or attended to, may be mentioned the *Elton pear*, figured in the London Horticultural Transactions, vol. ii. It ripens, on standards, for which it is best suited, from the middle to the end of September; but it must be gathered ten days before being ripe, else it is apt to get mealy. When in perfection, it is described as uniting much of the fine flavour of the bergamots with the melting softness of the beurrés. The fruit is without seeds, and indeed almost without internal cavity. The original tree stands on its own roots in an orchard of seedling pears at Elton in Herefordshire. It is about a hundred and fifty years old, but still healthy.

The *Aston-town pear* is regarded as a native of Cheshire, and said to have received its name from Aston-town in that county. The branches of the tree have a peculiar tendency to twist round in growing upwards. The young shoots are pendent, and the blossoms are produced chiefly at the extremities. The leaves are small and oval. The fruit somewhat resembles the swan-egg pear; is of a greenish colour, spotted with russet; when ripe, the flesh is melting, and high flavoured. It is in perfection early in October, but does not keep. The fruit seems to be improved when the tree is trained to a wall; but in order to have fruit in this way, the shoots should be trained downwards according to their natural inclination.

New Pears.

117. Of new pears of any kind, our list is very scanty. The *Wormsley bergamot* has of late years been raised by Mr Knight, from the blossom of the autumn bergamot, stripped of its stamina, and dusted with the pollen of the St Germain. It is a good melting pear, and the tree grows freely in any common soil where other pear-trees thrive; the blossom appears to possess the advantage of being very hardy; the fruit remains on the tree till the end of October, and is in perfection about three weeks afterwards. At this time, we have scarcely any winter keeping pears sufficiently hardy to

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grow on standards. Mr Knight, however, confidently predicts, that winter pears will, in the course of another generation, be obtained in the utmost abundance from standard trees; that is, that new varieties, combining perhaps the hardiness of the swan-egg with the valuable qualities of the colmart or chaumontel, will be produced.

118. All the kinds of summer pears ripen, in ordinary seasons, on the different sorts of standards, or on espaliers; the autumn pears, on dwarf standards or espaliers. Espaliers, however, are in both cases preferable to dwarf standards, as the tree may in the former way stand on a free stock, and yet have ample space allowed it. The finer French winter pears in general require a wall, with an east, south-east, or south-west aspect; and in the northern parts of the island a full south aspect. Several of the kinds, however, answer on espalier-rails; and as the fruit ripens more slowly and equably when hanging in the open air, than when assisted by the shelter and reflected heat of a wall, it is found to keep longer. While the espalier-trees are in blossom, and till the fruit be fully set, they require some protection; such as screens of reed or straw, or woollen nets.

A pear-tree, especially on a free-stock, cannot do with less than forty feet of wall. In many varieties the fruit-buds are produced chiefly at the extremities of the new shoots: if the dimensions of the tree must be much circumscribed, therefore, it will often happen, in the ordinary way of training and pruning, that the fruit-buds will be cut away. One well-trained horizontal tree, is, on this account, better than two or three upright or fan trees; and there is little danger of keeping the wall covered, however high it be. Miller mentions a summer bonchretien which extended fifty feet in width, and filled a wall thirty-six feet high, and was at the same time extremely fruitful. The object of the French gardeners, such as Quintinye, was to keep their pear-trees within narrow bounds: hence their prolix and confused descriptions of the mode of training and pruning, forming a perfect contrast with the concise and perspicuous directions of Hitt and Miller.

119. For wall pear-trees horizontal training is now very generally preferred to the fan mode; chiefly because in this latter way, the nearly upright position of the branches encourages the throwing out of numerous strong shoots, in producing which the sap of the tree is exhausted; these shoots are destined to be cut out in the winter pruning, and the middle part of the tree comes in this way to be barren. In the horizontal mode, provision is made for having fruit-bearing wood near the stem as well as at the extremities of the branches; and it is estimated that, on an average, wall pear trees so trained afford a third more of good fruit than such as are trained in the fan way, or suffered to ramble on the wall as chance may direct. It is a general rule, therefore, that the branches of pear-trees are not to be shortened unless where wood is wanted to fill up a vacancy; the only effect of shortening being, that in place of small fruitful spurs, rambling and unfruitful shoots are produced. During the summer, foreright and superfluous shoots are displaced with the finger. In this way, no wood buds are left to form shoots next season; and if disbudding be carefully performed, there will be little to do at the winter pruning. It is a rule, that the fruit spurs, especially of the finer French pears, should at all times be kept as close as possible to the wall.

120. But the mode of managing wall pear-trees recommended by Mr Knight (in the London Horticultural Transactions, vol. ii.) deserves here particular notice. It will be best understood by describing nearly in his own words, his mode of reclaiming an old St Germain pear-tree which had been trained in the fan form. The central branches, as usually happens in old trees thus trained, had long reached the top of the wall, and had become wholly unproductive. The other branches afforded very little fruit, and that little never acquired maturity. It was necessary therefore to change the variety, as well as to render the tree productive. To attain these purposes, every branch which did not want at least twenty degrees of being perpendicular, was taken out at its base; and the spurs upon every other branch intended to be retained, were taken off closely with the saw and chisel. Into these branches, at their subdivisions, grafts were inserted at different distances from the roots, and some so near the extremities of the branches, that the tree extended as widely in the autumn after it was grafted, as it did in the preceding year. The grafts were also so disposed, that every part of the space which the tree previously covered, was equally well supplied with young wood. As soon, in the succeeding summer, as the young shoots had attained sufficient length, they were trained *almost perpendicularly downwards, between the larger branches and the wall*, to which they were nailed. The most perpendicular remaining branch, upon each side, was grafted about four feet below the top of the wall; and the shoots thus procured, were trained inwards, and bent down to occupy the space from which the old central branches had been removed; and therefore very little vacant space any where remained at the end of the first autumn. In the second year, and subsequently, the tree yielded abundant crops, the fruit being equally dispersed over every part. Grafts of no fewer than eight different kinds of pears had been inserted, and all afforded fruit, and nearly in equal plenty.

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By this mode of training, Mr Knight remarks, the bearing branches being small and short, may be changed every three or four years, till the tree be a century old, without the loss of a single crop, and the central part, which is almost necessarily unproductive in the fan mode of training, and is apt to become so in the horizontal, is rendered in this way the most fruitful. Where it is not meant to change the kind of fruit, nothing more, of course, is necessary, than to take off entirely the spurs and supernumerary large branches, leaving all blossom buds which occur near the extremities of the remaining branches. In some varieties, particularly the crassane and colmart, the dependent bearing wood must be longer than in others.

The training the bearing shoots downwards, has also been found to throw young trees much sooner into a productive state. Fruit is in this way generally obtained the second year: even the colmart tree, which seldom produces sooner than six or seven years from the time of grafting, yields fruit by this mode in the third season. Mr Knight recommends giving to young trees nearly the form above described in the case of the old St Germain, only not permitting the existence of so great a number of large lateral branches. In both cases, the bearing wood should depend wholly beneath the large branches which feed it; for, in Mr Knight's opinion, it is the influence of gravitation upon the sap which occasions an early and plentiful produce of fruit.

121. To destroy old pear-trees, if they be tolerably healthy, is in any case very injudicious, because, by proper management, they may again be brought into a

Training of pear trees.

bearing state. If the soil be bad, it may be mended: if the tree be full of worn-out spurs, new horizontal branches, or new dependent shoots, as above exemplified, may be procured: if the sort of fruit be bad, grafts of more approved kinds may, as we have seen, be introduced. Mr James Smith, gardener to the Earl of Hopetoun, at Hopetoun House, has written a very sensible paper (published in the first volume of the Scottish Horticultural Memoirs) on the cultivation of French pears in Scotland. It contains some judicious remarks on the means of bringing into a bearing state such full grown trees as are nearly barren of fruit, although in a luxuriant state of growth. In the same volume there is a communication from Mr Thomas Thomson, an experienced gardener, on this subject. In order to check unprofitable luxuriance, he particularly recommends cutting some of the roots of the tree, at the distance of about four feet from the stem, especially such roots as incline downwards. He mentions his having brought a crassane tree into a bearing state by cutting it two-thirds through with a hand-saw, below the level of the earth, and above the forkings of the root. From being very luxuriant but barren, it was thus rendered less luxuriant but fruitful, yielding next season, "at one gathering, forty-seven dozen of handsome fruit." If horizontally trained trees have become full of old spurs and breastwood, the most effectual remedy (as described by another judicious Scottish gardener, Mr Alexander Stewart at Valleyfield, in *Hort. Mem.* i. 459.) is found in cutting out every second branch on each side, within a few inches of the stem. New shoots are trained along, in place of the former branches; but in the mean time a number of side-shoots from the remaining branches are laid in; these, Mr Stewart remarks, form fine fruit spurs, equal to the young wood from the stem of the tree; and they also tend to lessen the production of breastwood: they are however removed, as the regular new horizontal branches advance. In making use of these side shoots, it may be remarked, Mr Stewart had very nearly hit on the mode of management now adopted and recommended by Mr Knight.

In managing prepared borders, planted with the finer sorts of pear trees, it is important, that, during the summer, particularly if the soil be strong or inclined to clayey, they be occasionally forked over, or that the light crop supposed to be on this border be frequently hoed. If the season prove dry, and at the same time the soil be light, water is given to the trees. A hollow is formed around the stem, and two or three pailfuls of water poured into it once a-week or oftener; some *mulch* being at the same time formed to prevent rapid evaporation. In this way the fruit, while in progress, is kept constantly and uniformly in a growing or advancing state. When ripening approaches, the water is withheld lest the flavour should suffer.

Quince.

Quince.

122. The *Quince tree* is the *Pyrus Cydonia* of Linné, the *coignassier* of the French. This not being very much cultivated in Britain, it may be mentioned, that the tree is of low growth, much branched, and generally distorted; and that there are different varieties of the fruit,—globular, or apple-quince; oblong, or Portugal quince; and pear-shaped, or pear quince. The quince is a native of some parts of Germany. It was known in England in the time of Gerarde, and probably long before. The fruit has a peculiar, rather disagreeable smell, and an austere taste when raw; but when prepared it is by many held in esteem. A small portion of it added to stewed or baked apples is useful for giving quickness and flavour. Quince marmalade is commonly sold in the confectioners shops. The Portugal quince is the best, but the fruit is produced sparingly. Like the others, it is of a yellow colour; but the pulp has the property of assuming a fine purple tint in the course of being prepared. The quince tree is propagated by layers, by suckers, or by cuttings. It thrives best in a moist soil, but the fruit is superior in a dry one. In this country, the fruit scarcely ripens unless the tree be trained to a wall; and, even then, it is not ready till November.

Grape Vine.

Vine

123. The *vine*, or grape tree, (*Vitis vinifera*, L. *Pentandria Monogynia; Vites*, Juss.) it is perhaps superfluous to mention, has a twisted irregular stem, with very long flexible branches, supporting themselves by means of tendrils; the leaves large, lobed, alternate, on long foot-stalks; the flowers in a raceme, of a herbaceous colour, insignificant in appearance, but fragrant. The berry, or grape, is generally globular; in some varieties oval; of various colours, green, yellowish, or amber, reddish brown, and black.

124. It has generally been said, that the vine was introduced into this country by the Romans; but from Tacitus we learn, that it was unknown in Britain when Julius Agricola had the command. It was probably first cultivated here in the time of the later Emperors, perhaps about the close of the 3d century.

English vineyards.

At the date of the Conquest there seem to have been vineyards in the south and south west of England. From that period downward to the Reformation, vineyards appear to have been attached to all the principal religious foundations in England; and it is somewhat curious, that from the time of the Reformation to the present day they have in a great measure disappeared. A few, however, have occasionally been formed. From the *Museum Rusticum* we learn, that one was established at Arundel Castle in Sussex about the middle of the last century; and that in 1763, there were in the Duke of Norfolk's cellars sixty pipes of English burgundy, its produce. Professor Martyn of Cambridge has, with his usual industry, drawn together the evidence concerning the culture of the grape vine in Britain in former times, and the practicability of resuming it; and he concludes, that in former times there were many real vineyards in England,—not merely orchards and plantations of currants, as the Hon. Daines Barrington and others have suspected; and gives it as his opinion, that vineyards might still be successful in the southern and western parts of England, in proper soils and situations, if conducted by persons skilled in their management. The earliest and hardiest grapes, or those best suited to the climate, are not, however, well calculated for the making of wine. The miller and small black cluster may do; but they are inferior to the large black cluster, which has an austere taste. Mr Vispré, in 1786, published a dissertation on the growth of vines in England. He proposed to train the shoots, like the runners of melons and cucumbers, near the ground; and he actually found, that the berries thus produced were larger than those of the same kinds trained against a south wall. In the north of France, it is well known, the vines are trained very low, not rising more than four or five feet from the ground.

Vine.

125. Parkinson, in 1629, describes twenty-three kinds of grape vines, several of which are still cultivated, and in high esteem, such as the Muscadines, and the Frontignacs. The following are the principal kinds which are at this time cultivated in Britain; those which succeed in the open air being distinguished by an asterisk.

White Grapes.

- * White Muscadine,
- * White Sweetwater,
- * White Frontignac,
- * Malmsey Muscadine,
- * Royal Muscadine,
- White Muscat of Alexandria,
- White Constantia,
- White Hamburgh,
- Tokay,
- Greek Grape.

Red Grapes.

- * Brick Grape,
- Red Frontignac,
- Red Hamburgh.

Black Grapes.

- * Miller Grape,
- * Early July,
- * Black Sweetwater,
- * Small Black Cluster,
- Large Black Cluster,
- Black Muscadine,
- Black Frontignac,
- * Black Hamburgh,
- Alicant,
- * St Peter's,
- Claret.
- * Black Prince.

White grapes.

The *White Muscadine* is very generally cultivated against open walls in the southern parts of England; and, being an early grape, it ripens well. The berries are roundish, thin skinned, and of an amber colour when ripe; at which time their juice becomes sweet, and of delicate flavour. The bunches are small, but many are produced. Forsyth says, that it is the best vine we have for a common wall, and a great bearer; and Speechly remarks, that it is often cut and eaten before it be fully ripe, but that, when well matured, it is an exceedingly fine grape.

The *White Sweetwater* is likewise an excellent early grape, much cultivated in the open air. The berries are round, not of equal size, some being as large as cherries, while others remain nearly as small as mustard seeds; they are thin skinned, and full of juice, which is sugary, but not vinous. When nearly ripe, they become of an amber colour; when clouded with russet, they are in perfection. Nicol remarks, that this grape, like the former, is often cut before it be fully ripe, and that this has occasioned it to be less in repute than it deserves. The shoots are thick and strong, but not long; the leaves very large.

The *White Frontignac* vine is a copious bearer. The berries are round, and of a good size, closely clustered on a long bunch somewhat *shouldered*. When ripe they are excellent; and remarkable for uniting the qualities of being fleshy, and having a sweet juice and perfumed flavour,—not so powerful, however, as that of the black and red varieties, the last of which has a very strong musky flavour. The ripe berries have a fine white bloom or farina on them, from whence the name is given. It has a place in the vinery, and is also trained against open walls.

The *Malmsey Muscadine* grape has a sweet juice, and high flavour, and the vine is a good bearer. It is commonly planted in the vinery, but succeeds also against the open wall.

White grapes.

The *Royal Muscadine*, or White Chasselas, the d'Arboyse of Speechly and Forsyth, is an excellent grape for the vinery or the hot-house; the bunches large and shouldered; berries round, and amber-coloured when ripe; the juice rich and vinous. The vine generally grows remarkably gross and strong, both in wood and foliage.

The *White Muscat of Alexandria*, or Alexandrian frontignac, has large oval berries, which hang loose in the bunches, these being long, and not shouldered; when ripe the berries are amber-coloured; and the juice is then rich and racy; the skins are thick, and the pulp hard, but of a highly musky flavour. It is fit only for the grape-house or pine-stove.

The *White Constantia* berries are tolerably large, rather of an oval shape, of a sweet taste, with only a slight flavour. The bunch is of considerable size, and well formed. This is the kind which has acquired fame at the Cape of Good Hope. It is said to degenerate when transplanted. At Constantia farm it grows in a light sandy loam; the situation is low, but more elevated than other parts of the district. There is likewise a *red* Constantia; and a *black* Constantia appears in some catalogues; but this last has proved to be the same as the black frontignac.*

The *White Hamburgh*, or Portugal grape, grows in large long bunches; the berries are oval, pale white, with a thick skin, and firm pulpy flesh. The vine is a plentiful bearer, and grows very strong both in wood and leaves. It much resembles the Syrian.

The *Tokay*, when well managed, produces both large bunches and large berries, and becomes one of the finest grapes in the vinery. The berries are white, oval-shaped, skin thin, pulp delicate, and of agreeable flavour. The leaves on the under side are covered with a fine soft down like satin. It should be placed in the warmest end of the vinery, and is well suited for the pine-stove.

The *Greek grape* is a high-flavoured and delicate fruit. The berries are of moderate size, somewhat oval, bluish white; growing close, in middling sized bunches. The leaves of the tree resemble those of the sweetwater, but stand on shorter footstalks; it is a plentiful bearer either in the vinery or hot-house.

Red grapes.

The *Brick grape* gets its name from the berries being of a pale red or brick colour; they are thin skinned, with a sweet juice. The bunches are small, but two or three often proceed from the same shoot, so that the vine is, upon the whole, a plentiful bearer. It succeeds on walls and treillages, and is hardly deserving of a place in the vinery.

The *Red Frontignac* is an excellent musky flavoured grape, when fully ripe, of a brownish red colour. The juice of this, says Miller, has the most vinous flavour of all the sorts, and is greatly esteemed in France. It is well calculated for the vinery.

What is called the *Grizzly Frontignac* seems to be only the red in an unripe state, at which time the berries are greyish-coloured, with a few dark stripes.

The *Red Hamburgh*, or Gibraltar grape, grows in large bunches; the berries somewhat oval shaped, of considerable size, thin skinned, red when ripe, juicy,

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* A small quantity of wine was sent some years ago from Portugal to a mercantile house in Leith as a present, which was made from the Constantia grape grown in Portugal. It was a white wine, extremely sweet, but the flavour not particularly good,—altogether quite different from the Cape Constantia wine.

Fruit Garden.

Black Grapes.

with a rich vinous flavour. It is suited only for the vinery and hot-house.

Of the Black Grapes, one of the most hardy kinds is called the *Miller*, or Dusty Miller, from a white powdery appearance on the surface of its leaves: It is nearly allied to the black cluster grape. It is much cultivated in gardens, and against the front and gable walls of houses in the south-west of England: the fruit ripens freely, and is very good, the skin and pulp being delicate, and the juice sweet and pleasant; the berries are oval, of a middling size, and closely placed to each other in the bunches.

The *Early July* has small black round berries, with large stones; they grow loose on the bunches, which are small, but numerous; juice sugary, with but little flavour. It ripens early in September, without fire heat. There is also a White July grape, which is little cultivated.

The *Black Sweetwater* is a small roundish grape, growing close in the bunches; the skin is thin, and the juice very sweet. It ripens early, and is calculated either for the vinery or the wall.

The *Small Black Cluster* resembles the Miller grape, but the leaves are not quite so hoary, and are rather smaller. The fruit is sweet, and of delicate taste. This is extremely common on walls of houses near London.

In the *Large Black Cluster*, the berries are oval, and grow close in the bunch, which, notwithstanding the name, is not large. The juice has a harsh taste, and makes the palate feel rough, as in tasting Port wine; Mr Speechly indeed considers it as the sort used in the manufacture of that celebrated wine.

In the *Black Muscadine*, the bunches and berries are smaller than in the white; it is a very productive kind, and makes a fine appearance, the black berries having a bluish bloom. Fit for the vinery or the hot-house.

The bunches of the *Black Frontignac* are long, and the berries, which are round and of moderate size, are thinly or loosely hung on them. They are of good quality, the juice being vinous, and of exquisite flavour.

The *Black Hamburgh* is well known and generally liked. The berries are somewhat of an oval shape, the skin thick, and the pulp hard; but it is a well flavoured fruit, and the tree bears plentifully. The bunches are large, and handsomely shouldered. It answers very well in the vinery; but, in the open air, it comes to maturity only in very warm situations and in favourable seasons.

The *Alicant*, or Black Spanish grape, forms very long shouldered bunches, the berries being also large and of an oval shape; at first they are red or flame-coloured; but when ripe, they become of a dark brown or black colour; the skin is thick, and the stones large; the pulp soft and juicy, and of agreeable flavour. It is often called the Lombardy grape, and sometimes the Rhenish. It is excellent for the hot-house or the vinery. In autumn the leaves are finely variegated with red, green, and yellow.

St Peter's grape has the berry large, roundish, black; skin thin; the bunches large, handsomely formed, and making a fine appearance at table; the pulp delicate and juicy. The vine is a good bearer, but the grapes are late of ripening. They are apt to crack in the forcing house, or in the vinery. In fine seasons, this kind ripens on a south wall.

The *Claret grape* is distinguished by its harsh sourish taste, and dark claret colour; when the grapes are perfectly ripened in a hot-house, however, the taste is pleasant. The berries are small, and grow close, on small bunches. The leaves are large, and acquire a russet red or claret colour; on which account they have been recommended for making *vine-leaf* wine.

Fruit Garden.

Grapes.

The *Black Prince* is an excellent grape, well deserving a place in the hot-house or the vinery, where it produces both large berries and large bunches. Even on the open wall, in the south of England, it succeeds in favourable seasons: Forsyth mentions, that in this way he has had bunches which weighed a pound and a half, and which ripened in October.

Besides the list already given, two or three others deserve notice.

The *Verdelho*, or Verdellio grape of Madeira, is the kind from which the celebrated Madeira wine is understood to be principally made. The vine grows with great vigour in our grape-houses, and is remarkably productive of fruit, frequently yielding three bunches on a shoot. Here, however, the bunches are but small; the berries are also of diminutive size, of an oval shape, green colour, and with a thin skin. The fruit is very acid till it arrive at the last stage of maturity, when the berries become of a fine amber colour, and of a very rich saccharine taste, with considerable flavour. Mr Williams of Pitmaston, near Worcester, has given an account of this variety in the 2d volume of the London Horticultural Transactions; and he expresses his opinion, that in favourable situations in the south-west of England it would succeed on the open wall, especially where the soil is light, dry, and shallow, but that in a deep highly manured soil, it would run too much to wood and foliage. The leaf is dark green, and very thick; and would resist the autumnal frosts, and protect the fruit till a late period in October. The verdelho is much cultivated in the province of Languedoc in France; it is described by Delaunay under the name of *Verdal*, and is highly esteemed at Paris, its berries being accounted the most sugary and delicate in flavour of all the dessert sorts. In France the bunches become tolerably large, and very beautiful; and the berries also acquire considerable size.

The *Raisin de Carmes*, or, as it is sometimes called, *Raisin de Cabo*, is a grape of fine qualities. The fruit is produced in rather loose long bunches; the berries large and of an oval form. The skin is thickish, of a dusky purple colour, covered with a fine bloom; the pulp is firm and extremely rich, though containing a considerable portion of acid. The filaments and anthers frequently remain when the fruit is ripe. The vine needs a high temperature; in the stove it grows freely and bears well, but it requires particular attention at the time of flowering. The wood is rather slender, of a yellowish-brown colour; the leaves small, and pale green. It is figured by Hooker, in the *Pomona Londinensis*, t. 10.

The *Raisin grape* is of a brown or blackish colour; large, oval, fleshy and firm, but with a pleasant juice; forming handsome long bunches. It also is only suited to the hot-house.

The *Syrian grape*, is among the coarsest of the grape kind; but the vine is a good bearer under glass, and produces bunches of extraordinary size. The berries are large, oval, white, with a thick skin and firm pulp; they continue in good condition till January. In this country, Mr Speechly once produced a bunch which weighed 19½ lb. and he describes another which was four feet and a half in circumference, and near two feet in length. This last bunch was sent to the distance of twenty miles as a present. Four men were employed, two by turns, carrying the bunch suspended on a pole or staff resting on their shoulders. No doubt one man *could* have carried the bunch, if the weight alone be considered; but it was a great object to transmit it without bruise or injury. This may tend to illustrate a passage in the Sacred Writings (Book of Numbers, ch. xiii.), where the description of this mode of carrying a bunch of grapes has sometimes very unnecessarily excited a sneer.

127. In warmer countries than this, vines that are suffered to grow without pruning attain a large size, their stems assuming the appearance of trunks of trees. Vines that are regularly pruned or dressed, cannot be expected ever to arrive at such magnitude. Even in the ungenial climate of Britain, however, they sometimes have a surprising size and expansion. The Northallerton vine, about the year 1785, covered a space of 137 square yards, and the circumference of the trunk near the ground was almost four feet; it was then considerably more than a hundred years old. Lysons, in his Account of the Environs of London, describes a Black Hamburgh vine at Valentines in Essex, the branches of which extended 200 feet, the stem being 1 foot 13 inches in circumference. It sometimes yielded 4 cwt. of grapes in a season. Another Black Hamburgh vine still more famous for the quantity of its produce, has already been mentioned § 26, as existing in a grape-house at Hampton Court Palace. This season (1816) it yielded about a ton of grapes.

128. New varieties of grapes are of course only to be procured by sowing the seeds. When this is intended, the grapes should be left on the vine till almost in a state of decay, taking care, however, if they be exposed to the open air, to cover them from the attacks of birds. The stones, in this very mature state, become of a dark brown colour; they are to be separated from the pulp, and laid in a dry airy place till spring. Mr Speechly, in his work first published in 1786, recommends the bringing together of flowering branches of two different kinds of grape, calculated to modify or improve each other: the frontignac and other high-flavoured grapes, he observes, may add flavour to other kinds; the white sweetwater may be coupled with the red frontignac, with the black Hamburgh, or with the white muscat of Alexandria. He boldly augurs, that the best sorts of grapes hitherto known, will at some future day be esteemed only as secondary or inferior. The distinguished Mr Knight supports these views, and indeed has done much towards their accomplishment.

New Grapes. Under the name of *Variegated Chasselas* Mr Knight has described a new variety which sprung from a flower of the white Chasselas, dusted with the pollen of the Aleppo grape, which last, he remarks, readily variegates the leaves and fruit of the offspring of any white grape. The berries are striped and very beautiful; with a thin skin, and juicy. The leaves become variegated with red and yellow in autumn. It has been found to be a very hardy and productive variety, bearing well in the open air. When gathered in October, and hung up in bunches in rather a damp room, it keeps till February or later.

This active horticulturist has described (*Trans. Hort. Soc. Lond.* vol. i.) still another variety of variegated grape, in which the bunches on the same plant are of different colours. This too he considers as fit for the open air, at least in the south of England: it is very productive, though both the bunches and berries are small. It contains much saccharine matter, more perhaps than any grape except the *verdelho* of Madeira. Mr Knight therefore considers it as better calculated for the press, in a cool climate, than any we now possess, and observes, that if it were trained to low walls in the warmer parts of England, it would afford a wine of considerable strength.

Vine.

Several others besides Mr Knight are now engaged in the raising of seedling vines; and in all probability some excellent and hardy kinds will soon be produced; so that another generation may once more see vineyards common in this country. The raising of new vines is by no means a very tedious process. The fruit of the seedling may in general be tasted in the fourth year; while a florist waits patiently for five or six years before his seedling tulips shew flower, and perhaps nurses his breeders as many years more before they *break* to his mind.

129. Vines are often propagated by layers, which, when rightly managed, form good enough plants. Strong healthy shoots from different sides of the stool are bent down, generally in February, and gently twisted or notched: this twisted part is introduced into a flower-pot, filled with fresh mould, and which is sunk an inch or two beneath the surface. In the course of the summer, plenty of roots are sent out at the doubling, and in autumn the offset is separated from the parent plant. In the nurseries near London this mode is much practised; and both parent plant and layers may often be seen bearing fruit, so that the kind can be positively ascertained. Abercrombie describes the mode of forming layers in the open ground; but the advantage of having the plants in flower-pots is evident, as a ball of earth can thus be preserved to the roots. Indeed, the roots of the vine are so liable to be injured in transplanting, that flower-pots should always be employed.

Vines are likewise extensively propagated by cuttings. These are taken off at the usual time of pruning in autumn or winter, and are kept till the following spring, merely by sinking them nearly to the top in dry earth. It was formerly considered of great advantage to have an inch or two of old wood to each cutting; the cutting was from a foot to fifteen inches long, and a single cutting only could in this way be made from a shoot. The Rev. Mr Michell, a philosophical as well as practical horticulturist, first introduced the use of short cuttings, about three inches and a half long, and all consisting of the new wood, if properly ripened, and having only one bud or eye. Plants raised in this way he found to be furnished with more abundant roots, to come sooner into bearing, generally in the second year, and to prove more fruitful, than long cuttings, with several eyes, and a portion of the old wood attached. These cuttings are often planted in a nursery bed in the spring; but they are much forwarded by placing them, in pots, into the bark-bed of a stove. Mr Michell usually planted his cuttings in the naked bark, four or five inches asunder; being short and throwing out tufty roots, they are easily potted when thought necessary. Shoots of strong growth, it may be remarked, are not good for cuttings, having too much pith. Many gardeners are of opinion, that plants thus procured from cuttings become better rooted, and grow more freely, than those from layers.

There is still another and a very speedy mode of propagating the vine, especially the more tender varieties, which will be described when we come to speak of the Vinery.

130. In forming a border for vines, a matter of primary consideration is, that the roots shall not be able to penetrate to a wet subsoil: to guard against this, it

is common to take out the earth, and lay lime rubbish, which is firmly beat down, in the bottom. Any fresh and light, but rich soil, to the depth of a foot and a half, or two feet at most, answers perfectly well.

In France and Italy the most experienced vignerons are very scrupulous about permitting any gross or strong manures, such as dungs, to approach the roots of their fine vines, for fear of altering or deteriorating the flavour of the grapes. Rotted turf or clippings of box trodden under foot in the highway, are the manures there preferred. They who apply dungs, are considered as more anxious about quantity than quality. In this country, however, we must partly compensate for the want of a bright sky and hot sun, by giving vigour to the plants by means of manures, even if we should make some sacrifice of flavour. Marshall repeatedly urges the necessity of this, and recommends the digging in of some sheep's droppings or the cleanings of a poultry-house every year. Nicol too is a strenuous advocate for applying the essence of dungs, by watering vine-borders with dunghil drainings, which he declares to be the "nectar of vegetable life."

131. In planting vines, it is customary to cut clean at the end the strong root from which the fibres proceed. A hole or trench is then made in the border, corresponding to the length of the main root; this trench is formed with a ridge in the middle; and on this ridge the woody part of the root is laid, the fibres sloping down on each side. If the main root be three inches under the surface of the border, it is deep enough.

132. Hitt long ago recommended the training of the principal stem of the vine in a serpentine form; leading from it, parallel horizontal shoots, at the distance of eighteen inches from each other: from these, bearing branches are produced, which are nailed in, in an upright position, by which means, in his opinion, they are less apt to put forth collateral shoots, which rob the fruit. Forsyth has since shewn the advantage to be derived from training the bearing shoots also in the serpentine manner. This, it must be confessed, renders the laying in of the summer wood more troublesome; but, with a little practice, and due attention, all confusion or difficulty of that kind might be surmounted. It is evident that a good deal more bearing wood can thus be laid close to a wall, paling, or trellis, than by the ordinary method. Nicol approves either of the horizontal or the zigzag manner being adopted on low walls or trellises; but for the grape-house he prefers training directly up the roof. It is well known that in vineyards in the wine countries, the standard vines are seldom allowed to rise higher than three or four feet. It is found, that against our walls vines grow much stronger and afford larger grapes when not allowed to exceed four feet in height. They thus enjoy the reflected heat from the earth as well as from the wall. Vines are therefore frequently placed in the low intermediate spaces between peach and nectarine trees.

133. The watering of vines in the open border, in very dry weather, is sometimes necessary; but not oftener, perhaps, than once a week. After the fruit is set, the garden-engine is occasionally used, and water sprinkled over the whole plant, this being found to promote the swelling of the berries.

134. During summer the vine may be said to be constantly in a state of pruning. This consists in the regulation of all the new shoots, selecting the bearers for next year, and displacing all lateral, straggling, and superfluous shoots. In July, when the fruit is formed, the bearing shoot itself is shortened, in order to give vigour to the bunches. The vine is seldom, by judicious gardeners, divested of any of its leaves, which seem in this plant almost indispensable to the health and swelling of the fruit.

135. The removal of a small ring of the outer and inner bark from the stem or principal branches, has been found to hasten the production and maturity, and increase the size and flavour of grapes; and this practice is now followed to some extent in the south-west of England. The width of the ring of bark taken out may be from an eighth to a quarter of an inch; the former being sufficient if the plant be weak, the latter proper if it be luxuriant. Care must be taken not to injure the alburnum. The proper time for performing the operation is when flowering is nearly over, and when the berries begin to be formed. In the course of little more than a fortnight, granulations of new bark make their appearance on the upper side of the incision; these gradually increase, till nature has restored the covering of bark. The ring of newly deposited bark is rough, and becomes protuberant; so that a gibbosity remains at the place. The vine-shoot swells and becomes much larger *above* than below the incision. On vines thus treated, the berries are said to be earlier, to swell much faster, and to become larger and better flavoured, than on neighbouring vines left uncut. In England, the vine usually flowers in the open air towards the end of June or beginning of July. If the circle of bark be removed at either of these periods, the part will be covered with new bark before the ensuing winter, and no injury will be sustained by the vine. In forcing houses, the circle should not be removed till after the vine has flowered, the precise time depending on its state of forwardness. In very old vines it is not recommended that the incision be made on the main trunk, but on the middle-sized branches; and it may either be made on all the principal branches, or only on every other branch.

Barking.

136. In connection with this practice may be mentioned another, not altogether new, but which has of late been brought into particular notice, in a pamphlet published in 1815 by the Right Hon. Sir John Sinclair, Bart. This consists in entirely removing the parenchymatous outer bark from the stem and principal branches, but carefully preserving the inner concentric bark. The operation is performed in November, or the beginning of December. At that season it is easily done with the common garden knife, and there is then little danger of injuring the liber. The removing of old and rugged bark from vines has long been practised, with the view of preventing the lodging of insects, particularly the red spider; but besides being insured of exemption from these, the decorticated vines are said to make stronger shoots, and the quantity, quality, and flavour of the grapes to be thereby improved. This plan has been followed for several years by Mr King, a fruit-gardener at Teddington, in Middlesex; and as his profit must depend on the quantity of grapes he raises, and the price upon their quality, it is evident that if the practice did not prove useful, it would not be continued by him.

137. Vines seldom produce bearing shoots from wood that is more than one year old, unless the old wood be healthy and well cut back. The great object therefore is, to have abundance of wood of this age in every part of the wall or trellis. The bearing shoots for the following year are commonly left with four eyes each; the undermost does not bear, and consequently only three are expected to be productive; but each of these

Vine.

yields two or three bunches of grapes, which grow from the new shoots of the current year, the fruit-buds being always opposite to the wood buds. Sometimes more eyes are left, and more fruit is naturally produced; but it is not only inferior in size but in flavour. The shoots are laid in about eighteen inches asunder on the wall, to give room to the side shoots. Miller, Forsyth, and Speechly, unite in recommending for the time of winter pruning, the end of October, when the fruit is all gathered. Hitt proposes to delay it till the end of January, or beginning of February, affirming that vines cut in October make weaker shoots than those pruned after mid-winter. The shoots which were lately bearers are cut back to some good lateral shoot, and a few extended naked old branches are entirely removed, or cut back to some promising young shoots. In either case, the cut is made about an inch above the bud; and sloped backwards from it, so as to convey away the juice which may exude.

Bleeding.

If the wounds made in the autumn or winter pruning have not fully healed over, vines are apt to bleed when vegetation commences. Various remedies have been proposed. Hitt recommends, that after wiping the part dry, it should be basted with soot or with unslaked lime. Nicol is for searing the bleeding point, and then smearing it over with hot wax. Mr Knight, from his own experience, recommends a composition of four parts scraped cheese and one part calcined oyster-shells, or lime, to be pressed strongly into the pores of the wood; the sap almost immediately ceases to flow; and if this composition be properly applied, even a large branch may be taken off at any season without detriment from bleeding.

On the open wall or trellis, grapes are very subject to the attacks of wasps. Some of the finest bunches may be saved by surrounding them with bags of crape or gauze. It may be mentioned, that bunches which have arrived at maturity only in the end of October, may be gathered by cutting off the shoots on which they grow: if these be suspended in a cool apartment, the fruit will keep for a month in a tolerably good state.

138. Early in the 18th century a kind of flued walls were first used for the forwarding, or rather for the thorough ripening of grapes, at Belvoir Castle in Rutlandshire, where Hitt, the author of the Treatise on Fruit-trees, was an apprentice: mats were at the same time thrown over the vines at night, to save them from the chilling dews and hoar-frosts that occur in April and May. Since that time flued walls, with moveable glass frames, have been much used; the same vines being brought into bearing every second or third year, and, in the intermediate time, prevented from exhausting themselves, by the removal of the flower-stalks as they appear. Glazed houses for the culture of grapes have also been formed, under the name of Vineries,—to be afterwards described. Speechly remarks, that good crops of grapes may be obtained from vines trained against walls not more than six feet high, by making use of melon-frame glasses, a temporary narrow roof being made to receive the glasses. A slight degree of fire heat, he adds, would be of great advantage; and in no situation, we may remark, would *can-flues,* such as are described in the first volume of Scottish Horticultural Memoirs, be more suitable, these being easily removed, and as easily restored when wanted again.

In a very few places in England, vines are planted in the vineyard form, in ranges, about twelve feet asunder, the shoots being trained in a horizontal direction, to a series of stakes, three or four feet high, placed along the ranges.

139. We must not omit to mention, that one sort of vine may be grafted on another, in the ordinary way: the operation, however, must be performed with great care and exactness. In this way, if a wall have been planted with kinds injudiciously selected, they may, by grafting, be very speedily changed, preserving all the advantages of having strong well-rooted plants. In a small vinery or vine-frame, various kinds of grapes may thus be inserted on one stock. Speechly mentions a Syrian vine which in this way produced sixteen different sorts of grapes. The principal advantage of grafting, however, is looked for in the modifying and improving of the various kinds; the weak and tender being grafted on such as are robust and vigorous; for example, the black frontignac, placed on the Syrian, is said to produce well-shaped large bunches, with berries nearly the size of those of the Black Hamburgh. This Syrian vine is excellent for stocks; and by some horticulturists, seedling stocks of it, grafted with other kinds, are accounted preferable to cuttings or layers of those kinds themselves. Vine-grafts are gathered at the time of the winter pruning, from bearing branches; and they are kept sunk in light earth till the proper grafting season, which is about three weeks before the stock break into bud. Those in a hot-house must of course be grafted several weeks before those out of doors. The finer sorts are generally grafted by approach.

Fig.

Fig.

140. The *Fig-tree* is the *Ficus Carica* of Linné, Polygamia Diœcia; belonging to the *Urticæ* of Jussieu; it is the *Figuier* of the French. It is considered as a native of Asia, but it has been cultivated for time immemorial in the south of Europe. It was first introduced into this country in the 16th century. Two very large trees still remaining in the Archbishop of Canterbury's garden at Lambeth, are reported to have been the first planted in England, and to have been brought hither by Cardinal Pole. They are at any rate of great age. They are of the white Marseilles kind, and still continue to produce fruit.

141. Miller introduced several new varieties of the fig from Venice: he enumerates 14 sorts as deserving of cultivation in this country; but of these little more than one-half are now in repute. Those most esteemed are the following:

Brown Ischia.
Black Ischia.
Black Genoa.
White Genoa.
Small early white.
Malta fig.
Murrey-fig.
Common blue.
Brunswick.
Brown Italian.
Black Italian.

The *Brown Ischia* is a very large globular fruit, of a chestnut colour on the outside, and purple within; pulp sweet and of good flavour. It ripens by the middle of August, and the tree seldom fails to afford a crop.

The *Black Ischia,* also called Blue Ischia, is a very good sort. The fruit is short, of middling size, a little flatted at the crown; when fully ripe, the skin is dark purple or almost black, and the inside of a deep red: the pulp very high flavoured. The tree is a good bearer, and the fruit is ready early in September.

The *Black Genoa* is a long-shaped fruit; the skin of a dark purple, almost black, with a purplish bloom over

Fruit Garden.

Figs.

it; the inside bright red; the pulp high flavoured. It ripens from the middle to the end of August, and the tree is a good bearer.

The *White Genoa* is a large, almost globular fruit, of good flavour; the skin thin, of a yellowish colour when ripe, and light red within. The tree is considered as rather a shy bearer.

The *Small Early White* has a sweet pulp, but without much flavour. It ripens early, and is therefore well suited to our climate: indeed it seldom fails to produce a crop.

The *Malta fig* is a small brown fruit; the pulp sweet, and well flavoured. When permitted to hang on the tree till it be shrivelled, it forms a fine sweetmeat.

The *Murrey fig*, or brownish-red Naples fig, is a large globular shaped fruit, of pretty good flavour; it is distinguished by the murrey-coloured skin. It ripens in September.

The *Common Blue* or purple fig is of an oblong shape; the tree is a copious bearer; and the fruit ripens in the end of August.

The *Brunswick*, or Madonna, is a long pyramidal fig; the skin brown, the pulp with little flavour. Like the common blue, it is an early kind, and in this respect suited to Britain.

The *Brown Italian* is a small roundish fig, of high flavour; the skin becoming of a brown colour when the fruit is ripe; the inside red. The tree is a great bearer.

The *Black Italian* fig is likewise small and roundish; the pulp high flavoured, and of a dark red colour; the skin purple. The tree bears freely.

142. In this country, fig-trees require good walls, with south-east, south, or south-west aspects, and they occupy a good deal of space. It is proper, therefore, to select only such kinds as are likely to be productive, chiefly the four first enumerated. The trees likewise require careful management. Britain is certainly not the country for fig-trees; yet with due attention, fresh figs matured on the open walls, may grace the dessert from the middle of August to the end of October; and, by means of a fig-house, or even of dwarf fig-trees planted in front of a vinery, the season may be prolonged till December. It may here be remarked, that the fig in a green or fresh state, being a scarce fruit in this country, is often cut into longitudinal slices at the dessert: a good deal of the flavour is thus lost. Abroad, the person who eats a fig, holds it by the small end, and making a circular cut at the large end, peels down the thick skin of the fruit in flakes, the soft interior part forming only a single *bonne bouche*.

A friable loamy soil is best for fig-trees. French writers recommend light and poor soil, even sandy and gravelly; but in such situations in this country the tree does not succeed; and in any very dry soil the fruit is apt to fall off. If however the soil be otherwise good, the recurrence of this last inconvenience may in general be prevented by watering and *mulching*. A free exposure to air and sun is indispensable to the perfection of the fruit.

143. In the public nurseries, fig-trees are often propagated by suckers, and sometimes by cuttings. The cuttings are taken off in autumn, sunk in the ground, and protected with old bark and haulm during winter. Neither cuttings nor suckers form nearly so good trees as those procured by layers, provided the layers be formed of bearing branches. Indeed a single plant thus procured, by *layering*, from a tree in a full bearing state, and from the bearing wood of such a tree, is worth many others.

Fruit Garden.

Figs.

In general a young fig-tree is at first trained with three branches, nearly upright, this direction encouraging their rapid growth. If horizontal training be adopted, the two outer branches are afterward laid down horizontally, and from these upright branches are suffered to rise, at the distance of a foot or sixteen inches from each other. From the central shoot other shoots spring, and these are successively laid in horizontally at the distance perhaps of two feet from each other. The mode of training, however, generally adopted in this country, and approved by the best gardeners, is the fan-shape; keeping the outer branches nearly horizontal, so as to allow ample space for laying in the central ones. In some instances they are trained in the Dutch mode, with only two low horizontals, and upright shoots from these. In a few places in England, fig-trees are trained to espalier-rails. Sometimes these trees are untied, and, during the severity of winter, the branches are laid close to the ground in bundles, and well covered with straw or haulm, over which some earth is heaped. Another method of protecting them, employed both in England and France, is the erecting of two screens of reeds, one on each side of the rail.

144. The fruit proceeds immediately from the eyes of the shoots, without visible blossom; indeed the parts of fructification are entirely within. In warm countries two crops are produced yearly, one upon the former year's shoots, and another on the shoots of the same year. In this country the first of these crops is the only one to be depended on; the second often makes its appearance, but the figs are little larger than peas when arrested by the cold of approaching winter. Some gardeners direct that these young fruit be carefully swept from the branches at the winter's dressing; but a more cautious observer, Mr Smith at Hopetoun House, has found that, while he frees the trees of all half-ripened fruit, if he can save the very young fruit over winter, they afford, as might be expected, the earliest figs in the following season. While the fruit is ripening, such leaves as cover it, should be braced to the wall with small cross-sticks, and not cut off as is sometimes done.

145. In pruning fig-trees, the shoots of the former year must not be shortened, the fruit being produced at the upper part of these. When a branch becomes naked, or destitute of *laterals*, some advise the cutting it entirely out from the base; but if it be shortened, plenty of young shoots will in general be the result. Nicol remarks, that the most fruitful shoots are short-jointed, round, and not of length proportional to their thickness. The time usually chosen for pruning, is April or early in May; but some gardeners still prefer the autumn, as recommended by Miller, when less sap issues from the wounded parts.

In preparing the trees for winter, the branches are closely nailed to the wall; and when frost approaches, coverings of bass-mat, straw-screens, or some such means of defence, are employed. Perhaps the best mode of protecting them, is described by Mr Smith, in the second volume of Scottish Horticultural Memoirs. He recommends the use of spruce-fir branches, four or five feet long; these are fastened to the wall, each branch by two different points of attachment; and the tree is thus covered as equally as possible. The spruce-fir possesses this advantage, that the branches remain green over winter; and in March, when the days lengthen, the leaves begin to fall off, thus gradually admitting more and more air to the trees as the season advances. By adopting this method, Mr Smith has never failed to have good crops of figs. At Argenteuil near Paris, the culture of fig-trees is one of the chief employments of the people. The custom there, is to protect the branches by laying them down in the earth, and keeping them covered with soil for the space of two months and a half during winter. The principal pruning is there performed in the spring, by rubbing off the superfluous wood-buds, which are pointed, and leaving the young fruit-buds or embryo figs, which are round. Careful gardeners in our own country likewise perform most of their pruning in this neat and easy way.

Caprification.

146. We must not here entirely pass over the subject of the *caprification* of figs. By this is meant, in eastern countries, the introducing into the interior of the young fruit a sort of fly or gnat, which seems to act beneficially, not only by probably carrying in pollen and dispersing it, but by puncturing the pulp, and occasioning a defluxion of nutritious juices. Impregnation is thus not only more certainly accomplished, but the ripening of the fruit is greatly promoted. Caprification is imitated in France, and also occasionally in England, by inserting straws dipped in olive-oil. It has often been remarked, that the pricking of plums or pears hastens their maturation, and renders the fruit of richer flavour. It has been proposed to hasten the maturation of figs, by cutting out circles of the bark of the tree, from near the base of the bearing branches, thus retarding or interrupting the descending circulation of the sap: as in the case of vines above mentioned, § 135, both the outer and inner bark must be removed, but great care taken not to injure the alburnum.

Mulberry.

Mulberry.

147. The *Mulberry-tree* (*Morus nigra* of Linnæus; class *Monœcia*, order *Tetrandria*; nat. fam. *Urticæ* of Jussieu) is a native of Persia; but has been cultivated in England since the end of the 16th century. It is generally trained as a standard or half-standard; in a few places it appears as an espalier; and in Scotland it is often placed against a wall. It flourishes most in a rich and deep mellow soil. In old gardens, frequently one or two large standard mulberry-trees, perhaps a century old, may be observed; and these, in the autumn, are covered with fine and large fruit. Where it can conveniently be done, grass should be sown below such old trees: notwithstanding care in gathering, the best of the fruit falls from the tree; and in this way it may be daily collected from the sward, without being injured. On this account, and because of the large size to which the tree ultimately attains, the mulberry is better suited to the lawn than the garden. The fruit ripens in September, and must be used soon after it is gathered, not keeping more than two days.

148. Young trees seldom prove fruitful; and Professor Martyn has stated the true reason, to wit, that monœcious trees while young bear male flowers or catkins principally, and of course produce little or no fruit. Mulberry-trees purchased from public nurseries are not likely soon to prove fruitful, being generally layers from small stock plants, or stools, which have never fruited. The true way to procure fruitful plants, is to take cuttings, in the spring, from fruit branches of bearing trees, endeavouring to have a part of two years growth to each cutting. These may be about a foot and a half long, and planted about a foot deep, in a sheltered place: if covered with glasses and regularly watered, they strike the more certainly. Mr Knight has observed, that by grafting a young mulberry with a cion from a bearing branch of a full grown tree, a plant is procured which will bear fruit in the course of three years. As mulberry grafts do not *take* readily in the common mode, approach-grafting (§ 70.) is to be preferred.

The fruit being produced chiefly on the young wood, no pruning is applicable to standard mulberry-trees, farther than removing cross branches which rub on each other. Wall mulberry-trees are of course treated like the peach-tree.

149. A circumstance connected with the welfare of these trees may here be deserving of notice. The leaves of the black mulberry, not less than those of the white, forming a favourite food of silk-worms, they who amuse themselves with the breeding of these insects, often go to the gardens of their acquaintances, and collect leaves from the mulberry trees, without supposing that they are doing mischief; probably the proprietor of the trees may be as little aware of the evil: but the truth is, that wherever there is a leaf, there is a bud preparing for the next year; and when the leaf is plucked off, the bud perishes. If the successive leaves be withdrawn, it is evident that the tree must soon be exhausted, and unable to put forth buds in the spring. In this way we have seen black mulberry trees of considerable size destroyed in a very few years. The white mulberry (*Morus alba*, L.) is often cultivated in the shrubbery: of the leaves of this, as already noticed, the silk-worm is equally fond: by increasing the number of white mulberry plants, and robbing them only moderately of their leaves, the other kind may be saved.

Medlar.

Medlar.

150. The *Medlar-tree* (*Mespilus Germanica*, Linn.; *Icosandria Pentagynia*; *Rosaceæ*, Juss.) is a native of the south of Europe, but appears to be naturalized in hedges in England, and is therefore figured in "English Botany," t. 1523. The variety now commonly cultivated is called the *Large Dutch Medlar*, the fruit of which is large, approaching in shape that of an apple. The *Nottingham Medlar*, or English Medlar, is a smaller fruit, but of a more poignant taste, and by some preferred on that account.

151. Medlars are propagated by grafting or budding the variety wished for, upon seedling medlar stocks, sometimes on hawthorn stocks. The tree is of middling size; it is chiefly trained in standards; in a few places in espaliers. It is managed very much in the manner of the apple-tree, only the tree is kept rather more thin of wood. The flowers appear late in May. The fruit remains on the tree till the end of October, and is afterwards kept in the fruit-room till it mellow, and acquire a buttery softness, or be "rotten ripe," when only it is fit for the table. This may not take place till past mid-winter: if soft medlars be wanted more speedily, their maturation is forwarded by depositing them in moist bran for a few days.

Two or three medlar trees in the garden are sufficient, more being generally planted in the pleasure-grounds.

Small Fruits.

Small fruits.

152. We now proceed to notice what are called *Small Fruits*, Currants and Gooseberries, Raspberries and Strawberries.

153. *Currants* and *Gooseberries* belong to the genus *Ribes* of Linné; *Pentandria Monogynia*; *Cacti* of Jussieu. The genus is divided into *Ribesia* or Currants, without spines; and *Grossulariæ* or Gooseberries, with spines. Currants and gooseberries are northern fruits; they seem to have been unknown to the ancient Greeks or Romans. Even yet they are not very generally cultivated in Italy or France; one obvious reason being, that these countries possess a climate suited to much finer fruits. Currants were comparatively but lately introduced into Holland; yet from the industrious Dutch gardeners have we derived improved and large-fruited varieties, both red and white, which have deservedly banished all others from our gardens.

Red and White Currants.

Red and white currants.

154. Our common *red* currant is *Ribes rubrum* of Linnæus; and our *white* currant is merely a variety of this. R. rubrum grows naturally in different places in England and Scotland, and is figured in English Botany, t. 1289. Having been long cultivated, several improved varieties have been obtained. The kinds chiefly planted at present are, the large red; the champagne; the pale red, sometimes called grizzly; the long-clustered red; the large white Dutch; the white crystal; and the pearly. The finer and larger bunches, both of the white and the red currant, are used in the dessert, particularly late in the season: more commonly, however, the red is made into a jelly, with an equal weight of white sugar; and the white is much in request for the making of wine.

Currant bushes are propagated chiefly by cuttings. These are commonly prepared early in the spring. They should consist of last year's shoots, proceeding from bearing branches, and may be from nine inches to a foot in length. They are planted in a border of light earth, about four or five inches deep. In the spring, if the weather prove dry, they are occasionally watered till the leaves be expanded. In the course of the summer, all the shoots are displaced excepting three: indeed, some gardeners prevent the growth of more shoots, by extracting, at the time of preparing the cuttings, all the eyes or buds but three. In autumn these young bushes are transplanted, and sufficient space allowed them to grow for two years, during which time, if neat bushes be wanted, they are repeatedly pruned or trained. The currant thrives best in a rich loam, and in a free situation. The usual season for transplanting is October or November. They are often placed by the sides of walks or alleys, and allowed to remain many years; but it is better to plant them in quarters by themselves, and to renew them every seventh or eighth year, young bushes yielding fruit more plentifully, and of finer quality. When considerable plantations of currant bushes are formed, much ground is occupied by them, the distance between the rows not being less than seven or perhaps nine feet. But in these spaces, coleworts may be planted in October, to be used in the early part of spring, before the currant-trees come into leaf. If the ground be not cropped in this way, it should lie rough all the winter.

Currants.

155. Mr M'Donald, gardener at Dalkeith-House, raises currants, both red and white, of the finest quality. A good deal depends on the way in which he manages the bushes, especially during the ripening of the fruit. He prunes the bushes at the usual season of mid-winter, shortening the last year's shoots down to an inch or an inch and a half. Next summer the plants shew plenty of fruit, and at the same time throw out strong shoots. As soon as the berries begin to colour, he cuts off the summer shoots to within five or six inches before the fruit. This is commonly done with the garden shears, with which a man may go over half an acre of bushes in a day. Sun and air thus get free access, and more of the vigour of the plant is directed to the fruit: the berries are found not only to be of higher flavour, but larger than usual.

156. Currant-trees are sometimes trained against a wall. Two branches are led in a horizontal direction along the bottom of the wall, perhaps half a foot from the surface of the earth, and the growth from these of all upright shoots, which will admit of being arranged at the distance of five or six inches from each other, is encouraged. The fruit is produced plentifully on spurs or snags some years old, either on wall or standard bushes; but the largest berries are afforded by young wood, and this is therefore to be occasionally supplied. On a south or south-west wall, the fruit is about three weeks earlier than on standards; and on a north or east wall, if the fruit be defended from birds by means of netting, it will remain good till October: if matted over when ripe, it will endure even till November. Sometimes a few standard bushes are likewise matted up, and on these the fruit will sometimes hang, in pretty good condition, till the approach of frost. On espalier rails the fruit comes early, and of fine size and flavour. Currants, it may be remarked, should be gathered only when in a dry state; if collected in rainy weather, they lose their flavour.

Black Currant.

Black currant.

157. The *Black Currant* (*Ribes nigrum*, Linn.) is also considered as a native of Britain, and is described and figured as such in English Botany, t. 1291. It is very generally cultivated, though not in great quantity, in private gardens. The berries have a very peculiar taste, which however to many people is not disagreeable. In England, they are used in puddings and tarts. A well known jelly is made from them; and if a small proportion only of sugar be used, an agreeable rob is formed. The flavour of the young leaves in spring is strong; a small leaf, laid for a few minutes into an infusion of bohea tea, communicates its flavour, which has been compared to that of green tea.

The black currant bush agrees with a damp soil better than the red. The management of both is much the same; only the shoots of the black are not cut to spurs as in the red, the fruit being produced in a different way. The plants are regularly pruned every winter, from a third to a fourth part of the old or exhausted wood being cut out annually, and the straightest and best placed shoots being preserved. In summer, all superfluous growth is displaced, especially from the centre of the bushes. The black currant-tree produces more fruit as a standard than when trained against a wall; but in the latter way, the berries are considerably larger.

Gooseberry.

Gooseberry.

158. The *Gooseberry-bush* (*Ribes grossularia*, Linn. rough-fruited gooseberry, Eng. Bot. t. 1292, and *R. uva crispi*, L. common or smooth fruited, Eng. Bot.

t. 2057), if not a native plant, is at least completely naturalized in this country. It often appears in woods, and not unfrequently on the walls of ruinous buildings; but to these places the seeds may no doubt have been carried by birds. The culture of this fruit has for a number of years been particularly attended to in the north-west of England; and the size and beauty of the Lancashire gooseberries have procured them the first character. In the south of Europe, we believe, the fruit is generally small and neglected; and when foreigners witness our Lancashire berries, they are ready to consider them as forming quite a different kind of fruit. In France, the gooseberry is called *groseille à maquerau,* from its being used as a seasoning to mackerel.

159. The varieties of the fruit are very numerous, perhaps not fewer than two hundred. They are distinguished by names not less sonorous, nor less fanciful and unmeaning, than those bestowed by the Dutch on their tulips and hyacinths; such as, Glory of England, Glory of Eccles, Bank of England, Nelson's Victory, &c. Many new ones are constantly coming into notice, and others are falling into neglect. They are classed according as their colours are red, green, yellow, or white. The names of a very few of each of these, which are at present most in esteem, shall be mentioned.

Red.

Old Ironmonger,
Early Black,
Damson, or dark red,
Large Rough Red,
Red Walnut,
Warrington,
Smooth Red,
Hairy Red,
Red Champagne,
Nutmeg,
Captain,
Wilmot's early red.

Green.

Green Gascoigne,
Green Walnut,
White Smith,
Green Globe,
Green-gage.

Yellow.

Great Amber,
Globe Amber,
Great Mogul,
Hairy Globe,
Golden Drop,
Honeycomb,
Sulphur,
Conqueror,
Yellow Champagne,
Golden-knap,
Royal Sovereign,
Tawny.

White.

Large Crystal,
White-veined,
Royal George,
White Dutch,
White Walnut.

It must be admitted, that although the large gooseberries make a fine appearance on the table, they are often deficient in flavour, when compared with some of smaller size. Many of them have very thick strong skins, and are not eatable unless thoroughly ripened. Some of the large sort, however, are of very good quality, such as the red champagne and the green walnut. Among these, also *Wilmot's early red* deserves further notice. It was raised by Mr Wilmot at Islesworth in 1804, and has been cultivated by him very extensively on account of its valuable properties, being early ripe, of excellent flavour, and extremely productive. It usually ripens from the middle to the end of June. For culinary use in the month of May it is larger and better than most others, the skin not being tough, but the whole berry melting to a fine consistence. The gooseberry, it may scarcely be necessary to notice, is used not only for tarts, pies, and sauces or gooseberry creams, before being ripe; but, when at maturity, it forms a rich addition to the dessert for several months.

Gathered unripe, gooseberries can be preserved in bottles against winter: the bottles are filled with berries, close corked, and well sealed; they are then placed in a cool cellar till wanted. By plunging the bottles after being corked into boiling water for a few minutes, (heating them gradually to prevent cracking,) the berries are said to keep better.

160. Gooseberry-bushes, like currants, are propagated chiefly by cuttings, preferring for this purpose clean and strong shoots of the former year, about a foot in length. They may be planted any time early in the spring. They are trained for two or three years, and should have a stem six or eight inches high. Strong suckers of straight growth are sometimes used, but they are considered as apt to produce suckers again.

In many places little attention is paid either to the soil in which the gooseberry-tree is planted, or to its pruning and management; yet the fruit is greatly improved by attention to these circumstances. The best practical gardeners now prune the bushes so as to form them somewhat like a hollow sphere; no main stem is encouraged, as was formerly done; but the centre is cut out, and eight or ten side branches preserved, according to the size of the plant. All water-shoots of the former season are removed; but any young shoots wanted for branches, are left at full length. In this mode of pruning or training, the stem may be short, perhaps half a foot, instead of a whole foot. The bushes may also be planted nearer to each other than such as are allowed to rise many feet in height. They should not however be less than five or six feet asunder in every direction, the free admission of light and air being quite necessary. If the bushes be attended to in the month of June, and all central water-shoots and suckers be displaced, the additional light and air thus admitted, will be found very beneficial to the fruit, while the labour of winter pruning will be at the same time diminished. In many gardens gooseberry-bushes are still placed in single rows along the sides of borders; but this is not so good a plan as having a separate quarter for them. They may be planted in November, or any time before February; and the plantation should be renewed every seven or eight years.

161. The plan above described for prolonging the season of currants, by matting up the bushes when the fruit is ripe, it is still more important to adopt in regard to gooseberries, as this fruit forms a more desirable ingredient of the dessert. If some of the late yellow sorts be matted in September, they remain good till November. A few plants of the finer kinds are sometimes trained against a south or east wall; here the fruit not only comes earlier, but attains greater size than usual. They also do very well on a low espalier-rail. In some places, gooseberry-trees on the sides of the borders, are trained to a single tall stem, which is tied to a stake: this, though six or eight feet high, occasions scarcely any shade on the border, and it does not occupy much room, nor exclude air; while at the same time the stem becomes closely hung with berries, and makes a pleasant appearance in that state. Some sorts of gooseberry-bushes, and those producing the largest fruit, have a natural tendency to bend their branches downwards. In this case the branches must be supported with small forked sticks, in order to admit air, and to save the fruit from touching the ground.

It may be observed of the currant and gooseberry trees in general, that they are very easily raised from the seeds, these often, however, lying a year in the ground before vegetating. The seedling plants generally shew fruit in the third year of their growth, when an estimate of their merits can be formed: it is to be observed, however, that the fruit both of currant and gooseberry seedlings may improve in the fourth and fifth year.

Raspberry.

Raspberry.

162. The *Raspberry-bush* is the *Rubus idæus* of Linnæus (*Icosandria Polygynia*; *Rosaceæ* of Jussieu) and the *Framboisier* of the French. It is indigenous to several parts of Britain, and is figured in English Botany, t. 2442. The styles being persistent, the fruit has a bristly appearance, from which the name *raspis* or rasp has been given. The fruit is very desirable both for the dessert, and for making jam, tarts, and sauces. Eaten fresh with cream and sugar, it makes an excellent supper-dish, and may be had from July to November. It also forms the chief compound in a liqueur called Raspberry Cordial, for which purpose great quantities of the fruit are reared near London.

163. The varieties chiefly cultivated are the following: Common red and common white; large red Antwerp; large yellowish-white Antwerp; cane or smooth-stalked, also called reed raspberry; twice bearing white, and twice-bearing red. Some still prefer the common kinds of red and white, thinking that an increase of size in the larger varieties has been purchased at the expence of flavour; but the new varieties are, upon the whole, to be accounted preferable. The second crop of the twice-bearing kind is in general deficient both in flavour and size; but by means of it the raspberry season is prolonged till the beginning of November. It is to be particularly noticed, however, that the fruit should be regularly gathered as it ripens, and should be almost immediately used after being gathered: it will remain good on the bush for a few days after being ripe, but a dish of raspberries kept in the house for two days, will generally be found to have lost flavour, and possibly to be tainted by maggots.

164. Sucker-shoots rising abundantly afford plenty of plants; but they should always be taken from stools in full bearing. They are planted any time from October to February. The distance is seldom less than three feet between the plants, and the quincunx order is generally adopted, five feet being left between the rows. If the larger varieties be planted, the distances are increased. A raspberry plantation continues good for six or seven years; but after the lapse of that period, it should be entirely renewed: it is generally in perfection the third year after planting; so that a new raspberry quarter should be prepared two years before the old one be grubbed up.

165. During summer raspberry-plants receive little attention. The ground is repeatedly hoed, and a few of the superfluous suckers are sometimes removed. Before winter, the ground is commonly dug and left rough. In some places the stools are dressed at this season, (November); and a slight crop of coleworts is put between the rows. If this be not done, the general pruning is deferred till February or March, when the decayed stems of the former year are cut out, and the new ones regulated and tied: for there is this peculiarity about raspberry-bushes, that the stems which bear fruit in one year die in the following winter; leaving in their place a succession of new stems, which have been produced during the summer. Where the stools are very strong, six or eight stems are allowed to remain; but in young or weak plants, only half that number are suffered to carry fruit. At the same time, the tender tops which have been injured by frost and hang down, are cut off. Plants pruned or dressed before winter, it may be observed, sustain most injury from frost; the old stems, when left, affording a degree of protection to the young shoots. In exposed situations stakes are found necessary for supporting the stems; but in general it is thought sufficient to twist the shoots loosely together, and to tie them at top with a strand of bass-mat: Sometimes, the tips of half the shoots on one stool, are tied to half the shoots of the next; and in this way a series of festoons or arches is formed, producing a very agreeable appearance, and at the same time affording security against the highest winds.

The raspberry-bush grows freely in any good garden soil; but it is the better for being slightly moist. Although the place be inclosed by trees, and even slightly shaded, the plant succeeds. In an inclosed and well sheltered quarter, with rather a damp soil, containing a proportion of peat-moss, we have seen very great crops of large and well-flavoured berries produced; for example, at Melville House, the seat of the Earl of Leven in Fifeshire. Sometimes a few plants are trained against a west wall, or a trellis or rail, and the fruit here comes more early and of larger size. By training against a north wall, the crop is proportionally retarded.

New varieties of raspberry are easily raised from the seed; and they come to bear in the second year.

Strawberry.

Strawberry.

166. The *Strawberry* (*Fragaria* of Linnæus) belongs to the same class and order, and natural family, as the raspberry; the plant is called *le Fraisier*, and the fruit *la Fraise*, by the French; and it is the *Erdbeere* of the Germans. Several *species* of strawberry are cultivated in our gardens, and many *varieties*; indeed new hybrid productions are yearly appearing. We shall mention the kinds which are at present most esteemed.

1. Scarlet.

167. The *Scarlet Strawberry*, (*Fragaria Virginiana* of the Hortus Kewensis.) This is the only sort of small strawberry cultivated for the Edinburgh market, a place distinguished for excelling all others in the abundance and excellence of this kind of fruit. It is a native of Virginia, and very different in habit from our wood plant, the leaves being dark green, of a more even surface, the flowering stem shorter, and the fruit commonly concealed among the leaves. It is a hardy species, producing plenty of fruit on high and rather bleak situations, near Edinburgh, where the Chili strawberry does not prosper.

2. Alpine.

168. The *Alpine* (*F. collina*) is larger than our wood species, the stem higher, the leaves broader; the fruit red, (sometimes white,) tapering to a point, and of considerable size. The fruit is of excellent flavour; and being produced from June to November, the plant is well deserving of culture. The summer shoots, it may be mentioned, must not be cut off; for they flower and yield fruit the same season, and it is on this property that the autumn crop depends. From observing this, Mr Knight was led to a new mode of treating the al-

pine strawberry. He sows the seeds early in the spring, in pots which he places in a moderate hot-bed in April. As soon as the plants have attained sufficient size, they are planted in the open ground, where they are to remain. They begin to blossom soon after midsummer, and continue to produce fruit till stopped by the frost. The powers of life in plants thus raised, Mr Knight remarks, being quite energetic, operate more powerfully than in plants raised from seeds even in the preceding year; and he therefore concludes that the alpine strawberry might with propriety be treated as an annual plant.

3. Carolina. 169. The *Carolina* (*F. Caroliniana*) is very regular in form, and of a fine red colour; but inferior in flavour to the scarlet. It does not appear to be a distinct species.

4. Wood. 170. The *Wood strawberry* (*F. vesca*, Lin.) has been cultivated from time immemorial, and in some places it is still preferred. It is a native of most of the woods of Britain, and figured by Sowerby, t. 1524. There is a variety with white fruit.

5. Pine. 171. The *Pine strawberry* (*F. grandiflora*, Hort. Kew.; *F. ananas* of some writers.) The leaves resemble those of the scarlet, but are somewhat larger, and evidently of a thicker substance; the flowers also are larger, and the fruit approaches in size and shape to the Chili, being large, tapering, very pale red on the exposed side, and greenish on the shaded side. When the plants are kept free from runners, this kind is very productive of fruit, and is therefore highly deserving of cultivation.

6. Chili. 172. The *Chili* (*F. Chiloensis*, Hort. Kew.) is distinguished by its very thick oval leaves, which, with the leaf-stalks, are set with hairs. The flowers and fruit are both uncommonly large. Some English gardeners speak slightingly of this kind, saying that it is a bad bearer: it has therefore been rather neglected. In the neighbourhood of Edinburgh, however, it proves abundantly productive: 50 Scots pints have frequently been gathered from an acre, by a single person, in the course of a day. It is the only large strawberry cultivated for the Edinburgh market, and is generally sold there under the name of hautboy. The Chili, it may be noticed, has a red berry; while the true hautboy is of a greyish colour.

7. Hautboy. 173. The *Hautboy*, or *Hautbois* (*F. elatior*, Smith, *Fl. Brit.*; *Eng. Bot.* t. 2197.) is remarkable for its very large oblong fruit, with a musky flavour. There is a variety called the Globe Hautboy, which is much esteemed, but apt to degenerate.

174. Of late years many new varieties have been raised from seed: Some have for a time acquired a name, and have again been forgotten: others however are likely to retain their character. When ripe seed is wished for, the fruit should be allowed to wither somewhat on the plant before being gathered. It may, in passing, be observed, that although, in compliance with popular practice, we term the fruit a berry, it is not such in correct botanical language: a berry (*bacca*) contains the seeds within a pulp; but here we find the seeds on the outside; it is, in fact, a fleshy receptacle, having the surface studded with the seeds.

In Covent Garden market, strawberries are sold in small pottles, the fruit having the calyx-leaf attached. In the Edinburgh market, they are sold in wicker-baskets, each basket containing a Scots pint, or four English pints, the fruit being freed from the calyx-leaves.

Edinburgh strawberries. 175. As it is generally admitted that the market-gardeners in the vicinity of Edinburgh excel in the culture of strawberries, their mode shall here be detailed.

A clayey soil or strong loam is considered as best suited to the strawberry; on a sandy or very light soil, it never succeeds. Indeed as the fruit naturally ripens in June, when drought may be expected, we might conclude *à priori* that a retentive soil would be much more proper for it than an open one. New plantations are formed either in September or in the beginning of April, the soil being trenched or at least deeply delved, and at the same time manured. The offsets are always taken from the runners of plants of the preceding year, in preference to those from plants of longer standing. They are placed in rows two feet distant, thus affording sufficient room for delving, or turning over the surface earth between them, a practice which is found very beneficial, both during summer and winter. Three plants are commonly put in together at each place: the distance between each stool or cluster of plants, is at least fifteen inches; sometimes a foot and a half. When the weather is dry at the time of planting, they are watered every day till they be well established. For the first year few berries are produced; and the common practice is, to sow a line of carrots, or some such crop, between the strawberry rows. In May the runners are cut off, this being found to promote the swelling of the fruit. Every stool is rendered quite distinct and free from another, and the earth between them is stirred with the spade or hoe. In the dry weather of summer, strawberries are (by some careful cultivators, for it is not a general practice) watered, not only while in flower, and when the fruit is setting, but even when it is swelling off: as the berries begin to colour, however, watering is desisted from, lest the flavour should be injured.

About eighty acres in the vicinity of Edinburgh are occupied by market-gardeners, in strawberry crop, for the supply of the Scottish capital; and the amazing average quantity of 60,000 Scots pints (240,000 English) are yearly sold in Edinburgh and its neighbourhood. In a favourable season, about 75,000 Scots pints (300,000 English) have been brought to market; and it will be remembered that the berries are freed from the calyx-leaves, which leaves in the English market greatly swell the measure. When the distance is considerable, the wicker baskets are packed over each other in a hamper-creel, and conveyed to town on a light cart hung on springs. The highest price is commonly half a guinea a Scots pint; but this is only got for a few pints at the beginning of the strawberry season: the average price is about 1s.; the lowest 9d. a Scots pint. The berries are picked as they ripen, by women and children hired for the purpose, to whom the strawberry harvest is a profitable time.

As soon as the strawberry season is past, the plants are shorn over, and all runners are again cut off. Towards the end of October, the ground between the rows is delved over. The cultivation of strawberries is thus attended with a good deal of expence, requiring much labour and constant assiduity in digging and hoeing between the plants, clearing them of weeds, cutting off runners and leaves, watering (where that is practised), and picking the berries for market. They may, with success, be continued on the same land for an indefinite space of time, but the plants must be renewed every fourth or fifth year, and manure at that time supplied. It is however found preferable to change the crop altogether after twelve or fifteen years.

176 Strawberries are generally placed in a quarter of the garden by themselves, and it should be one which is freely exposed to sun and air. They are sometimes,

Strawberry.

however, planted in single rows, as edgings to borders, and in this way they often produce great crops. In either case, care must be taken to replant them every fourth or fifth year at farthest. The alpine and wood species may be placed in situations rather cool and shady; perhaps as an edging in the shrubbery. In such places they produce their fruit perfectly well, and late in the season, which is desirable.

177. The fruit has evidently received its English name from an old practice of laying *straw* between the rows: in clear weather, the ground is thus kept from drying too much, and less watering is requisite; while, in drenching rains, the berries are preserved from being soiled by the earth. This custom is still followed in some parts of France; and it has of late been partially revived in the neighbourhood of London, through the recommendation of Sir Joseph Banks. contained in the first volume of the English Horticultural Memoirs. When the fruit is formed, some lay tiles or moss around the plants; these answer the same purpose as straw, but certainly not more effectually, and the procuring and applying them must be attended with more trouble.

178. Strawberries are a favourite dessert fruit, and by different means they are brought to table from February till November. By various kinds of forcing (to be afterwards noticed) they are procured from February till June; they are produced abundantly in the open air during the months of June and July; and by means of the alpine and wood sorts, the strawberry season is prolonged till the end of October. The fruit should be used very soon after being gathered. If kept only for a few hours, the flavour is found to have considerably diminished. The berries are generally eaten along with cream and pounded sugar.

179. Strawberries are readily raised from the seed, and new varieties are thus procured. If sown early, they seldom fail to produce flowers and fruit in the succeeding year. In collecting the seeds, it is proper to observe that the berries be perfectly ripe, so that the seeds may be brushed from their surface, or may part with facility.

Having thus given an account of the fruits which are usually cultivated within our walled gardens, in the open air, it may be proper in this place to take some short notice of several other fruits, and nuts, which are occasionally cultivated in the garden, but more commonly in the lawns or pleasure-grounds surrounding it, or in the orchard and its environs; and likewise to mention more particularly some of the native fruits which are still gathered for use in the country.

Fruits occasionally cultivated.

Pomegranate.

180. The *Pomegranate-tree* (*Punica granatum*, L.; *Icosandria Monogynia; Myrti*, Juss.) is a native of the Levant, but naturalised in the South of Europe. It was introduced into England toward the end of the 16th century. At first it was treated as a delicate plant; but now it stands in the open border. It is only, however, in sheltered situations, against a south wall, and in favourable seasons, that it produces tolerable fruit: it acquires indeed a considerable size, nearly that of an ordinary pippin, but is quite deficient in flavour. The tree requires a rich strong soil; in a poor and dry soil, it will not even shew flowers. To the northward of London, the fruit scarcely every approaches maturity. A variety with double flowers is frequently planted against the sides of houses by way of ornament; and when clothed with its scarlet flowers, it is not only very beautiful, but grateful by its odour. The pomegranate is generally propagated by layers. The flowers proceed from the extremities of branches produced the same year. The stronger branches of the former year are therefore shortened, in order to obtain a supply of new shoots. The best time for this pruning is November.

Olive.

181. The *Olive*, (*Olea Europæa*, L. *Diandria Monogynia; Jasmineæ*, Juss.) which constitutes much of the riches of the south of France, Italy and Spain, with difficulty survives in the mildest parts of our island. Protected during winter in the same way as the myrtle, generally by short litter laid around the stem, and by a slight temporary screen of evergreen branches, it sometimes flowers; and in some very warm seasons, it has produced a few unripe fruit.

Pishamin.

182. The *Pishamin* or date-plum, (*Diospyros Lotus*, L.; *Polygamia Diœcia; Guaiacanæ*, Juss.) is chiefly cultivated on account of its fine shining leaves. Its fruit, however, is relished by some. It is the size of a cherry, of a yellow colour, and eaten, like the medlar, in a state of over-maturity or incipient decay. The plant is tender for the first year or two; and even afterwards requires a sheltered situation, and rich but dry soil. It was known in the time of Gerarde, but is still very little attended to in gardens.

Cornelian cherry.

183. The *Cornelian cherry* (*Cornus mascula*, L.; *Tetrandria Monogynia; Caprifoliaceæ*, Juss.) was formerly much cultivated as a fruit-tree, and it is enumerated as such in all the old books on gardening. The fruit was used in making tarts, and a rob *de cornis* was kept in the shops. It is now transferred to the shrubbery, where its early flowers, appearing in February and March before the leaves, render it ornamental. The wood is remarkably hard; so that spears were in ancient times formed of it.

Apple genus.

184. Besides the common apple, pear, and quince, several others of the Pyrus genus are cultivated. The *Chinese apple* (*P. spectabilis*, L.) is planted in many gardens and shrubberies in the south of England, chiefly on account of its fine show of deep red buds and large blossoms, which appear early in May. It is increased by grafting on crab stocks. Beautiful trees of this kind, some of them above twenty feet high, are to be seen in gardens in the neighbourhood of London. The *Siberian crab* (*P. prunifolia*, L.) is prized chiefly for its elegant little fruit, resembling large Duke cherries, which are very ornamental in shrubberies, in the autumn and early part of winter. The *Small-fruited crab* (*P. baccata*, L.) is planted with the same view. From the fruit of this sort, as we learn from Pallas, the quass or cider of Siberia is made; and we may add, that it makes an excellent preserve with syrup. The *Japan apple*, (*P. Japonica*, L.) blossoms and bears fruit if trained against a south wall; but the fruit is of no value. The plant requires to be covered with a bass-mat or close straw-net during winter. The *Sorb, or Service-tree*, (*Pyrus torminalis* of Hort. Kew.; *Cratægus torminalis*, L.) is a large tree, growing naturally in some parts of England, as in Hertfordshire, from whence the fruit is brought to London in large quantities in autumn. It is figured in Sowerby's "English Botany," t. 298. The fruit is of the shape of the common haw, but larger; of a brownish colour when ripe; if kept till it be soft, in the same way as medlars, it has an agreeable acid flavour. It succeeds in any strong clayey soil; it is scarcely ever cultivated as a fruit-tree, but is often planted in lawns and about orchards.

Chinese.

Siberian crab.

Small crab.

Japan.

Sorb.

Azarole.

185. The *Azarole-tree* (*Cratægus azarolus*, L.; properly a Mespilus) has a still larger fruit, but does not produce it so freely, being a native of the Levant. When fully ripe, the fruit has an agreeably acid taste, for which it is so much esteemed in Italy and the south of France that it is frequently served up in desserts. It is the *pommette* of the French. In this country it is seldom used.

Native Fruits.

Bullace.

Sloe.

Bird-cherry.

186. Of the genus Prunus, we have several species growing naturally in our woods, and by the banks of rivers. The small black cherry or guigne, (*P. cerasus*, Eng. Bot. t. 706,) and the red-fruited variety, commonly distinguished as *Prunus avium*, have already been mentioned, as well as the common wild plum, (*P. domestica*,) which if not native, is at least completely naturalized. To these may be added the bullace, the sloe, and the bird-cherry. The *Bullace plum* (fruit of *P. insititia*, Eng. Bot. t. 841,) when mellowed by frost, is not unpleasant; indeed it is one of the best of our native productions. It may be made into an excellent conserve, by mixing the pulp with thrice its weight of sugar. It varies with dark purple or almost black fruit, and light or wax-coloured fruit. The *Sloe* (fruit of *P. spinosa*, Eng. Bot. t. 842.) likewise requires to be mellowed by frost. To home-made wines, it is calculated to communicate the colour and roughness of red Port; indeed it is said to enter as an ingredient into the manufacture of this wine. The juice of the unripe fruit forms the German acacia. When the fruit is ripe, the juice affords an almost indelible ink, which is sometimes used for marking linens. Mr Knight (in the London Horticultural Transactions, vol. i.) seems to consider the sloe as the original species from which all our cultivated plums have been derived; but on what grounds he passes over the common wild plum and the bullace, which are more nearly allied, he does not enable us to determine. The *Bird-cherry*, (fruit of *P. padus*, L. Eng. Bot. t. 1383.) in Scotland the Hag-berry, is, to most palates, nauseous. The fruit is scarcely used, unless occasionally that in Scotland an infusion of it is made in the favourite liquor of the country, whisky.

Barberry.

187. The *Barberry bush* (*Berberis vulgaris*, L.; *Hexandria Monogynia*; *Berberideæ*, Juss.) is a native of various parts of this country; and is figured in "English Botany," t. 49. The fruit is in considerable demand for preserving; and the berries of the variety without stones are preferred for this purpose. If planted in good soil, and pruned somewhat in the manner of gooseberry-bushes, barberry plants yield both larger bunches and larger berries. In the shrubbery, while in flower, they are ornamental; and the sensitive stamina may afford entertainment; for when the antheræ are ready, if the bottom of the filament be irritated with the point of a knife or a straw, the stamen rises with a sudden jerk, and strikes the anthera against the pistillum. In autumn, the scarlet fruit makes a fine appearance.

Elder berries.

188. The *Elder* (*Sambucus nigra*, L.; *Pentandria Trigynia*; *Caprifoliaceæ* of Ventenat,) is a well-known native tree, figured in English Botany, t. 476. In Scotland it is called Bourtree. Elder berries may be included in the list of native fruits; for they are still sometimes gathered for the making of elder wine.

Roan berries.

189. The *Mountain ash* (*Sorbus aucuparia*, L.; *Icosandria Trigynia*; *Rosaceæ*, Juss.; Eng. Bot. t. 337.) is perhaps the most ornamental native tree we possess. It is deservedly planted in pleasure grounds; its foliage, flowers, and berries being all beautiful in succession, and the whole tree forming a fine object. Roanberries are still held in some esteem in the Highlands of Scotland, and in Wales; and in both countries, the boughs of the tree are used in many superstitious ceremonies.

Bramble berries.

Cloud-berries.

190. Of the genus Rubus, the raspberry has been already mentioned. The *Common bramble* (*R. fruticosus*, L.; Eng. Bot. t. 715.) may be added as one of our native fruits, and not one of the worst. The *Stone bramble*, (*R. saxatilis*, Eng. Bot. t. 2233.) is another: In Scotland, the fruit has a distinct name, Roebuck-berry. *Cloud-berries*, or knot-berries, (the fruit of *R. chamæmorus*, Eng. Bot. t. 716.) are perhaps the most grateful and useful kind of fruit gathered by the Scots Highlanders: on the sides and near the bases of the mountains, it may be collected for several months in succession. It is not cultivated without difficulty, and it very seldom yields its fruit in a garden. With this may be coupled the *Dwarf crimson bramble*, (*R. arcticus*, Eng. Bot. t. 1585.) This is found only on the highest and wildest mountains of Scotland. The berry is excellent; but it is not easily obtained in sufficient quantity; for though the plant grows freely in gardens, and shews its flowers, it rarely produces its fruit in low situations.

American cranberry.

191. Of the cranberry (*Vaccinium*, L.; *Octandria Monogynia*; *Ericæ*, Juss.) there are various species, three of them native; but the most important is a transatlantic species, which however we may be excused for introducing in this place. It is called the smooth-stemmed *American cranberry*, (*V. macrocarpon*). This is an addition made within these few years to our list of cultivated fruits. The plant was indeed known; but the opinion given in Miller's Dictionary was general, that "they can only be cultivated for curiosity in gardens, for they will not thrive much, nor produce fruit, out of their native swamps and bogs." To the indefatigable Sir Joseph Banks, we are indebted for pointing out the practicability of cultivating it for use. Wherever there is a pond, the margin may, at a trifling expence, be fitted for the culture of this plant, and it will continue productive for many years. All that is necessary is to drive in a few stakes, two or three feet within the margin of the pond, and to place some old boards within these, so as to prevent the soil of the cranberry bed from falling into the water: then to lay a parcel of small stones or rubbish in the bottom, and over it peat or bog earth to the depth of about three inches above, and seven inches below the usual surface of the water. In such a situation the plants grow readily; and if a few be put in, they entirely cover the bed in the course of a year or two, by means of their long runners, which take root at different points. From a very small space, a very large quantity of cranberries may be gathered; and they prove a remarkably regular crop, scarcely affected by the state of the weather, and not subject to the attacks of insects.

Common cranberry.

Blaeberry.

192. The native species of *Vaccinium*, which afford berries in the highlands of Wales and Scotland, are the following. The *Common cranberry*, or moss berry, (*V. oxycoccos*, Eng. Bot. t. 319.) Great quantities of this berry are gathered in upland marshes and turfy bogs, both in England and Scotland. The berries are made into tarts, and have much the same flavour as the Russian imported cranberries, or those procured by cultivation. The *Bilberry*, blaeberry, or whortleberry, (*V. myrtillus*, Eng. Bot. t. 456.) is gathered in autumn for making tarts: in Devonshire the berries are eaten with

clotted cream: in the Highlands of Scotland, they are sometimes eaten with milk, but more commonly made into jellies. The *Red bilberry*, or Cowberry, (*V. vitis idæa*, Eng. Bot. t. 598,) is acid and rather bitter, and decidedly inferior to the cranberry. It makes however a very good rob or jelly, which in Sweden is eaten with all kinds of roast meat, and forms a sauce for venison, which is thought superior to currant jelly.

Nuts.

Nuts.

The *Nuts* which grow in this country, and which form part of the dessert, remain to be noticed.

Hazel.

193. The *Hazel*, (*Corylus avellana*, Lin.; Eng. Bot. t. 723; *Monœcia Polyandria; Amentaceæ*, Jussieu,) is a native of Britain, and very common. In September, great quantities of the nuts are collected by the country people, and sent to market. There are several varieties, particularly the White Filberd, and the Red Filberd; the Cob-nut, remarkable for its large size; the Cluster-nut; and the Dwarf Prolific-nut. In some gardens small plantations of dwarf filbered trees are made. The trees are not allowed to rise more than six or seven feet, and they are trained, like gooseberry bushes, open in the centre. When full grown, the cup thus formed by the expanded branches is about six feet in diameter. Each tree is twelve feet from another. The intermediate spaces are occupied with different crops that require frequent hoeing, the success of the nut trees being much promoted by repeated stirring of the ground. So great is the produce of nuts from small trees managed in this way, that in some parts of Kent such plantations are formed with a view to the supply of the London market. The trivial name *Avellana*, it may be remarked, is derived from a town near Naples, the inhabitants of which have long cultivated the Spanish filberd tree to a great extent, much of their riches depending on the sale of the nuts.

The hazel tree grows vigorously in a strong loam, or in any soil which is somewhat retentive and moist. It is sometimes propagated by suckers, but better plants are procured by layers. In this way only are the different varieties continued: by sowing the nuts, trees may be got for the thickening of a wood or forming a coppice, but not for cultivating with a view to the fruit. A few trees of the different varieties are ornamental on the side of any bank which may occur in the pleasure grounds. Early in spring, generally about the end of February, the catkins or male flowers, and the female gems with their bright red styles, are displayed, and make a pleasing appearance at that still dreary season.

Constantinople hazel.

194. The *Constantinople hazel* (*C. colurna*, L.) produces nuts which are twice the size of the common hazel nut, and grow in large racemes. It seldom, however, yields its fruit in this country, nor is it much attended to. Indeed a large bush or tree of it is seldom to be met with in our gardens. In the Botanic Garden, Leith Walk, Edinburgh, one of the finest specimens in Britain occurs: it is now (1816) about 25 feet in height, and fifty years old.

Walnut.

195. The *Walnut-tree* (*Juglans regia*, L.; *Monœcia Polyandria; Terebinthaceæ*, Jussieu) is considered as a native of Persia, but as having come to us from France, the name *walnut* being regarded as a corruption of *Gaulnut*. The date of its introduction is not known. Large and old trees of it are very common in many parts of England, where it ripens its fruit regularly. In Scotland, however, the fruit comes to perfection, only in fine seasons: in ordinary years it attains merely that state in which it is fit for pickling. Several varieties are cultivated, particularly the round, and the oval walnut; the large walnut; and the tender shelled, The chief thing to be attended to in the culture of the tree, is to induce it to spread its roots near the surface, and to prevent their getting down into cold wet soil. As it generally attains a large size, it must stand in the lawn or park, or a row of walnut-trees may form part of the screen of the orchard. Mr Boutcher of Edinburgh long ago recommended the inarching of a branch of a bearing tree, the quality of whose fruit was known, upon a common stock, and added, that fruit was thus produced in one-third less time. The same idea has lately occurred to Mr Knight, and in this way he has procured plants which proved fruitful in three years. It is evident that the peculiar varieties can only be continued by *layering* and grafting; for large plantations, however, the nuts are sown. The nuts are ready in October, and are gathered by beating the trees with long poles; they may be kept through the winter, by covering them with earth in the manner of potatoes, and mixing some dry mould among them to fill the interstices; for this last purpose, dry sand being preferable.

Chestnut.

196. The *Chestnut-tree* (*Fagus castanea*, L.; or *Castanea vesca* of Brown; *Monœcia Polyandria; Amentaceæ*, Juss.) is considered as a native of the southern parts of England, where, at any rate, it has long been naturalized. It has a place in "English Botany," t. 886. It is not much cultivated for its fruit in this country. As a forest-tree it is well known, though perhaps scarcely duly prized. The variety preferred is called the Spanish chestnut. It may be proper to observe, that when fruit is the object, *grafted* trees should be resorted to. The grafting of chestnut-trees has long been practised in Devonshire, and it is now likely to become general. The stocks may be raised from the common nuts, but the grafts are to be taken from bearing branches of such trees as yield the largest and fairest fruit. The timber of these grafted trees is of little value; indeed the tree generally continues in a dwarf state: but the fruit is not only sooner produced, but is of better quality and more abundant. The nuts are not so large as those imported from Spain; but they are more sweet. They may be kept in earthenware jars, in a cellar somewhat damp, or covered with earth or sand in the manner recommended for walnuts. The French call these grafted trees, *marroniers;* and the forest trees, *chataigniers*. The chestnut is suited to the same kind of situations as the walnut-tree above spoken of.

Chinquapine.

197. The *chinquapine*, or dwarf Virginian chestnut, (*Fagus pumila*, L.) has long been known in English gardens; but the fruit is small, and has not been much attended to.

198. In this country, even in ordinary seasons, several of the fruits which have now been treated of, such as the grape, the peach and nectarine, and the fig, and more particularly the finer varieties of these, are found to be brought to greater perfection, or the trees are more effectually kept in a healthy and fruitful state, by having recourse to a certain degree of artificial heat. If this be true in the south of England, much more may it be affirmed of all that part of the island which lies to the north of York. Glazed houses, under various names, have therefore been contrived for the purpose of forwarding and defending the blossom of the trees, and the setting of the fruit, in the spring, and for ripening the bearing wood for next year in the autumn, the

maturation of the fruit itself, at least in the case of peaches and nectarines, being left as much as possible to the influence of the sun and air. The vinery, the peach-house and the fig-house, ought not, in general, to be considered as *forcing* houses; but as calculated rather to assist the natural efforts of the plant and to make up for the imperfections of the climate, every possible use being in the mean time made of the natural climate. They may, however, be converted into *forcing*-houses, by varying the time of applying the artificial heat; and in this way, not only cherries and strawberries, but grapes and peaches, may be obtained many weeks before the natural season arrive. The pine-apple, which has not yet been spoken of, requires continually an increased, and even high temperature; while the orange tribe needs little more than to be saved from frost during winter.

The disposition of hot-houses, in regard to the garden and pleasure grounds, has been already spoken of. A suite or range of glazed houses is generally formed together, with only glass partitions between them. In this case the green-house is sometimes placed in the middle, and the stoves at each end, so that, during winter, a person may pass into either hot-house without opening a direct communication between it and the external air, which, on account of the rarefaction of the air within, is ready to rush in.

Hot-houses are comparatively of modern invention. They were unknown in the days of Gerarde and Parkinson, that is, of Elizabeth and James VI. After the civil wars, horticulture seems to have received more attention; but a glazed house, with a furnace and flues, does not appear to have been constructed previous to 1684. Sir Hans Sloane, writing in that year, mentions that Mr Watts, gardener at Chelsea Garden, then recently instituted, had a new contrivance for preserving tender exotic plants during winter; "he makes under the floor of his green-house a great fire-plate, with grate, ash-hole, &c. and conveys the warmth through the whole house by tunnels, letting in upon occasion the outward air by the windows." The green-house was thus converted into a stove, or made to answer the purpose of both. Separate houses for plants belonging to very warm climates were soon found to be necessary; and in 1724, Bradley describes a stove or conservatory, with flues and every thing in the manner of a modern dry stove. The bark stove was soon afterwards introduced; the heat resulting from the fermentation of tanners bark being employed, however, in the culture of pine-apples before it was applied to ornamental plants of hot climates. Two kinds of stoves are at present in common use, the dry stove and the bark stove.

Dry Stove.

Dry stove.

199. The dry stove is generally constructed with upright glass frames in front, and sloping glass frames by way of roof, extending perhaps to within four feet of the back wall of the house, which space of four feet is commonly covered with slates. The angle at which the glass is made to slope is usually about 35°. The floor is raised two feet above the exterior surface, in order to give room for the flues, which if sunk low do not draw freely. The flues are carried to the extremity of the house, and returned several times, according to the length and breadth of the building. They are constructed of fire-brick, and the covering is composed of square tiles, about an inch and a half thick. In Scotland, where sandstone abounds, the covers are usually formed of flags, two inches or somewhat more in thickness. The flagstones of the Hailes Quarry, near Edinburgh, are excellent for this purpose: the finer laminæ from the quarry at Carmylie, in Forfarshire, commonly called Arbroath pavement, are apt to crack and shiver from exposure to heat. They are generally made about 18 inches deep, and of nearly equal breadth, and horticultural writers have in general recommended these dimensions; but there can be little doubt that the breadth should be nearly double the depth. Mr Stevenson, civil engineer, founding on some experiments made in constructing a drying-house, has strongly recommended this improvement. (*Scottish Hort. Mem.* i. 143.) He observes, that "the flues in general use are of too small dimensions; there is not capacity in them for allowing the heated particles of air to expand; so that the heat passes rapidly through such narrow flues, and makes its escape with the smoke, in what may comparatively be called a latent state, without being allowed to act on a surface large enough to rob it of its caloric." He farther remarks, that an apartment heated with flues of a wide, but shallow form, is less liable to sudden changes of temperature, than where the flues are small; and that such flues possess the advantage of seldom or never requiring to be cleaned. The furnace is generally so situated, as that the upper part of the arch is as high as the top of the flue, where the heat is introduced into the house. The height of the body of a furnace, of the usual dimensions, is two feet four inches, varying however, according to the slope of the ground; the width is nearly the same; the length of it inside three feet; the door a foot square; and the length of the back of the furnace two feet. In the dry stove a stand is erected for supporting shelves on which the plants are to be placed; the stand and shelves together being called the *stage*. In this stove all kinds of succulent plants, such as cacti, mesembryanthema, stapeliæ, and aloes, are preserved, with many other tender plants which do not require bottom heat.

It may here be noticed, that it having been found that certain parts of hot-houses where one furnace only is employed, are not heated equally with other parts nearer to the furnace, it has been proposed to convey to these parts heated air from the furnace by means of tinned iron tubes. Nicol and others object to these tubes resting on the flues, as being apt to diminish the evolution of heat from their surface: they might, however, be carried free of them, and certainly deserve further trials. Such tubes, it is to be observed, are only necessary in hot-houses already built. In the constructing of new houses, a small flue, perhaps 2½ inches or a brick square, can easily be carried along in the back wall. Heated air drawn from the furnace into this flue can be conveyed to the opposite end of the house, and there admitted by a valve or door at pleasure. Matters must of course be so contrived, that no smoke can pass into this small flue.

Bark Stove.

Bark stove.

200. The bark stove is distinguished by having a large pit, nearly the length of the house, three feet deep, and six or seven feet wide. This pit is formed with brick walls, and has a brick pavement at bottom, to prevent the earth from mixing with the tan, which would hinder its heating. It is filled with fresh tanners bark, well dried; and in the bark, pots containing plants from the East or West Indies, or tropical climates, are plunged. The bark acquires and long retains a moderate heat; but besides this, it preserves a

Fruit-Garden.

Bark Stove.

degree of genial moisture, well calculated to keep the fibres of the roots in constant vigour and action. Experience has shewn that a house of forty feet can be properly heated by one furnace. If thought proper, the house may be made large, and there may be two tan-pits and two furnaces, the house being divided in the middle by a glass partition. In this case a higher temperature may be maintained in the one division, than is thought necessary in the other. Over the flues a wooden grate, or crib trellis, is laid; and on this are placed the most tender of the succulent tribes, such as some of the melon-thistles, cereuses, and euphorbiums. The range of temperature which plants can endure in the bark stove is considerable, from 63° to 81° Fahrenheit, or nine degrees above and below the mark *ananas*, on the botanical thermometer. This instrument is hung in the middle of the house, at a considerable distance from the furnace, and out of reach of the sun's rays.

201. It is not uncommon to give air to such a hothouse only through the day, and to shut it up close at night, perhaps even increasing the temperature in the evening. Judicious horticulturists reverse the practice. Knowing, for example, that in the West Indies, chilly and cold nights usually succeed to the hottest days, they rather imitate nature, by shutting up the house during the day, and throwing it open at night. This practice, however, can only be followed, in our climate, in the summer and autumn seasons.

202. Forcing stoves are of modern invention. In principle, they differ in no respect from the stoves already described; their application only is different. The bark forcing stove has a tan-pit, in which pots of roses, narcissuses, and other flowers, are plunged, in order to their production at an early season. Pots with strawberries, kidney-beans, or perhaps dwarf-cherry-trees, are likewise set in the pit, or on shelves around. Sometimes small borders are formed in this bark-stove, next to the front and also next to the back wall; a few dwarf fruit-trees are thus introduced, which yield an acceptable addition to the spring dessert. In some places, the more delicate kinds of grape-vines are here also cultivated, and trained along the rafters of the upper sashes.

Forcing stoves are intended chiefly for peaches, nectarines, vines, figs, early cherries, the best sorts of apricots and plums, sometimes apples, and occasionally gooseberries, currants, and raspberries. The whole area of the house is filled with well prepared rich compost, two feet deep. The trees, having been previously trained to near a bearing size, are transplanted into the prepared border. These stoves are begun to be worked early in the spring; and when the crop is gathered, the glass frames are opened wide, or perhaps altogether removed, in order to admit air and rain, and thus harden the annual shoots of the trees. In this open state, the houses remain till after mid-winter, when they are partially shut, in order gradually to prepare the trees for the increased temperature. Different kinds of trees require different modes of management, and also a variation of temperature: in all first-rate gardens, therefore, a separate hot-house is allotted to the peach-tree, called the Peach-house; another to cherries, called the Cherry-house; a third to the production of grapes, called the Vinery or Grape-house, and in some places, a fourth, to figs, called the Fig-house. The difference in the structure of these houses is not considerable.

203 In general it may be remarked, that what is called *forcing* is the more perfectly performed in proportion as less forcing or violence is employed. All the operations of nature are gradual; and a good gardener will always follow these as the safest examples. He will never willingly apply artificial heat before buds have naturally swoln; he will then increase the temperature gradually for some weeks; he will in particular, guard against any sudden decrease of warmth, it being most necessary towards success, to continue the course of vegetation uninterruptedly, through foliation, inflorescence, and fructification. In all kinds of forcing, it is of importance that free admission of air be given according to the state of the atmosphere; and it too should be given and withdrawn by degrees, especially in the early and cold time of the year: the sashes, or the ventilators, may, for instance, be partially opened by 8 in the morning, top air being given before front air; full air may be allowed about 10; a reduction should take place before 3 P. M., and the whole be closed between 4 and 5, according to the season and other circumstances.

Fruit-Garden.

Peach-house.

We shall now proceed to notice the peach-house, cherry-house, vinery, and fig-house, in succession; then the pine-stove and appendages; and the orangery. Here we shall take occasion to introduce a short description of the magnificent and commodious suite of hot-houses at Dalmeny Park, near Edinburgh, plans and elevations of which we are enabled to lay before the reader; and we shall subjoin some account of improvements which have lately been adopted or proposed in this branch of horticulture. The cultivation of the melon, being allied to that of the cucumber, will lead us to the kitchen-garden.

The Peach-house.

Peach-house.

204. A peach-house, intended to be commanded by one furnace, is commonly made about 40 feet long, 10 or 12 wide, and about 14 in height. It has sometimes no upright glass in front; merely a parapet 18 inches high, upon which the rafters immediately rest. In some places the peach and nectarine trees are trained to a trellis next to the glass, none being placed on the back wall; in others the trees are trained only to the wall, or to a trellis placed against it; but in the greater number of cases, small trees are trained nearly half way up the glass roof, and at the same time others of full size are placed against the back wall. The flue passes in front, but at some distance from the parapet, and is returned also at some distance from the back wall; so that both flues taken together, with the space between them, occupy nearly the centre of the house. The old practice of having the back wall itself flued, is now discontinued, *standing flues* within the house being found preferable. Both parapet and flues rest on pillars, so as to allow the roots of the trees free egress to the border on the outside of the house. If early or forced fruit be wanted, the house is made narrower and shorter, so as to give a greater command of temperature. In such houses, either three or four dwarf trees, with intermediate *riders*, are planted; the riders being taken out at the end of four years at farthest. When small trees are also trained in front, three are commonly sufficient there, or nine or ten trees in all. Fire-heat is generally applied about the middle of February, the temperature being for a time kept at 45°; and afterwards gradually increased to 50° or 55° Fahr. The temperature is regulated by a thermometer, every morning and evening; during sunshine, air is admitted, to keep down the heat, as near as possible, to the average point. Trees thus forced, generally shew their blossoms in March. While in flower and till the fruit be *set*, gentle steam-

Peach-house.

ing is practised, by sprinkling water on the surface of the warm flues. After this, washing the foliage with the garden engine is found very conducive to the health of the plants. When the stones of the fruit are formed, the temperature is raised to about 60°, and the crop is thinned, if thought necessary. Water is now liberally applied to the border. After May, little fire-heat is given, and air is very freely admitted through the day.

Mr Knight strongly recommends the exposing the fruit, when ripening, to the full influence of the sun in warm and bright days, and covering it with the glass roof during cold night air or rains. He has, in the *London Horticultural Transactions*, vol. i. p. 199, described an improved peach-house. The angle of the roof is only 28° in Lat. 52°. In order that the lights may be moved to the required extent with facility, they are made short, and divided in the middle. The back wall does not exceed nine feet high. Two rows of trees are planted; one in front, trained on an almost horizontal or very slightly inclined trellis; and the other on the back wall. The house is 50 feet long, but commanded by a single furnace.

The usual displacing of useless buds and spray, and laying in of new shoots, are operations which must, of course, be attended to, as in the management of peach and nectarine trees on the open wall.

Some of the best fruits for the peach-house are, the red magdalen, the white magdalen, royal George, noblesse, late mignone, early Newington, teton de Venus, and Catherine peaches; and of the nectarines, the Newington, the red Roman, and the violet. But all the kinds formerly mentioned § 88. are occasionally placed in the peach-house.

The Cherry-house.

Cherry-house.

205. The cherry-house, if one furnace only be employed, is nearly of the dimensions mentioned for the peach-house. The cherry-house is always considered and managed as a forcing-house. There is commonly a glass front between two and three feet high; thus giving room in the fore-part of the border, for some dwarf trees, either cherry or fig, or perhaps apricot; the principal cherry-trees being trained against a trellis in the back wall. The flue along the front and at each end, is covered with a small horizontal grate or trellis of wood, and on this pots of strawberries or of kidney-beans are forced. For the dwarf trees in front, such as have been kept in pots or tubs for some time, are to be preferred. Forcing in the cherry-house is usually begun about the new-year; but for a month before the fire is lighted, the house is shut at night, so as gradually to accustom the plants to the confined air and increased temperature. At first the temperature is kept at 40°. Till the flower-buds appear, air is admitted, in the day-time, freely; but after this, till the season become mild, with great caution by the upper sashes only. When the fruit is setting, in the beginning of March, the temperature is kept as steadily as possible about 50°. After it is set, water is given plentifully at the root, and also dashed over the foliage, and air is freely admitted when the weather will permit. When the fruit is colouring, little water is given, the temperature is raised, and as much air as possible is given. When the crop is gathered, the house is generally thrown quite open; in many cases, even the glass-roof is taken off. By much the best cherry for forcing is the common Mayduke.

Cherry-house.

206. The kinds of strawberries preferred for forcing, are the scarlet, the alpine, and wood strawberry. The plants undergo a course of preparation for a year before they be forced. They should always be taken from the most fruitful plants; and the offsets nearest to the parent plant are to be preferred. During the first summer, they are not only regularly deprived of all runners as they appear, but the flowers are also picked off: vigorous plants, filling the pots, are thus secured for fruiting in the following spring. If the fruit be wanted very early, the plants are placed in a hot-bed frame in the end of October, and there brought to flower, being transferred to the forcing-house when the furnace is set agoing. They generally yield ripe fruit early in March, and continue to afford successive gatherings till the end of April, making a pleasing appearance at this season, and a rich addition to the spring dessert. Water is pretty liberally supplied till the fruit begin to ripen, when it is given sparingly. It may here be remarked, that if strawberry plants which have been prepared as for forcing, be planted in front of a hot-wall, they can scarcely fail to ripen fruit early in May.

207. Of kidney-beans the best kind for forcing, is the early speckled dwarf. The beans are sown, in small pots, (called 24's or 16's,) in any sort of light rich earth, three beans in each, and placed in the house when fire-heat is begun. As they advance, they require frequent watering, and as much air as circumstances will permit. The pods should be gathered when rather young, as in this way the plants continue longer to yield them.

The Vinery or Grape-house.

Vinery.

208. A vinery with two furnaces is generally fifty feet in length, and fourteen or fifteen in width within; the height of the back wall being ten or twelve feet, and of the parapet about eighteen inches. When one furnace only is employed, the length of the house should never exceed thirty or thirty-five feet. The parapet wall is generally supported on small arches or lintels, as already described in the peach-house, so that the vines, which are planted inside the house, may send abroad their roots in search of suitable nourishment. Sometimes the vines are planted without, and introduced through slanting apertures.

209. Very commonly the roof is formed of sashes, which can be let down for the admission of air. In a grape-house described by Mr Knight, (*Hort. Trans. Lond.* vol. i. p. 100,) the air is admitted at the ends, where all the sashes are made to slide; a free current may thus be made to pass through the house. Besides, about four feet of the upper end of every third light of the roof is made to lift up, being attached by hinges to the wood-work on the top of the back-wall; and in this way, air is given in hot and calm weather, without any additional shade. Here it may be remarked, with great submission to that eminent horticulturist, that *currents* of air are seldom wanted in hot-houses; they often indeed prove hurtful. To give air, therefore, principally by means of currents seems not a good plan; for the small openings in the roof are not likely to be able to counteract the rush of cold air at the ends. In giving air to vines, it is of great importance to have a free and soft circulation: this will prove highly salubrious to the plants, while, in the same temperature of the atmosphere, a current would be hurtful.

210. In planting a new grape-house the young vines are put in, in February or March, and little or no fire heat is given; they make strong shoots the first year,

but only such as are wanted for the trellis are preserved, perhaps three on each plant, and in general these are trained straight towards the roof, ten or twelve inches separate from each other. In September, if the wood be not properly ripened, a little fire-heat is given for this purpose. Next year a good deal of fruit begins to appear; but only a few bunches are permitted to come forward, in order to prove the kinds. In the third year, if well managed, they fill the roof; and if the wood be thoroughly ripened, they may be considered as established plants.

211. We shall here mention an incomparably more speedy mode of storing a new grape-house, which may be adopted wherever a vinery previously exists in the garden, or where there is a friend's vinery in the neighbourhood. This mode is frequently practised at the gardens of Dalkeith House, by Mr James Macdonald, and we have witnessed its complete success.

In the end of June or beginning of July, when the vines have made new shoots from ten to twelve feet long, and about the time of the fruit setting, he selects any supernumerary shoots, and, loosening them from the trellis, bends them down so as to make them form a double or flexure in a pot filled with earth, generally a mixture of loam and vegetable mould; taking care to make a portion of last year's wood containing a joint, pass into the soil in the pot. The earth is kept in a wet state; and at the same time a moist warm air is maintained in the house. In about a week or ten days, roots are found to have proceeded plentifully from the joint of last year's wood, and these may be seen by merely stirring the surface of the earth, or sometimes they may be observed penetrating to its surface. The layer may now be safely detached. Very frequently it contains one or two bunches of grapes, which continue to grow and come to perfection. A layer cut off in the beginning of July generally attains, by the end of October, the length of fifteen or twenty feet. A new grape-house, therefore, might in this way be as completely furnished with plants in three months, as by the usual method, above described, in three years. Supposing the layers to be made on the 1st of July, they might be cut, and removed to the new house on the 9th: by the 9th of October, the roof would be completely covered with shoots, and next season the house would yield a full crop of grapes. It is not meant that they should be allowed to do so, if permanently bearing plants be wished for: on the contrary, they should be suffered to carry only a very moderate crop, as it is pretty evident that the roots could not sustain the demand of a full one; or at any rate, that the plants would necessarily shew their exhausted state, by barrenness in the following season. By this means the more delicate kinds, as the frontignac, may be quickly propagated: we have seen layers of the Gibraltar or red Hamburgh made in the beginning of July, reach the length of thirteen feet before the end of the month, yielding at the same time two or three bunches of grapes. The more hardy, such as the white muscadine, form still stronger plants in that space of time. Little difficulty is experienced in removing the plants from the pots into the holes prepared for them: if there be fears of preserving a ball of earth to the new roots, the pots may be sunk with them, and then broken and removed; or the plants may be kept in the pots till autumn, when they may very easily be taken out of them without detriment. Mr Macdonald's experience does not lead him to think that plants propagated in this way are less durable than those procured by slower means, and where the roots and branches bear a relative proportion to each other. But supposing they were found to be less durable, it is evident that one may thus very easily keep grape-houses constantly stored with healthy fruit-bearing plants, and that the kinds may be changed almost at pleasure. When it happens that too much bearing wood has been trained in, the plants are relieved, and sufficient sun and air admitted, by thus removing two or three shoots; and supposing these to contain each several bunches, of some fine sort of grape, they are not lost, but may be ripened, by setting the pots on the side-shelves, or flue trellis, of the pinery, or any hot-house.

212. The proper management of the grape-house has now become an important part of the duty of a gardener. To lay down particular rules in this place is impossible; a few general hints only can be given. A great deal of useful information on this subject may be found in the excellent Treatise on the Culture of the Vine, by Mr William Speechly, London, 1789; and in the Forcing Gardener, by Mr Walter Nicol, Edinburgh, 1809. These and similar books the gardener should study, as containing the results of experience; but many cases will occur, in which he must depend on his own practical knowledge, and be guided solely by his own judgment.

The forcing of the earliest grape-house is often begun in January. Till all the buds be broke, air is daily admitted by the sashes, and the heat is kept moderate, so that the thermometer may indicate only 50° or 55° in the mornings and evenings when the sun has no influence. The temperature is then gradually raised, in the course of a fortnight or three weeks, to about 70°. When the flowers appear, it is increased nearly to 75°, and the house is frequently steamed, by sprinkling water on the flues, or on the walk when the sun shines, grapes being found to set best in a strong moist heat. The gardener now selects his bearing wood for next year, and trains the shoots to an upper trellis, a foot above the other, and the wires of which are perhaps two feet apart; while he nips off all lateral and superfluous produce, and at the same time shortens the bearing shoots at an inch beyond the uppermost cluster. While the berries are swelling, water is moderately given. Nicol, indeed, recommends, that it should be given liberally till they begin to ripen; but this has been considered as likely to deprive the grapes of their proper raciness and flavour.

The thinning of the bunches deserves attention. This is sometimes neglected; but in many kinds, without this attention, the berries in the middle of the bunch are apt to get mouldy and to rot; and in all cases where thinning is practised, the berries become larger and more equal in size. In the operation of thinning, particular care should be taken that the left hand, with which the bunch is held, be kept cool, and also quite free from perspired matter. For this purpose, the gardener should have a vessel with pure cold water beside him, into which he may now and then dip his hand, to keep it cool and clean. Without this precaution the berries often suffer from being handled, acquiring a rusty diseased look, and not swelling freely.

When the grapes approach maturity, all are agreed that no more watering is proper. Air, however, is freely admitted. In general, a proportion of the foliage, especially on the stubs on which the clusters hang, is removed. The fruit ought to remain till it be fully ripe; but this the impatience of the owners seldom permits. When the fruit is all gathered, the stubs which bore it

Vinery.

are cut off, and the new shoots are let down from the upper trellis to their proper places. Watering both of border and foliage is now resumed, and the house is usually left fully exposed to the atmosphere. The general pruning is performed from the middle to the end of October, and time is thus given for the healing of the wounds before forcing be again commenced. At this pruning the loose part of the outer bark on the old wood is carefully peeled off, and the whole plant and the trellises are washed with some penetrating liquid, calculated to destroy the minute eggs of insects. For about a fortnight after this severe pruning the house is kept shut, but it is afterwards freely exposed as before.

The management of the late grape-house entirely resembles that of the early, making due allowance for the difference of season. It is not intended for *forcing* the fruit, but merely for supplying the deficiencies of our natural climate in spring and autumn.

As the vinery may remain without its glass-covers for many months in the year, in some places, especially in the south and west of England, the peach-house is formed exactly of the same dimensions; and, when the peach season is over, the glass frames are transferred to the vinery, and, if the blossoms have escaped, a crop of ripe grapes, of the best sorts, is thus procured in September or October, and the new wood is thoroughly ripened.

Fig-House.

Fig-house,

213. The fig-house is generally constructed on the same plan as the cherry house, with fig-trees on the back wall trellis, and either dwarf figs, cherries, or apricots in front, the flues being likewise covered with a small trellis for holding pots of strawberries or kidney-beans. A separate hot-house, however, is but seldom erected for the cultivation or the forcing of figs; a few dwarf trees, such as the brown Italian, and purple Italian, introduced into the peach or cherry house, being by most people thought sufficient. It has been found by experience, that dwarf standard fig-trees, planted in the middle of a vinery, between the flues, and so under the shade of the vines, bear fruit plentifully, ripening both the spring and autumn crops. This may be seen in the vinery which forms a part of the splendid range of hot-houses at Preston Hall near Edinburgh, designed by Mr John Hay.

The Pinery.

Pinery.

214. Three sorts of frames, pits, or houses, are required for the successful or extensive culture of the pine-apple: a bark pit, for nursing the crowns and suckers; a low stove, generally called the succession pit, where the plants are kept till they be ready for fruiting; and a pine-stove or fruiting-house.

215. The *Pine-apple* is the *Bromelia ananas* of Linnæus, (belonging to the class and order *Hexandria Monogynia,* and to the natural family *Bromeliæ* of Jussieu.) Some have supposed it to be a native of Africa; but Linnæus considered it as a Brazilian plant. It was introduced into this country as a curiosity about 1690; and Bradley has preserved to us correct information concerning its first cultivation for the sake of the fruit. In 1724, Henry Telende, gardener to Sir Matthew Decker, at Richmond, had forty ananas, which ripened their fruit by means of the artificial heat arising from the fermentation of tanner's bark; and by the year 1730, pine-stoves, of various kinds, were established in all the principal English gardens.

Pine-apple.

The name *pine-apple* seems to be derived from the general resemblance of the fruit to some large cone of a pine-tree. The fruit may be described botanically as a kind of pulpy scaly strobilus, composed of a number of coadunate berries. In richness of flavour it cannot be surpassed; and it is one of the greatest triumphs of the gardener's art to be able to boast, that this fruit can be produced in Britain in as high perfection as in a tropical climate. Its culture is however very expensive, the plants requiring constant attention for at least two years, very commonly for three.

216. The following are the most approved varieties:

The Queen pine.
Brown sugar-loaf.
Striped sugar-loaf.
Montserrat.
The King pine.
Green pine.
Black Antigua.
Black Jamaica.

The *Queen pine* is perhaps the most common in this country, and in Europe, as it is the hardiest. The fruit is of an oval or rather tankard shape, of a yellowish colour, but the pulp pale. It grows to a large size, sometimes weighing 3 lb.

The *Brown sugar loaf* is of a pyramidal or conical shape, with a yellow or straw-coloured pulp, and brownish leaves. The plants may be distinguished by the leaves having purple stripes on the inside throughout their whole length. The fruit also grows to a large size. Its juice is accounted less astringent than that of some other varieties, and consequently it may be eaten more freely.

The *Striped sugar-loaf* is so named, from its green leaves being striped with purple; in one sub-variety they are prickly, in another smooth. In colour and flavour, the fruit resembles the Queen pine, and it is nearly as hardy.

The *Montserrat pine* is distinguished by the leaves being of a dark brown, inclining to purple on the inside; and by the pips or protuberances of the fruit being larger and flatter than in the other kinds.

The *King pine* is a large fruit, first raised in this country by Miller; its leaves are of a grass green colour; the pulp is hard, and rather stringy, but of good flavour when ripe.

The *Green pine* is not common; when ripe, the fruit is of an olive hue.

The *Black Antigua pine* is shaped like the frustum of a pyramid. The leaves of the plant have a brownish tinge, and fall down; they have strong prickles, thinly scattered. The pips of the fruit are large, often an inch over; it attains a large size, weighing sometimes 3lb. or 4lb.; it is of a dark colour till it ripen; very juicy, and high flavoured.

The *Black Jamaica* is likewise a very large kind, and similar in habits and character to the black Antigua.

217. In gardens of the first order, the pinery is now generally placed in a detached situation, and the three kinds of pits or houses above mentioned conveniently form a continuous range or suite by themselves; the fruiting-house, being higher in the roof, occupies the centre, and the nursing pit and succession house are placed to the right and left.

Nursing pit.

218. The *nursing pit* is commonly about three or four feet high in front, and between seven and eight at the back wall, or the difference between the height in front and in rear does not exceed one-third of the breadth, whatever that may be. The front and roof are of glazed frames. These pits are generally furnished with

Pine-apple.

small flues; but as a much less degree of heat (from 55° as the minimum, to 65° or at most 70° Fahr. as the maximum) is required in these than in the fruiting-house, sometimes no flues are employed, the heat being trusted entirely to the fermentation of a dung hot-bed, lined when necessary. When flues are used, tree-leaves or tanner's bark are still proper for receiving the pots, and equalizing the heat.

The pine-apple is propagated, by planting either the crowns or tufts which grow on the fruit, or by the suckers which appear on the fruit-stalk, or which proceed from the base of the plant. The crowns are therefore in general returned to the gardener, after having been presented at table attached to the fruit; and they are kept four or five days longer, till the place of separation be healed over or dried; they may however be almost immediately planted, if the parent plant have not received water perhaps for a fortnight before, in order to heighten its flavour. The stocks also from which fruit has been cut, if thought of superior quality, may be encouraged to set out many suckers, by plunging them in a hot-bed, and regularly watering them; such suckers making excellent plants.

Some writers give nice and curious directions for forming a compost for pine-apple plants; but vegetable mould, such as rotted tree leaves afford, may be considered as perfectly good. Even kitchen garden mould which has not been exhausted, answers very well. If old pasture soil be used, it should be mixed with well rotted dung, and laid in heap for a year before being used, during which time it should be repeatedly turned. The pots used for crowns and suckers are three inches in diameter, inside measure, and 4½ deep, for the smaller plants; 4 inches in diameter, and 6 deep, for the larger; but it is much worse for the plants to have pots too large than too small. Dry shivers or chips of broken pots, or clean gravel, to the depth of an inch, are placed in the bottom of the pots. No water is given for a few days, till the plants shew signs of growing. The principal potting is naturally in July and August, after the fruiting season. Next April, or as soon as the growing season has fairly commenced, the plants are shifted into larger pots, 5 inches in diameter within, and 7 deep. They are shaded by a canvas sheet for a few days, at least during sunshine; and when the plants begin to grow again, water is given both at root and over the leaves with a fine rosed watering-pot. During winter, it may here be remarked, water is given only once a week, or even seldomer; and it is kept for some time in the pit or stove before being applied. To the roots of young plants, dunghil drainings are sometimes supplied. Minute rules for admitting air are laid down by Speechly, Macphail, Nicol, and Abercrombie: these should be studied by the gardener; but much must still depend on his own experience and sagacity.

Succession pit.

219. The *succession pit* resembles in structure the nursing pit. In this, during the second autumn and winter, the plants are kept merely vegetating. If they be maintained in health, it is not expected that they should increase in size, unless perhaps that, having more room, they may swell at bottom: the temperature therefore is kept rather lower than in the nursing pit. When plants are shifted into this, which is commonly when they are about a year old, the business should if possible be completed in one day. The pots now used are 24's, or 7 inches across, and 9 deep. Any injured parts of the roots are carefully cut off, and a few of the oldest or lowest leaves are removed.

Fruiting house.

220. In the *fruiting-house*, more room, greater height, and at the same time a higher temperature are required. The pots here used are from 8 to 10 inches in diameter, and 10 inches deep. In the bottom of these fruiting-pots, it is better to put half rotted grass-turf than shivers or gravel. From the time that the plants begin to shew fruit, the temperature is not suffered to fall below 65° Fahr.; it is kept generally at 75°, or at least above 70°: in sunshine it is allowed to rise to 85°, or even 95°, as fresh air can thus be more freely admitted. Water is given very cautiously, sufficient only to keep the plants healthy, but not to injure the flavour of the fruit. Pine-apples should be cut a short time before they attain complete maturity, or be dead ripe. When the fruit changes colour, in most varieties when it becomes greenish-yellow or straw-coloured, and when it also diffuses its peculiar odour to some distance, it may be considered as fit for cutting.

221. A clearer idea of the course of culture, in the nursing pit, succession pit, and fruiting-house, may perhaps be obtained from the following compendious view of the operations, suggested by Abercrombie, in which specific days or months are assumed, merely in order more distinctly to mark the anniversary or relative periods.

NURSING PIT.

1816. Aug. 15. Crowns or suckers planted.

—— Oct. 30. If the plants, from rapid growth, require more room, some are removed to another pit, and the remainder set at increased distances.

1817. Mar. 30. Such plants as need it, are shifted into larger pots. Plants of the same standing are now distributed to houses where the treatment differs, as the plant is expected to fruit at the end of two or of three years. It may be noticed, that the large varieties, such as the black Antigua and black Jamaica, always require three years culture; and that crown and fruit-stalk suckers are seldom so forward as those from the base or root of the plant.

Three-year fruiting plants.

NURSING PIT *continued.*

1817. May. Plants intended to complete a year in this pit, are repotted; having the ball of earth shaken away, and the old root-fibres pruned off.

SUCCESSION PIT.

—— Aug. 15. Plants that have been in the nursing pit the previous year, are shifted and transferred to this house.

FRUITING HOUSE.

1818. Aug. 15. Plants which have remained one year in the nursing pit, and a second year in the succession pit, are removed to this house.

1819. Aug. 1. Such plants ripen their fruit.

Two-year fruiting plants.

SUCCESSION PIT.

1817. Mar. 30. Forward plants from the nursing pit are put into larger pots, and brought for culture here.

—— May or June. Succession pines are sometimes intermediately shifted, without disturbing the balls of earth.

FRUITING HOUSE.

—— Aug. 15. Plants from the succession pit, after being only *one* year in the first and second stages, are shifted into the largest pots, and placed here.

1818. Aug. 1. Such plants afford fruit fit for cutting.

222. Success in the culture of this fruit, it may be remarked, very much depends on two circumstances; on giving them plenty of room in the nursery pit and succession frame, so that the lower part of the plant may swell out and increase in bulk, without being drawn up; and on keeping the fruiting plants in a continued healthy or vigorous state: for this last purpose, early in the spring the tan of the fruiting house should be stirred, and a fresh quantity intermixed, so as to

Pine-apple.

raise a new fermentation and accompanying heat. In the different pine-stoves it is found very advantageous frequently to white-wash the plaster, and to repaint the wood work.

223. The plants, especially if weak or not healthy, are subject to the attack of a small species of coccus (*C. hesperidum*, Lin.) commonly called the pine-bug. The insects adhere closely to the leaves, often near the base, and seem almost inanimate. Mr Miller recommends turning the plants out of the pots, and cleaning the roots; then keeping them immersed for four-and-twenty hours in water in which tobacco stalks have been infused: the bugs are then to be rubbed off with a sponge, and the plants, after being washed in clean water and dripped, are to be repotted. Mr Muirhead, a gardener in the north of Scotland, has described a similar mode, (*Scottish Hort. Mem.* vol. i. p. 209,) only in place of tobacco juice he directs flowers of sulphur to be mixed with the water. With a bit of bass-mat fixed on a small stick and dipt in water, he displaces as many of the insects as he can see. He then immerses the plants in a tub of water, containing about 1 lb. of flowers of sulphur to each garden-pot-full. They remain covered with the water for twenty-four hours, as desired by Miller. They are then laid with their tops downward, to dry, and are repotted in the usual manner. What share of the cure, in either of these ways, may be due to the sulphur or to the tobacco liquor, does not clearly appear; the rubbing off or loosening the insects is evidently important; and it is not unlikely that immersion, in simple water, so long continued, may alone be sufficient to destroy them. Indeed, the experience of one of the best practical gardeners in Scotland (Mr Hay) leads him to conclude, that even moderate moisture is destructive to these insects. During many years, he regularly watered his pine-plants over head with the squirt, during the summer months: this was done only in the evening; it never injured the plants; and the bug never appeared upon them.

The Orangery.

Orangery.

224. This is merely a green-house, and indeed is generally employed in part for protecting ornamental plants and shrubs. In a few places the orange trees are planted in the border soil, in the manner of shrubs in a conservatory. The genus *citrus* includes not only the orange, but the shaddock, lemon, citron, and lime: it belongs to the class and order Polyadelphia Polyandria, and natural order Aurantiæ of Jussieu. In warm countries the trees rise to the height of perhaps fifty feet; here they seldom exceed the size of shrubs. The species may readily be distinguished by the petiole or leaf-stalk: in the orange and the shaddock, this is winged; in the lemon, citron and lime, which are considered as varieties belonging to one species, it is naked. The orange and shaddock fruits are almost spherical, and of the yellowish-red colour known by the name of orange; the lime is spherical, but of a pale yellow; the lemon is oblong, with a nipple-like protuberance at the end; the citron is oblong, and distinguished by having a very thick rind.

Orange.

225. Of the *Orange* (*Citrus aurantium*, Lin.) there are two principal varieties; 1. The sweet orange, including the China orange, the Portugal orange, and similar kinds; and, 2. The bitter orange, including the Seville orange, and other varieties called *bigarades* by the French. The Seville orange-tree produces its fruit more readily in this country, and has larger and more beautiful leaves than the China orange: the former is therefore more generally cultivated, but the latter also succeeds very well in some places. There are besides, the willow-leaved or Turkey orange, the dwarf or nutmeg orange, the double-flowering, and many other varieties, some with the leaves variegated yellow and white.

Sir Francis Carew is said, by Mr Lyson, (*Environs of London*, vol. i.) to have introduced orange trees into this country, in the reign of Elizabeth; but whether he brought plants, or raised them from the seeds of oranges brought home by Sir Walter Raleigh, is not clear; it may be remarked, however, that it has long been known from experience, that in this climate orange plants raised from seed shew no inclination to produce fruit; whereas Sir Francis Carew's yielded plenty of fruit. What is further curious in the history of these early orange trees, is, that they were planted in the open border, and protected during winter merely by a moveable shed. They grew on the south side of a wall, not nailed against it, but at full liberty to spread; they were 14 feet high, and extended about 12 feet wide. They were finally cut off by the great frost of 1740, after having stood a century and a half. Professor Martyn informs us, (Miller's *Dict.* in loco), that they had, the year before, been inclosed in a permanent building like a green-house; and he very justly remarks, that the dampness of new walls, and the want of the usual quantity of free light and air to which they had been accustomed, might probably have killed them, even had the great frost never occurred.

Orangery.

226. The orangeries of this country are supplied in two ways; either by plants raised from the seed, and budded, inarched, or grafted by our nurserymen and gardeners; or by small budded trees imported in chests from Italy.

The best stocks are common citrons, this tree making strong straight shoots, and receiving readily either orange or shaddock buds; they are procured by sowing ripe citron seeds. Next to these, Seville orange stocks are desirable; the seeds may be taken from rotten Seville oranges, which are generally the ripest. They are sown in pots sunk in a bark hot-bed, and, about two months afterwards, each plant is transferred to a small flower-pot, about five inches in diameter. They are gradually hardened, by admitting air, till the end of September, when they are transferred to the greenhouse for the winter. Next spring they are forwarded, by being again plunged in a moderate hot-bed; but after midsummer they are hardened as much as possible, and in August they are ready for budding. The buds should be taken from trees in a bearing state, and which are known generally to afford a good crop, preferring buds from round shoots to those from flat shoots. The plants are again preserved in the greenhouse through the winter; and in the following spring, they are once more planted in a gentle hot-bed, the stocks at the same time being cut off about three inches above the buds: By this means, the stem of the future tree generally grows up straight in one season.

Trees raised in the way now described, require no less than fifteen or sixteen years to attain the size of those imported in boxes from the Mediterranean. The latter, if they be good plants, if they have not suffered greatly from the voyage, and if they be properly managed on their arrival, will bear fruit in three or four years. But it is chiefly the shaddock and citron that are thus imported. Those stocks which have two buds inserted in them, it is observed, make finer heads than such as have one only. To recover the trees after their being so long out of the earth, requires some care and

Orangery.

attention: they are planted in fine vegetable mould, in pots having channel to the depth of some inches in the bottom, so as to drain away superfluous moisture, and are placed in a hot-bed; at the same time, hay bands are wrapped round the stems, to prevent the sun's rays from over-drying the bark.

227. Young orange trees are every season repotted, generally in April, for successive years, till they produce fruit. The earth or compost must be prepared at least a year before, so that any dung mixed with it, may be very completely rotten. When the trees become large, that is six or eight feet in height, they are generally planted in wooden cases or tubs. When old orange trees have been mismanaged, it is found very useful to plunge them into a hot-bed: this is accomplished by planting them in baskets, and sinking these into the bed. The baskets are made of a less size than the tubs, and when the trees are restored to these, the baskets are cut away, and the empty space filled with prepared earth. It is a rule to remove, every season, a considerable portion of the earth, taking great care not to injure the roots; its place is supplied with a fresh quantity of the prepared soil.

228. In the orangery during winter, the trees receive regular but moderate watering, and as much free air as the nature of the season will permit. In May, they are removed to the open air: the place should be sheltered from high winds, and it is found best that the plants should be exposed only to the morning and afternoon sun, and shaded from the mid-day glare and heat. Here they remain till about the middle or near the end of October. They produce their pure white and very fragrant flowers in June; and after the first season of flowering, blossoms and fruit are seen together on the same plant, the latter remaining a year or fifteen months on the tree before it be ripe. The clusters of blossom and fruit are thinned progressively, as there seems to be occasion.

In different places of England, Seville orange trees have of late been planted in the open border, in emulation of Sir Francis Carew's trees, and covered during winter with moveable glass frames. It is found generally indispensable, however, that the walls should be flued, and that some slight fire heat be in this way afforded during severe frosts. The bottom of the border on which orange trees are planted, must absolutely be dry; it is necessary, therefore, to lay at least two feet of lime rubbish, or some similar material, beneath the border soil.

Shaddock.

229. The *Shaddock* (*Citrus decumana*, L.) is the pampelmous of the French, Delaunay however describing the *chadec* as a large variety of *C. aurantium*: the denomination *Shaddock* was given from the name of the English officer who first conveyed the plant from the East to the West Indies. It is managed like the orange tree, but is somewhat more tender, and must be treated accordingly. In a well-arranged orangery, however, and under the care of a judicious gardener, it produces large and ripe fruit. Even in Scotland this is the case; as at Woodhall, near Hamilton, the seat of Mr Campbell of Shawfield.

Citron.

230. The *Citron* (*Citrus medica*, L.) is also cultivated like the orange; but being rather more tender, must be less early exposed in the spring, and sooner put under glass in the autumn. The summer situation should be the warmest and most sheltered in the garden. There are several sub-varieties of the citron, particularly one with very large fruit, the *poncire* of the French.

Lemon.

231. The *Lemon* is generally budded or inarched on a citron stock. Its culture is the same as that of the orange; but it is more hardy than that species, and requires more free air during winter. It should also be watered somewhat more liberally. In some parts of England, lemon-trees succeed very well in the open border against south walls: they are sheltered during winter by moveable glass frames, and produce plenty of large fruit, making a pleasant variety on the wall.

Lime.

232. The *Lime* is propagated and treated much in the same way as the lemon.

233. Having thus given a general account of forcing-houses, or hot-houses for producing fruit, taken separately, we shall now describe a range or suite, and at the same time shall illustrate what we say by reference to the plans, elevations and sections contained in Plates CCCX. and CCCXI. The magnificent suite of glazed houses represented in the former Plate, it will be observed, is by no means ideal, but exists in the garden of Dalmeny Park, the seat of the Earl of Rosebery near Edinburgh; and the accuracy of the plans may be relied on, Mr Hay, the designer employed at Dalmeny, having, with permission of the noble proprietor, favoured us with them. We shall at the same time give a short description of the garden, and particularly of the walls, as illustrative of some improvements in this branch of horticulture introduced by Mr Hay.

Dalmeny Park garden.

234. The garden at Dalmeny Park lies on the face of a bank having a considerable declivity to the south and south east. It is bounded on the north by a low hill crowned with trees perhaps about 40 years old; on the west, by rising ground with trees of the same standing; and on the east, by hollow marshy ground, likewise covered with trees. On the south flows a little rill, the bed of which terminates the slope on which the garden is placed: from this lowest point the ground rises gradually to the south, to some height. Part of this rising ground on the south side of the streamlet is included within the ring fence which surrounds the garden, and is laid out in shrubbery and parterres; through these the walk from the house to the fruit-garden is conducted. The soil of the lowest part consists chiefly of bog or peat earth, admirably adapted for the growth of American shrubs, such as rhododendrons and kalmias. The garden contains about two Scottish acres within the walls. The fruit-tree borders are 18 feet wide, and the walks seven feet broad; the soil beneath the gravel of the walks was prepared with the same care as that of the borders. The walls in general are 14 feet high; the east wall is somewhat more. They are built of bricks manufactured at Leven in Fife, and regular bricklayers were brought from Newcastle for the purpose of rearing them. The whole extent of the south wall, 361 feet in length, is flued, the heat being supplied by twelve furnaces placed on the north side of the wall, six on each side of the central door. The tops of the furnaces are covered with flags, which are on the same level as the soil of the garden; and the stock holes or entrances to the furnaces have hatchway covers, in which are two ventilators to admit air. In this way the furnaces produce no disagreeable appearance. The trees on this wall may, at the same time, be covered with the osnaburg canvas mentioned in § 84. From the corners of the walls where they meet at right angles, a wall is extended diagonally about 17 feet. This extension is found very useful in breaking the force of the wind when ranging along the walls. At the same time it does away in a considerable degree the formal box shape of the garden when viewed from the higher grounds in the neighbourhood. The apex of the projecting wall is rounded: here a

jargonelle pear-tree is planted; the branches are trained to both sides of the wall, and the fruit of course ripens at different times.

235. The contrivance for watering or washing the foliage of the wall-trees in this garden deserves particular notice. Water is supplied to the garden from a reservoir situated on an eminence a considerable height above the garden walls. Around the whole garden, four inches below the surface of the ground, a groove between two and three inches deep has been formed in the walls, to receive a three-quarter-inch pipe for conducting the water. About 50 feet distant from each other are apertures through the wall, two feet and a half high and ten inches wide, in which a cock is placed, so constructed, that on turning the handle to either side of the wall, the water issues from that side. It has a screw on each side, to which is attached at pleasure a leathern pipe, with a brass cock and director, roses pierced with holes of different sizes being fitted to the latter. By this contrivance all the trees, both outside and inside the wall, can be most effectually watered and washed in a very short space of time, and with very little trouble. One man may go over the whole in two hours. At the same time, the borders, and even a considerable part of the quarters, can be watered with the greatest ease when required. The conveniency and utility of this contrivance must at once be perceived by every practical horticulturist. The same plan of introducing water is adopted in a garden which Mr Hay planned and executed for Lord Viscount Duncan at Lundie House near Dundee; and after the experience of several years it has been greatly approved of. The water at Lundie is conveyed to the garden from a considerable height, and is thrown from the point of the director with great force and to a good distance. A sketch of the cock, pipe and director, is given in Plate CCCX. Fig. 6; *a* the cock; *b b* the leathern pipe; *c* the director.

PLATE CCCX.

236. In the middle of the north wall of the garden is the great range of hot-houses, consisting of seven, a central one, and three on each side. The entire suite extends from east to west 181 feet. The elevation of this fine range is seen in Plate CCCX. Fig. 2. The houses differing considerably in breadth, the eye is not offended with monotonous uniformity; and the addition of a central door, with a diamond-trellis arch, ornamented with tender and showy climbing plants, is a great improvement in point of appearance. The ground plan of these houses is given at Fig. 1. of the same Plate. The middle division A, with those on the right and left of it, B and C, are peach houses. On the back wall are placed trellises, to which the principal peach-trees are trained. Small trees are also trained on low sloping trellises in the front, over the flues. The farthest east division D, is what is called a *Double Peach-house*; peach trees being trained on the back wall as in the other houses, and likewise in front on a wire trellis on the roof of the house, reaching upwards as far as the first or under sash only. The trees on the front part of the house may be forced before those on the back wall. To accomplish this, the upper sashes of the house are kept off, thus admitting air freely to the trees on the back wall; while meantime the front trees are inclosed within the first two returns of the flues, by means of moveable shutters made for the purpose, one of them being placed on hinges, and used as a door. Hence the name of Double Peach-house. The partition remains only until the fruit be set; at which time it is removed, and the roof-sashes put on. By these means the fruit season in this house is protracted a considerable time, perhaps a month or more. Fig. 5. in Plate CCCX. is a section of this double peach-house.

The other three divisions of the range, E, F, G, are grape-houses. The back walls are all covered with trellises. A vine is planted in the middle, and trained on the trellis at the top of the house, where in general there is plenty of light in the early time of forcing. The lower part of the trellis is covered with fig-trees, which, as already mentioned, § 213. have been found to succeed very well in such situations. Fig. 3. Plate CCCX. is a section of division F.

In all the houses of this suite, air is given by moving the upper sashes by means of weights and pulleys placed in a cavity in the back wall, as seen at *a a a*, in the sections, Figs. 3, 4, and 5.

Into each of the hot-houses is introduced a three-quarter-inch pipe, coming from an inch one, which passes along the back of the walls. The cocks are of the same kind as those in the walls already described; and the directors, when screwed upon them, water the houses with very little trouble, and are exceedingly useful in keeping under the red spider, and other insects.

237. On the north side of this range, opposite to the middle hot-house, is a mushroom-house, constructed on Oldacre's plan, (to be afterwards described). It has a large and a small pit, with four shelves on the back wall, and three shelves on each of the two ends, all of which may be used for the purpose of raising mushrooms, either at the same time, or in succession. The large pit is partly filled with earth, and kitchen vegetables are kept in it in time of severe frost. Sea cale can also occasionally be forced in this pit. Fig. 4. Plate CCCX. is the section of the mushroom-house, and also of the middle peach house, the ground plan of the mushroom-house being at H, and of the peach-house at A.

238. On the east side of the garden is situated the melon ground. The garden wall is extended on the north of it to the length of 152 feet, of the same height as the other walls, and flued like the rest of the wall having a south aspect. The pine-stoves are situated here. The ground on which they stand falls considerably from north to south. The furnaces are placed on the south side of the stoves; and, on the same side, there is a narrow nursing pit, four feet broad, the whole length of the house. This pit may, at pleasure, be divided, at the furnaces, into three divisions, D, D, D. The glass-roof of the pit covers the top of the furnaces, and from thence heated air is introduced, by means of apertures with dampers, into either pit as it may be wanted. Heated air can also be admitted from the stove to the small pit, by means of openings in cast iron doors, which can be shut when required. When still more of the warm air is wished to be communicated from the stove to the small pit, the doors are made to lift out altogether, and as the front flue of the stove passes these doors, the heated air has free access to rush in; or it can be admitted from the vacuities between the flue and front wall. As the tan in the small pit is of no great body, and cannot long maintain its heat, the front of the pit is built of brick, with pillars and holes similar to a pigeon house; and there is an inclosed space in front of it, to receive a lining of warm dung, when the heat is wished to be increased. This lining is covered over with flooring, which forms part of the walk, tends to prevent the dissipation of the heat, and gives the whole a neat and clean appearance.

PLATE CCCXI.

The spaces over the top of the furnaces can at pleasure be converted into distinct or separate forcing places, by putting in the covers of the dampers, and fixing two wooden divisions across, at the extremities of the furnaces. In these places, potatoes may be forced in early spring; or, if a taste for fine flowers be indulged, the single and the double Cape jasmine (*Gardenia florida*, L.), which are not easily brought to blossom, may here be made to flower, by placing the pots among wet mosses, (*hypnums*,) the moist heat thus supplied proving very congenial to the plant. From the spaces over the top of the furnaces the heated air can at pleasure be directed into either of the two succession houses, being admitted by removing one or other of the covered dampers at *d*, *d*, Fig. 1. Plate CCCXI.

There are niches along the back wall of the pine-stove, nearly opposite to the middle of each sash. They are narrow on the outside, but are bevelled inwards to at least double their exterior width. The bevelled sides are plastered, and covered with a trellis; on these, grape vines are trained, the principal shoot, after reaching the roof, being conducted down the rafter, as far as the first row of pine plants in the back of the pit. To these recesses two sets of shutters are adapted, one for the outside, the other for the inside. During winter the outer shutter is removed, and the inside shutter employed. The vine, after being pruned, is led without, and fixed there during winter, exposed to the cold of that severe season. When brought in to be forced, the inner shutter is of course removed, and the outer shutter put in. The time of forcing these vines may thus in a great measure be regulated by the gardener, and made to suit the conveniency of the family. Fig. 1. Plate CCCXI. is the ground-plan of this pine-stove. A is the first succession-pit, containing nine sashes; B the second succession-pit, with ten sashes; and C the fruiting-pit, with eleven sashes. Fig. 2. is the elevation. Fig 3. is the section; and, it will be observed, that, for the sake of distinctness, this section is drawn to an enlarged scale, nearly double that employed in drawing the ground plan and elevation of the stove, Plate CCCXI. At *k* is a moveable gangway, eighteen inches broad over the glass roof of the narrow pit, for giving access to the front of the stove. It may be mentioned, that there are two returns of the flue beneath the pathway at the back of the pit. The heated air is drawn from between these two flues by means of cast metal covered dampers, *b*, *b*, &c. in Fig. 1.; the covers being only put on while the workmen are changing the tan in the pit, or on similar occasions. The small holes seen in the back wall of the ground plan, Fig. 1. *a a*, &c. communicate with the cavities of the flue on the side next to the back wall. Those seen in the *curb* or back wall of the tan-pit *c c*, &c. communicate with the cavity of the flue next to it; and those in the path-way *b b* with the cavity between the flues. In this way, heated air is drawn from the sides of the flues at thirteen places on the back wall of the house, and at ten places on the *curb* of the pit.

The line *e f g h i*, Fig. 3. in Plate CCCXI. extended to the north wall, shews the declivity of the ground on which the pine-stoves are placed. Nearly opposite to the door in the back wall of the pine-stove there is a door in the garden wall, leading to the pine-shed, where the plants are kept in time of shifting. In front of the pine-stoves, it may be noticed, are situated the general forcing-pit, the melon-pits, and the cucumber frames.

Improved hot-houses.

Before leaving the subject of glazed houses, we may notice some improvements which have of late years been proposed.

239. Mr Knight remarks, that where sunshine and natural heat do not abound, the form which admits the greatest quantity of light through the least breadth of glass, and which affords the greatest regular heat with the least expenditure of fuel, must be the best. It is evident that the sun's rays ought to fall as perpendicularly as possible on the glass roof; because the quantity of light which glances off without entering the house, must be inversely proportionate to the degree of obliquity with which it strikes upon the surface of the glass. Mr Knight made many experiments to ascertain by what elevation of the roof the greatest quantity of light can be made to pass through it; and he found that in latitude 52°, the best angle of elevation is 34°. But it cannot be denied, that the rays of the sun will fall, in a directly perpendicular direction, on this inclined plane, only twice in the year, and then for only very short spaces of time: at all other periods, they must fall in an inclined direction, and never perpendicular to the plane of the glass. Without expecting, therefore, that the rays will ever fall precisely perpendicular upon it oftener than twice in the year, it is of importance that they should do so as much as possible, during those periods when the influence of the sun is most desired. Mr Knight (in *Hort. Trans. Lond.* vol. i. p. 100.) and the Rev. Mr Wilkinson (same volume, p. 162.) do not agree as to the proper inclination of the glass-roof: instead of 34°, proposed by the former, the latter would have the angle 45°. It seems unnecessary to detail the reasons assigned by either writer.

240. It has been remarked by Sir George Mackenzie, that if a form for the glass roof can be found, such that the rays will be perpendicular *to some part of it* during the entire period of the sun's shining, not on two days, but on every day of the year, that form must be considered the best. This form is to be found in the *sphere*; and he proposes the quarter segment of a globe, or a semi-dome; though, to catch the sun at all times, the segment would have to correspond with the greatest segment of the circle which the sun describes. He does not propose to bring each pane of glass into the form of a small segment of a sphere; this would not only be expensive, but unnecessary. The size of a glazed house of this kind can scarcely with propriety exceed a radius of fifteen feet, that is, thirty feet of length for training. The plan, elevation and section of a vinery constructed on the principles thus suggested by this ingenious and scientific horticulturist, have been published by the London Horticultural Society in the second volume of their Transactions; and in Plate CCCXII. we have given these, with considerable improvements since made by the author. It has been found, that the frame for the glass-roof may easily be formed of ribs of hammered iron; each rib consisting of three slips of iron, such as shewn at full size at Fig. 4. The ribs are fixed in an iron plate at the bottom. The distance between them at the base is about fifteen inches; and when the gores contract to half that width, every alternate rib may stop. The word *gore*, we may remark, is that commonly used for a slip of any material so cut, as when joined to others to form a globe or any round figure. The frame-work might also be made of wood; but the wrought iron is not only much cheaper at first, but far more durable. The under frames may be about thirteen feet high; they are rivetted into an iron ring at top, and made fast all round to the coping and upright wall. Iron rods may be placed for supports at *x*, *x*, *x*, *x*, Fig. 3. if thought necessary. The width of the panes at the bottom is about a foot, diminishing to six inches at the second set of ribs; when they begin again at one foot, and contract upwards to four inches.

PLATE CCCXII.

Air is admitted by sliding shutters, which may be glazed if thought proper, in the parapet wall in front; and also by wooden shutters, moving on pivots, and opened or shut by means of cords along the back wall; and by windows in the pediment roof. The glass-roof itself is immoveable; but the upper part of it may be made into moveable sashes if required, by forming a sufficient number of ribs with grooves, and fixing stay rods on the under sashes, to receive the upper ones when let down: and Sir George Mackenzie mentions, that, from viewing the structure of the roof of Short's old observatory at Edinburgh, he is convinced that the glass semi-dome might be made in two parts, and placed on rollers, so as to expose at pleasure every plant in the interior to the direct influence of the sun. If it is wished at times, to defend the plants from the sun, a *gore* of canvas may be so contrived as to cover one-half of the glass. The general appearance of such a house (as seen in the elevation, Plate CCCXII. Fig. 1.) is doubtless highly elegant; and it seems pretty evident, that several such houses, tastefully disposed in a garden, would have a much finer effect than one great range, although the latter must necessarily be more economical. Mr Knight, we understand, highly approves of this invention, and is of opinion that it will answer every purpose, better than any form hitherto contrived.

242. It may here be mentioned, that Mr Robert Fletcher, at Bonnyrig, near Edinburgh, a good many years ago, constructed a grape-house, in the form of a regular polygon of 24 sides, having a base 24 feet in diameter. A thin brick wall, two feet high, passes around, forming the proper angles: on this wall rest the couples which support the central or flat part of the roof, which is eight feet in diameter. An iron ring connects the couples at the base as well as at the top. The length of the couples is 10 feet 3 inches. Between these are glazed sashes, 3 feet wide at base, and tapering to 1 foot at top. In this way the ceiling is 8 feet 6 inches from the ground, and the sashes incline at an angle of 40°. The door of the house is to the north; the furnace close by one side of the door; the flue makes a circuit around the house at the distance of 2½ feet from the wall, and the smoke escapes on the other side of the door. Air is admitted, as wanted, by means of three ventilators on the south-west side; but in point of fact air can pass in by many crevices, particularly at the flat part of the roof, and no putty has been used in glazing. The brick wall being founded merely on the surface of the ground, the roots of the vines pass under it in any direction. The soil is dry and rather shallow. In the end of June, Mr Fletcher forms a heap of vegetables, commonly the weeds from his garden, in the centre of the floor of the house; when this heap begins to decompose, some degree of heat is produced, a good deal of vapour rises, and nutritious gases are exhaled: the heap is occasionally fed, so as to keep up the fermentation till about the middle of September. In this house, and under this sort of management, has this ingenious person, for a number of years, raised very good crops of grapes of different sorts, particularly the black Hamburgh, the Lombardy, and the white sweetwater, the berries of all these kinds becoming large and of high flavour.

243. It may also be noticed, that Mr Henderson, nurseryman at Brechin, has constructed a small hot-house, which he styles the *triple meridian*. The narrow end of it is placed to the south, and the roof, which is ridge-shaped, is inclined in the same direction, by a slope of one foot in six. In consequence of the position of the house, one side has the sun's rays approaching to perpendicular at 9 A. M. and the other at 3 P. M.; and, on account of the slope to the south in the roof, the sun's rays are enjoyed partially all the time he is above the horizon. Air is admitted by ventilators. After several years trial, Mr Henderson has found such a construction to answer all his expectations.

If melons be the crop raised, no furnace is necessary. In place of fire heat, the warmth arising from the fermentation of weeds, or a mixture of grass and rushes, is sufficient; proper chambers for holding these, and enabling them to communicate their heat, being prepared within the house. The employment of refuse vegetables in such a melon-house, or in Mr Fletcher's grape-house, must operate as a premium for the destruction of nettles, thistles, and other weeds.

244. At Lord Mansfield's garden at Scone in Scotland, the hot-houses are constructed on a new plan, inasmuch as they have no *upright* front glass, and all the sashes are *fixed*, or not calculated to slide up and down. Air is admitted by ventilators in front, and at the top of the back wall. The houses are 12 feet high; the back wall two feet higher, or 14 feet; and the front or parapet wall only two feet. The advantages of this plan seem to consist in saving the expence, at first, of upright wooden rafters or pillars, and in preventing the breakage of glass, which must to a certain extent be occasioned by the moving of sashes up and down. But it is not to be concealed that these immoveable sashes are attended likewise with some disadvantages. A liberal circulation of air is sometimes necessary to the health of the young fruit, which, without it, drops off at the time of the first swelling; and an equable exposure to the air is highly important for communicating flavour to peaches and nectarines when just approaching to ripeness. Air admitted, however, only by openings in the front parapet and in the top of the back wall, must in some measure form currents, which, as formerly remarked, (§ 209.) are seldom desirable. Even in avoiding injuries to the glass, the advantages cannot be very considerable, particularly if the moveable sashes be drawn up and down in a steady manner by means of pulleys and weights. Whoever erects a house with a glass roof, must of course lay his account with occasional accidents, whether the roof be fixed or moveable, and one would be apt to think, that the repairs of panes accidentally broken on fixed roofs, could scarcely be accomplished without very considerable risk of increasing the damage, in clambering over them with ladders.

Gathering and keeping of Fruits.

245. Fruits in general should be gathered in the middle part of a dry day; not in the morning, before the dew is evaporated, nor in the evening when it begins to be deposited. Plums readily part from the twigs when ripe: they should not be much handled, as the bloom is apt to be rubbed off. Apricots may be accounted ready when the side next the sun feels a little soft upon gentle pressure with the finger. They adhere firmly to the tree, and would over-ripen on it. Peaches and nectarines, if moved upwards, and allowed to descend with a slight jerk, will separate if ready; and they may be received into a tin cup or funnel lined with velvet, so as to avoid touching with the fingers or bruising. If this funnel have a handle two or three feet long, the fruit may be gathered with it from any low or ordinary wall. The old rule for judging of the ripeness of figs, was to observe if a drop of water was hanging at the end of the fruit; a more certain one is, to notice when the small end becomes of the same colour as the large end. The most transparent grapes

Fruit Garden.

Keeping of fruit.

are the most ripe. All the berries on a bunch never ripen equally; and it is therefore proper to cut away unripe or decayed berries before presenting the bunches at table. Autumn and winter pears are gathered, when dry, as they successively ripen. The early varieties of apples begin to be useful for the kitchen in the end of June; particularly the codlins and the jenneting; and in July they are fit for the dessert. From this time till October or November, many kinds ripen in succession. The safest rule is to observe when the fruit begins to fall naturally. Another easy mode of ascertaining, is to raise the fruit level with the foot-stalk; if ripe, it will part readily from the tree: this mode of trial is also applicable to pears. A third criterion is to cut up an apple of the average ripeness of the crop, and examine if its seeds have become brown or blackish; if they remain uncoloured, the fruit is not ready for pulling. Immature fruit never keeps so well as that which nearly approaches maturity; it is more apt to shrivel and lose flavour. Winter apples are left on the trees till there be danger of frost: they are then gathered on a dry day.

In all cases the fruit is plucked with the hand, and great care taken to avoid bruising. For collecting the fruit from half standard and full standard trees, a step-ladder is employed. This ladder may be so contrived that the back shall come away by removing a bolt. The same ladder may thus be used for high wall-trees; but in this case two rods of iron should be made to project six or eight inches from the top, to keep it from resting on the branches of the trees, and injuring them.

246. Hitt's method of keeping pears may be shortly mentioned. Having prepared a number of earthen-ware jars, and a quantity of dry moss (different species of hypnum and sphagnum), he placed a layer of moss and of pears alternately till the jar was filled; a plug was then inserted, and sealed around with melted rosin. These jars were sunk in dry sand to the depth of a foot; preferring a deep cellar for keeping them, to any fruit-room.

247. Miller's plan may also be noticed. After sweating and wiping, in which operations great care must be taken not to bruise the fruit, the pears are packed in close baskets, having some wheat-straw in the bottom and around the sides to prevent bruising, and a lining of thick soft paper to hinder the musty flavour of the straw from infecting the fruit. Only one kind of fruit is put in each basket, as the process of maturation is more or less rapid in different kinds. A covering of paper and straw is fixed on the top, and the basket is then deposited in a dry room, secure against the access of frost, "and the less air is let into the room, the better the fruit will keep." A label should be attached to each basket, denoting the kind of fruit; for the basket is not to be opened till the fruit be wanted for use.

248. Mr James Stewart, an experienced gardener at Pinkie, in Scotland, has long preserved his choice apples and pears in glazed earthen-ware jars, provided with tops or covers. In the bottom of the jars and between each layer of fruit, he puts some pure pit sand which has been thoroughly dried on a flue. The jars are kept in a dry airy situation, as cool as possible, but secure from frost. A label on the jar indicates the kind of fruit; and when this is wanted or ought to be used, it is taken from the jars, and placed for some time on the shelves of the fruit-room. The less ripe fruit is sometimes restored to the jars, but with newly dried sand. In this way he preserves colmarts and other fine French pears till April; the terling till June; and many kinds of apples till July, the skin remaining smooth and plump. Others who also employ earthen-ware jars, wrap each fruit in paper, and in place of sand use bran.

249. Mr Ingram at Torry in Scotland, a very intelligent gardener, has succeeded uncommonly well in the management of the fruit room. For winter pears he finds two apartments requisite, a colder and a warmer; but the former, though cold, must be free of damp. From it the fruit is brought into the warmer room as wanted; and by means of increased temperature, maturation is promoted, and the fruit rendered delicious and mellow. Chaumontels, for example, are placed in close drawers, so near to a stove, that the temperature may constantly be between 60° and 70° Fahr. For most kinds of fruit, however, a temperature equal to 55° is found sufficient. The degree of heat is accurately determined, by keeping small thermometers in several of the fruit-drawers, at different distances from the stove. The drawers are about six inches deep, three feet long, and two broad; they are made of hard wood, fir being apt to spoil the flavour of the fruit. They are frequently examined, in order to give air, and to observe the state of the fruit, it being wiped when necessary. Mr Ingram remarks, that, in Scotland particularly, late pears should have as much of the tree as possible, even although some frost should supervene; such as ripen freely, on the other hand, are plucked rather before they reach maturity.

250. Winter apples are generally left on the trees till there be danger of frost. They are then gathered, when dry, as formerly noticed; and are laid in heaps, and covered with mats or straw, or short grass well dried. Here they lie for a fortnight or more, to *sweat* as it is called, or to discharge some of the juice of their skin, which thus contracts in a certain degree. After this they are wiped dry with a woollen cloth, and placed in the fruit-room. Sometimes, when intended for winter dessert fruit, they are made to undergo a farther sweating; and are again wiped and picked: they are then laid singly on the shelves, and covered with paper. Here they are occasionally turned, and such as shew any symptoms of decay are immediately removed. Baking fruit is kept in a close but cool place, where the temperature undergoes little variation. It is found to be advantageous to keep each sort separate. Sometimes apples and pears for baking are kept in baskets or hampers. Thick paper is considered a better material for lining and covering such baskets or hampers than straw, and straw is better than hay.

It may be proper to mention, that some entirely disapprove of the sweating of fruit, affirming that it thereby acquires a bad flavour, which it retains, or at any rate that the natural flavour of the fruit is deteriorated. They consider it better to carry the fruit directly from the tree, carefully avoiding all sort of bruising, and to lay it thinly on the shelves of the fruit-room; afterwards wiping, if it appear necessary. The room, they say, should be dry; but the only use that should be made of a stove, is to take off the damp.

As connected with the forcing department, we now proceed to speak of the culture of the melon under frames placed upon a hot-bed.

Melon.

251. The *Melon* is the *Cucumis Melo*, L.; *Monœcia* Melon.
Monadelphia; and belongs to the natural order *Cucur-*

bitaceæ. The genus cucumis affords the rich melon for the dessert; the cucumber, well known for its cooling qualities; and the coloquintida of the apothecaries. The water-melon, the squash and the pumkin, belong to the same natural family, but to a different genus, Cucurbita, distinguished chiefly by the swelling rim of the seed. The melon has been cultivated in England since before 1570; but the precise period of its introduction is uncertain.

252. Many are the varieties of this fruit, but a few only are worth cultivating: particularly different sorts of Cantaleupe, the Romana, Polignac, oblong ribbed, rock, Portugal, and Salonica. The largest kinds are in general of inferior quality, being valuable chiefly to the market gardener, who finds his advantage in having a large and shewy fruit rather than one whose only merit consists in being high-flavoured.

The *Cantaleupes* are well known, and generally cultivated. In most of them the outer coat is rough and warty. The fruit is of middling size, rather round than long. There are several subvarieties: one has a greenish pulp; another and more esteemed sort has the pulp of an orange colour: there is likewise a scarlet, and a white cantaleupe; besides the black rock cantaleupe, and the netted cantaleupe, the last possessing excellent qualities. The cantaleupe has received its name from a seat of the Pope near Rome, where the fruit was either originally produced, or is supposed to have been so.

The *Romana* is an early melon, small in size, but of fine flavour; and the plants are very plentiful bearers. There are two or three subvarieties, of which the large netted Romana is the best; it is of an oval shape, high-flavoured, and at the same time very solid and ponderous.

The *Polignac* is a rich-flavoured fruit, pretty generally cultivated.

The *oblong ribbed*, sometimes called the musky melon, is of agreeable flavour, and the plants produce abundantly.

Rock melons, or carbuncled melons, are of different sorts; with green pulp, scarlet pulp, black and silver rock.

The small *Portugal* melon is an early variety, not destitute of flavour, and it is produced very plentifully.

The *Salonica* melon was little known in this country till recommended by Mr Knight. Its form is nearly spherical, and without any depressions on its surface; its colour approaches that of gold, and its pulp is pure white. It is allowed to remain upon the plant till it be completely matured, for it improves in flavour and richness till it become quite soft, and even shew symptoms of incipient decay. The consistence of its pulp is nearly that of a water melon, and it is very sweet. A full grown specimen of the fruit generally weighs about 7lb.

253. In the cultivation of the melon it is a matter of much importance to procure proper seed. Some gardeners are so scrupulous on this point, that they will not sow the seeds unless they have seen and tasted the fruit from which they were taken. It is proper at least not to trust to seeds which have not been collected by judicious persons. Some make it a rule to preserve always the seeds of those individual specimens which are first ripe, and even to take them from the ripest side of the fruit. A criterion of the goodness and probable fertility is generally sought by throwing them into a vessel containing water; such as sink are considered as good and likely to prove fertile; those that float as effete. It is remarked of seeds brought from the continent, that they must have more bottom heat, and the young plants less water, than are necessary for seeds ripened in this country, or young plants sprung from these.

The seeds are seldom sown till they have been two or three years kept; from this age till they be five years old, they succeed very well. The plants produced from such seeds are not so luxuriant, and are therefore more tractable and more prolific. The cause is supposed to be, that the albumen of the seed is deteriorated by the keeping, and the plants thus starved, in a certain degree, at their first germination; the fruitfulness of plants in general being promoted by checking their luxuriance. When gardeners intend to sow seeds which have been kept only for one year, they are in the practice of carrying them for some months in the pockets of their small clothes; the warmth from the body being found to promote the desirable maturation or siccity. If, on the other hand, the seeds have been kept for many years, steeping them for some days in weak oxymuriatic acid (chlorine) might probably tend to excite germination.

254. The seeds are sown at two or three different periods of the season; the first sowing taking place early in February, the next about the middle of March, and another later. They are sown in broad shallow pans or in common flower-pots sunk to the brim in a small hot-bed, called the seed-bed, covered with a one-light frame. Here the temperature is kept as near as possible to 65°; a little air is given in the day time, but during night the frame is closed, and covered with single or double mats according to the state of the weather. When the plants are about an inch and a half high, they are pricked into nursing pots, three in each, and placed generally in an intermediate frame of two lights, till they shew one or two of their rough leaves, when they are ready for final transplanting.

255. The melon ground, or quarter in which the melon beds are formed, should have a dry bottom, a free exposure to the south, and be sheltered from the north and east. It is desirable also to have it inclosed by a hedge of yew, beech, holly, or privet; and it is an advantage to keep it under lock and key, no kind of plants being so apt to be disordered or injured by the curiosity of ignorant intruders. In many places, the melon ground is formed in the slip, or on the exterior of the garden; and where this is the case, there is generally a cart access, which, considering the quantity of stable-dung required, proves very convenient.

256. The soil or compost for melons is prepared at least a year before it be used, and, like other composts, it is frequently turned over and thoroughly mixed. Two thirds of fresh hazel-coloured loam, from the surface of an old pasture, and one third of rotten cow-dung, or of the remains of old hot-beds, form an excellent soil. This compost is generally passed through a screen; but there is no need for its being made very fine.

257. The site of the hot-beds is scooped out to the depth of a foot, that the surface and lights may be kept low. The bed is generally made between three and four feet high, and the back four inches higher than the front. Stable dung and litter are the usual ingredients of these as of other hot-beds; but some use tanner's bark, in which case it is necessary to have a brick pit, or a strong wooden frame erected. The earth is not put on till the temperature become steady and moderate, which it generally does in the space of a week. The beds are covered with large frames, each having three sashes or lights. These are generally

Fruit Garden. Melon.

about four feet wide, and six feet in length: but sometimes they are made eight feet in length, by three feet wide.

258. In some places, pits are built with brick in the following manner. After the size of the glass-covers is fixed upon, and supposing that a three light pit is intended, the brick work is made 3 feet 6 inches deep on the fore-side, and 4 feet 6 inches or 5 feet on the back; the bottom part all around, to the height of 2 feet 6 inches, is built with small openings, the more numerous the better; for this purpose no mortar is used in this part of the building; but above it, mortar is used; the walls are the thickness of brick on bed. If three such pits be required, they are placed one in front of another, at the distance of three feet: the whole is surrounded with a wall, the top of which is six inches higher than the open building of the pits, and so far sunk as that the height may not appear offensive to the eye. The pit is filled with tanners bark or tree-leaves to a little above the open building, and covered with earth as in the common way; and the vacant space around the outside of the pit, to a little above the open building, is filled with stable-dung, or with weeds, in the season when these are to be had; for either of them, in fermenting, produces a sufficient degree of heat. When the heat of this lining is abated, and when a continuance of increased temperature is required, the exhausted matter is removed, and a new lining supplied. It may be proper to add, that the eave of each pit should have a small spout to carry off the water, otherwise the lower side of the bed is apt to become too damp.

259. In laying on the earth on the bed at first, a hillock or ridge is formed in the middle, somewhat more than a foot high, the covering in all other parts of the bed not exceeding two inches in thickness. In the beginning of March the young plants are transferred thither with great care, the breaking of the fibres or bruising of the roots being very detrimental. Some are for transplanting as soon as may be, after the unfolding of the third leaf, or in other words the first true or rough leaf; but the more general plan is, to allow two or three of the rough leaves to shew themselves before transplanting. Others put the plants in separate flower-pots for a few weeks, and afterwards turn them out with all the earth attached, into the melon frame. One plant to each light is generally sufficient, especially of the cantaleupe, or larger melons; but most cultivators put two plants; and some even crowd three under each light. When four leaves are expanded, the top is by many pinched off, in order to promote the setting out of lateral shoots or runners; but some allow the first shoots to extend the length of five or six joints before *stopping* them. Afterwards the points of these lateral shoots are pinched off, to encourage the putting forth of subordinate shoots, from which fruit is to be looked for. But all shoots that are either very luxuriant or very weak are equally useless, and may be removed. A few reed stalks are often spread thinly over the surface of the beds, for the shoots to run upon.

When the plants have established themselves, earth is gradually added, and pressed close down till the other parts of the bed be almost on a level with the spots on which the plants are situated. This thick layer of earth has one great advantage; it renders very little watering necessary. When water is given, it should scarcely touch the leaves. The heat is regulated by keeping a Fahrenheit's thermometer within the frame; which should as nearly as possible indicate 70°.

If the beds be in good heat, the frames are generally filled with runners in six weeks, and by this time the roots will have extended to the extremities of the beds. Linings are now added; and these being covered with soil, well trodden down, the roots penetrate into it, and thence draw additional nourishment; while, at the same time, the linings assist greatly in keeping up the heat.

260. As there is little opportunity under a glass-frame for the wind to perform its part in conveying the pollen, careful gardeners generally assist by taking off some fully expanded male flowers, and laying them or shaking them over the female flowers, which are situated on the crown of the embryo fruit. Even without fecundation, fruit will be produced; but it never acquires perfection, and the seeds of such fruit will not germinate. The different varieties of melons, it may be remarked, should not only be kept in distinct frames, but, if possible, at some distance from each other, to lessen the chance of the pollen of one kind accidentally reaching the stigma of another. One fruit is selected on each principal runner, preferring that which is nearest the stem or has the thickest footstalk; this is encouraged while the rest are picked off. If the melon be a small-sized variety, sometimes two are permitted on a shoot. It is a general rule not to leave more than four or five fruit on each plant, if of the larger kinds; or eight or ten, if of the smaller. A more correct way of estimating, perhaps, is to allow each plant only to carry 20lb. or 30lb. weight of fruit. It may be mentioned, that where late melons are wanted, an easy way to procure plants is to take some of the superfluous shoots of the first crop; for the plant grows freely by cuttings.

If water be now given, it should be introduced without touching the stems, leaves, or fruit; it is seldom needed more than once a week, even in dry and warm weather. Great attention is requisite in allowing the plants free air as often as possible. Some have contrived bent tin pipes, connecting with the open air, and passing through the body of dung, by means of which a current of slightly warmed air is introduced even in the worst weather. When the weather happens to be very cold, mats are laid over the frames.

261. In the southern parts of Britain, melons are also raised on hot-beds. The plants are at first under hand-glasses; but the shoots or runners are allowed to spread from under the glass, and cover the hot-bed as the season advances. The beds are hooped over, and when heavy rains threaten, they are closely covered with mats. Frames of oiled paper answer very well for the raising of melons. A kind of paper made from parings of skins, and used for packages, under the name of *leather-paper*, is stronger than common paper, and can easily be made so as to possess equal transparency. This leather-paper seems excellently adapted for the purpose.

A piece of clean tile is introduced below each fruit; and during the course of its swelling, it is not uncommon to turn it gently once a week, that both sides may be equally exposed to the sun's rays. But it should not be oftener turned, for fear of twisting and injuring the fruit-stalk, and so preventing the conveyance of nourishment through it. At this time very little water is given, dryness tending to heighten the flavour, and air is as freely admitted as the weather will permit. When the leaves press against the glass, the frame is raised two or three inches; but leaves should never be cut when it can possibly be avoided. Nicol recommends the removing of those which shade the fruit; but it is doubtful whether the advantage arising from the additional sun-light thus acquired, will counterbalance the detriment occasioned by the loss of leaves, these being organs on which Mr Knight found the success of this fruit most essentially to depend.

The fruit should always be gathered before it be dead ripe. It is known to approach maturity, by its beginning to crack near the footstalk, and by the peculiar rich odour it then emits. It is cut, with all its stalk to it, early in the morning, before the sun has had access to it, and it is kept in a cool place till served up. If melons be deficient in external colour, this may be brought on merely by laying them in the frame for a day or two. Melons should in general be eaten exactly when ripe, or *sharp ripe*, as gardeners call it; but rather a day or two before than after maturity.

262. A late crop of melons from seed is often produced in a flued pit. The seeds for this crop are sown in the beginning of July, and the seedlings are planted out towards the end of the month. Tanner's bark, or tree leaves, afford sufficient warmth at this season: indeed, the remains of the bed of bark or leaves on which early kitchen-vegetables, or tender annual flowers, have been raised in the beginning of summer, a little aided by fresh materials, answers all the purposes. No fire-heat is required till September. In the end of October the melons are ready: they are not equal in flavour certainly, to those ripened under the brighter and more powerful sun of June and July; but are very acceptable at that season of the year,—the more so that, owing to the caprices of fashion, those in high life chiefly spend the later months of autumn and the beginning of winter in the country, while they waste the summer amidst the smoke of London. The melons which do not ripen, are sometimes pickled like mangoes, and are said to make a very good substitute for these.

263. In the first volume of the London Horticultural Transactions, Mr Knight has given a general account of his highly interesting views on the subject of vegetable physiology, and has illustrated this account, by alluding to the habits of the melon and the mode of culture best adapted to it. This gentleman's gardener, it appears, had not been previously acquainted with the proper management of the melon, and Mr Knight therefore particularly attended to it himself. Experience soon taught him, (what was previously in some measure known,) that much of the flavour of the fruit depends on the plant possessing efficient foliage, that is, healthy leaves, presenting their upper surface to the light, and remaining as much as possible undisturbed in that position. Free use of pegs is therefore to be made, not only with the view of keeping the shoots in their position, but of preserving the leaves upright; and water is to be introduced without touching the leaves, as already recommended.

Cucumber.

Cucumber.

264. The *cucumber* naturally follows the melon, being not only a species of the same genus, (*Cucumis sativus*, L.) but requiring pretty much the same sort of culture, only the fruit is produced perfectly well in a lower temperature. It is a tender annual, a native of warm climates. It was early known in this country, but did not come into general cultivation till the middle of the 17th century.

265. The varieties most in esteem are the following:

Early long prickly, (green.)
Longest green prickly.
Early short prickly, (green.)
Dutch or white short prickly.
Cluster cucumber.
Smooth green Roman.
White Turkey cucumber.

The fruit of the *Early long prickly* is from 5 to 7 inches long, of a green colour, with few prickles. The plant is a good bearer; and upon the whole, this is accounted the best cucumber for the general summer crop, the pulp being very crisp and pleasant.

The fruit of the *longest green prickly* is from 7 to 10 inches in length; it has a dark green skin, closely set with small prickles. This is a hardy sort, but does not come early.

The *Early short prickly* is not more than 4 inches long; the skin green, rather smooth, but with a few small black prickles. This is one of the hardiest and earliest sorts, and is often preferred for the first crop.

The *Dutch* or *white short prickly*, though not much cultivated, is recommended by a very competent judge, the Rev. Mr Marshall, as preferable even to the early long prickly; it has fewer seeds; is evidently different in taste from most other cucumbers, but of agreeable flavour.

The *Cluster cucumber* is a very early sort, named from the circumstance of the flowers appearing in clusters of three or four together; the fruit is seldom more than 5 inches long; it is at first of a fine green colour, but becomes yellowish as it ripens. The stems of this variety are much inclined to climb, by means of their tendrils, upon sticks; the leaves are small, and the plant altogether occupies but little room.

The *Smooth green Roman* is also an early sort; the fruit becomes large and long, and is quite smooth; the plants grow very strong, and require a good deal of room.

In the *White Turkey*, the stalks and leaves are larger than in the other varieties; the fruit also is very long, sometimes from 10 to 15 or even 20 inches; it is quite straight, and has a smooth skin destitute of prickles; it is produced sparingly, and late in the season. There is likewise a long green Turkey variety, which is sometimes sown for the late crop. Late cucumbers, however, are much less cultivated than the early varieties; most gardeners being of opinion, that those kinds which are best for the early crops are also best for the late.

266. Three crops of cucumbers are generally raised in the year. The earliest are of necessity produced on hot-beds, or in flued pits. Pickling cucumbers are generally raised either on a slight hot-bed or under a hand-glass, and planted in the open air in June. When they have thrown out a few joints, they are topped, in order to encourage lateral or fruit branches; and these are trained on the ground at eight or nine inches apart, and generally kept down by pegs. In some places, the seed is at once sown in drills in the open air; the fruit being produced in August and September, and well adapted for pickling. But drilled cucumbers succeed only in the southern parts of England; in the northern half of the island they will not do. The prickly sorts are chiefly used in the recent state; and the smooth green is much liked for preserving.

The soil recommended by Nicol is composed of three-fourths light rich black earth from pasture land; an eighth part vegetable mould from decayed tree leaves; and an eighth part well-rotted cow-house dung.

For the early crops, the seed is sown about the end of December or beginning of January, on a small hot-bed, covered with a one-light frame. Where there is the conveniency of a stove, this seed-bed is sometimes dispensed with. Seed which is several years old is preferred, being less apt to produce exuberant shoots than what is recent. The plants soon rise, and the seedlings are transferred from this seed-bed to a larger or two-light frame, which serves as a nursery. Here great care is necessary to the giving of air, in order to strengthen the plants, and prevent them from drawing up weak; at the same time, too free access of cold air would probably kill them. When the seed-leaves are about half an inch broad, some of the best plants are pricked into small pots, generally three into each pot, the pots having been previously filled with light rich earth, and sunk into the bed to acquire equal temperature. The plants not potted are pricked out on the surface of the bed, at such a distance from each other, as to permit the lifting of each with a small ball of earth at the time of final transplanting. Less or more water is given, according to the state of the weather, and the warmth of the beds.

The young plants are *stopped* at the first joint. This operation consists in pinching off closely the runner-bud which springs from the axilla of the second rough leaf: it is best performed when the end of the shoot is little bigger than a large pin's head. In this way a stronger and more compact growth is promoted, and the emission of fruitful lateral runners is secured. When the plants have formed one joint, and when the first two rough leaves are from two to three inches broad, which is generally the case in a month, they are ready for final transplanting, or *ridging out*, as it is technically called. There must now be in readiness a fruiting hot-bed, or several beds, covered with two-light or three-light frames. As in the case of melons, a small hillock of earth, somewhat less than a foot high, is formed under the centre of each light, the rest of the bed being covered only to the depth of two or three inches. Into these beds, when of a proper temperature, the plants in pots are placed, preserving the ball of earth entire about the roots; in general three plants are set in the middle of each hillock. If the plants have not been potted, they are transferred with as much soil adhering to them as may be. The frames are covered with mats at night, which are taken off through the day. Air is given by tilting the upper end of the glass cover, more or less according to the state of the weather, and of the hot-bed. In a dry season, water is regularly given; and when the heat of the bed declines, linings are applied. As the plants advance in growth, the other parts of the surface of the bed are filled up nearly to an equality with the hillocks. In July, the nightly covering of mats is omitted, and the glass covers are drawn fully off through the day.

When the blossoms appear, some of the male flowers are shaken over the female, as in the case of the melon. So certainly efficacious is this operation, that it is called *setting* the fruit. When cucumbers are grown in drills in the open ground, the impregnation is entrusted entirely to the agency of the winds and of insects.

The subsequent management of cucumbers consists chiefly in admitting air as freely as the state of the weather will permit, and in affording liberal but judicious supplies of water, generally avoiding the foliage; although a sprinkling upon the leaves appears not to be disadvantageous, for we know that cucumbers thrive better in a moist than in a dry heat; and if the red spider appear, water is the remedy.

Sometimes a crop of cucumbers is raised by means of hand glasses, placed upon cavities containing hot dung. Instead of hand-glasses, oiled paper covers are occasionally used: these remain night and day till the middle of June, and in general answer very well, all danger of frost being then over.

267. For the natural ground crop, or drilled cucumbers, the beginning of June is the proper sowing time. The plan usually followed is this: the ground being made fine and level, shallow circular hollows are formed with the hand, a foot wide, and half an inch deep in the middle. The distance between each hollow is about three feet and a half; the distance between the rows of hollows, between five and six feet. Eight or ten seeds are sown in each cavity, to be afterwards thinned out to three or four. They are watered two or three times a week according to the state of the weather, preferring the morning or the evening for this operation. Pickling cucumbers are gathered chiefly from the middle to the end of August; and they are best when not more than three inches in length. Cucumbers form a very extensive and profitable article to the London market gardeners. In March they fetch above a guinea a dozen; in August and September they are sold at a penny a dozen. One village (Sandy in Bedfordshire) has been known to furnish 10,000 bushels of drilled cucumbers in one week.

268. Some persons are careless about the seed which they use, or at least are ready to sow any kind that is recommended to them. This is wrong: when one is possessed of an approved kind, the safest way is to preserve seed of it. With this view, one good fruit is allowed to remain till it become yellow; it is then placed, upright, in the full sun for some weeks, to acquire the most perfect maturation. The individual fruit having most prickles is commonly selected for this purpose. The seeds are afterwards thoroughly washed from the pulp, dried, and tied in paper bags, to remain for a year at least.

269. Curious cultivators sometimes amuse themselves by planting cuttings of late cucumber plants in the beginning of October: these, if placed in a hot-house or a well regulated hot-bed frame, grow freely, and produce fruit about mid-winter. But in order to have cucumbers at this season, a better plan is, to make them succeed melons in a flued pit, these being generally ripened off by the middle or end of October. The seedling cucumbers may be previously reared in small pots beside the melons, so as to be ready to take their places. They are watered once in four or five days, and commonly over the foliage, especially when, as winter advances, the fire-heat is made stronger. All the pruning necessary at this season, is to stop the shoots as they shew fruit, at a joint or two beyond the fruit. A few cucumbers are thus procured at the end of December or the beginning of January.

Gourds.

270. Allied to the melon and cucumber are the different kinds of *gourds*, two or three of which are sometimes cultivated, and may here be mentioned. Gourds.

The *Pumpkin*, Pumpion, or more correctly Pompion, is the fruit of the Cucurbita Pepo of Linnæus. The pumpkin was the melon or millon of our early horticulturists, the true melon being formerly distinguished by the name of Musk-melon. The pumpkin is now cultivated principally for ornament or curiosity; but in some of the villages of England, the country people plant it on dunghils, at the back of their houses, and train the shoots to a great length over grass. When the fruit is ripe, they cut a hole on one side, and having taken out the seeds, fill the void space with sliced apples, adding a little sugar and spice, and then bake the whole. Pumpkin.

The *Water-melon*, or Citrul, (the fruit of the *Cucurbita citrullus*, L.) although it forms both the food and the drink of the inhabitants of Egypt for several months in the year, is little regarded in Britain. It requires Water-melon.

the same attention and expence as the common melon; the hot-beds and glass frames, indeed, would need to be even of a larger size. In a few places only, two or three plants of the water-melon are occasionally cultivated with such attention as to procure the ripe fruit.

Squash.

The *Squash* and the *Warted gourd*, the fruits of the Cicurbita melopepo and C. verrucosa, though commonly cultivated as esculents in North America, are considered in this country only as curiosities. In the same way are viewed the *Bottle-gourd* or false Calabash, C. lagenaria; and the *Orange-gourd*, C. aurantia, lately introduced, which last is really ornamental, when trained spirally round a pole, or against a wall, and loaded with its yellow fruit.

Calabash.

Succada.

The *Succada*, or Vegetable Marrow, is a kind of small green gourd lately introduced. It is raised under a hand-glass, and afterwards transplanted into a good aspect, and trained to a trellis. When the fruit is of the size of a hen's egg, it is dressed in salt and water, squeezed, and served up in slices on a toast.

KITCHEN GARDEN.

KITCHEN GARDEN.

271. The order in which culinary plants are arranged or treated of, is not a matter of much importance. They may be divided into the cabbage tribe; leguminous plants; esculent roots, either tuberous or fusiform; the alliaceous tribe; spinach plants; boiling salads, including those plants the stems and leaves of which are generally blanched; fresh salads; plants for soups, and for garnishings; with the various sweet herbs, those used for preserves, and as medicines. The mushroom stands alone, being the only one of the fungi which is cultivated.

Several of the plants may no doubt be considered as belonging to more than one of these divisions; but they shall be treated of under that title to which they seem chiefly allied, and only named under the others. In treating of each article, nearly the same method shall be pursued as has been adopted in speaking of fructiferous plants. The botanical name shall always be given, as the want of this has been found by experience to create considerable embarrassment and uncertainty, in consulting the popular treatises on horticulture published in France and Germany. The class and order of Linnæus or Willdenow, and the natural order of Jussieu, to which the plant belongs, shall also be mentioned; and the French, German, or Italian names shall be set down, wherever it may seem of any importance to mention them. The country to which the plant is indigenous shall be noticed; with the date of its introduction into Britain if an exotic, or of its being used as food if a native. Where different *varieties* are cultivated, as of peas, onions, lettuce, or others, the principal varieties shall be enumerated and described. The mode of culture shall then be detailed. The means of keeping or preserving esculent roots and other culinary articles through the winter shall not be omitted; and the way in which each plant is used in the kitchen it may be proper generally to mention.

Cabbage Tribe.

272. Of all the classes of cultivated culinary vegetables, the cabbage tribe is the most ancient as well as the most extensive. The *Brassica oleracea* of Linnæus (belonging to the class Tetradynamia, order Siliquosa, and to the natural order Cruciferæ of Jussieu) being extremely liable to sport or run into varieties and monstrosities, has in the course of time become the parent of a numerous race of pot-herbs, so very various in their habit and appearance, that to many it may appear not a little extravagant to refer them to the same origin. Besides the different sorts of white and red cabbage, and savoys, which form the leaves into a head; there are various sorts of borecoles, coleworts, and kale, which grow with their leaves loose in the natural way; and there are several kinds of cauliflower and broccoli, which form their stalks or flower-buds into a head. All of these, with the turnip-rooted cabbage, and the Brussels-sprouts, claim a common origin from the single species of *Brassica* above mentioned. This original cabbage-plant grows naturally on the sea-shores in different parts of England, but it has not been observed in Scotland. It is figured in English Botany, t. 637. It is a biennial plant; the stem leaves are much waved, and variously indented; the colour is sea-green, with occasionally a tinge of purple. Early in the spring the wild cabbage or colewort from the sea-coast is said to be excellent, but it must be boiled in two waters to remove the saltness.

Close cabbages.

Close Cabbages.

White cabbage.

273. *Common white cabbage*, (*Brassica oleracea capitata alba*, L.)—Some sort of cabbage, as remarked by Mr White in his History of Selborne, must have been used by our Saxon predecessors, for they named the month of February *sprout-kale*. Cabbage was a favourite vegetable with the Romans; and their Italian kind would doubtless be introduced during the long period of their sway in the south of Britain. To the inhabitants of the north of Scotland cabbages were first made known by the soldiers of the enterprising Cromwell.

274. Of the common white cabbages there are many subvarieties, some of which are preferable for a summer crop; others for an autumn crop; and a third set, for winter supply. The Small early dwarf, Large early Yorkshire, Early dwarf Yorkshire, Early Battersea, and Early sugar-loaf, are generally preferred for summer use, and are ready from May to July; in some early situations, even in April. The Imperial, Large sugar-loaf, Hollow sugar-loaf, and Long-sided, are excellent for autumn use, and also, in private gardens, for the winter crop. The Large drum, the Scots, and the American cabbage, resist the severity of winter, and grow to a large size; but they are better suited to field culture and the feeding of cattle.

275. Very few remarks on the kinds of close cabbages seem requisite. The Long-sided is also called Large-sided; it is an excellent sort, but rather tender, so that it should not be sown till May, nor planted out till July. The Scots cabbage is much cultivated in cottage gardens in Scotland; it grows to a large size, and is seldom affected by the severest frost. The Drum is named from its flatness at top, resembling the head of a drum: it is also called White Strasburgh, and of it chiefly the Germans make their sour-krout. The American also grows to a large size, and lasts good till a late period in the spring. The Musk or perfumed cabbage is almost lost, being preserved only in a few private gardens. A small firm cabbage called the Russian has also become rare, being very apt to degenerate in this country: it is the least and most

Close cabbages.

humble of the cabbages, but it is hardy, quick of growth, and pleasant to the taste. The French gardeners describe a crisp-leafed early kind, which cabbages in forty days; so that, if planted out in the last week of March, it is ready for cutting in the first week of May.

276. In sowing cabbage-seed, a rich, light, open spot is selected; a covering of earth from an eighth to a quarter of an inch is sufficient for all the brassica tribe. The time of sowing for the early or summer crop is the beginning of August of the preceding year. In about six or eight weeks, or when the plants have got several leaves, they are thinned, and the plants taken out are pricked into beds at three inches distance every way; in this way the transplanted seedlings grow firm and shapely, and keep short-stalked, which is a great property, while those left in the seed-bed get more room to establish themselves. Some part of this crop is finally planted out in October and November, and the rest early in the following spring. The plants are set in rows between two and three feet wide, and at least two feet asunder in the rows. Some gardeners, indeed, plant their earliest cabbages considerably closer in the rows, perhaps at fifteen inches between the rows, and eight or nine inches between the plants in the line. This is done merely with the view of securing a full crop; by cutting every second cabbage in April, the others are allowed to have room to come to larger size. By market-gardeners, winter spinach is often sown where the summer cabbages are planted; and when the spinach is cleared off in April, there is thus a crop of cabbage on the ground, which is encouraged by stirring the earth and drawing it around the plants. These operations, it may be remarked, are not to be omitted in any of the cabbage rows. Indeed, the oftener the ground is stirred, the better is the crop. In the end of April, or beginning of May, the early cabbages naturally begin to turn in their leaves, and to harden in the centre. Some gardeners then bind the leaves close with willow twigs or strands of bass-mat, so as to produce a degree of blanching in the middle; and they are thus a fortnight sooner fit for use.

277. The seeds of cabbages for autumn and winter use are sown in the end of February or beginning of March. If pricked out into shady borders in May, and allowed to remain there for some weeks, they form more compact plants, and are less apt to have long stalks. In June they are finally transplanted, at the same distances as the early kinds. If the weather prove dry at the time of transplanting, they are watered every evening till they have again taken root. These cabbages come to be fit for use in the autumn months, and they continue good, in sheltered situations, and in ordinary seasons, till February or March. To preserve them from severe weather, some market gardeners trench a piece of ground in ridges in November, and lay the cabbages as close as possible on one side in the trench, covering the stems with earth: the outer part of the more exposed side of the cabbage is generally injured, but the inside remains sound.

The best soil for cabbages is a rich mould, rather clayey than sandy; and it can scarcely be too much manured, as they are an exhausting crop.

In some places, the roots and stems of a portion of the summer crop are allowed to remain in the ground, which is slightly delved and perhaps manured in the autumn. In January or February of the following year, very fine cabbage-sprouts are produced, not much inferior in quality to small young cabbages.

278. Young cabbage plants are also used as coleworts or open greens. With this view some of the close-growing middle-sized kinds are sown, such as the large York, or the sugar-loaf. The seed is sown in the latter part of summer at different times, so that the plants may be ready for use during winter and in the following spring.

Red Cabbage.

279. The *Red Cabbage*, (*Brassica oleracea capitata rubra*) is chiefly used for pickling; and the dwarf red variety certainly does make one of the most beautiful pickles that can be presented at table. It is also shredded down in winter salads. In the north of Scotland, a sort of open red cabbage is much cultivated by the common people, under the name of Aberdeen cabbage.

Savoy Cabbage.

280. Of the *Savoy Cabbage*, (*Brassica oleracea sabauda*), which is distinguished by having wrinkled leaves, there are two principal sorts, the yellow and the green, the latter being esteemed the hardiest. Savoys are sown about the middle of April, and planted out in June. They may be planted considerably closer than the common cabbage. If savoys are wished before winter, the seed is sown in February, or even in the preceding autumn; in which last case, fine large plants, well cabbaged, are ready for the table in the months of September and October. The later crop affords a supply through the winter and till February or March: Savoys, far from being injured by moderate frost, are reckoned better when somewhat pinched by it.

The roots of cabbages or savoys, when planted year after year on the same land, are very subject to the attack of a particular kind of grub, the larva of a small fly; the roots swell into knobs, and the plant becomes sickly and stunted. The cabbage ground should therefore be changed every year.

The culinary uses of the close cabbages, are too well known to require notice. The spare leaves or heads are always useful where milch cows are kept; and young open cabbage plants, or such as are just closing in the centre, make excellent coleworts, as already mentioned.

281. The raising of the seed of the different sorts of cabbage, affords employment to many persons in various parts of England. It is well known that no plants are more liable to be spoilt by cross-breeds than the cabbage tribe. Unless the plants of any particular variety, when in flower, be kept at a very considerable distance from any other, also in flower, bees are extremely apt to carry the pollen of the one to the other, and produce confusion in the progeny. Market gardeners, and many private individuals, raise seed for their own use. Some of the handsomest cabbages of the different sorts are dug up in autumn, and sunk in the ground to the head; early next summer a flower stem appears, which is followed by abundance of seed. A few of the soundest and healthiest cabbage stalks furnished with sprouts, answer the same end. When the seed has been well ripened and dried, it will keep for six or eight years. It is mentioned by Bastien, that the seed growers of Aubervilliers have learned, by experience, that seed gathered from the middle flower-stem produces plants which will be fit for use a fortnight earlier than those from the seed of the lateral flower-stems: this may deserve the attention of the watchful gardener, and assist him in regulating his successive crops of the same kind of cabbage.

In the neighbourhood of all considerable towns, market gardeners and others raise white cabbage and savoy plants for sale at very easy rates: this proves a great conveniency to those who have only small gardens, and who perhaps require only 200 or 300 cabbage plants.

Open Kale.

Open Kale. *Colewort*, *Kale*, and *Borecole*, (*Brassica oleracea*, vars.) are general terms for greens that do not cabbage or form heads, but remain loose and open. The common colewort is plain; the others are generally curled or crumpled.

Colewort. 281. *Common coleworts*, (or Dorsetshire kale), being intended chiefly for winter and spring use, are commonly sown in July, and planted out in August. They are set pretty close together, perhaps not more than eight or ten inches apart every way. They withstand completely the usual frosts of our winters. But young plants of the common cabbages, particularly of the large sugar loaf variety, are now generally used as coleworts, and sold in the markets, under that name, from December to April. So completely, indeed, have these cabbage coleworts supplanted the true kind, which is more hardy, but at the same time coarser, that one of the most popular modern books of gardening (Abercrombie's *Practical Gardener*) describes only the former sort under the title of coleworts.

Kale. 282. The principal kinds of *kale* are German greens, Scots kale, Buda, Red curled, and Milan.

Of the *German Greens*, a tall growing light coloured kind is preferred, as producing a large quantity of small tufts or loose heads of delicate leaves on the stalk in the spring months, when coleworts are getting scarce. German greens are sown in May, and planted out in June, at eighteen or twenty inches asunder every way. Some are also sown in June, and planted out in August, to be ready for use late in the following spring.

The seed of the *Scots kale*, (Siberian borecole, or choux pancalier), is sown in the beginning of July; and in the course of August the young plants are set out in rows a foot and a half wide, and ten inches distant in the rows. This green bears the severest cold without injury, and indeed is not reckoned good for use till it have endured some sharp frosts.

The *Milan kale* cultivated in this country has a thick stem, the leaves of a dark green colour, and much curled or fimbriated. Milan greens are greatly prized in France, and different varieties are there cultivated. The Anjou kale grows to a large size; as does likewise a sort called Cesarean kale. Neither of these is so tender as the other kinds; but the produce being great, they might probably be found useful in the feeding of cows.

A very tall variety of open kale is described by the late Mr Delaunay, in the last edition of "*Le Bon Jardinier*" published by himself. It is called *Choux palmier.* It frequently rises to the height of six feet, with a straight bare stem, the leaves displaying themselves only at top, and thus producing the appearance of a little palm tree. The leaves are much puckered, and so much rolled back at the edges, that they appear narrow, while at the same time they hang in a curved manner; thus aiding the illusion. This variety is evidently to be considered merely as a curiosity. It was first raised in Italy, and is not very hardy. Another tall sort, sometimes rising nearly to the same height, is described by the same author under the name of *Capousta*, or Russian kale. The leaves are of a fine purple colour, much cut and fringed. This variety is represented as extremely hardy, resisting the utmost severity of a Russian winter.

Borecole. 283. The *Borecoles*, properly so called, are of two kinds, the tall purple and the dwarf purple. But all the curled and cut-leaved kale or colewort plants, are commonly called Borecoles. There is a variegated sort which is very ornamental when growing, but not so good for the table as those of more ordinary appearance.

All kinds of kale seeds are sown in the beginning of April; the young plants are generally pricked into a nursery bed for a few weeks, to enable them to gain strength; and they are finally transplanted in June or July, in rows three feet asunder, and two feet apart in the rows, giving water if the weather be dry. A few are generally not planted out till September, that they may afford a supply late in the following spring. The only other attention requisite, is the drawing of earth to their stems before winter, in order to support them in times of snow or storm.

Brussels Sprouts.

Brussels sprouts. 284. The variety called ***Brussels sprouts*** may be classed with the kale plants. The leaves come out in small crowns or sprouts all along the stem, and are very delicate when boiled. The culture is nearly the same as that of coleworts in general. The seed is sown in March or April, and the seedlings are planted out in June, preferring showery weather, or watering carefully at root. They grow upright and pyramidal, and may therefore be placed nearer to each other than more spreading kinds. They are earthed up in October, are ready for use by midwinter, and continue good till March or April. Brussels sprouts are much used in London during the spring months; but they seldom appear in the Edinburgh market, nor is the plant so much cultivated in Scotland as it deserves.

Cauliflower.

Cauliflower. 285. Cauliflower and broccoli, (*Brassica oleracea*, var. *botrytis*), are curious varieties of the cabbage; the flower-buds forming a close firm cluster or head, for the sake of which alone the plants are cultivated. These heads or flowers being boiled, wrapped generally in a clean linen cloth, are served up as a most delicate vegetable dish. *Cauliflower* is a particular favourite in this country. "Of all the flowers in the garden," Dr Johnson used to say, "I like the cauliflower." Its culture, however, had been little attended to till about the close of the 17th century; since that time it has been greatly improved, insomuch that cauliflower may now fairly be claimed as peculiarly an English product. Till the time of the French revolution, quantities of English cauliflower were regularly sent to Holland; and the Low Countries and even France, depended on us for cauliflower seed. Even now, English seed is preferred to any other.

The two varieties called the early and the later cauliflower, are scarcely different. The first is the kind generally produced under hand-glasses, and the difference consists merely in the seed having been saved from the most forward plants. A variety having the stalks of the head of a reddish or purple colour has lately been introduced, under the name of Red Cauliflower; and it is reputed more hardy than the other sorts.

286. The seed for the early crop is sown about the

20th August of the preceding year, in frames or beds. In September, the seedlings are pricked, either into a dry border near a wall, where they may be hooped over and defended with bass-mats during the severe frosts of winter, or into common glass frames, with two or three sliding lights. In the month of March they are finally planted out, water being given if the season be dry. They are placed in rows, commonly about two feet and a half asunder, and two feet apart in the rows. If the soil be not rich, less distance may answer. It is a rule that cauliflower plants should never be set deep in the ground. The subsequent culture consists chiefly in repeated hoeings, and in drawing earth, or manure perhaps, close up to the roots and stems. Cauliflower plants have justly been declared "rough feeders;" in fact, the more liberally the cleanings of stables and cow-houses are supplied, the larger produce may be expected. They also require regular and free supplies of water, at least in dry seasons. As the flower or head advances, some of the large outer leaves are bent or broken over above it, partly to shade it from the sun, and partly to preserve it from too much rain.

287. To diversify the time of forming the heads, some of the early cauliflowers are planted out on different successive occasions. But seeds sown in February or March on a hot-bed, or in the front border of a stove or forcing-house, afford young plants to succeed those kept over winter; and by sowing again in May, pricking into nursery beds in June or the beginning of July, and transplanting proportionally late, this delicate pot-herb is produced till the end of October. Even after this, the cauliflower season is prolonged for nearly two months by various devices. Sometimes the plants are raised with balls of earth, and sunk nearly to the head in the borders of peach or grape houses, or in common glass frames, in sand or very light dry earth; and sometimes they are merely hung up in a shed or out-house, and thus kept for some weeks. They have been preserved in still another way, described by Mr Smith, gardener at Keith-Hall in Scotland, (*Scottish Hort. Mem.* vol. i. p. 129.): He digs a pit, about eighteen inches deep, near the bottom of a wall. On a dry day he takes up the cauliflower stocks in an entire state, and wrapping the leaves round the head, or flower, deposites them in the trench, the heads sloping downwards, and the roots extending upwards, so that the roots of one layer cover the tops of another; he then covers up the whole closely with earth, preserving a slope from the wall, and beating it smooth with the back of the spade, so that rain may run off. In this way, the cauliflower is said to keep good till the middle of January.

288. For the early supply of the London market, very great quantities of cauliflower are fostered under hand-glasses during winter and the first part of spring; and to behold some acres overspread with such glasses, gives a stranger a forcible idea of the riches and luxury of the capital. Two, three, or even four plants are, at first, placed under each glass; in fine weather, the cover is tilted in order to admit air. When the plants are somewhat advanced, in the end of February or beginning of March, the spare plants are removed with a scoop-trowel, and planted out separately, leaving one, or at most two, under the glass. The plants thus left under the covers are ready for market in the end of April or beginning of May, and fetch a high price. A method of producing cauliflower pretty early, and with great certainty, is this:—The plants are set in small pots in the winter season, and kept in any convenient part of the floor of a vinery, or other glazed house. In the beginning of March they are taken out of the pots, with the ball of earth attached, and planted in the open ground. If they be here protected against severe frosts with bell-glass covers, they come into head in the course of April, if the weather prove favourable.

It may be mentioned, that in some places it is not an uncommon practice to sow a little radish seed on the cauliflower ground, a fortnight before planting out the cauliflowers. It is found that the flies, or larvæ, which infest the young plants, prefer the tender leaves of the radish to those of the cauliflower, and that the latter thus escape. Market gardeners often mix spinach seed with the radish, but from a different motive; they thus procure a useful crop soon after the cauliflower is removed. More frequently, however, these gardeners employ the cauliflower ground in producing a late crop of cucumbers for pickling.

When seed is wished for, some of the best early plants are selected, and left to flower, plenty of earth being drawn up to their roots. The seed ripens in September, but at various times, on the different branchlets of the same head, so that it is proper to gather it at successive times as it appears ripe.

Broccoli.

Broccoli.

289. *Broccoli* is generally considered as merely a variety of cauliflower. It is indeed nearly allied, and the useful part consists, as in cauliflower, of the clustered unexpanded flower-buds; but the broccoli plant is distinguished by its cut leaves, its larger growth, and greater degree of hardiness. There are several varieties of broccoli, two of them particularly distinct, the purple and the white. No culinary plant is so liable to *sport* as broccoli; so that new kinds, slightly different, are continually coming into notice or favour, and as speedily sinking into neglect.

Of the purple, there are several sub-varieties, the early, dwarf, branching, and Cape broccoli, the last but lately introduced. What are called the brown and the black broccoli are likewise slight variations of the purple. They are more hardy, and better suited for exposed situations; but they do not form heads so completely as some other kinds; the tender stems and hearts of the plants, with the small heads on the lateral branches, being the parts chiefly used. The dwarf sulphur-coloured is much esteemed, and cultivated to great perfection near Edinburgh. By many, the sort called green broccoli is accounted the best. The white, Neapolitan, or cauliflower-broccoli plant, is rather more tender than the others, but the flower is at the same time more palatable; it forms a close curdly head of considerable size in the spring months, and the plants do not branch as most of the purple kinds do. A hardy variety of the white would therefore prove a great acquisition.

290. Broccoli seed is sown in April for an autumn crop, to be planted out in the beginning of June; and, for a spring crop in the following year, the seed is sown late in May, or even in June. The seedlings are afterwards placed in nursery beds, where they remain till the middle or end of July, when they are finally transplanted. A light, but deep and rich soil, in an open situation, is preferred. To those situated near the sea, it may be interesting to know, that sea-weed forms an excellent manure for broccoli. In the second volume of Scottish Horticultural Memoirs, p. 266, Mr William

Broccoli.

Wood, one of the most successful cultivators of broccoli near Edinburgh, gives an account of his remarkable success with this sort of manure. When drift ware abounds on the shore, he bestows on the quarter next intended for broccoli a very liberal supply, immediately digging it in roughly. The ground is afterwards slightly delved over before planting. From the soil thus treated, very large and fine heads are produced. It may be added, that grubs will not infest the roots, as they are very apt to do when stable manure is used. The broccoli plants are set in lines, two feet asunder, and a foot and a half apart in the lines. Water is given when thought necessary, according to the state of the weather. They are hoed and earthed up like cauliflower plants. Nicol recommends, that, in the end of October, the most forward crops, especially of the tall growing kinds, should be raised and laid over on their sides pretty closely together, placing the heads just clear of one another. If this be done in a dry soil and free situation, the plants are seldom injured by the frost of the severest winters. The heads of winter broccoli generally begin to appear early in January, and they continue till April.

In gathering broccoli, five or six inches of the stem are retained along with the head; and in dressing, the stalks are peeled before boiling.

Cape broccoli.

291. The early purple Cape broccoli, already mentioned as lately introduced into this country, deserves more particular notice. The seed, it was understood, was first brought from the Cape of Good Hope, but the same kind has since been received from Italy. A particular account of the mode of cultivation is given by Mr John Maher, in the first volume of the London Horticultural Transactions, p. 116. Three crops are sown: in April, between the 12th and 18th of the month; in May, between the 18th and 24th; and in August, between the 19th and 25th; and by means of these, this kind of broccoli is procured from September till the end of May. The seeds are sown very thin, on a border of light rich earth. In about a month the plants are finally transplanted, at the distance of two feet every way, in a sandy loam, well enriched with rotten dung. Frequent hoeings are given, and the earth is drawn to the stem as in the case of ordinary broccoli. Mr Maher never pricks the seedlings into a nursery bed. He finds, that the head is by that measure rendered less in size, and more apt to run to flower and seed. A part of the second crop is often transplanted into pots (sixteens), and plunged into the open ground, where the head forms. Against December, these pots are removed into a shed, frame, or pit; and in this way fine broccoli is secured in the severest weather of winter; the head often six or seven inches in diameter. The seed for the third crop is sown in a frame; and about the third week in October the plants are ready for transplanting. A few good plants for affording seed are selected at this time, and planted in a remote part of the garden, covering them with hand-glasses during winter, in the manner of cauliflower.

292. When broccoli seeds are to be saved, plants with the largest and finest heads are selected, observing that no small foliage appear on the surface of the head. Mr Wood, already mentioned, makes it a rule to take up such plants in April, and lay them, in a slanting direction, in a rich compost, (cleanings of old ditches, tree leaves, and rotten dung,) giving, at the same time, a plentiful watering, if the weather be dry. The raising, he thinks, prevents them from producing *proud seed*, or from degenerating. When the heads begin to open or push, he cuts out the centre, leaving only four or five of the outside flower-stalks to come to seed. The centre, it may be remarked, would probably produce the stronger seeds; but the object seems to be, to check the tendency to luxuriancy and consequent sporting in the plant.

Kohl-rabbi.

Kohl-rabbi.

293. The *Kohl-rabbi* or turnip-rooted cabbage (*Brassica oleracea*, var. *Napobrassica*, not a variety of *B. rapa*, or turnip, as supposed in Salisbury's Botanist's Companion), has large broad leaves, and the stem protuberant like a turnip at the base: there are two varieties, one swelling above ground, the other in it. Both are sometimes used in a young state for the table; but they are not much cultivated in this country. Kohl-rabbi is very hardy, and might probably be advantageously cultivated in the colder parts of the island; for it is found to be a very profitable crop in Sweden and other northern countries.

Leguminous Plants.

Peas.

Pea.

294. The *Pea* (*Pisum sativum*, Lin. **Diadelphia Decandria**; *Papilionaceæ* or *Leguminosæ*) is an annual climbing plant, so well known as not to need any description. The legumes or pods are commonly produced in pairs; the seeds contained in these are the part of the plant used, and to which, in common discourse, the name *peas* is always given. In some varieties, called Sugar-peas, the inner tough film of the pods is wanting, the pods of such, when young, being boiled with the peas within them, and eaten in the manner of kidney-beans. Concerning the native country of the pea, there is no certainty; it is guessed to be the south of Europe. It has been cultivated in Britain from an early period; but some of the best varieties, such as the sugar-pea above mentioned, were introduced only about the middle of the 17th century.

There are very many varieties, differing in size, time of coming in, colour of flower and fruit, and also in taste: but the principal distinction is as to their being early or late; supposing the sorts to be sown on the same day, the former are ready a fortnight at least before the latter.

295. The early peas are called *hotspurs* and *hastings*. Of these there are different subvarieties, especially the Charlton, Reading, Golden, Double dwarf, and Early frame pea; the last being so called from its being often forced in hot beds, especially for the London market. These being comparatively of dwarfish growth, do not require sticking; and it is a common remark, that peas supported on sticks yield more, but that those recumbent on the ground ripen soonest. Some of these kinds are generally sown towards the end of October, in front of a south fruit-wall, and at right angles to it, or inclining a point to the east, in order to catch the morning sun. With some slight protection of branches of evergreens or old peas-haulm, the crop survives the winter, and produces young peas by the end of May. Many gardeners prefer sowing in longitudinal rows near the wall, the crop thus ripening more equally. In January and February more peas, of the early sorts, are sown, to follow in succession those sown before winter. Some gardeners are in the practice of raising

Peas.

peas in boxes placed in any hot-house, and planting them out when two or three inches high. They must be handled with care, being very brittle; but with due attention, few plants fail; and it has long been remarked, that transplanted peas are much more productive of pods or fruit, than such as remain where they have been sown.

296. In March and April full crops of later peas are sown. Some of the smaller kinds are the Blue Prussian, Dwarf marrowfat, and Spanish dwarf. These, if well earthed up, and if the rows be sufficiently distant from each other, succeed very well without sticking. To them may be added Leadman's dwarf, which is smaller than any of them, while at the same time the plant is very prolific, and the pea remarkably sweet. Of the large and late kinds, the Tall marrowfat, the Green marrowfat, the Grey rouncival, and the Sugar-pea, have long retained their character; while the Spanish moratto and Imperial egg pea, are also in good repute, as hardy plants and copious bearers. The Crown pea or Rose pea is well known; but it is as frequently cultivated for ornament as for use: It is remarkable that Parkinson, in his "Paradisus," ascribes to it a Scottish origin. A new white pea raised by Mr Knight must not be omitted. It is sometimes called Knight's marrow pea; sometimes the Wrinkled pea, the circumstance of the skin of the fruit being wrinkled or contracted, being an obvious mark of distinction. The plant is of luxuriant growth, requiring tall sticks to support it; the pods are large, and the peas are of peculiarly excellent flavour when boiled.

The larger kinds of peas require nearly four feet distance between the rows. They are frequently hoed, and when about three or four inches high, earth is drawn to the rows, this being found greatly to promote their growth. The sticking or supporting takes place when they are about eight or ten inches high. The sticks are of different heights for the respective kinds; three feet is enough for the smallest kinds; the hotspurs and dwarf marrowfats require about five feet; and the larger sorts seven or eight feet. Sometimes double rows of peas are sown, and the sticks placed in the middle, the plants being earthed towards the sticks: Or two rows of sticks may be made to serve three rows of peas, the heads of the sticks being inclined towards each other; but in this way the middle row of peas cannot be earthed up or hoed after sticking. Where branches cannot be procured, two lines of strong packthread on each side of the rows, form a tolerably good substitute. In some places, in very dry weather, the crops of peas are regularly watered when in flower and fruiting.

The small early peas are sweeter and of more delicate flavour than the large kinds. In well ordered gardens, therefore, a small quantity of the hotspur sorts is sown every ten days from the middle of March till the middle of June, choosing for them a moist strong soil, in order to counteract the effects of the summer heat. It is not reckoned proper to sow peas on land which has been recently manured, as they are, in such situations, apt to run to haulm: This crop is seldom sown, therefore, till the second season after dunging. In large gardens, and particularly in market gardens, instead of delving, a slight plough may be used for turning over the ground; and the one-horse drill, for sowing, as recommended by Meager so long ago as 1670.

Among the chief enemies of peas may be mentioned slugs and mice. The former often abound in damp situations, or places surrounded by trees. The remedy usually applied, is the spreading of new slaked lime over the surface of the ground, very early in the morning when the slugs are abroad. A simple preventive of the attacks of mice consists in being particularly careful, in sowing the peas, to leave none exposed on the surface; if the seed be all duly covered, these animals do not seem to be very expert at discovering the rows.

It is generally thought advisable to change the seed yearly; few gardeners therefore ripen their own seed. Indeed the professed seed-growers possess superior opportunities for saving the kinds in a genuine state; and if they be men of judgment and fidelity, it is better for the gardener to buy from them, than to trouble himself with saving either the seeds of peas, or of any other garden plants which are apt to degenerate by intermixture of pollen.

Beans.

Beans.

Bean.

297. The *Bean* (*Vicia Faba*, Lin.) belongs to the same class and order, and natural family, with the pea. It is the *Fève de marais* of the French. It is perhaps superfluous to mention, that it is an annual plant, rising from two to four feet, with a thick angular stem; the leaves divided, and without tendrils; the flowers white, with a black spot in the middle of the wing; seed-pods thick, long, woolly within, and inclosing the large ovate flatted seeds, for the sake of which the plant is cultivated in gardens. It is a native of the East, but has been known in this country from the earliest times.

298. There are two principal kinds of the plant, the garden bean and the field bean: The first only falls to be spoken of here. Of this there are many varieties. The *Mazagan* is one of the hardiest and best flavoured of the small and early sorts. Mazagan is a Portuguese settlement on the coast of Africa, near the Straits of Gibraltar; and it is said that seeds brought from thence, afford plants that are more early and more fruitful than those which spring from home-saved seed. The *Lisbon* is next in point of earliness and fruitfulness; some indeed consider it as merely the Mazagan ripened in Portugal. The *Dwarf-fan* or *cluster* bean is likewise an early variety, but it is planted chiefly for curiosity: it rises only six or eight inches high; the branches spread out like a fan, and the pods are produced in small clusters. The *Sandwich* bean has been long noted for its fruitfulness; the *Toker* and the *broad Spanish* are likewise great bearers. Of all the large kinds, the *Windsor bean* is preferred for the table. When gathered young, the seeds are sweet and very agreeable; when the plants are allowed room and time, they produce very large seeds, and in tolerable plenty, though they are not accounted liberal bearers. There are several sub-varieties, such as the Broad Windsor, Taylor's Windsor, and the Kentish Windsor. The *Long-podded* bean rises about three feet high, and is a great bearer, the pods being long and narrow, and closely filled with oblong middle-sized seeds. This sort is now very much cultivated, and there are several subordinate varieties of it, as the Early, the Large, and the Sword Longpod. The *White-blossomed* bean is so called, because the black mark on the wing of the blossom is wanting. The seed is semitransparent; when young it has little of the peculiar bean flavour, and is on this account much esteemed; it is at the same time a copious bearer, and proper for a late crop. It may be men-

tioned, that Delaunay, in *Le bon Jardinier*, describes as excellent a new variety cultivated at Paris, which he calls the *green bean* from China; it is late, but very productive; and the fruit remains green, even when ripe and dried.

299. The early sorts, such as the Mazagan and Lisbon, are sown in the end of October or beginning of November, in a sheltered situation, in front of a wall, reed-fence, or other hedge, and in drills about two inches deep. The plants are earthed up in November as they advance. In severe frost, some haulm or fern is laid over them, as in the case of early peas. In March and April, as the beans begin to shew flower, they are kept close back to the fence, by means of lines of pack-thread. When the lower blossoms are fully expanded or beginning to fade, the tops of the stems are pinched off, this being found to forward the production of pods. With this sort of care, a crop is generally procured about the end of May or first of June. Successive autumn and winter sowings are managed much in the same way; being sown in rows, eighteen inches apart, in sheltered borders or quarters. It is necessary to guard against the ravages of mice, which are very apt to attack the new sown rows. Some gardeners sow their winter beans thickly, and cover them with a frame, transplanting them in February or March: in this way they prove very productive.

300. In February and March, full crops of the late and large beans, such as the Windsor, Sandwich, and Long-podded, are planted, in a free and open exposure. The middling sized kinds are allowed two feet between the rows; but the large growing kinds, two and a half or even three feet. The plants in the rows, however, are only five or six inches separate. Sometimes the beans are planted with a blunt setting-stick, observing to close the earth down upon the seed; but drills drawn, two inches deep or a little more, with the hoe, are in general preferred. One of the principal things to be attended to is the earthing up: in performing this operation, it is necessary to take care that the earth do not fall on the centre of the plant so as to bury it; for this occasions it to rot or fail. Nicol says, that topping is not necessary for any but the early crops, and is practised only to make them more early. Most other horticulturists are of opinion that topping improves the crop both as to quantity and quality; and it is very commonly performed on the late crops as well as the early. The crops of beans when in flower, it may be remarked, are very ornamental to the kitchen-garden, and render it a pleasant walk, the flowers having a powerful fragrance, not unlike that of orange-flowers. The latest crops in May and June are sown in strong or moist land, as on an arid soil scarcely any return could at this season be expected. For these late crops, the long pods, broad Spanish, and Toker are preferred. In a dry season, it is found useful to soak the seed-beans for several hours in soft river water, before planting.

An expedient sometimes resorted to in order to prolong the bean season, may here be mentioned: A bed or quarter of beans is fixed on; and when the flowers appear, the plants are entirely cut over, a few inches from the surface of the ground. New stems spring from the stools, and these produce a very late crop of beans.

In gathering beans for table use, such pods as are too old should as much be avoided as such as are too young, the seeds decreasing in delicacy after they attain about half the size which they should possess at maturity. When beans are to be saved for seed, none of the pods should be gathered for the kitchen, the first pods being the most vigorous, and affording the best seed. The whole plant should be pulled up; and the seeds should be allowed to dry in the pods, these last still remaining on the stems.

Kidney-bean.

Kidney-bean.

301. The *Kidney-bean* (*Phaseolus vulgaris*, Lin. Common kidney-bean; and *P. multiflorus*, Willd. Scarlet runner) belongs to the same artificial and natural classes as the pea and the bean. In this country it is often called *French bean;* and it is the well known and favourite *haricot* of France. It is an annual, originally from India; its stem is more or less twining, but in the dwarfish kinds it scarcely shews this propensity; the leaves are ternate, on long foot-stalks; the flowers on axillary racemes; the corolla generally white, sometimes yellow or purple: The pods are oblong, swelling slightly over the seeds; these last are generally kidney-shaped, smooth and shining when ripe, varying exceedingly in colour, white, black, blue, red, and spotted. The date of the introduction of the kidney-bean into this country is not known: it was in familiar use in the days of Gerarde. The unripe pods chiefly are used in Britain; but in France, the ripe seeds or beans are also very much employed in cookery, being dried in the autumn and kept for winter use.

302. There are many varieties, both of what are called *dwarfs*, and of *runners*. By Dwarfs are meant kinds that do not much exceed a foot in height, and do not need support; by Runners, such as have long climbing stems, and which require stakes. Of the former, the Early white dwarf, Early black or Negro, the Speckled dwarf, Early yellow, and the Battersea and Canterbury white, may be mentioned as principally esteemed. Of the latter, the Scarlet runner is preferred, the pods being tender, especially if gathered young, and being produced in succession for a long time. This was formerly considered as merely a variety of the common kidney-bean; but Willdenow has described it as a distinct species, under the name of *Phaseolus multiflorus;* it is distinguished by its racemes equalling the leaves in length, and by its bracteæ or floral leaves lying close to the stalk; while in the common kidney-bean, the former are shorter than the leaves, and the latter project from the stalk. The scarlet runner is frequently cultivated as an ornamental flower, particularly in forming fancy hedges: when trained near a wall, and led up with lines of pack-thread or spun-yarn, it unites both characters, or is at once shewy and useful. The white runner seems to differ from the scarlet, merely in the colour of the blossoms and of the seeds. The Dutch white runner produces long smooth pods, but does not afford so many successive gatherings as the other two.

303. The kidney-bean is too tender for sowing earlier than the middle or end of April. From that time successive crops are sown every fortnight or three weeks, till July; and in this way the young and tender pods are to be had all the summer and autumn. The dwarfish sorts are sown in drills from two to three feet asunder, perhaps three inches separate in the lines, and covered with something less than two inches of soil. As they advance, they are hoed and cleared of weeds, a little earth being at the same time drawn to the stems. As the young pods come to be fit for use, the more regularly and completely they are gathered, the greater is the successive produce. The runners, being rather more tender, are not sown till about the middle of May.

Kitchen Garden. Kidney-beans.

As tall slight stakes must be placed for them to climb upon, the distance allowed between the rows of these is commonly four feet. If the runners be sown in July, they continue to produce pods till stopped by the frost. In dry seasons, frequent watering greatly conduces to the abundance of the crops. For the latest summer crop, the seed is commonly soaked for some hours in milk and water. Mr Marshall recommends laying it in damp mould till it begin to chit or germinate, and then sowing it in watered drills. The white Canterbury is the sort generally sown to produce small pods for pickling.

For a supply of seed, some of the early summer plants, either dwarfs or runners, should be left untouched; the first produced pods being always the best, the whole strength of the plants being thus directed to perfecting the seeds. These will ripen in September. The haulm is then pulled up, and allowed to dry with the pods on it; the seed being found in this way to acquire further maturation.

304. Kidney-beans are easily forced, and they form a very desirable early spring dish. They are sometimes raised in hot-beds; but more generally, and with greater certainty, in hot-houses. They are sown in pots in January and February, and placed on a flat trellis over the flues, on shelves, or in any other convenient situation. Three plants are generally allotted to each pot of a foot in diameter. A light rich earth, or what is called a cucumber mould, is the soil preferred. With frequent moderate supplies of water they make good progress, and afford pods in March, April, and May. The dwarf-speckled is the kind generally used in hot-houses; but, for hot-beds, the early white is perhaps better, as being of more dwarfish growth.

French gardeners have enumerated above two hundred varieties of the haricot, but of these not more than twenty are in esteem. They speak of a new variety called the Yellow Kidney-bean of Canada, which they describe as the most dwarfish, and the earliest of all. The Rice Kidney-bean they mention as a slender runner, rising six feet high, but having seeds which, even when ripe, are not larger than peas. The pods they describe as very good in the unripe state, and quite delicious when prepared under roast fowl.

Esculent Roots.

Esculent roots.

It is, perhaps, scarcely necessary to explain, that the term *roots* is applied to the tubers of the potato and Jerusalem artichoke only in compliance with popular practice; the true roots of the plants consisting of the small fibres or radicles only.

Potato.

Potato.

305. The *potato* (*Solanum tuberosum*, L.; *Pentandria Digynia*; *Luridæ*, L.; *Solanaceæ*, Juss.) may be considered as a perennial plant, as it will continue to spring up for many successive years on the same spot. The stem rises from two to three feet in height, is branched, succulent, and frequently spotted with red; the branches long and weak; flowers white, or tinged with purple; the fruit is a round berry, green at first, but black when ripe, commonly called potato-apple. The part used consists of the tubers, which are produced on runners, proceeding from the stem of the plant.

Kitchen Garden. Potatoes.

306. Sir Joseph Banks has satisfactorily shewn, that potatoes were first brought from South America to Spain about the middle of the 16th century, as they are mentioned, under the name of *papas*, in Cicia's Chronicle, printed in 1553, and now a very rare book. They were not introduced into this country till near the close of the century, when they appear to have been brought from Virginia by the colonists sent out by Sir Walter Raleigh, and who returned in 1586; Herriot, one of these colonists, describing the potato, under the name *openawk*, in his account of the country they had visited, preserved in De Bry's Collection of Voyages. It is said, that Sir Walter Raleigh planted them on his own estate near Cork. They were soon carried over into Lancashire; but near half a century elapsed before they were much known at London. Gerarde and Parkinson describe the plant by the title of Batata Virginiana, to distinguish it from the Spanish potato, Convolvulus batatas. It was at first raised only in botanic gardens. Parkinson mentions, however, that the tubers were sometimes roasted, and steeped in sack and sugar, or baked with marrow and spices, and even preserved and candied by the comfit-makers. In 1663, the Royal Society took some measures for encouraging the cultivation of potatoes, with the view of preventing famine. Still, however, although their utility as an article of food was better known, no high character was bestowed on them. In books of gardening, published towards the end of the 17th century, a hundred years after their introduction, they are spoken of rather slightingly. "They are much used in Ireland and America as bread," says one author, "and may be propagated with advantage to poor people."—"I do not hear that it hath been yet essayed," are the words of another, "whether they may not be propagated in great quantities, for food for swine or other cattle." Even the enlightened Evelyn seems to have entertained a prejudice against them. "Plant potatoes," he says, writing in 1699, "in your worst ground. Take them up in November for winter spending; there will enough remain for a stock, though ever so exactly gathered." The famous nurserymen, London and Wise, whose names have been already repeatedly mentioned, have not considered the potato as worthy of notice in their Complete Gardener, published in 1719; and Bradley who, about the same time, wrote so extensively on horticultural subjects, speaks of them as inferior to skirrets and radishes.

The use of potatoes gradually spread, as their excellent qualities became better understood. It was near the middle of the 18th century, however, before they were generally known over the country: since that time they have been most extensively cultivated. In 1796, it was found that, in the county of Essex alone, about 1700 acres were planted with potatoes for the supply of the London market. This must form no doubt the principal supply; but many fields of potatoes are to be seen in the other counties bordering on the capital, and many ship-loads are annually imported from a distance.

The cultivation of potatoes in gardens in Scotland, was very little understood till about the year 1740; and it was not practised in fields till about twenty years after that period. It is stated in the "General Report" of Scotland, (vol. ii. p. 111), as a well ascertained fact, that in the year 1725-6, the few potato plants then existing in gardens about Edinburgh, were left in the same spot of ground from year to year, as recommended by Evelyn; a few tubers were perhaps removed for use in the autumn, and the parent plants were then well covered with litter to save them from the winter's frost. Since the middle of the 18th century, the cultivation of potatoes has made rapid progress in that country; so that they are now to be seen in almost every cottage garden.

Professor Martyn, in his edition of the "*Gardener's Dictionary*," has given an account of various notices that occur concerning the introduction of the potato, in the writings of successive horticulturists, and most minute and accurate details respecting its tillage, derived from all the best sources of information, and selected with great judgment and care. To the learned and industrious Professor's labours, and to the article AGRICULTURE in this work, we must refer the inquisitive reader, contenting ourselves in this place, in addition to the short history already given, with some account of the qualities of the plant, of a few of the principal varieties, and of its culture in gardens.

The potato is now considered as the most useful esculent that is cultivated; and who could *à priori* have expected to have found the most useful among the natural family of the Luridæ, several of which are deleterious, and all of which are forbidding in their aspect! It is at the same time the most universally liked; it seems to suit every palate. So generally is it relished, and so nutritious is it accounted, that on many tables it now appears almost every day in the year. It is commonly eaten plainly boiled, and in this way it is excellent. When potatoes have been long kept, or in the spring months, the best parts of each tuber are selected, and mashed before going to table. Potatoes are also baked, roasted, and fried. With the flour of potatoes, puddings are made nearly equal in flavour to those of millet. Bread has also been formed of it, with a moderate proportion of wheat flour; and potato starch is common. To cottagers having a number of children, the potato is of inestimable value. Dr Johnson, in his "Journey," remarks, that before the Scottish peasantry acquired cabbages, they must have had nothing; but with much more reason might it now be said, that they must have been destitute indeed, before they knew the potato. By many cottagers in Scotland, and especially in Ireland, potatoes are cultivated on what are called *lazy-beds*. In constructing these, the manure is laid on the surface; sets of potatoes are placed immediately on it; and a little earth is thrown over all. In this way a very great return is procured.

307. In regard to general qualities, potatoes are of two kinds, mealy and waxy; the former of a loose, the latter of a firm contexture. They are distinguished as to shape, into round, oval or kidney, and clustered; and as to colour, into white, and red or purple. It would be quite an unprofitable task to enumerate the many varieties which have been raised from seed, and have obtained a name for a day. A few of those at present in esteem can alone be named. Kidney potatoes of various sorts have long been in repute, particularly the White and the Yorkshire. Red, and White, and Black potatoes, have their admirers. The Early dwarf, Champion, Early frame, Manly, Cumberland early, Fox's yellow seedling, and the Goldfinders, still retain their fame for summer use: but they are perhaps excelled by varieties well known in Scotland by the names of the Ash-leaved, and Mathew Cree's early. The large red-nosed kidney, a white potato with a tinged eye, is a great favourite in the London market, for general culinary purposes; and the Don potato is the kind most esteemed, and most commonly sold in the Edinburgh market. For the feeding of cattle, the Ox-noble, a large round sort with deep eyes; the American cluster; the Yam potato; and the Lancashire, or large round rough red potato, are held in high estimation.

The raising of potatoes being now considered as rather the business of the farm, in many gardens only a quarter of *early* potatoes is to be found. For the original production of the varieties called *earlies*, we are indebted to the kitchen gardeners near Manchester. Encouraged by the demand of that populous town, they vied with each other to have potatoes first in the market: they noted those plants that flowered early, saved them, and sowed their seeds; by again watching the earliest of these, they procured varieties which arrive so much sooner at a state approaching maturity, as far as the tubers are concerned, that young potatoes may be had for table two months after planting. The most productive of these, and least apt to degenerate, are such as do not shew a disposition to flower.

308. The potato is chiefly propagated by cuts of the tubers, taking care to leave one or two eyes or buds to each cut, but eradicating all clustered eyes. The best shaped and cleanest potatoes are selected for this purpose. The cuts are the better for being allowed to dry for a day or two before planting. Any light soil, in a free airy situation, suits the potato. Too much manure can scarcely be given, if the quantity of produce be alone looked to; but potatoes of more delicate flavour are procured from ground not recently enriched. About the middle of March some of the early kinds, such as the ash-leaved, are planted on a light warm border. As they are to be taken up soon, sixteen inches between the lines is accounted enough, and seven or eight inches between each plant. They are commonly planted in drills, and covered to the depth of three or four inches. The tubers being small, are generally only cut in two to make sets; but not more than two eyes are left on each set. Rooted shoots accidentally produced among the stock of early potatoes, have been found to afford a very speedy return. Instructed by this circumstance, some gardeners lay the sets on a floor sprinkled with sand or barley-chaff, till they have sprung four or five inches, thus advancing the growth of the plants as much as possible under a low temperature, so as to avoid all unnecessary expenditure of their excitability. Great care must be taken, however, to preserve their germs and roots from injury in transplanting. By this means the plants are forwarded nearly three weeks in their growth. The young potatoes are fit for use in June and July, and in August the tops of the parent plants change to a yellow colour, indicating maturity. Only a few plants are taken up at once; for the young and immature tubers do not keep good beyond a day or two: it is found better, therefore, to let them remain in the ground till wanted, and in this way they may be made to meet the later sort. About the middle or end of April, the general potato quarter is planted. Two feet is the space commonly allowed between the rows, and from ten to fourteen inches between the plants. For planting, some use the potato dibble; which is an instrument about three feet long, with a cross handle at top for both hands, the lower end blunt and shod with iron, and having a cross iron shoulder, about four inches from the bottom, so that the holes must of necessity be struck of equal depth. The only attention the crop requires is hoeing, and drawing earth to the stems: the oftener this last operation is performed, the greater is the produce. The potatoes are taken up and used in the autumn months; the winter supply being drawn

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from the fields, as already mentioned. Potatoes are taken up with a fork made for the purpose, and which consists of three or four short flat tines, fixed on a spade handle. The winter store is carefully housed; or, what is better, it is lodged under ground, in pits covered with earth, and with straw during frost.

309. The late or field potatoes, it may be remarked, afford in most places a great part of the supply for spring and summer; and any improvement in the mode of keeping them, is deserving of attention. The Rev. Dr Dow of Kilspindie (in the first volume of Scottish Horticultural Memoirs) has described a mode, the advantages of which have in various places been confirmed by experience. The potatoes destined for long keeping he puts into small pits, holding about two bolls each; these are formed under the shade of a tree, wall, or stack of hay, and are covered with earth and straw in the usual way. In the following spring, about May, when warmth begins, the potatoes are examined; all shoots or buds are rubbed off, and such as shew any tendency to spoil, are laid aside. The pits being cleaned out, are nearly filled with water; and when this is absorbed, the potatoes are returned into it, every parcel or half-boll being watered as it is laid in. A layer of turf is placed with the grass next to the potatoes; a plentiful watering is then given; and the whole is covered with earth to the depth of two feet, and well beaten together with the spade. This operation is repeated once a month, as long as the potatoes are wished to be preserved. Dr Dow states, that he has thus kept them till September, quite plump and unimpaired in taste; and although, from the liberal supplies of water, we might expect them to be drenched with moisture, he assures us that they continue as mealy as ever.

The potato, although it most fortunately produces its tubers freely in our climate, must be considered as rather a delicate plant. Its leaves are blackened by the first approaches of frost in the autumn. Every body knows how apt potatoes kept in the house or cellar are to be injured by frost. The best means of guarding against this evil in these places are, to bring in potatoes in as clean and dry a state as possible, and, when risk of frost is apprehended, to place over them a covering of straw at least a foot thick.

It is well known, that if any of the larger sorts of potatoes of the former year's growth be kept in the cellar till May or June, they never fail to shoot, producing both roots and runners; but it is not perhaps generally known, that if these be carefully placed in boxes among decayed tree-leaves or other very light vegetable mould, and still kept in the cellar, they will yield a crop of small potatoes about mid-winter. A small supply may thus be procured by way of curiosity; but the potatoes are rather watery, and quite deficient in flavour.

In private gardens of a superior order, the first early potatoes are in some measure forced. In February two or three slight hot-beds are formed, and the potatoes are planted thickly on these. They are hooped over, and covered with mats at night and in bad weather. The more air they have the better, provided frost do not get leave to nip them. They require moderate but regular watering, particularly in March, when there is generally some dry weather. The young tubers are gathered in April and May in succession as they are formed.

310. Many persons amuse themselves with raising seedling potatoes. Some of the largest, first produced, and thoroughly ripened berries are gathered from several different good varieties; these may be preserved in dry sand till spring; or the seeds may be immediately separated from the pulp, and kept in paper-bags over winter. In April the seed is sown, in any fine light soil, in drills half an inch deep, and perhaps a foot asunder, keeping the kinds carefully separate, and marking them with tallies. When the plants rise, they are thinned out to six inches apart. They are kept clear of weeds, and once or twice earthed up. When the haulm decays, the tubers are taken up; they are carefully preserved from frost during the winter; and being planted next spring, the crop which results will determine the qualities of the different kinds. They should be boiled separately, and regard had to their flavour, mealiness or waxiness, size, shape and colour. When the seed of early varieties can be procured, it is, for different reasons, to be preferred. Mr Knight suspected the cause of these early varieties not producing flowers, to be the preternaturally early formation of the tubers, drawing off for their support that portion of sap which should have gone to the production of the blossom. He therefore devised means for preventing the formation of tubers; and when this was accomplished, he found no deficiency in the production of flowers and berries. The means were simple: having fixed strong stakes in the ground, he raised the mould in a heap round the bases of them; on the south side he planted the potatoes. When the plants were about four inches high, they were secured to the stakes with shreds and nails, and the mould was then washed away with a strong current of water from the bases of their stems, so that the fibrous roots only entered the soil, and no runners or tubers could be produced.

Curl.

311. The disease called *curl* has in many places proved extremely troublesome and injurious. It has given rise to much discussion, and to detail all the various opinions would be a useless task. It may, however, be remarked, that the experiments of Mr Thomas Dickson (*Scottish Horticultural Memoirs*, i. 55.) shew, that it arises from the vegetative powers in the tuber planted having been exhausted by over-ripening. That excellent horticulturist observed, in 1808 and 1809, that cuts taken from the waxy, wet, or least ripened end of a long flat potato, that is, the end nearest the roots, produced healthy plants; while those from the dry and best ripened end, farthest from the roots, either did not vegetate at all, or produced curled plants. This view is supported by the observations of a very good practical gardener, Mr Daniel Crichton at Minto, who, from many years experience, found (*Id.* p. 440.) that tubers preserved as much as possible in the wet and immature state, and not exposed to the air, were not subject to curl. And Mr Knight (in *Lond. Hort. Trans. for* 1814) has clearly shewn the beneficial results of using, as seed-stock, potatoes which have grown late, or been imperfectly ripened, in the preceding year. Mr Dickson lays down some rules, attention to which, he thinks, would prevent the many disappointments occasioned by the curl. He recommends, 1. The procuring of a sound healthy *seed-stock* (stock of tubers for planting) from a high part of the country, where the tubers are never over-ripened. 2. The planting of such potatoes as are intended to supply seed-stock for the ensuing season, at least a fortnight later than those planted for a crop, and to take them up whenever the stems become of a yellow green colour, at which time the cuticle of the tubers may be easily rubbed off between the finger and thumb. 3. The preventing those plants that are destined to yield seed-stock for the ensuing year, from producing flowers or berries, by cutting off the

Potatoes.

flower-buds; an operation easily performed by children, with a sickle, at a trifling expence.

Mr John Shirreff (in the same volume, p. 60.) takes a general and philosophical view of the subject, applying to the potato the doctrine by which Mr Knight had accounted for the disappearance of the fine cider fruits of the 17th century. The maximum of the duration of the life of every individual, vegetable as well as animal, is predetermined by nature, under whatever circumstances the individual may be placed: the minimum, on the other hand, is determined by these very circumstances. Admitting, then, that a potato might reproduce itself from tubers for a great number of years in the shady woods of Peru, it seems destined sooner to become abortive in the cultivated champaign of Britain; insomuch, that not a single healthy plant of any sort of potato that yields berries, and which was in culture twenty years ago, can now be produced. Mr Shirreff concludes, therefore, that the potato is to be considered as a short-lived plant, and that, though its health or vigour may be prolonged, by rearing it in elevated or in shady situations, or by cropping the flowers, and thus preventing the plants from exhausting themselves, the only sure way to obtain vigorous plants, and to ensure productive crops, is to have frequent recourse to new varieties raised from the seed. The same view, it may be remarked, had occurred to Dr Hunter, who, in his "Georgical Essays," limits the duration of a variety in a state of perfection to about fourteen years. A fact ascertained by Mr Knight deserves to be particularly noticed: it is this; that by planting late in the season, perhaps in June or even in July, an exhausted good variety may in a great measure be restored; that is, the tubers resulting from the late planting, when again planted at the ordinary season, produce the kind in its pristine vigour, and of its former size.

Jerusalem Artichoke.

Jerusalem Artichoke.

312. The *Jerusalem Artichoke,* or tuberous-rooted sunflower, (*Helianthus tuberosus,* L.; *Syngenesia Polygamia frustranea; Corymbiferæ,* Juss.) is a perennial plant, originally from Brazil. It has the habit of the common sunflower, but grows much taller, often rising ten or twelve feet high. Though its roots endure our hardest winters, the plant seldom flowers with us, and it never ripens its seed. The roots are creeping, and have many tubers clustered together, perhaps from thirty to fifty at a plant. These are eaten boiled, mashed with butter, or baked in pies, and have an excellent relish. The plant was introduced into our gardens early in the 17th century; and before potatoes became common, it was much more prized than at present. The epithet *Jerusalem* is a mere corruption of the Italian word *Girasole,* or sunflower; the name *artichoke* is bestowed from the resemblance in flavour which the tubers have to the bottoms of artichokes. As the potato is the *pomme de terre,* this is the *poire de terre* of the French.

The plant is readily propagated by means of the tubers. They are cut in the manner of potato sets, and planted, in any light soil and open situation, in the end of March. They are placed in rows, three feet asunder, and a foot or fifteen inches apart in the rows. In September they are fit for use; and in the course of November they are dug up and housed, being kept in sand like carrots. Sometimes they are left in the ground, and dug only as wanted, being best when newly raised. The only disadvantage is, that in this way they cannot be had in severe frosts. It is not very easy to clear the ground of them where they have once grown; and on this account, some gardeners devote a by-corner to them, and allow them to remain from year to year, taking up only what is wanted for the occasional use of the family. But the tubers thus produced are not so clean or well flavoured as those produced on newly delved ground by yearly planting.

Turnip.

Turnip.

313. The *Turnip* (*Brassica Rapa,* L.) is a biennial plant, growing naturally in some parts of England, and figured in "English Botany," t. 2176. The root-leaves are large, of a deep green colour, very rough, jagged and gashed. In the second season it sends up a flower-stalk, four or five feet high, having leaves which embrace the stem, very different from the former; smooth, glaucous, oblong, and pointed. The cultivated variety with a swelling fleshy root has long been known. Of this there are several well marked subvarieties, distinguished as garden or as field turnips. To the former belong the Early Dutch, Early Stone, and the Yellow; to the latter, the Large White, the Globe, the Swedish, the Red-topped, and the Tankard or oblong.

314. For the supply of the table during the early part of summer, some of the early Dutch turnip is commonly sown. If the weather prove dry, regular watering is proper. For a general crop, the large green-topped white turnip is accounted excellent, as being soft, juicy, and sweet. One of the kinds with which the London market is often supplied is the stone turnip, a hard sweet sort, seldom of a large size. The yellow is now perhaps less cultivated than it formerly was; but the yellow Dutch may still be considered as one of the best kinds for winter use, as no frost hurts it, and it is of excellent flavour. It is a very distinct variety, the flesh being yellow throughout; whereas, in the other varieties, any difference of colour is only in the rind. The red or purple-topped turnip was formerly much cultivated; but the green-topped has now in a great measure superseded it, though less hardy. The general crop is often sown towards the end of June, when refreshing showers may be expected. It not uncommonly occupies the ground from which early peas have just been removed. But as turnips are most desirable for the table in a young state, a small sowing is commonly made once a month from April to August. If sown earlier than April, the plants are apt to run to seed. To divide the seed more equally when sown broadcast, a little fine earth is mixed with it in sowing. It is frequently sown in drills, an inch deep, and somewhat more than a foot asunder. If rain do not occur, frequent watering is of great advantage to the young crops. A light sandy loam, not recently manured, is best for turnip; in a rich garden soil, the roots are apt to become rank and woody. When the root-leaves are about an inch broad, the plants are hoed; and, if they have been sown broadcast, thinned to six or eight inches distance from each other. When young turnips are daily drawn for the table, they may be allowed to stand somewhat closer, the proper degree of thinning being accomplished by pulling for use. If sown in drills, they may stand at five inches from each other in the lines. Turnips bear transplantation with difficulty; yet in moist and rainy weather, spots where the seed has failed may be filled up. When showery weather has made the leaves spring too much, so as to

Turnip.

threaten the production of a flower-stem, it is sometimes found useful to tread them down, by placing the foot gently on the centre of the plant. In some gardens, turnips are sown on a slight hot-bed in February, and thus forwarded by two or three weeks; but the beds must have as much air as can possibly be given.

315. For winter use many families prefer the Swedish turnip, which may either be stored or remain in the ground. The stone and the yellow are also very hardy. The surplus of the garden crop, it may be remarked, may advantageously be given to milch cows; and, if the turnips be slightly boiled, no disagreeable flavour is communicated to the milk.

316. If seed is to be saved, it is of advantage that the plants be transplanted, it being thought, that from those so transplanted a progeny having sweet and tender roots may be procured; while from the untransplanted stock-turnips, larger but coarser roots may be expected. It is very important, at all events, to have the plants intended for seed-stock kept at as great a distance as possible from all others of the brassica genus. This seclusion of the seed-stock plants is often more completely accomplished by seed-farmers, than it can possibly be in private gardens.

317. The turnip-fly, or beetle, (*Haltica nemorum*), is very destructive to the crop when in the seed-leaf. One of the easiest remedies is to sow thick, and thus ensure a sufficiency of plants both for the fly and the crop. Mr Archibald Gorrie, a Scottish gardener of merit, has found, from repeated experience, that if quicklime be slightly dusted over the crop while yet in the seminal leaf, no attack will be made. A preventive is often found in sowing late, the young beetles being compelled to feed on other herbage, and disappearing before the turnip expands its leaves.

If garden turnips be carefully packed in the store-house, and covered with plenty of straw, they keep in good order till March or April. Some are in the practice of cutting the top close off, but others prefer keeping up the power of growing. In some places both the green tops and the small roots of stored turnips are entirely cut off. It may be mentioned, that when turnips are left in the ground over winter, the top leaves form tender greens very early in the spring, which are particularly good for eating with salted meat.

Navew.

Navew.

318. The *Navew* or French turnip is a variety of the *Brassica Napus*, Lin. or Rape, which grows naturally in different parts of Britain. (*Eng. Bot.* t. 2146). It is the most esteemed *navet* of the French, (who have no appropriate name for our round turnips,) and the *Steckrüben* of the Germans, in some places called *Teltower Rüben*. The root is small, and oblong or carrot-shaped; of excellent flavour: "two of these in seasoning," says Justice in his Scots Gardener's Director, "will give a higher relish than a dozen of other turnips." It was anciently used throughout the south of Europe, and was more cultivated in this country a century ago than it is now. It is still in high repute in France, Germany, and Holland. It is put whole into soups, and is merely scraped, not peeled. It is remarked by Mr James Dickson, (one of the Vice-Presidents of the London Horticultural Society, but better known as an excellent cryptogamic botanist,) that "stewed in gravy, the navew is excellent, and being white and of the shape of a carrot, when mixed alternately with these upon a dish, it is very ornamental." In the paper alluded to, (*Lond. Hort. Mem.* i. 27.) Mr Dickson has given different receipts by an eminent French cook in London, for dressing the navew. It succeeds in any soil, either moist or dry; but in a dry light soil the flavour is highest. In strong garden soil, the roots get as large as parsnips, and resemble them considerably; but they are coarse, and deficient in flavour. The seed is sown in April, and the plants are thinned out to about five or six inches apart. The navew is sold in Covent Garden market, but chiefly to foreigners, who prefer it much to the turnip. For seed, some of the best plants are selected, and planted as remote from other brassicæ as circumstances will permit.

Carrot.

Carrot.

319. The *Carrot* (*Daucus carota*, Lin.; *Pentandria Digynia*; nat. ord. *Umbelliferæ*) is a biennial plant. In its wild state, it is a common weed in this country, growing by the road-sides, and known by the name of *bird's-nest*, from the appearance of the umbel when the seeds are ripening. It is figured in *English Botany*, t. 1174. The root of the wild carrot is small, dry, of a white colour, and strong flavoured. The root of the cultivated variety is succulent, and commonly of a yellow or an orange-colour; it is universally known, and very generally relished, when cooked in various ways.

Several varieties are cultivated, particularly the Orange carrot, with a large long root, of an orange-yellow colour; the Early horn and the Late horn carrot, of both which the roots are short and comparatively small; and the Red or field carrot, which acquires a large size.

320. Carrots are sown at two or three different seasons. The first sowing is made as early perhaps as new-year's day, or at any rate before the first of February, on a warm border or in front of a hot-house. Some employ a gentle hot-bed for this first crop; while others only hoop over the border, and cover it with mats during frost. The main crop of carrots is put in, in March or April; and in June or July a small bed is sown to afford young carrots in the autumn months. In some places a sowing is made a month later, to remain over winter, and afford young carrots in the following spring. These, however, often prove stringy, but they are useful in flavouring soups. In light early soils, it is better that the principal crop should not be sown sooner than the end of April or beginning of May; for in this way the attacks of many larvæ are avoided. For the early crops, the horn carrot is best; for the principal crops, the orange variety is preferred, but the red is also much cultivated.

The seeds having many forked hairs on their borders, by which they adhere together, are rubbed between the hands with some dry sand, so as to separate them. On account of their lightness, a calm day must be choosen for sowing; and the seeds should be trod in before raking. They are sown either at broad-cast, or in drills a foot apart. When the plants come up, several successive hoeings are given; at first with a three inch, and latterly with a six inch hoe. The plants are thinned out, either by drawing young carrots for use, or by hoeing, till they stand eight or ten inches from each other, if sown by broad-cast, or six or seven inches in line. The hoeing is either performed only in showery weather, or a watering is regularly given after the operation, in order to settle the earth about the roots of the plants left.

Carrots thrive best in light ground, with a mixture of sand. It should be delved very deep, or even trenched, and at the same time well broken with the spade. If the soil be naturally shallow, the late horn carrot is to be preferred to the orange or red. When manure is added to carrot ground, it should be buried deep, so that the roots may not reach it, else they are apt to become forked and diseased. In general it is best to make carrots the second crop after manuring. From the Scottish Horticultural Memoirs, however, (vol. i. p. 129.) we learn, that pigeons-dung, one of the hottest manures, far from injuring carrots, promotes their health, by preventing the attacks of various larvæ.

A considerable quantity of carrot-seed for the supply of the London seedsmen, is raised near Wethersfield in Essex; but much is imported from Holland. Cautious gardeners generally *prove* this and some other kinds of seeds, such as onions, before sowing. This is easily done by putting a sprinkling in a pot, and placing it under a hot-bed frame, or in a forcing house. Other gardeners transplant a few good roots, and raise their own seed: in this case it is better to gather it only from the principal umbel, which is likely not only to afford the ripest and largest seed, but the most vigorous plants.

321. Carrots are taken up at the approach of winter, cleaned, and stored among sand. They may be built very firm, by laying them heads and tails alternately, and packing with sand. In this way, if frost be excluded from the store-house, they keep perfectly well till March or April of the following year. Some persons insist that the tops should be entirely cut off at the time of storing, so as effectually to prevent their growing; while others wish to preserve the capability of vegetation, though certainly not to encourage the tendency to grow.

Carrots are now cultivated on an extensive scale in the field. They are excellent for milch cows or for horses; so that the overplus of a garden may always be turned to good account.

From old Parkinson we learn, that carrot leaves were in his day thought so ornamental that ladies wore them in place of feathers. It must be confessed that the leaves are beautiful. If during winter a large root be cut over about three or four inches from the top, and be placed in a shallow vessel with water, over the chimney-piece, young and delicate leaves unfold themselves all around, producing a very pretty appearance, enhanced no doubt by the general deadness of that season of the year.

Parsnip.

Parsnip.

322. The *Parsnip*, (*Pastinaca sativa*, L.; *Pentandria Digynia*; nat. ord. *Umbelliferæ*), is a biennial plant. The wild parsnip is not uncommon by the way sides near London, and in many parts of England, chiefly on calcareous soils: it is figured in *English Botany*, t. 556. The garden variety has smooth leaves, of a light or yellowish green colour, in which it differs from the wild plant, the leaves of which are hairy and dark green; the roots also have a milder taste: it does not, however, differ so much from the native plant, as the cultivated does from the native carrot. It has long been an inmate of the garden, and it was formerly much more in use than it is now. It was, in Catholic times, a favourite Lent root, being eaten with salted fish. It is doubtless a highly nutritious esculent, and the increase of its cultivation might be useful to the labouring class in England. In the north of Scotland, parsnips are often beat up with potatoes and a little butter; of this excellent mess the children of the peasantry are very fond, and they do not fail to thrive upon it. In the north of Ireland, a pleasant table beverage is prepared from the roots, brewed along with hops. Parsnip wine is also made in some places. If the crop prove too large for the use of the family, the superfluous part (as has been remarked of turnips and carrots) will be found to be very acceptable and useful to a milch cow.

The soil preferred for parsnips is a light loam, but almost any soil will do, provided it be pretty deep; the parsnip requires, however, a stronger soil than the carrot. The quarter should be trenched, or at least deeply dug, in order that the roots may have liberty to strike freely downwards. The seed is sown, broadcast, in March, either alone, or together with a proportion of radishes, lettuces, or carrots, and in light soils it is well trodden in: the salad plants being soon removed, or the carrots drawn young, do not materially hinder the growth of the parsnips, which spread and swell chiefly in the latter part of the summer. The parsnips are hoed out to about eight or ten inches asunder, or in strong ground a little wider; and the hoeing is repeated as often as the growth of weeds may render it proper. When the leaves begin to decay, the roots are fit for use. They are taken up as wanted during the winter, the root not being in the least injured by frost. About the beginning of February, however, the remaining part of the crop is raised and stored among sand, as the roots become stringy as soon as the new growth takes place, and the flower-stalk begins to form. In some places, the whole crop is taken up in the end of October, and either stored in sand like carrots, or placed in covered pits in the manner of potatoes. If two or three large roots be transplanted to a sheltered border, they will not fail to ripen their seeds, and to afford a sufficient supply: it is proper to tie the flower-stems to stakes, as they grow high, and are apt to be broken over by the wind. Seed that is more than a year old should never be sown.

In the first volume of the Scottish Horticultural Memoirs, (p. 405), Dr Macculloch has described two varieties of parsnip, which are cultivated in the Channel Islands, and there attain extraordinary size,—the *Coquaine* and *Lisbonaise*. The former runs deep into the soil, perhaps three or four feet; the latter becomes thick, but remains short, and is therefore suited to shallow soils. The French writers describe a variety having the root of a yellowish colour, more tender, and of a richer taste than the common kind: they call it the Siam parsnip.

Red Beet.

Red beet.

323. *Red Beet* (*Beta vulgaris*, L. *Pentandria Digynia*; *Atriplices*, Juss.) is a biennial plant, a native of the sea-coast of the south of Europe. It was cultivated by Tradescant the younger in 1656. It was formerly called in this country *beet-rave* (or beet-radish), from the French name *bette-rave*. The leaves of the cultivated sort are large, thick, and succulent, generally red or purple; the roots large, perhaps three or four inches in diameter, and a foot in length, and of a deep red colour. They are boiled and sliced, and eaten cold, either

Red beet.

by themselves or in salads; they also form a beautiful garnish, and are much used as a pickle. The roots of a variety having green leaves are by some accounted more tender than those of the red-leaved sort, and are on that account preferred. Others prefer those with dark red leaves, provided these be small and few in number. There is a short or turnip-rooted variety, also of a purple colour, and used for the same purposes. From its mode of growth, this is much better suited than the others to heavy or to shallow soils.

Red beet requires a light but rich soil, of considerable depth, and which has not been recently manured. The ground should be trenched or very deeply delved, and at the same time broken small with the spade. The seed is sown in April, in drills, an inch deep, and fifteen inches asunder. If sown in March, many of the plants are apt to send up flower-stalks, and so become useless. Kitchen gardeners often sow red beet along with carrots and onions; and drawing these two last for the market when young, they leave the beet alone to occupy the ground.

324. In lifting beet for the winter stock, care should be taken that the roots be not anywise broken or cut, as they bleed much. For the same reason, the tops or leaves are cut off at least an inch above the solid part of the root. They are cleaned, and laid in close rows along the floor of the cellar or store-house, sometimes without any covering of sand, taking care however, to exclude frost; but more frequently packed with sand in the manner of carrots.

If a few strong roots of red beet be left standing in the rows, or rather be transplanted to some convenient spot, they will next year shoot up and produce seed. The flower-stems should be tied to stakes to prevent their breaking over. It is scarcely necessary to add, that they should be removed as distant as possible from flowering plants of the green variety, or of the white species.

325. From a variety of the garden beet, having a red skin but white flesh, sugar is prepared in some parts of France and the Netherlands; a manufacture which was introduced during Buonaparte's government, when West India sugars were utterly prohibited. A small species of beet has been cultivated for a good many years in France, under the name of *Castelnaudari*, but which is very little if at all known in this country. It is described as possessing a fine flavour something like that of a hazel-nut. It is ready for use in August. The colour of the root is the same as that of common beet-rave; but its leaf is smaller, rounder, and rather of a livid hue.

The *White Beet*, although stated by some writers (as Salisbury, in the "Botanist's Companion") to be only a variety of the red, is in reality a very distinct species, *Beta Cicla* of Linnæus; but as the leaves and not the roots of this species are used, it will fall to be treated of under the section *Spinach plants*.

Skirret.

Skirret.

326. The *Skirret* (*Sium Sisarum*, L.; *Pentandria Digynia*; nat. ord. *Umbelliferæ*) is a native of China. It has been cultivated in our gardens since the middle of the 16th century, and was formerly more esteemed and more in use than it is at the present day. In the "*Systema Horticulturæ*, by J. W. gent. 1682," *skirwort* is declared to be the "sweetest, whitest and most pleasant of roots." It is a perennial plant; the lower leaves pinnated; the stem rising about a foot high, and terminated by an umbel of white flowers. The root is composed of fleshy tubers, of the size of the little finger, joined together in one head: these form the part of the plant used. They are considered wholesome and nutritive, but, having a sweetish taste, are not relished by many persons. They are generally boiled and served with butter like parsnips. In the north of Scotland, the plant is cultivated under the name of *crummock*. It is the *chervis* of the French.

Any light deep soil is found to answer for skirret. If the ground be naturally moist, so much the better. In very dry soils, or during long-continued drought, watering is proper. The seed is not sown sooner than the beginning of April, lest the plants should run to flower the first season, when the tubers would become harsh and stringy. Repeated thinning and hoeing are proper, as in the case of similar crops. When the leaves begin to decay in autumn, the tubers are considered as fit for use; but they are generally left in the ground, and taken up as wanted. Sometimes the plants which remain over winter, are dug up in the spring, and the side-shoots, each with an eye or bud, are transplanted for a new crop. These are commonly put in with the dibble, and covered over head with an inch depth of soil. But the tubers yielded by plants propagated in this way are not so large as those of seedling plants.

Scorzonera.

Scorzonera.

327. *Scorzonera*, or garden viper's grass, (*Scorzonera Hispanica*, L.; *Syngenesia Polygamia æqualis*; *Cichoraceæ*, Juss.) is a native of Spain, the south of France, and Italy. The stem rises two or three feet high, with a few embracing leaves, and is branched at top; the lower leaves are eight or nine inches long, and end in a sharp point; the flowers are yellow. It was cultivated in gardens in this country in the end of the 16th century. The tap root is the part used; it is carrot-shaped, about the thickness of one's finger; tapering gradually to a fine point, and thus bearing some resemblance to the body of a viper: it has a dark brown skin, but is white within, and abounds with a milky juice. The outer rind being scraped off, the root is steeped in water, in order to abstract a part of its bitter flavour. The plant is not, in the present day, much cultivated.

The seeds are sown in any cool deep soil, generally in drills, about a foot separate, where they are to remain, after being thinned out to four inches apart. The plant is perennial; but the roots are fit for use only the first autumn and winter after sowing, while as yet no flower-stem has risen; the roots, like all others, becoming tough when the flowers are produced. To avoid the risk of the plants running to flower the first season, the seed is not sown till the middle of April. If a few strong plants be left, they yield seeds freely the following year; or the plant may be propagated by slips in the manner of skirrets; but the roots thus procured are not so good or tender as those from seed. In some gardens, the roots are lifted in November, and stored in the manner of carrots; in others, they are left in the ground, and taken up during winter as wanted.

Salsify.

Salsify.

328. *Salsify*, or purple goat's-beard, (*Tragopogon porrifolius*, L.; *Syngenesia Polygamia æqualis*; *Cichoraceæ*, Juss.), is a biennial plant, a native of some parts

Salsify.

of England, but not common; figured in *English Botany*, t. 638. It is the *salsifis* or *cercifis* of the French. The root is long and tapering, of a fleshy white substance; the herb smooth, glaucous, and rising three or four feet high; the leaves resembling those of the leek, as intimated in the trivial name; the flowers of a dull purple colour, closing soon after midday; the seed, as in other species of goat's-beard, remarkable for having attached to it a broad feathery crown. It has been cultivated for a century past in our gardens, but Gerarde and Parkinson do not mention it; while they recommend the yellow goat's-beard, *Tragopogon pratensis*, which is now neglected. Salsify roots boiled or stewed like carrots, have a mild sweetish flavour. The stalks of year-old plants are sometimes cut in the spring when about four or five inches high, and dressed like asparagus. Salsify is at present, however, but little attended to.

It is sown in April, and thinned, like similar crops, to six or eight inches apart. A mellow and deep soil affords the best plants. They may remain in the ground all winter, and be taken up as wanted. If two or three roots be left, or be transplanted in the autumn, they will afford abundance of seed the following year.

Radish.

Radish.

329. The *Radish* (*Raphanus sativus*, L.; *Tetradynamia Siliquosa;* nat. ord. *Cruciferæ*) is an annual plant, originally from China. It is mentioned by Gerarde; and was probably known in England long before his time. The leaves are rough, lyrate or divided transversely into segments, of which the inferior less ones are more remote; the root fleshy, fusiform in some varieties, in others subglobular; white within, but black, purple, or white on the outside; the flowers pale violet, with large dark veins; pods long, with a sharp beak.

There are two principal varieties, distinguished by the shapes of the roots already mentioned: 1. With fusiform roots, the long-rooted or spindle-rooted radish, the *rave* of the French; 2. With subglobular roots, the turnip-rooted radish, the *radis* of the French. The roots of both are used principally in the way of salad, in winter and the early part of spring. Formerly the leaves were often boiled and eaten; but now the roots only are employed; and as they are always used raw, the plant might, without impropriety, have been ranked under the title of *Salads*.

330. Of the spindle-rooted kind, the subvarieties much in cultivation are, the small-topped or short-topped purple, the leaves of which occupy little room; and the pink or rose-coloured, or, as it is frequently called, the salmon radish. There is also an early dwarfish short topped red, and an early short-topped salmon-radish, sown for the first crops, and used for forcing. Of the turnip-rooted kind, there are several subvarieties. The small turnip-rooted white or Naples radishes, when they appear in the green market in spring, are not unfrequently mistaken for young turnips: they should be eaten young, when crisp and mild, being, when full grown, rather hot and harsh. There is also a small turnip-rooted red radish; and the queen radish, both red and white. The black turnip-rooted or Spanish radish (*raifort* of the French) has a dark coloured skin, but is white within; though rather coarser than the others, it is much esteemed for autumn and winter use.

Radishes are sown for the earliest crop in the beginning of November in a sheltered border, or in front of a pinery or green-house; and they are ready for drawing early in March. More seed is sown in December or January: and sowings are continued once a fortnight till April, so as to secure a succession of young roots as they may be wanted.

Any sort of light soil answers, but it should be of sufficient depth to allow the long roots to penetrate easily. A slight covering of fern (*pteris*) is found very useful in the early spring months, when sharp frosts occur: this covering may be raked off in the day-time, and restored at night, without much injury to the leaves of the young radishes. When very dry weather occurs in the end of march, the crops are regularly watered. They who wish to have large radishes, are sometimes at the pains to prick a number of holes with the finger, and to drop a seed into each hole. Only a little earth is then tumbled into it, the greater part of the hole being left vacant. The root is thus induced to swell, and long and semi-transparent radishes are procured. Some gardeners mix spinach seed with their later sowings of radishes; so that when the radishes are drawn, the other soon covers the ground. Others sow lettuce and onions along with radishes. If radishes are to be drawn when small, they are allowed to stand at two inches only apart; otherwise they have twice that space or more allowed them. When crowded, they are apt to become stringy in the root.

331. The turnip-radish is sown in February or March, and the plants are thinned out to about six inches with a small hoe. The red and the white queen radish, and the black Spanish radish, are sown from the middle of July to the middle of September, and thinned out in the same manner. They are fit for use in the beginning of September; and before hard frost comes on, they are generally taken up, and stored among sand like carrots, the tops being cut close off: in this way they are ready for use throughout the winter.

The dwarf early short-topped red, and early short-topped salmon radishes, are easily forced on a hot-bed: if the seed be sown by the middle of November, the radishes will be fit for drawing by the end of December, and will afford a supply for a month. Care must be taken to have a sufficiently thick layer of earth to hinder them from penetrating into the dung.

The seed of any of the sorts is easily procured by transplanting a few of the best and most characteristic plants of the respective kinds: the sorts should be placed as far from each other as possible, to prevent commixture of pollen.

It may be noticed, that the young and green seed-pods are sometimes used for pickling; and are perhaps scarcely inferior to nasturtiums.

It may also be mentioned, that Delaunay, in his *Bon Jardinier*, 1815, describes a new sort of turnip-radish, introduced of late years into France from Egypt; it is remarkable for being of a yellow colour. It has more poignancy than any of the kinds except the black; and experience has shewn that it may be produced, in the Paris gardens, at almost any season of the year.

Alliaceous Tribe.

Onion.

Onion.

332. The *Onion* (*Allium Cepa*, L. *Hexandria Monogynia; Asphodeli*, Juss.) is a biennial plant, well

marked by its fistular leaves, swelling stalk, and bulbous root. Neither the native country of the plant, nor the date of its introduction into this island, are known. There are several varieties in cultivation. One of the chief of these is the Strasburgh, which is of an oval shape, attains a considerable size, and keeps very long. The Deptford onion may be considered as a subvariety of the Strasburgh. The white Spanish onion grows to a large size, and is of a flat shape. Allied to this is the large silver-skinned onion, the most beautiful of all the varieties: the small silver-skinned is preferred for pickling. The globe onion is likewise much cultivated, being a good keeper; and the Reading and the Portugal are frequently sown.

333. For the principal crop, the seed is sown in February or the beginning of March, according to the state of the weather, and the dryness of the ground. The onion delights to grow on light but rich ground, which has not been recently manured: it should be well delved, broken fine, and exactly levelled. In heavy land, it is thought better to sow in the end of March or beginning of April. The seed is either sown at broad-cast or in shallow drills; a very slight covering of earth is given, and the bed is merely smoothed with the rake; the more that onions grow on the surface, the better they prove. The usual proportion of seed is about an ounce to a pole of land. Market gardeners sometimes sow thicker, with the view of drawing young onions, which are called cullings, or in Scotland *sybies* (from *siboules*.) A small quantity of lettuce seed is frequently sown along with onions; and very fine lettuce plants are thus procured, without materially injuring the onion crop. A first hoeing is given when the plants have advanced three or four inches in growth, and they are then thinned out with the hand to about four inches apart. Another hoeing is given, generally about a month or six weeks afterwards, according to the kind of season; and the broadcast plants are then singled out to about six inches square, and those in drills to about four or five inches in line. After the onions have begun to swell, the hoe cannot be used, and any large weeds are drawn out with the hand. If the weather be dry at the time of thinning, a plentiful watering is necessary for settling the earth to the roots of the remaining plants. About the end of August the crop is ripe, which is known by the leaves falling down. The onions are then drawn, and laid out on a dry spot of ground, such as a gravel walk, and occasionally turned. In a fortnight they are generally found sufficiently firm and dry for keeping; and they are then stored in a garret or loft, (never in a cellar,) and excluded as much as may be from the air. They are still very apt to grow; and to prevent this, some are at the pains to select the finest bulbs, and singe the radicles with a hot iron. In many places they are strung in bunches, and suspended from the roof of the loft.

334. The secondary crop of onions is sown in August or the beginning of September, and called the Michaelmas or winter crop. They are thinned in the usual way; and weeds must be carefully kept down, as they spring up very rapidly at this season of the year. In the spring months, when the keeping onions fail, part of these autumn sown onions are drawn for use: the remainder form bulbs, which are ready in the early part of summer. In the course of May, however, some bulbs will be observed pushing a flower-stem: these are cast out; and to check this tendency, and divert the growth to the bulb, the crop is *laid over*, as it is called. This operation is described by Nicol in his "Kalendar." Two people, with a rod or rake-handle, walk along the alleys, holding the rod so as to strike the stems an inch or two above the bulb, and bend them flat down. Winter onions thus managed, may be taken up about the end of June, and are generally firm and keep long.

In order to procure firm diminutive bulbs proper for pickling, some seed should be sown late in the spring, perhaps about the middle of April, in light and very poor land. It should be sown pretty thick; and the seedlings need scarcely be thinned, unless where they rise absolutely in clusters. The bulbs thus treated are generally of a proper size for pickling in August. The small silver skinned variety, it has been already mentioned, is well adapted for this purpose.

It may here be noticed, that such of the keeping onions as have sprouted in the loft, are sometimes planted in a bed early in the spring, especially by market-gardeners. In a short time they appear fresh, throwing out long green leaves. They are then sent to market, tied in small bunches, and sold as a substitute for *scallions*, and under that name.

335. It has long been known, that young seedling onions might be transplanted with success. Even Worlidge, in his little treatise on gardening,[*] published in the end of the 17th century, praises this mode. The practice has of late years been revived, and recommended in England by Thomas Andrew Knight, Esq. and in Scotland by Mr James Macdonald, gardener to the Duke of Buccleuch at Dalkeith. Mr Knight's plan is, to sow the onion seed at the ordinary autumn season, thick under the shade of a tree, and to transplant the bulbs the following spring: he thus procures onions equal in size and other qualities to those imported from Spain. Mr Macdonald, again, transplants the young spring sown onions. He sows in February, sometimes on a slight hot-bed, or merely under a glass frame; and between the beginning of April and the middle of the month, according to the state of the weather, he transplants the young seedlings, in drills about eight inches asunder, and at the distance of four or five inches from each other in the row. It is evident, that by thus having the crop in regular rows, hoeing may not only supersede hand-weeding, but may be more effectually performed. The bulbs thus enjoying the great and well-known advantages of having the surface-earth frequently stirred, swell to a much larger size than those not transplanted; while in firmness and flavour they are certainly not inferior to foreign onions. At the same time the transplanted onions remain free from wire-worm or rot, while those left in the original seed-bed are frequently much injured by both. The beds destined for these onions having probably been under a winter crop, are deeply delved over in the beginning of April, and thus rendered clean at the most critical season of the year for the larvæ that infest the soil. Besides, the plants grow with superior vigour, in consequence of the repeated hoeings, and are thus better able to resist injuries. Mr M'Donald, indeed, sometimes practises the dipping of the roots of seedlings in a puddle prepared with one part of soot and three parts of earth; but this may probably be dispensed with, as it seems likely that the exemption from the attacks of the worm or the power of resisting them, depend rather on the other circumstances mentioned. It

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[*] *Systema Horticulturæ*, by J. W. gent.—2d edit. 1683.

Onion.

may be added, that all the varieties of onion seem to answer equally well for transplanting.

Various means have been suggested of guarding against the attack of the maggot alluded to. One of the most simple and most important, consists in selecting a fresh soil and an airy situation, never sowing on recently manured land. It is proper to avoid having very tender plants at the season when the maggot is known commonly to make its appearance: by sowing a fortnight or three weeks later or earlier, crops might often be saved. It is frequently remarked, that while spring sown onions are cut off, the autumn sown crop escapes. Mr Machray at Errol has suggested the propriety of sowing onions only after crops known not to be subject to the attacks of the maggot, such as strawberries and artichokes. This plan, he informs us, (*Scottish Hort. Mem.* i. 274.) he has practised for a number of years, and has found effectual in preserving his onions; while it is attended with no inconveniency, as nothing can be more easy than to keep up a succession of strawberry and artichoke plants.

336. The procuring of fresh seed is a matter of importance; for if it be kept over a year, a great part will not germinate. Onion seed can be ripened in our climate; but some how or other it is very apt to degenerate. A good deal, however, is yearly saved in the neighbourhood of Deptford. Imported seed is always *proved* by attentive gardeners, and also by seedsmen: a small sample being sown in a flower-pot, and placed in a hot-house, the quality, as far as capability of germination is concerned, is soon determined. When it is intended to collect home seed, some of the firmest, largest, and best shaped bulbs are selected, and planted out in February or March, in good ground, near a south wall or hedge. When the heads are formed, they are supported by lines of small cord passed between stakes. In September, if the season be favourable, the seed ripens, turning to a brown colour, and beginning to burst the cells which contain it. The heads are then gathered; and when dried, the seeds are beat out, and kept in paper bags.

Tree onion.

337. A bulbiferous variety is cultivated in some gardens, under the name of *Tree onion*. Its culture has been recommended by Mr George Nicol of Edinburgh, in the Memoirs of the Caledonian Horticultural Society, (vol. i. p. 350.) under the title of *Allium Canadense*, a species for which it has very generally been mistaken. The stems from two-year old plants rise more than two feet high. Several bulbs of different sizes are produced at the top of the stem, and these, as well as the root-bulbs, may be used for kitchen purposes like common onions. They are of good flavour, though rather stronger in taste than common onions. They are well adapted for keeping, and especially for pickling. Mr Nicol observes, that they are very seldom infested by maggots; and he recommends, therefore, that a few stock-bulbs should be preserved in gardens, to provide against the contingency of the crop of common onions failing.

This bulb-bearing or tree-onion is figured in the "Botanical Magazine," plate 1469, and described by Dr Sims as merely a variety of the *Allium cepa*. It is certainly not the *Allium Canadense* of Willdenow or Pursh, (for which, as already noticed, it has been generally mistaken,) the Canadian plant having flat linear leaves, and a slender uninflated stem, with top-bulbs resembling those of garlic. But, on the other hand, it differs from the common onion, not only in producing bulbs at top, but in having a stronger alliaceous flavour, and in being perennial. Possibly therefore it might constitute a distinct species.

Egyptian onion.

338. The *Egyptian onion*, or *Ground onion*, has been considered as another variety of *Allium cepa*, but seems to be more nearly allied to *A. fistulosum.* Instead of producing bulbs at the top of the stem like the former, this plant produces clusters at the surface of the ground in the manner of potatoes. It was brought from Egypt, it is believed, during the occupation of that country by the British army, and was first cultivated in the neighbourhood of Edinburgh in 1811, by Lieutenant Burn of the Royal Navy. The bulbs are planted in April, at a foot or sixteen inches asunder, and covered with earth only about half an inch deep. In the course of the season, a number of bulbs form in clusters around the parent bulb, as already described; those nearest the surface grow largest; those toward the centre are soonest ripe, and may be removed to give room to the others. If intended for keeping, they should be taken up before they attain maturity. If allowed to remain long in the ground, they sometimes become of a very large size. The bulb seems quite hardy, having been observed to brave the severity of frosty weather, at least equally well as the common onion. Flower stems rise sparingly, and only from strong bulbs. In quality the ground onion seems not inferior to the common onion. It more speedily reaches maturity, being planted in April, and reaped in August and September. Maggots have not been observed to infest it; but it has not been ascertained that they will not attack it. From our own experience we suspect, that it will speedily degenerate in this country.

Scallion.

339 The *scallion* seems to be a third variety of the Allium Cepa, distinguished by the circumstance of its never forming a bulb at the root. Miller states, that the scallion is propagated by parting the roots in autumn; that it grows in almost any soil or situation, and resists our severest winters. He adds, that being green and fit for use very early in the spring, it is worthy of a place in all good kitchen gardens. It was, indeed, formerly much in use; but the true scallion is now very little known, and is said to exist only in a few gardens, where it is preserved by way of curiosity. Some derive the name *scallion* or *escallion* from *ascalonicum*, and without more ado identify it with the rocambole, (*A. ascalonicum*); others consider it as synonymous with the Welch onion, (*A. fistulosum*); but both these species were well known to Miller, and accurately distinguished by him, and yet he describes the scallion as something different. In popular language, scallion means sometimes a thick-necked seedling onion, drawn for use in the green state; and sometimes, as already mentioned, a winter kept onion which has sprouted, and is planted for some weeks in the spring till it acquire green leaves.

Leek.

Leek.

340. The *Leek* (*Allium Porrum*, L.; *Poireau* of the French) is a native of Switzerland, and a biennial plant. The stem rises three feet, and is leafy at bottom, the leaves an inch wide. The flowers appear in May, in close very large balls, on purplish peduncles. The whole plant is used for culinary purposes; but the blanched stem is most esteemed. It is in season in winter and spring, and is chiefly used in soups, and for stewing. It is mentioned by Tusser in 1562, but was

no doubt known in this country long before that date. The Welch are proverbially fond of leeks.

> "Leek to the Welch, to Dutchmen butter's dear!"

sings Gay; and the description of a plain prose writer justifies the remark: "I have seen the greater part of a garden there stored with leeks," says Worlidge, speaking of Wales, "and part of the remainder with onions and garlic." Leeks formerly constituted an ingredient in the dish called *porrage*,—a name, indeed, which may be supposed to be derived from *porrum*.

There are three varieties: the narrow-leaved or Flanders leek; the Scotch, or flag leek, sometimes called the Musselburgh leek; and the broad-leaved or tall London leek. The latter variety is often cultivated; but for exposed situations, the Scotch leek is by much the more hardy.

Leeks are raised from seeds sown in the spring, much in the same way as onions, and occasionally along with these. They are at first sown closely in beds; and in June or July, when early cabbage or an early crop is removed, the leeks are planted out in rows about a foot apart, and six inches asunder in the rows. The tips of the leaves, and the points of the fibrous roots, are commonly trimmed off before planting. A good rule is, to make a deep hole with the dibble, and merely to lay in the leek-plant up to the leaves, without closing the earth about it. In this way the stem of the leek is encouraged to swell and lengthen, and is at the same time blanched. This plan, however, must either be adopted only in moist weather, or the plants must be well watered, so as to ensure their taking root. It is remarked, that if the leaves be topped two or three times during the summer, the leeks grow to a larger size; as new heart leaves are pushed forth, and the stalks, or useful part, are thus increased. They are ready for use in the autumn and winter. When there is a prospect of severe frost, part of the leek crop is sometimes lifted, and laid, with the roots in sand, in a cellar.

In good seasons, the seed ripens perfectly well in this country. For producing seed, the largest plants are selected, and in February are transplanted to the south side of a wall or hedge. As the flower-stems advance, they are supported by strings passed along and fixed to stakes, being apt to be broken by the wind, especially when the heads get large and heavy. When ripe, which is generally in September, the heads become brown; they are cut off along with part of the stalk, and hung up for some weeks, and the seed is then rubbed out.

Cibol.

Cibol.

341. The *Cibol*, or Welch Onion, (*Allium fistulosum*, L.; *La Ciboule de St Jacques* of the French), is a perennial plant, a native of Siberia. It appears, from Parkinson, that it was cultivated in 1629, but it was known long previously. Although called Welch *onion*, it produces no bulb; but the fistular leaves, and the lower part of the stems, are much used in salads in the spring months. They have rather more of the garlic than of the onion flavour. Sometimes they are planted as scallions; indeed, some consider this plant as the true scallion, but without sufficient evidence.

Cibols are chiefly raised from seeds, which are sown in July. The seedling plants soon appear; but, in the course of October, the leaves go off, and the ground seems quite bare. As early as January, however, they again begin to shoot, and by March they are fit for use, being then very green and tender. As might be expected of a Siberian plant, it withstands our severest winters. The wide-swelling fistular leaves give it rather a curious appearance; a few plants may therefore be suffered to stand on a south border of the garden, where they will in general ripen their seed.

Dr Johnson (*Dict. in loco*) remarks, that the name *cibol* is frequently used in the Scotch dialect, but that the *l* is not pronounced. By the term *cibo* or *sybie*, however, the Scots mean a young seedling onion of the common kind, gathered for use before the swelling of the bulb: the true cibol is very little cultivated in Scotland, and is not distinguished by the common people.

Chives.

Chives.

342. The *Chive*, or Cive, (*Allium Schœnoprasum*, L.) is a perennial plant, of more humble growth than any of its congeners in the garden. It is a native of Britain, but not common: it occurs, among other places, in the south of Scotland, on low hills near Hawick; it is figured in "English Botany," plate 2441. The bulbs are very small and flat, and grow connected together in clusters. When gathered for use, they are cut or shorn like cresses, and on this account are generally spoken of in the plural. The young leaves are employed principally as a salad ingredient in the spring, being accounted milder than scallions. Occasionally the leaves and small bulbs are used together, slipped to the bottom, and thus forming, as it were, separate little cibols. Sometimes they are added as a seasoning to omelets; and they are useful for other culinary purposes.

Chives are readily propagated by parting the roots, either in autumn or spring, and they will grow in any soil or situation. They should be repeatedly cut during the summer season, the successive leaves produced in this way being more tender. A small bed or border thus managed, will afford a sufficient supply: it will continue productive for three or four years, when a new plantation should be made. Chives are sometimes planted as an edging; and if they be allowed to grow up, they make a pretty enough appearance with their pale purple flowers in June.

Garlic.

Garlic.

343. *Garlic* (*Allium sativum*, L.; *Ail* of the French) is a perennial plant, growing naturally in Sicily, and in the south of France. The leaves are linear, long, and narrow. It has a bulbous root, made up of a dozen or fifteen subordinate bulbs, called cloves. It was cultivated in England in 1548; but had probably been known long before that period. When an entire bulb is planted, it does not fail to throw up a flower-stem in the summer; but this is not wished. Garlic is therefore propagated by detaching the cloves, and planting them; and in this way the tendency to flower is less. It may be propagated also by the seed; but this mode is tedious, three years elapsing before a tolerable crop is produced. The soil should be light and dry, well delved, and broken fine. The sets are placed four inches distant from each other in every direction, and between two and three inches deep. The smaller the cloves, the more healthy and productive are the plants. They are put in, in February or March. About the middle of June the leaves are tied in knots, to prevent the stronger plants from spindling or running to flower, and

to promote the swelling of the bulbs. The crop is taken up in August, when the leaves begin to wither. The roots are tied in bunches, and hung in a dry room for use. Garlic is used in seasoning various kinds of dishes, being in general introduced only for a short time into the dish while cooking, and withdrawn when a sufficient degree of flavour has been communicated. It is much more employed in French cookery than in ours. An ordinary sized bed commonly furnishes a sufficient supply for the use of a large family in this country.

Shallot.

Shallot.

344. The *Shallot* (*Allium ascalonicum*, L.) is a perennial plant, a native of the Holy Land, where it was observed by Hasselquist. *Eschalot* (or *Eschalotte*, F.) is the more correct denomination, the name being derived from Ascalon, a town in Palestine. In some old books it is styled *barren onion*, from the circumstance of its seldom sending up a flower-stalk. In size and general growth the plant resembles the chive; but it produces bulbous roots composed of cloves like garlic. These are used for culinary purposes in the manner of garlic; but they are milder, and do not communicate to the breath the offensive flavour which garlic or even raw onions impart.

The culture of shallots is greatly similar to that of garlic; only the offsets or cloves are planted more early, and the crop is somewhat sooner taken up. The smallest and longest cloves form the best sets, being least subject to grow mouldy. A good soil is desirable for them; but one that has been manured for a former crop is to be preferred; for in soil newly dunged, the plants are much more apt to be infested with maggots. Mr Marshall very properly recommends planting in autumn where the soil is dry, and in spring where it is naturally damp. The severest frosts seem to have no effect in injuring the roots. The crop is taken up, in the end of summer, when the leaves become discoloured; and the bulbs are hung up in nets in a cool airy place, for use.

Mr Machray at Errol mentions (*Scottish Hort. Mem.* i. 275), that he has found soot mixed with the manure given to shallot beds effectual in preventing the appearance of maggots; while the shallots were improved in size. But Mr Henderson, gardener at Delvine in Scotland, has recommended the planting of shallots in autumn, as the surest way of enabling them to escape or withstand the attacks of these vermin, (*Scottish Hort. Mem.* i. 200.) He plants his shallots about the middle of October, the ground being previously manured with old well-rotted dung mixed with house ashes. He mentions, that he had, on one occasion, a parcel of spring planted shallots only seven feet distant from those planted in autumn; and that the former were totally destroyed by the maggot, while the latter proved productive and good.

Rocambole.

Rocambole.

345. The *Rocambole* (*Allium Scorodoprasum*, L.; *Ail d'Espagne* of the French) is a perennial plant, indigenous to Sweden and Denmark. It has compound bulbs like garlic, but the cloves are smaller; it sends up a stem two feet high, which is bulbiferous. We know that the rocambole was cultivated by Gerarde in 1596, but it was probably introduced long before. The cloves are used in the manner of garlic or shallot, and nearly for the same purposes. At the top of the stem, along with the flower, in July and August, small bulbs (which have sometimes been called *seeds*) are produced; these may likewise be used, and indeed they are, strictly speaking, the proper rocamboles.

The plant may be propagated by means of either sort of bulbs; but those of the root are most speedily productive. They are commonly planted in the spring; but in dry ground they are put in, in the autumn, the produce being in this way of a larger size. Those plants which do not push up a flower-stem naturally produce the strongest root-bulbs; and if it is not wished that the plants should fruit, the smaller the offsets planted the better. The culture is otherwise the same as that of garlic. A few rows of rocambole are sufficient.

Spinach Plants.

Spinach.

Spinach.

346. *Spinach* (*Spinacia oleracea*, L.; *Diœcia Pentandria; Atriplices*, Juss. *Epinard*, F.) is an annual plant, with the leaves large, the stems hollow, branching, and, when allowed to produce flowers, rising two feet high. It is diœcious, or the male and the female flowers are produced on different plants; the former come in long spikes; the latter appear in clusters, close to the stalk, at every joint. Spinach is the only diœcious plant cultivated for culinary use. Western Asia is the country of which our garden spinach is considered as originally a native. It has been cultivated in Britain from the earliest times of which we possess any horticultural record, for the sake of the leaves, which are used in soups, or boiled and mashed, and served up with butter, and eggs hard done.

There are two principal varieties, the prickly-seeded, with triangular, oblong, or sagittate leaves; and the smooth-seeded, with round or blunt leaves. The former is the more hardy, and is employed for winter culture; the latter has more succulent leaves, and is preferred for summer crops.

For the winter crop, therefore, the seed of the prickly kind is sown in the beginning of August, when rains may soon be expected. A light dry but rich soil is preferred; and a sheltered situation is desirable. When the plants shew four leaves, the ground is hoed, and the spinach moderately thinned; and the hoeing is repeated, as the growth of weeds may require. In October and November, the outer leaves of the spinach are generally fit for use; and in mild weather, during the winter and early spring, successive gatherings may thus be procured. In February, some fine dry days generally occur, and at this time the surface of the ground around the winter spinach is stirred, the plants cleaned, and finally thinned out. With due attention, the prickly spinach thus proves productive till April or May.

The first sowing of smooth-seeded or round-leaved spinach is commonly made in the end of January, on a sheltered border. This early crop, if sown broadcast, is at first thinned out to three inches apart, and, at subsequent hoeings, to eight or ten inches. Successive sowings are made in February, March, and April, in the ordinary garden compartments, and these are at once thinned out to six or eight inches apart. In some places these crops are placed between wide rows of cabbages, as they afford a crop before the cabbages advance much in growth. Sometimes radish seed is sown along

Spinach.

with them, the radishes, on the other hand, being drawn off in time to give room to the spinach. If spinach be sown late in the season, it is done only on moist clayey grounds, the quality of which, while it promotes the production of leaves, rather retards the inclination to flower; and the sowings are repeated every fortnight. Spinach is often sown in shallow drills, about a foot asunder: this mode is more troublesome at first; but this is compensated by the facility with which the thinning, cleaning, and gathering are afterwards accomplished: indeed, less thinning is necessary, as drilled spinach is generally cut straight over like cresses. When spinach is sown in drills, between rows of other vegetables, the prickly-seeded should be preferred, even in spring, as it does not grow so large, nor spread so wide.

When spinach seed is wanted, the plants are thinned out to at least a foot separate. A very few plants with staminiferous spikes are sufficient for fertilizing a considerable row of the female or seed-bearing plants. The seed ripens in August; it should be covered with a net, small birds being very fond of it.

White Beet.

White beet.

347. The *White Beet* (*Beta Cicla*, L.; *Pentandria Digynia*; *Atriplices*, Juss.) is a biennial plant, a native of Portugal and Spain. This has been known and cultivated in gardens since the days of Gerarde and Parkinson; not for the sake of the roots, which are generally small, seldom larger than a person's thumb, but for the lower leaves and their foot-stalks: the leaves are thick and succulent, and are boiled as a spinach, or put into soups. There is a larger variety, called the great white or sweet beet, of which the stalks and midribs of the leaves are stewed and eaten as asparagus, under the name of *chard*.

White beet is sown in the beginning of March, on an open spot of ground. When the plants have put out four leaves, they are hoed and thinned out to at least four inches asunder. A month afterwards, a second hoeing is given, and the plants are left perhaps eight inches separate. The outer leaves being first picked for use, a succession is afforded for the whole season. The plants endure for two years, but it is best to make a small sowing annually. When beet-chards are wanted, the plants are frequently watered during summer; they are kept protected with litter over winter, and have earth heaped against them. In this way the chards may be had till the approach of the following summer.

Mangold-Wurzel.

348. A variety, by some considered a hybrid between the red and the white beet, having very large roots, as well as large leaves, was introduced into this country about the year 1786, chiefly by the exertions of the late distinguished Dr John Coakley Lettsom. It was called in Germany, Mangold-Wurzel, or Beet-Root; but Abbé Commerell, in recommending it in France, having mistaken Mangold, *beet*, for Mangel, *want*, converted the name into Racine de Disette; and in this country we have sanctioned the blunder, by adopting the name Root of Scarcity. Of this variety most of the roots weigh 10lb. or 12lb.; in rich and deep soil, often 20lb. Some which grew in the island of St Helena weighed above 50lb. each. The seed is sown in March; and the seedlings, when their roots are the size of goose-quills, are transplanted into rows a foot and a half distant, and nearly as much apart in the rows. In transplanting, the leaves are cut over at top, but the roots are not touched; and the tap root is not fully sunk in the soil, but only so deep as that half an inch may project above ground. The root is rather coarse for table use, but excellent for cattle. The mid-rib of the leaf, dressed like asparagus, is pretty good.

Orache.

Orache.

349. *Garden Orache*, or Mountain Spinach, (*Atriplex hortensis*, L.; *Polygamia Monœcia*; *Atriplices*, Juss.) is an annual plant, a native of Tartary. The stem rises three feet high; the leaves are various in shape, thick, pale green, and glaucous, and of a slightly acid flavour. There are two varieties, the White or pale green, and the Red or purple. Orache was formerly much cultivated as a spinach; but now it is less frequently sown. Some, however, prefer it to common spinach, and it is much used in France. It is sown in drills, in autumn, soon after the seed is ripe; and the plants are thinned out, next spring, to four inches asunder. The stalks are good only while the plant is young; but the larger leaves may be picked off in succession throughout the season, leaving the stalks untouched, and the smaller leaves to increase in size; and still the spinach thus procured will be found very tender.

Wild Spinach.

Wild Spinach.

350. *Wild Spinach*, or Good Henry, (*Chenopodium bonus Henricus*, L.; *Pentandria Digynia*; *Atriplices*, Juss.) is a perennial plant, indigenous to Britain, growing by road-sides in many places. It is figured in Sowerby's "English Botany," pl. 1033. The stem rises rather more than a foot high; it is round and smooth at the base, but upwards it becomes somewhat grooved and angular; it is covered with minute transparent powdery globules. The leaves are large, alternate, triangular arrow-shaped, and entire on the edges. While young and tender, it makes no despicable substitute for spinach. Curtis mentions, that in some parts of Lincolnshire it is greatly esteemed, and cultivated in gardens in preference to common spinach. Withering observes, that the young shoots, peeled and boiled, may be eaten as asparagus, which they resemble in flavour. The leaves are often boiled in broth, of which they form a very palatable ingredient.

The seed is sown in March or April, in a small bed. In the course of the following September, in showery weather, the seedlings are transplanted into another bed which has been deeply dug, or rather trenched to the depth of a foot and a half, the roots being long and striking deep, while at the same time they are branched; so that each plant should have a foot or fifteen inches of space. Next season the young shoots, with their leaves and tops, are cut for use as they spring up, leaving perhaps one head to each plant, to keep it in vigour. The bed continues productive in this way for many successive years. The first spring cutting may be got somewhat earlier, by taking the precaution of covering the bed with any sort of litter during the severity of winter.

Herb Patience.

Herb patience.

351. *Garden Patience*, or Patience Dock, (*Rumex Patientia*, L.; *Hexandria Trigynia*; *Polygoneæ*, Juss.) is a perennial plant, a native of Germany. The leaves are broad, long and acute-pointed, on reddish foot-

Patience.

stalks; the stems, when allowed to spring up, rise to the height of four or five feet. In old times, garden patience was much cultivated as a spinach. It is now very much neglected, partly perhaps on account of the proper mode of using it, not being generally known. The leaves rise early in the spring; they are to be cut while tender, and about *a fourth part of common sorrel* is to be mixed with them. In this way patience-dock is much used in Sweden, as we have been informed by the late Sir Alexander Seton of Preston, who had an estate in Sweden, and frequently resided there. This mixture may be safely recommended as forming an excellent spinach dish. Garden patience is easily raised from seeds, which may be sown in lines, in the manner of common spinach, or white beet. If the plants be regularly cut over two or three times in the season, they continue in a healthy productive state for a good many years.

Boiled Salads.

Boiled salads.

UNDER this title (not perhaps strictly correct, as *salad* may be considered as implying rawness in the vegetable) we include a few plants which cannot well be ranked as pot-herbs, and yet are generally boiled before being presented at table. One of the chief of these is

Asparagus.

Asparagus.

352. (*Asparagus officinalis*, L.; *Hexandria Monogynia; Asparagi*, Juss.; the Asperge of the French, and Spargel of the Germans.) This is a perennial plant, which occurs native in some parts of England, as near Bristol, and in the Isle of Portland; and it has been observed sparingly in one place in Scotland, Seaton Links, East Lothian. It is figured in "English Botany," t. 339. In its native state it is so dwarfish in appearance, even when in flower, that none but a botanist, attending to the minute structure, would consider it as the same species with our cultivated plant. The roots consist of many succulent round bulbs, forming together a kind of transverse tuber; numerous stems arise, with alternate branches, subdivided into alternate twigs; the leaves are very small, linear and bristle-shaped; the flowers yellowish-green, the berries red. The whole plant, with its fruit, is very elegant in appearance, and is often placed in chimneys as an ornament in the autumn months. The early shoots, when about three or four inches high, are greatly esteemed for the table. For the sake of these, the plant has been cultivated in gardens for ages.

There are two varieties, the Red-topped and the Green-topped; the former commonly rising with a larger shoot, but not reckoned so delicate in flavour as the green sort.

353. Asparagus is propagated either by seeds, or by year-old plants purchased from nurserymen or market-gardeners. It is best to raise the plant from seed; and it is of considerable importance to procure the seed from an experienced and attentive gardener; for seed gathered from the strongest and most compact shoots, is found, as might naturally be expected, to yield by much the better plants. It is sown at broad-cast on a seed-bed in March, not very thickly; and the bed is slightly trodden, and raked smooth: or it is sometimes sown in shallow drills, six inches asunder, and earthed in from half an inch to an inch deep. The young plants are kept as free of weeds as possible during the summer: and in the end of October following, some rotten dung or other litter is spread over the surface of the ground to protect the buds during winter. In the following March or April, according to the dryness of the season, these year-old plants are transferred from the seed-bed into a quarter prepared for them.

Asparagus.

Asparagus ground should be light, yet rich; a sandy loam, well mixed with rotten dung or sea-weed, is accounted preferable to any. The soil should not be less than two feet and a half deep; and before planting a bed, it is considered good practice to trench it over to that depth, burying plenty of dung in the bottom, as no more can be applied there for eight or ten years. It can scarcely therefore be too well dunged: besides, although the plant naturally grows in poor sandy soil, it is found that the sweetness and tenderness of the shoots depend very much on the rapidity of the growth, and this is promoted by the richness of the soil. Damp ground or a wet subsoil are not fit for asparagus: indeed the French consider wetness as so prejudicial to this plant, that they raise their asparagus beds about a foot above the alleys, in order to throw off the rain.

The plants are generally raised with a narrow-pronged fork, to avoid cutting the roots; and when they are taken up, the roots are kept in a little earth, or covered with a mat, till replanted, being very apt to sustain injury from drying, or being too much exposed to the air. A trench about six inches deep being prepared, the roots are carefully laid in, a foot distant from each other, the buds or crowns being kept upright, and about two inches below the surface. A foot between each ordinary trench is reckoned sufficient; but between every four rows a double distance is left for an alley. Some plant in single rows, at two feet and a half or perhaps three feet apart; and this is by many experienced asparagus farmers considered as better than the bed form.

It is a general rule, that, in dry weather, the new planted beds or rows should be carefully watered. With attention to this rule, asparagus may be transplanted at a later period of the season than March or April. From the Scots Horticultural Memoirs, (Vol. i. p. 71.) we learn, that this operation has been very successfully performed at midsummer. The plants were at that time fourteen months old, and from twelve to fifteen inches high. Being removed with care, and well watered, none of them failed; on the contrary, they gained considerably on those left in the seed-bed. Next spring the remainder of the seedlings were planted out, but many of them failed, while the midsummer plantation continued to grow vigorously, and far surpassed those that survived of the spring planting.

354. Another mode of propagating asparagus is followed by some cultivators. They sow the seeds in the spot where the roots are to remain; either by dibbling holes about half an inch deep, and at a foot distant, and dropping two seeds into each hole for fear of one failing; or making drills an inch deep, and three feet asunder, and sowing rather thickly so as to insure a crop, and afterwards thinning out, at first to five or six inches, and ultimately to nine or ten. In this way, it is thought, stronger plants are produced.

It is a common practice to take a crop of onions along with the drilled seedling asparagus; and likewise to plant rows of cauliflower, or sow drills of carrot or turnip, between the lines of transplanted asparagus the first year.

Several hoeings are given in the course of the summer, generally three. In the end of September, or beginning of October, the haulm decays, and is cut over; all the refuse is dug into the alleys, and the superfluous earth thus acquired is often spread over the beds to the depth of an inch or more, which is called *landing up*. Frequently small dung, or perhaps sea-weed, is spread on the beds, and this is accounted the better practice; the surface being previously stirred with a fork, so as to allow the juices of the manure washed down by the rains to be readily imbibed.

In the spring dressing of the beds, the intervals are slightly delved over. For this purpose, the narrow pronged fork, already mentioned, is generally employed, being much less apt to injure the roots. This dressing is given just before the buds begin to appear, and the raking requires some delicacy of hand.

The same practice, both for the autumn and spring, is observed for the second year; it being only in the third year after planting out, or the fourth from the seed, that cutting for use is begun. In April, a few shoots may generally be cut; in May and June they come rapidly and copiously. In the first productive season, only the large buds or shoots are taken, the smaller being left to spring up and draw strength to the plants. In subsequent years all the shoots are gathered as they advance, till the end of June or beginning of July. A common rule is, to cease to cut, or to let asparagus *spin*, (grow up,) when green peas come in. With due attention, an asparagus quarter may be kept in a productive state for ten years or more. In cutting the shoots for use, some of the earth is removed, in order to enable the gatherer to avoid the succeeding buds below. Some use a common gardener's knife, and others employ a narrow-pointed knife, with its blade notched like a saw. Shoots two inches under the ground, and three or four above, make the best dishes of asparagus. The crop, if judiciously cut, may last nearly three months; from the middle of April to the middle of July. An asparagus quarter should not contain less than a pole of ground, as it often needs this quantity to furnish a good dish at one time. For a large family about sixteen roods are kept in a productive state, which are calculated to furnish, on an average, between 200 and 300 shoots every day in the height of the season. Several of the market gardeners in the neighbourhood of London have many acres of asparagus ground, as mentioned in a former part of this article, § 38.

355. The *forcing* of asparagus was practised in England in the middle of the 17th century. Meager mentions, that the London market was, at that period, supplied with forced asparagus early in the year: "Some having old beds of sparragus which they are minded to destroy, and having convenience of new or warm dung, lay their old plants in order on the dung, and the heat doth force forward a farewell crop," (p. 188.) The forcing of this article is now carried to a considerable extent in the neighbourhood of London. It is likewise very generally practised in private gardens.

A common hot-bed, prepared with horse dung, is formed according to the size of the frame or frames. A layer of turfs is sometimes placed on the dung, to prevent the access of the vapour from it, which is apt to hurt the flavour of the crop. About four inches of good light soil or old tan-bark are placed on the turf. In this plants six or eight years old are closely deposited. These plants are sometimes got from nurserymen, to whom such stock is no longer useful; or one of the oldest beds in the garden is for this purpose sacrificed, care being taken to have succession beds coming forward. But where the demand for the market, or for a private family, is regular, the best way is to have several successive beds in progress. Those plants intended for forcing may be transplanted as usual when one year old, but in much closer order, and so kept till the fourth year. A three-light garden frame will hold from 600 to 800 three-year-old plants. The roots are placed as close together as possible (as already hinted), with the buds standing upright, and covered with three or four inches of soil. The temperature of the dung is generally regulated merely by guessing the heat imparted to sticks plunged into it: if it becomes too weak, a *lining* of weeds or dung is heaped around the sides: if it prove too strong, some air holes are formed by pushing large sticks into the sides and withdrawing them, leaving empty spaces, or by removing the glass covers for some time. The proper temperature is about 55° Fahrenheit. Air is occasionally admitted, by raising the glasses a little; and sometimes a slight watering is necessary. At other times, in severe weather, mats are laid over the frames. A little fine light earth is sometimes added, once or twice, as the buds rise. In five or six weeks some of the shoots are generally fit for gathering. In France they often cut in a fortnight; but shoots produced in this rapid way are in a great measure colourless and tasteless, having been forced nearly without access of light and air. In gathering the shoots from a hot-bed, it is thought better to avoid cutting with a knife, and to employ only the finger and thumb; by a gentle twist the shoot is detached, and with less risk of injuring the tender buds below. Each light or frame yields on an average 300 shoots, which come in succession during about three weeks. Where a regular winter supply of this article is desired, beds are made up in succession accordingly from November to March. After being forced, the plants are cast on the dunghil as useless.

Mr Nicol describes a mode of forcing asparagus in flued pits, such as are used for young pine-apple plants. A layer of old half rotten bark, placed over well fermented dung, forms the bed, the plants being placed in light dry earth. Very little fire-heat is found to be necessary; generally a slight fire at night is sufficient. Watering, and the regular admission of air, are to be attended to. He remarks, that by means of very simple expedients, one half of a flued pit may be forced, and the other kept back, and thus a succession of shoots secured.

356. Asparagus, it may be remarked, was a favourite of the Romans; and they seem to have possessed a very strong growing variety, as Pliny mentions that, about Ravenna, three shoots would weigh a pound; with us, six of the largest would be required. It is much praised by Cato; and as he enlarges on the mode of culture, it seems probable that the plant had but newly come into use. In this country, Dutch asparagus was preferred in the end of the 17th century; and this variety is still distinguished for affording the thickest shoots. In a garden formed at Dunbar in the very beginning of the 18th century, by Provost Fall, (a name well known in the mercantile world,) asparagus was for many years cultivated with uncommon success. The variety used was the red topped, and it was brought from Holland. The soil of the garden is little better than sea sand. This was trenched two feet deep, and a thick layer of seaweed was put in the bottom of the trench, and well pressed together and beat down. This was the only manure used either at the first planting, or at subsequent dressings. There was an inexhaustible sup-

ply of the article generally at hand, as the back-door of the garden opens to the sea-shore.

Sea-Cale.

Sea-Cale.

357. *Sea-Cale, (Crambe maritima,* L.; *Tetradynamia Siliquosa;* nat. ord. *Cruciferæ*), is a perennial plant, growing naturally on many of the sandy and gravelly beaches of the west of England, and also among cliffs on the sea coast of Essex and Sussex. It is not mentioned by Lightfoot in his Flora of Scotland; but it grows on the shore of the Frith of Forth at Caroline Park, near Edinburgh. It is figured in English Botany, t. 924. The roots are spreading (rather than creeping, as they are commonly described); the whole plant is smooth, glaucous, or covered with a fine bloom; the lower leaves large and waved; the stalks rise near two feet high, producing white flowers, followed by spherical seed-pods, resembling peas, each containing only a single seed.

358. The common people, particularly on the western shores of England, have for time immemorial been in the practice of watching when the shoots begin to push up the sand or gravel, in March and April, and cutting off the young shoots, which are thus blanched and tender, and using them as a pot-herb. It was toward the middle of the 18th century, however, before sea-cale was introduced into the kitchen-garden. About the year 1767, it was first brought into general notice in the neighbourhood of London by the late distinguished Dr Lettsom, who cultivated it in his garden at Grove Hill. In the "*Gardener's Dictionary,*" published in 1774, by James Gordon at Fountainbridge, are contained directions for the cultivation of this vegetable, and for blanching it by covering the beds four inches deep with sand or gravel. A good many years afterwards, a detailed account of its culture was given by the Rev. Mr Laurent, in the third volume of Young's *Annals of Agriculture*. The late Mr Curtis, well known for his botanical writings, next published a tract recommending it; and in the first volume of the *Transactions of the Horticultural Society of London*, there is a very good paper on its cultivation, by Mr John Maher, gardener at Edmonton. It is now become a pretty common vegetable in Covent Garden market, and has even begun to appear on the green stalls of the Scottish metropolis.

359. The bed or quarter intended for sea-cale is trenched deep, at least two feet. The soil should be sandy and light, but at the same time mixed with fine rich mould; and it may here be noticed, that of all manures for this crop, *drift ware* or sea-weed is the best. The plant may be propagated either by offsets or pieces of the roots having two or three eyes or buds attached to them, or by seeds. The latter mode is generally preferred. The seeds are sown in March, perhaps about two inches deep. Three seeds are sometimes set in a triangular form, six inches apart, leaving a space of two feet between the triangles. If the quality of the seed is any wise doubtful, two or more are commonly put in each hole, to make sure of a crop, any superfluous plants being afterwards thinned out. During the first summer, the only culture necessary is hoeing, to keep the plants clear of weeds. In November, some gardeners cover the whole bed with rotten dung, in the way that is often practised with asparagus. This is raked off in the spring, and the surface of the earth stirred with the asparagus fork. During the second year, the same plan is followed. In the third year, most of the plants will be strong enough to be blanched for use.

Sea-Cale.

360. The blanching is accomplished in different ways. For a long time the only provision for this purpose was to make the shoots pass through several inches of soil before reaching the surface, and afterwards drawing up the earth to them as they advanced. It was an improvement to use sifted coal-ashes for the earthing up, and a farther improvement to use old tree-leaves for that purpose. Some cultivators placed hoops over the beds, and covered them close with mats. Large flower pots, such as are denominated No. 1, inverted over the plants, were found very useful in forwarding the etiolation, and in keeping the plant crisp and clean. Blanching pots with handles were afterwards used; and a figure of one of these is given, in the *London Horticultural Transactions*, vol. i. plate 1. A very great improvement in the constructing of blanching pots was suggested by Mr R. A. Salisbury, Secretary to the London Horticultural Society,—the making them in two pieces, or with moveable tops or lids. Such are now used in the neighbourhood of Edinburgh, and are found exceedingly convenient; a figure of one of them may be seen Plate CCCXII. Fig. 5. These pots should be nearly as wide at top as below, in order to give room for the cutting of such shoots as are ready, without breaking the others; and the covers should fit very nicely, so as to exclude light and air as completely as possible; the pot in this way serving not only for blanching, but to a certain extent for forcing. It is necessary to have from thirty to fifty such covers; each affording only as much as will form a dish, during the season. Sir George Mackenzie, Bart. whose name has more than once been mentioned as a horticultural improver, has described (*Scottish Hort. Mem.* i. 313) a simple and easy mode of blanching practised in his garden at Coul. This consists in covering the beds with clean dry straw, which is changed when it becomes wet or heavy. Oat straw, when it is broken in the thrashing-mill, is found to be well suited for this purpose.

361. It is justly remarked by Nicol, that vegetables are seldom improved by forcing; but that sea-cale is perhaps an exception; the forced shoots produced at midsummer being more crisp and delicate in flavour than those procured in the natural way, in April or May. Certainly no vegetable is more easily or more cheaply forced. It is done in two ways; either in the beds in the open air, or in hot-bed frames or flued pits. In the open air beds, the operation consists merely in placing blanching covers over the plants as soon as the leaves are decayed in the end of autumn; and then covering up the whole bed with stable-dung, packing it closely between the pots, and heaping it over the tops of them to the depth of six inches or more. In the course of December the sea-cale vegetates, and advances in proportion to the heat generated by the fermentation of the covering of dung. In general, it is fit for cutting in January and February. If the heat of the litter at any time decline, a portion of new stable dung is mixed with it. The advantages of having blanching pots with moveable lids, are, in this kind of forcing, very great: the temperature may more easily be ascertained, by lifting a lid in one or two parts of the bed, and introducing a thermometer: in the same way, it is easy to examine whether the shoots be ready for cutting, and to select the most forward from several stools, without materially disturbing the dung and dissipating the

Kitchen Garden.

Sea-Cale.

heat. The method of forcing sea-cale on the open ground was described by Mr Maher, in 1805, in the paper above alluded to; but he was not acquainted with blanching-pots having moveable tops. It is also described by Nicol, in his "Kalendar," 1810, with the improved blanching-pots. It is curious, therefore, that Abercrombie, in his "Practical Gardener," 1813, should take no notice of it, while he recommends planting sea-cale in hot-beds under frames and glasses.

362. Mr Barton, gardener at Bothwell Castle in Scotland, covers the sea-cale beds to the depth of a foot and a half, with leaves, as they fall from the trees, and are raked from the shrubberies and walks in the end of autumn, adding over all a very slight layer of long dung, sufficient only to keep the leaves from being blown about. The shoots rise sweet and tender among the leaves, early in the spring, being in some measure forced, and very perfect etiolation is at the same time accomplished.

In a hot-bed frame, or in flued pits, sea-cale is forced nearly in the same manner as asparagus. The plants should be strong and healthy, and at least three years old: they are by this mode of forcing exhausted, and not worth preserving. The best way therefore is, to sow a bed of sea-cale annually: in this way a regular succession of plants will always be ready, either for forcing in the open ground or in hot bed frames.

By the various improvements, therefore, of late years made in the culture of sea-cale, this desirable vegetable may be commanded for table, with very little trouble or expence, at any time from November till May; a period including all the dead months of the year. It may be affirmed that sea-cale shoots, when duly blanched, are not inferior to asparagus when prepared like it; and farther, that they form an excellent ingredient for soups. Not only the head or shoot (sometimes also called the crown) is fit for use, but the blanched stalks of the unfolding leaves, four or five of which are attached to each head. Before boiling, these are detached, and tied in small bundles like asparagus. It is a vegetable which (as remarked by Sir George Mackenzie, in the paper already mentioned) cannot easily be overdone in cooking; it should be thoroughly drained, and then suffered to remain a few minutes before the fire, that a farther portion of moisture may be exhaled. From four to six heads, according to the size, make a tolerable dish.

363. It is somewhat strange, that in France the use of sea-cale as a delicate culinary vegetable, should be nearly unknown. Bastien, in an edition of his popular *Manuel du Jardinier*, published in 1807, describes the *chou marin d'Angleterre* correctly enough: but he appears to have tried to make use of the full grown leaves, instead of the blanched shoots in early spring: a coarser mess can hardly be imagined; and it is no wonder therefore that he should deny the merits of sea-cale, and resign the plant, as he does, with a sneer, to colder climates!—*mais elle convient mieux que d'autres dans des climats froids.* When the French gardeners learn how to cultivate it, and particularly when they are able to force and to blanch it at mid-winter, by the simple means above described, there can be no doubt that sea-cale will become a favourite with the Parisians.

When seed is wanted, if two or three strong plants be left to flower, they will not fail to produce it in plenty. The flower is of a rich white colour, and gives the plant an ornamental appearance; when fully expanded, the flowers smell strongly of honey.

Kitchen Garden.

Artichoke.

Artichoke.

364. The *Artichoke* (*Cynara Scolymus*, L.; *Syngenesia Polygamia æqualis*; *Cinarocephalæ*, Juss.) is a perennial plant. It is a native of Italy according to Linnæus, and of the south of France, according to Garidel: but Beckmann, (*History of Inventions and Discoveries*, translated by Johnston, vol. i. p. 339, et seq.) has given reasons for thinking, that its native country is uncertain, the Italian and French specimens being probably only the outcasts of gardens, and that the plant mentioned by ancient Greek and Roman writers, is not to be considered as our artichoke, but as a similar plant, the true artichoke having been brought to Italy from the Levant only in the 15th century. It is not known to have been cultivated in English gardens till near the middle of the 16th century.

It is a remarkable and a well known plant in gardens. From the root spring many large pinnatifid leaves, three or four feet long, covered with an ash-coloured down; the midrib deeply channelled and furrowed. The appearance of the flower-heads is familiar. These, in an immature state, contain the part used, which is the fleshy receptacle, commonly called the *bottom*, freed from the bristles and seed-down, vulgarly called the *choke*. In the usual way of cooking, the entire heads are boiled. In eating, the portions of the receptacle adhering to the base of the calyx-leaves or scales are also used. The bottoms are sometimes fried in paste, and they form a desirable ingredient in ragouts. They are occasionally used for pickling; and sometimes they are slowly dried, and kept in paper-bags for winter use. In France the bottoms of young artichokes are frequently used in the raw state as a salad; thin slices are cut from the bottom, with a scale or calyx-leaf attached, by which the slice is lifted, and dipped in oil and vinegar before eating.

365. There are two varieties cultivated; the French, conical, or green artichoke; and the Globe or red artichoke. The head of the former is rather of an oval shape; the scales are open, and not turned in at top as in the globe artichoke. The latter is distinguished not only by the shape, and by the position of the scales, but by being chiefly of a dusky purple colour. The receptacle of the globe artichoke is more succulent than that of the French, but the latter is generally considered as possessing more flavour.

Artichokes are increased by rooted slips or suckers taken off at the time of the spring dressing, in the beginning of April. They delight in a light loam, cool but dry, and which is at the same time rich and deep. In preparing for this crop, the soil should be trenched to the depth of three feet, or at least two feet and a half, and manure should be liberally placed in the bottom of the trench. In dry weather, the young plants require regular watering for some time. Artichokes will grow pretty well in a situation somewhat shaded, but they should not be under the drip of trees. In a free and airy situation, however, the heads are of better quality.

Nicol mentions, that the strongest crops he ever saw, grew in rather a mossy earth that had been trenched fully a yard in depth, and had been well enriched with dung, and limed; and that the plants were generally covered before winter with a mixture of stable litter and sea-weed. This last article, we believe, is one of the very best manures for artichokes. In no place is the plant to be seen in greater perfection than in gardens in the Orkney Islands; and we know that the luxuriance of the plants in these is to be ascribed to the liberal supply of sea-weed dug into the ground every autumn. It was long ago remarked by a horticultural writer, that "water drawn from ashes, or improved by any fixed salt, is very good for artichokes." *Systema Agriculturæ*, 1682.

366. The plants are often placed four feet apart every way: sometimes they are planted three feet apart in rows, and the rows are kept six feet asunder. In many of the market-gardens near London, the rows are eight or ten feet from each other; intermediate low-growing crops are sown or planted, the artichokes being always allowed five feet free. Some gardeners plant two offsets together; and if both survive and prove strong, they afterwards remove one. Others plant three offsets in a triangular patch or stock, each offset being ten or twelve inches from the other; and these stocks are afterwards treated as if they were single plants. A crop of spinach or turnip is generally taken, for the first year, even between the closest rows. At the end of the first season after planting, a small and late crop of artichoke-heads is procured, generally in October. In the second year, the leaves of the plants will almost meet in the rows.

To encourage the production of large main heads, some detach all the lateral heads in a young state. These are commonly in a fit state for eating raw, having attained about one third of their proper size; and they are for this purpose frequently sold in Covent Garden market, chiefly to foreigners. Another thing practised with the same view, is the shortening the ends of the large leaves. When all the heads are gathered, the whole stalks are broken down close to the ground, in order to save the useless expenditure of sap, and to promote the setting out of young shoots at the root.

In November the plants are earthed up, or, in other words, a portion of earth is drawn around each plant. It was formerly a custom to make a trench between the rows, and to fill this trench "with dung which would not freeze;" the earth thrown out, forming a ridge around the plants. Some modern writers recommended the making of the trench, but omitted to speak of filling it with dung; so that the roots of the plants were thus more exposed than if the ground had been left untouched. In this way the forming of any trench came into disrepute; and, as already noticed, the best practical gardeners now only draw the earth from the surrounding surface towards the plants. Long dung, peas haulm, old tanners bark, or such stuff, are then laid around, but kept at some distance from the stems and leaves of the plants.

367. The spring dressing is equally important. The litter and earth being removed, in March or April, according to the kind of season, the stocks are examined; and two or three of the strongest or best shoots being selected for growing up, the rest are removed: this is often done merely by pressure with the thumb, but sometimes a knife or chisel is employed. It was formerly mentioned that this is the proper time for procuring young plants. It is remarked by gardeners, that the shoots from the under part of the stock, which are soft and crisp, are preferable to those from the crown of the roots, which have hard and rather woody stems. If the shoot be six or eight inches long it is enough; and if it be furnished with two or three small fibres, they are sufficient to ensure its growth.

Artichoke plants continue productive for several years; but, every season, some well-rotted dung or fresh sea-weed, should be delved into the ground at the winter dressing. It is certain, however, that after a few years, the plants begin to degenerate, the heads becoming smaller and less succulent. It is therefore a general rule not to keep an artichoke plantation beyond four or at most six years. Scarcely any kind of grub or wire-worm ever touches the roots of artichokes: they form, therefore, an excellent preparative for a crop of onions, shallot, or garlic. In many gardens a small new plantation is formed every year; and in this way the artichoke season, which begins in June, is prolonged till November; those from the old stocks continuing till August, when those from the new stocks come in. If the last gathered be cut with the stems at full length, and if these be stuck among moist sand, the heads may be preserved a month longer.

If some of the large heads on the old stocks be suffered to remain, the calyx-leaves expand, and the centre of the head becomes covered with jagged purple florets, producing a fine appearance. The flowers possess the quality of coagulating milk, and have sometimes been used in place of runnet. In general the seed is not perfected in our climate. When ripe seed is wanted, it is found useful to bend down the heads after flowering, in such a way that the autumnal rains may be cast off by the calyx-scales; and the heads are retained in this posture by being tied to stakes.

368. The *chard* of artichokes, or the tender central leaf-stalk blanched, is by some thought preferable to that of the cardoon. When the artichoke quarter is to be shifted, and the old stocks are at any rate to be destroyed, the plants may be prepared, after midsummer, when the best crop of heads is over, for yielding chards against winter. The leaves are to be cut over within half a foot of the ground; the stems as low as possible. In September or October, when the new shoots or leaves are about two feet high, they are bound close with a wreath of hay or straw, and earth or litter is drawn round the stems of the plants. The blanching is perfected in a month or six weeks. If the chards are wished late in winter, the whole plants may be dug up, before frost sets in, and laid in sand in their blanched state; in this way they may be kept for several weeks.

Cardoon.

Cardoon.

369. The *Cardoon*, (*Cynara Cardunculus*, L.) or, as it is sometimes written, *Chardon*, is known by nearly the same name in all the European languages. It is a perennial plant, and is considered as indigenous to the south of France and to Spain. It so greatly resembles the artichoke as to require no other description. It rises to a greater height than that plant, and becomes sometimes really a gigantic vegetable. It was cultivated in 1683, by Sutherland, in the Botanic Garden at Holyroodhouse, Edinburgh; but its use as a culinary plant was known in England previous to that period. The leaf-stalks of the inner leaves, which are fleshy and crisp, afford the eatable part, or chard. They are rendered white and tender by blanching, to the extent of two or even three feet. Cardoons are in season in winter; they are employed in soups and stews, and sometimes as a salad, eaten either raw or boiled. In this country they are not much in demand, and the crop is to be seen only in some private gardens, and in a few of the principal market grounds near London.

The best soil for cardoons is one that is light, and not over rich; but it ought to be deep. Although the cardoon is a perennial plant, it is sown for use every year. Formerly the plants were raised on hot-

Cardoon.

beds, and transplanted in May or June; but now the seed is generally sown where the plants are to remain. This is not done sooner than the middle or the end of May, lest the plants should be inclined to throw up flower-stems. Some gardeners sow in small hollows, perhaps three inches deep, and four feet distant from each other every way. Two or three seeds are placed in each hollow, for security; but only the strongest plant is ultimately retained. Others sow in trenches, prepared as for celery, and keep the plants much closer in line, not allowing more than nine or ten inches to each plant; it is better, however, that they should have more space. The cardoon requires a good deal of water; and in very dry weather this should be copiously afforded, as it tends both to make the leaves succulent, and to prevent the inclination to flowering. The young plants that are rejected in either way, may be transplanted, if wished; but in this case it is useful to preserve a small ball of earth with each plant, and liberal watering is proper.

370. In September, when the leaves are large, they are tied up for blanching, leaving only the top free. This is generally done with hay or straw bands, and a dry day must be selected for the purpose. At the same time a hillock of earth is formed around each plant, to the height perhaps of a foot or eighteen inches; and this is smoothed on the surface, that the rain may run off, and not fall into the centre of the plants. In proportion as they advance in growth, additional bands are added, and the earth is raised higher. When the plants are in trenches, they are gradually earthed up like celery, without using bands: the earthing is of course begun in July. In either way, the blanching is completed in about two months. If severe frost come on, the tops are covered with haulm or long litter. If cardoons be wanted more early, the tying and earthing may be begun sooner; but the leaf-stalk will not probably be found so broad and thick as it ought to be.

A few of the strongest plants are sometimes left, to produce their flowers and seeds the following year; but ripe seed is to be procured only in very favourable seasons in this country. It is therefore generally imported from Holland or France; and it keeps for several years.

In France, the native prickly plant is sometimes cultivated, under the name of Cardoon of Tours, and is accounted preferable to the common garden variety. So formidable are its spines, that great care is necessary in working about it, to avoid personal injury; a strong leather dress, and thick gloves, are therefore worn. This prickly sort has not yet been introduced into Britain.

Rampion.

Rampion.

370. The *Rampion* (*Campanula Rapunculus*, L.; *Pentandria Monogynia*, *Campanulaceæ*, Juss.) is a biennial plant; a native of England, but rare; figured in English Botany, t. 283. The lower leaves are oval-lanceolate, and waved. The whole plant abounds with a milky juice. The part used is the root, which is of the size and shape of a small radish, but of a white colour, and mild taste, or with only a slight degree of pungency and bitterness. It is eaten either raw, in fresh salads, or more commonly boiled like asparagus. It is much more esteemed in France, under the name of *raiponce*, than in this country. There the roots and the young leaves are used together in the spring months. So little is it cultivated here, that Nicol does not speak of it in his "Gardener's Kalendar."

The seed is sown in the end of May, in a quarter somewhat shady. If sown earlier, or in a warm sunny situation, the flower-stems would be apt to spring up the first year, when, as repeatedly mentioned in similar cases, the roots would become hard and unfit for use. The seed is very minute, insomuch that, to enable the gardener to sow it equally and thin enough, it should be mixed with sawings of timber. A thimble-full of the seed is sufficient to sow a large bed. When the plants are about an inch high, they are hoed, and thinned out to the distance of three or four inches from each other. They are afterwards to be kept free of weeds, and the surface is occasionally stirred. The roots are ready for use at the approach of winter, and continue good till the spring growth commences. If a few plants be left, a flower-stalk rises, and the pale purple bell-flowers appear in the end of July, followed by plenty of seed in the autumn.

Fresh Salad and Soup Herbs; Garnishes, &c.

Several of the principal plants which are used raw in salads, are likewise employed in making soups; such are lettuce, endive, and parsley. Others are merely salad plants; such are cresses and radishes.

Lettuce.

Lettuce.

371. *Lettuce* (*Lactuca sativa*, L.; *Syngenesia Polygamia æqualis*; *Chicoraceæ*, Juss.; *Laitue*, F.; *Gartensalat*, G.) is an annual plant, the original country of which is unknown. Some authors indeed seem inclined to consider it as merely an accidental variety, sprung from some of the other species of Lactuca. It was cultivated in England in the middle of the 16th century, and probably much earlier. The leaves are large, milky, frequently wrinkled, usually pale green, but varying much in form and colour in the different varieties. The use of lettuce as a cooling and agreeable salad is well known; it is also a useful ingredient in soups. It contains, like the other species of this genus, a quantity of milky juice of an opiate nature, from which of late years a medicine has been prepared by Dr Duncan senior of Edinburgh, under the title of *lactucarium*, and which he finds can be administered with effect in cases where opium is inadmissible.

372. Many varieties are cultivated: but these are generally considered as belonging to one or other of two kinds, the Coss (also called Roman and ice) and the Cabbage lettuce; the former with long upright leaves, the latter with the leaves round, rather flaccid, and growing squat upon the ground. The sorts at present most approved are, of the coss lettuces, the Egyptian green, and the white coss or Versailles; of the cabbage lettuces, the imperial, and the grand admiral, or admirable. The large Roman and the Cilicia lettuce, brown and green, are the kinds chiefly used in soups, or for stewing.

By means of successive sowings, and by care during winter, fresh lettuce is now produced almost the whole year round. The plants are used either when quite young and open, or when at full growth and cabbaged. A small sowing is often made in January, the seedlings being transplanted in March. A considerable crop is sown in the end of February; the main sowing is in March and April; and sometimes a portion of lettuce

Lettuce.

seed is sprinkled in along with onions or carrots, the lettuces being drawn before they can hurt the other crop. Lettuce seed is sown at broad-cast, and is merely raked into the ground. The plants bear transplanting very well, particularly in showery weather; and a part of each crop should be regularly transplanted, to come in season immediately after those left in the seed-beds. They may be transplanted very young; when they have four or six leaves, they are fittest for this purpose. They are placed from ten to fifteen inches apart, according to the size they are likely to attain. When it is wished to forward the cabbaging of cos lettuce, the leaves are sometimes tied together, in the manner practised with endive. If the winter do not prove very severe, lettuces will stand without much injury close by the foot of a south wall, and be fit for use in January, February, and March. In some places they are protected by hoops and mats; in others, by means of glass-frames; and sometimes a few cabbage lettuces are kept on a slight hot-bed.

When it is wished to save seed, the best plants of the approved kinds are selected, and planted at a distance from all others, so as to avoid any intermixture of pollen. If the plants have stood over winter, they produce their flowers more abundantly, the stem becoming thick, and rising between two and three feet high; and such plants also ripen their seed more certainly and early.

Endive.

Endive.

373. *Endive* (*Cichorium Endivia*, L.; *Syngenesia Polygamia æqualis; Cinarocephalæ*, Juss.) is an annual, or at most a biennial plant, a native of China and Japan. The root-leaves are numerous, large, sinuate, toothed, smooth; the stem rises about two feet high, is branched, and produces pale blue flowers. It was introduced into this country about the middle of the 16th century.

There are three varieties; Broad-leaved Batavian, Green curled leaved, and White curled leaved. The curled varieties having less of the bitter quality, are now generally preferred; and the green curled, being the hardiest sort, is adopted for the late or winter crops. Endive is one of the principal ingredients in autumn and winter salads, and is frequently used for stewing, and for putting in soups.

The seed is not sown till after the middle of May, often not till near the middle of June; because, if sown earlier, the plants would be apt to run to flower. Another sowing is made in July. The seeds are scattered thinly, so that the plants may not rise in clusters, and become weak. When they are about three or four inches high, they are transplanted into a well prepared bed of rich soil, in rows a foot asunder, and at the distance of ten inches from each other in the row; or in large drills, at the same distances, the blanching being in this way facilitated. In dry weather, watering is necessary.

374. The blanching is the next operation; and on this being well done, the tenderness, crispness, and mild flavour of the endive depend. It is accomplished by tying up the heads with strands of bass-mat or small willow twigs: this must be done when the plant is dry, that is, when neither rain nor dew rests on it; and some nicety is requisite in gathering the leaves together in regular order, so as not to cross each other, and in rejecting such leaves as are unhealthy. The plants are at first tied two inches below the top; afterwards about the middle of the plant. In three weeks or a month they are found to be blanched; and they continue fit for use in this state for about a fortnight. A few plants are therefore tied up every week, when the weather permits, in order to their being ready for use in succession.

The plants from later sowing are placed in sheltered borders near a wall or hedge; and when very severe weather comes on, the rows are protected with dry fern or any other light covering. After October, indeed, the mode adopted is to make some trenches or small oblong mounds of earth, and to sink the plants nearly to the head in these: here they become sufficiently blanched in four or five weeks; and if additional plants be sunk in the trenches every fortnight when the weather happens to be so mild and dry as to permit it, the endive season may be continued for a long time. Endive thus blanched in the earth must be dug out with the spade, and it requires to be very thoroughly washed.

A few of the strongest and most early plants are selected for producing seed. These are planted in the beginning of March, in a sheltered situation, if possible near a paling, to which the flower-stems may be tied, so as to prevent accidents from the wind. The flowers come out in June, and are succeeded by ripe seeds about the middle of July. The seeds are gathered at different times, as they are observed to become ripe.

Parsley.

Parsley.

375. *Parsley* (*Apium Petroselinum*, L.; *Pentandria Digynia; Umbelliferæ*) is a biennial plant, considered as a native of Sardinia, but naturalized in several places of England and Scotland.

Three varieties are cultivated; Common parsley, and Curled parsley, for the leaves; and Large-rooted or Hamburgh parsley, for the roots.

The common and the curled parsley are raised in drills, generally on the edges of a border in the kitchen-garden. They are sown in February or early in March, as the seeds lie from a month to six weeks in the ground before springing. Parsley bears transplanting, so that blanks in the edging may easily be filled up in rainy weather.

In order to have fresh parsley leaves through the winter, it is worth while to lay some larch or beech branches, or long broom, over the parsley border, and above these, in hard weather, a little dry bean haulm, *braken* fronds, bents or reeds, preferring the two latter articles on account of their durability. Mr Nicol remarks, that in this way fine young parsley may be had all winter, and may be gathered even from under the snow.

If a few strong plants be allowed to run to flower in May or June, plenty of seed will be produced in August.

It may be right to notice, that the poisonous plant called fool's-parsley (*Æthusa Cynapium*), a common weed in rich garden soils, has sometimes been mistaken for common parsley. They are very easily distinguished: the leaves of fool's-parsley are of a darker green, of a different shape, and, instead of the peculiar parsley smell, have, when bruised, a disagreeable odour. When the flower-stem of the fool's-parsley appears, the plant is at once distinguished by what is vulgarly called its *beard*, three long pendent leaflets of the involucrum. The timid may shun all risk of mistake, by cultivating only the curled variety. This last, it may be remarked, makes the prettiest garnish.

Hamburgh Parsley.

Hamburgh parsley.

376. ***Hamburgh parsley***, although considered only as a large-rooted variety of the common kind, is somewhat different in its whole appearance. The leaves have longer foot-stalks, and their subdivisions are not so numerous; the leaflets, at the same time, are much broader, and of a darker green. The roots are at least six times larger than those of common parsley. For the sake of these it is cultivated; and this variety might therefore without impropriety be ranked among the esculent roots.

It was introduced by Philip Miller, from Holland, in 1727. He could not for some years persuade the market-gardeners of London to cultivate it: Now, however, it is regularly brought to Covent Garden; but in many parts of the country it still remains nearly unknown. The roots, which are the size of ordinary carrots or parsnips, are of a white colour, sweet and tender: they are frequently boiled and eaten like carrots, and are excellent in soups and stews.

The culture of this variety of parsley necessarily differs from that of the other two, the object being here to produce large roots. In March or April it is sown in beds, the soil of which has been deeply delved, or perhaps trenched, and at the same time made fine. The plants are afterwards thinned out with the hoe to six or eight inches asunder; and this is all the culture they require. They are ready for drawing in the end of August. In October the roots are commonly raised, and placed in sand till wanted. They have more flavour, however, when newly taken from the ground; and if a bed be sown about midsummer, the roots continue young and good through the winter, being raised when the weather permits.

Celery.

Celery.

377. *Celery* (var. of *Apium graveolens*, L. or smallage) is a biennial plant. Smallage grows in many places in England and Scotland, frequently by the sides of ditches near the sea. It is figured in *English Botany*, t. 1210. The effects of cultivation in producing upright, mild, and sweetish stems of celery from an original stock of a rank coarse taste and abounding with suckers, are very remarkable. The blanched leaf-stalks are used raw as a salad, from August till March; and also in soups or for stewing.

378. Two very distinct kinds of celery are cultivated; the Upright or Italian, and the Celeriac or turnip-rooted celery. Of the former there are two sub-varieties, with hollow and with solid stalks. The hollow is much cultivated for eating as salad; the solid is considered as preferable for soups and stews, and indeed is by many accounted the best for all purposes; but it is less able to endure the severity of winter, and is very brittle, and therefore troublesome to the market-gardener. There is a large upright variety with red stalks, much used for kitchen purposes. Celeriac differs chiefly in the roots swelling out like turnips: these are cut into slices, and either eaten raw in salads, or used as an ingredient in stewed dishes and soups. The leaves, at the same time, are shorter than in the other varieties, and spread open horizontally. Celeriac is not often brought to market.

Celeriac.

Celery is sown at several different times, in order to ensure a succession of plants fit for transplanting at various seasons. The first sowing is commonly about the beginning of March, on a gentle hot-bed; the second, perhaps three weeks afterwards, on a sheltered border; the third, about the beginning of May, on a moist shady border. The strongest plants of the first sowing are generally ready, from the middle to the end of April, for pricking into nursery beds of rich earth, in which they may stand separate three or four inches every way, in order to gather strength. Water is given, and the plants are shaded from the sun for a few days. A quantity of every successive sowing should thus be pricked out. Some gardeners, however, content themselves with sowing very thin, and take the plants directly from the seed-bed to be placed in the trenches; but it is not a good plan. If any plants be inclined to run to flower, it is better they should shew this tendency in the nursery-bed.

Celery.

379. An improvement on the formation of the seedling-bed has been adopted at Mr Walker's of Longford, near Manchester. It is made entirely of very old hotbed dung, laid thinly on a piece of well trodden soil, or ground beat hard with the back of the spade, so as to be impervious to the roots. The young celery plants, therefore, form bushy fibrous roots, as they cannot send down tap-roots: and in consequence of this, they shew no inclination to throw up a flower-stem till the following spring.

Towards the end of May, the most forward plants may be transplanted into the trenches for blanching. In dry weather, at this season, water is given freely both to the transplanted plants, and to those left in the seed-bed. The usual modes of transplanting and blanching are the following: Trenches are formed, at the distance of three or four feet from each other, a foot and a half wide, and about a foot in depth. The soil in the bottom of this trench is delved and worked fine; and, if thought necessary, a little rotten dung or rich compost is mixed with it. The soil for celery should be deep and rich, somewhat moist, yet of a light nature: in mossy earth, if moderately dry, it succeeds remarkably well; the natural plant, smallage, as has been remarked, delights in growing by the sides of ditches. The earth taken from the trench is laid in ridges on each side, ready to be drawn in as wanted. The plants being trimmed, or having the tops of the long leaves cut off, and any side shoots removed, are placed in the bottom of the trenches, at the distance of four or five inches from each other. As they advance in growth, the earth is drawn in towards them, perhaps once in ten days, taking care to perform this operation only in dry weather, and not to cover the heart or centre of the plants with soil. When the plants rise considerably above the surface of the ground, all the earth laid in ridges will be exhausted; a new trench, therefore, is now opened between each row, for a supply of soil to continue the earthing up till the celery be fit for use, or till the leaf-stalks be blanched from eight to fourteen inches in length. The management of all the sowings is similar. The last is destined to stand over winter; and although the seedlings were directed to be raised on a moist shady border, the soil into which they are finally transplanted, should be as dry as possible. In severe weather, peashaulm or other loose litter is thrown over the beds. It is a common complaint, that very fine looking celery is often found to be rotten at the base of the leaf-stalks: the fact is, that after the blanching is completed, celery will not keep good in the ground for more than a month

Celery.

at most. The necessity of successive crops is therefore evident. In lifting the plants for use, it is proper to dig deep, and to loosen the roots with the spade, so that the entire celery plant may be drawn, without risk of breaking the leaf-stalks or injuring the main roots, the fleshy tender part of which is relished by many.

380. Celeriac, after being raised in a seed-bed, is planted out on level ground, or in very shallow drills, as it requires but one earthing up, and that a slight one.

Attentive gardeners generally save celery seed for their own use. All that is necessary, is to select several strong healthy plants of the winter stock, and plant them out in rich soil early in the spring. When the stems run up to flower, they are apt to be broken by high winds, and should therefore be secured by stakes. The seed is ready in the end of August, and is dried in the usual way. It may be mentioned, that the seed, when bruised, communicates the celery flavour to soups, and may be thus employed when stalks or roots cannot be procured.

Garden-Cress.

Cress.

381. The *Garden-cress* (*Lepidium sativum*, L.; *Tetradynamia Siliculosa*; *Cruciferæ*, Juss.) is an annual plant, the native country of which is not known. Besides the common or plain sort, which is the kind principally used for salads, there are two varieties, with curled leaves and with broad leaves. The plant partakes strongly of the smell and taste which distinguish the Cruciferæ. Like mustard, it is very easily raised during winter on a slight hot-bed; and in the spring months, in close patches, under hand glasses, in the open border, or in drills near a south wall, or in front of a hot-house. It is therefore a favourite article in winter and early spring salads. Where it is wanted through the summer, it must be sown once a fortnight, as it is only fit for use when young and tender. The plain cress is sown thick, and remains so; but the curled and the broad-leaved require to be thinned out to half an inch asunder. The curled variety makes a pretty garnish; it is rather the hardiest of the kinds, and may therefore be sown late in the season. If a row of cress plants of each of the different sorts be allowed to spring up, plenty of seed will be produced in the autumn. During winter, cresses are often raised on porous earthen-ware vessels, of a pyramidal shape, having small gutters on the sides, for retaining the seeds. These are called pyramids; they are somewhat ornamental, and they afford repeated cuttings.

American Cress.

American cress.

382. The *American Cres*, (*Erysimum præcox*, Smith; *Tetradynamia Siliquosa*; *Cruciferæ*, Juss.), although its name might lead us to expect a transatlantic origin, is a native plant of this country. It was formerly considered as a variety of the common winter-cress, (*E. barbarea*); it was described as such by Ray and Petiver: Miller made it a distinct species, by the name of *E. vernum*; and Sir J. E. Smith has figured and described it, under the name of *E. præcox*, *Eng. Bot.* t. 1129. It is only biennial; while the common winter-cress is perennial. It has smaller leaves, more frequently sinuated; the pods thicker, and the seeds larger. It is often called Black American cress, and sometimes French cress.

Mustard.

It is either sown at broad-cast, on a small bed of light earth, or thinly in drills a foot asunder. Three or four sowings are usually made, at intervals of about five weeks, from March to July; and in this way young leaves are always to be had. A late sowing is made in August or September on some sheltered border; the plants stand the winter without injury, and are fit for use in February and March. The plants being cut over, or the outside leaves gathered, new leaves are produced, fit for use in succession.

White and Black Mustard.

Mustard, (*Sinapis*, L.; *Tetradynamia Siliquosa*; *Cruciferæ*, Juss.), is of two kinds, white and black. Both are annual plants, and both natives of this country.

White mustard.

383. *White mustard*, (*S. alba*), grows naturally in our fields, though not so common as some of its congeners. It is figured in *English Botany*, t. 1677. It is cultivated only as a small salad, and is used while in the seed-leaf, along with cresses. It may be raised at all seasons; during winter, in boxes in a hot-house or on a hot-bed. When it is wished to save the seeds, a spot of ground somewhat remote from other similar plants should be chosen.

Black mustard.

384. The *Common* or *Black mustard*, (*S. nigra*) is a more common native than the white. It is figured in *English Botany*, t. 969. The French call the plant *senevé*, and confine the term *moutarde* to prepared table mustard. The tender leaves are sometimes used as greens in the spring, and the seed-leaves occasionally as a salad ingredient; but the plant is chiefly cultivated for the seed, which, when ground, affords the well known condiment. If the seeds taken fresh from the plant be ground, the powder has little pungency, but is very bitter; by steeping in vinegar, however, the essential oil is evolved, and the powder becomes extremely pungent. In moistening mustard powder for the table, it may be remarked, that it makes the best appearance when rich milk is used; but this mixture does not keep good for more than two days. The seeds in an entire state, are often used medicinally.

The black and the white mustard plants may be distinguished by observing, that the black is a larger plant than the white; that it has much darker leaves than the white, and the divisions of the leaves blunter; the whole upper part of the plant smooth, and the upper narrow leaves hanging downwards; the flowers small, the pods generally quite smooth, and lying close to the stem; while, in the white, the flowers are large, the pods rough or hairy, and standing out from the stalk. The names white and black are given in consequence of the colour of the respective seeds.

Black mustard is principally cultivated in fields; but a small bed of it in the garden is often found convenient. The plants require considerable space, and repeated hoeings. The seed ripens in August.

Chervil.

Chervil.

385. *Chervil*, (*Scandix Cerefolium*, L.; *Pentandria Digynia*; *Umbelliferæ*), is an annual plant, a native of various parts of the continent of Europe, and sometimes observed naturalized near gardens in England, but not admitted into our Flora by Sir J. E. Smith. The leaves are of a very delicate texture, three times divided. The plant rises from a foot to near two feet high, when in flower; but it is the foliage only when in a young state that is used. It was formerly much

Chervil.

more cultivated in gardens than it is at present. The young leaves, however, are still sometimes put in soups, and frequently form an ingredient in salads.

It may be right to mention, that care should be taken to distinguish between this and the rough chervil, (*Scandix Anthriscus,*) which is a common denizen of our way sides, and not a wholesome plant. The seeds of the wild species are rough or prickly, while those of garden chervil are smooth. While the plants are only in leaf, they may be distinguished by those who are no botanists by the smell; the leaves of garden chervil, when rubbed, emitting a pleasant scent; while the smell of the wild kind is disagreeable. Chervil is much relished in Holland; and it is said, that some of the Dutch soldiers brought into this country to repress the rising in favour of the Stuarts, perished by using our wild species.

The seeds of garden chervil are sown in autumn, soon after they have ripened, commonly in shallow drills, about eight inches apart. They quickly come up, remain during winter, and are fit for use very early in the spring. Chervil may be repeatedly cut like parsley. It may also be sown in spring or summer; but at these seasons it almost immediately runs to flower. If a few plants be left uncut, they will afford plenty of seed in the end of July. There is a very beautiful variety cultivated in the Paris gardens, with finely frizzled leaves.

Purslane.

Purslane.

386. *Purslane* (*Portulaca oleracea*; *Dodecandria Monogynia*; *Portulaceæ*, Juss.; *Pourpier* of the French) is an annual plant, a native of the East. It has a round smooth rather procumbent stem, and diffused branches; the leaves somewhat wedge-shaped and fleshy; the flowers yellow, and sessile. Purslane was well known in England at least as early as the middle of the 16th century. The young shoots and succulent leaves are the parts used. They were formerly much more in request for salads and pickles, and as pot-herbs, than they are at present.

There are two varieties, the Green and the Golden, the principal difference consisting in the colour, but the former being rather the more hardy. Purslane requires a warm situation, and a rich light soil. It is sown any time from May to July. Nicol, in his "Kalendar," speaks of sowing it in the open border in the end of March; but this may be considered as an oversight, the time being much too early. The seed is very small, and attention is necessary to the sowing of it thinly. In dry weather, it is proper to water the young plants at night two or three times a week. With this care they will be three or four inches high, and ready for cutting, in the space of six weeks. Purslane when cut over springs again, and it may be repeatedly cut. When thus taken young, it is of a cold and tender nature, and forms a pleasant salad. If it be wanted earlier than June, it must be raised on a hot-bed, and planted out toward the end of April. If a few of the earliest and strongest plants be left, they soon run to flower; and in warm seasons they ripen their seeds; but imported seed is always to to be had in the shops, and it keeps good for several years.

Fennel.

Fennel.

387. *Fennel* (*Anethum Fœniculum*, L.; *Pentandria Digynia*; nat. ord. *Umbelliferæ*) is a perennial plant, which, though not an original native, is now so completely naturalized in several parts of England, that it has been admitted into the British Flora by Sir J. E. Smith, and figured in "English Botany," t. 1208. Fennel or finckle has long been an inmate of our gardens. Its finely cut leaves and capillary leaflets make it an ornamental plant, especially when strong, rising perhaps to the height of five or six feet. Three varieties are cultivated; the dark green leaved, the sweet fennel, and finochio or Azorian fennel. The tender stalks of common fennel are used in salads; and the leaves boiled enter into many fish sauces. The blanched stalks of finochio are eaten with oil, vinegar, and pepper, as a cold salad; and they are likewise sometimes put into soups.

Common fennel will grow in any soil or situation. It may be propagated either by parting the roots, or by seeds. The seeds should be sown in autumn soon after they are ripe. A few plants are sufficient for a family, and they endure for many successive years.

Finochio.

Finochio is a dwarfish variety, characterized by a tendency in the stalk to swell to a considerable thickness. This thickened part is blanched by heaping earth against it, and is then very tender. As the plant grows rapidly, and the swoln stem is best when young and tender, several successive sowings are requisite, at least where the article is much in request. Owing to the peculiar nature of this variety, it is more tender than the common fennel, and often perishes in the course of the winter. Misled by this circumstance, several horticultural writers describe it as an annual species.

Dill.

Dill.

388. *Dill* (*Anethum graveolens*, L.) is a biennial plant, a native of the corn fields in Spain and Portugal. It has long been cultivated in our gardens as an aromatic and carminative, and the leaves were formerly used in soups and sauces; but the plant is now scarcely employed, unless that the seeds are sometimes added to cucumber pickles. In order to ensure a crop, the seeds should be sown when they ripen in autumn. If some plants be allowed to scatter their seeds, plenty of seedlings will rise in the spring.

French and Common Sorrel.

Sorrel (*Rumex*; *Hexandria Trigynia*; *Polygoneæ*, Juss.; *Oseille* of the French) is of different kinds.

French sorrel.

389. *French sorrel* (*R. scutatus*, L.) is a perennial plant, a native of France and Italy; it was cultivated in England before the middle of the 17th century, and it is now common. The leaves are somewhat cordate or hastate, but blunt or rounded, and entire; glaucous, smooth, soft, and fleshy; the stems rise from a foot to a foot and a half high. It is sometimes called Roman sorrel; and, from the breadth and bluntness of the leaves, gardeners often distinguish it by the name of Round-leaved sorrel; our native species being their Long-leaved sorrel. The acid is considered as more grateful than that of common sorrel, and the leaves are more succulent; it is therefore preferred for kitchen use. The plant runs at the root, and is in this way easily propagated. It grows best in a light sandy soil; and the plants are placed about a foot apart. The only attention it requires is the cutting off of the flower-stems and branches in July, so that new leaves may push out for autumn use. In three or four years, however, the plants generally give indications of decay; and new

ones must be raised from seed, or offsets procured from young and vigorous plants. If a few stems be allowed to remain in the summer, plenty of seeds may be procured in autumn.

Common sorrel.

390. *Common Sorrel* (*R. Acetosa*, L.) is a well-known perennial native, growing in meadows and by the sides of rivers; and is figured in "English Botany," t. 1270. The lower leaves have long foot-stalks; they are arrow-shaped, blunt, and marked with two or three large teeth at the base: the upper leaves are sessile, and acute. It is easily raised from seeds sown early in the spring. It thrives best in a shady border. The leaves are used, like those of French sorrel, in various soups, sauces, and especially in salads. As formerly mentioned, they give an excellent flavour to herb patience, used as a substitute for spinach. This species, it may be remarked, is used in France nearly as much as the other, which we generally call French sorrel.

There is a third species of sorrel, reckoned by the Parisians more delicate than either of the others. It is the *Rumex arifolius* of the *Flore Française*. Its leaves are larger and less acid; and it very rarely throws up a flower-stem.

Wood-sorrel.

391. *Wood-sorrel* is an entirely different kind of plant, (*Oxalis Acetosella*, L.; *Decandria Pentagynia*; belonging to the *Gerania* of Jussieu.) Having a very grateful acid taste, the leaves form a desirable addition to salads, particularly when young, in the months of March and April. It is to be found in almost every wood: but if the roots be transplanted, in tufts, into the more shady parts of the shrubbery, they will there establish themselves, and be at hand when wanted.

Corn-Salad.

Corn-salad.

392. *Corn-salad*, or *Lamb's Lettuce* (*Valeriana olitoria*, Willd.; *V. Locusta*, Lin.; *Tetrandria Monogynia*; *Dipsaceæ*, Juss.) is a small annual plant, growing on the margins of our fields, (*Eng. Bot.* t. 811.) and only 2 or 3 inches high. Cultivated in gardens, it rises, when in flower, a foot or more in height. The leaves have a pale glaucous hue; they are long and narrow, the lower ones rather succulent. The flowers are very small, pale bluish, and collected into a close little corymb. In the fields, lamb's-lettuce may be gathered in March, and it flowers in April. In gardens it may be had still more early in the spring; indeed during the greater part of a mild winter. The tender leaves are little inferior to those of young lettuce, having a slight agreeable flavour; they form an excellent ingredient in winter and early spring salads. It has very long been a favourite spring salad-plant in France, under the various denominations of *mâche*, *doucette*, *salade de chanoine*, and *poule-grasse*. Gerarde tells us, that foreigners using it when in England led to its being cultivated in our gardens. The seeds are sown in autumn, generally about the end of August. They are either sown at broad-cast or in drills, on a small bed or border. The plants soon rise, with a low tuft of oblong narrow leaves: they are then thinned out to two or three inches asunder: and in February they are fit for use. The entire plant is drawn, in the manner of lettuce. The younger the plants are when used, the better: in warm dry weather, the leaves soon acquire rather a strong taste, disagreeable to many persons. Sometimes a small sowing is made in February, which affords plants with fine tender leaves in April and May. A few plants may be allowed to spring up to flower, and they perfect their seeds in July and August. The culture of lamb's lettuce, as a salad plant, has for some time past been declining, but without any good reason.

Milk-Thistle.

Milk-thistle.

393. The *Milk-Thistle*, or *Our Lady's Thistle* (*Carduus Marianus*, L.; *Syngenesia Polygamia æqualis*; *Cinarocephalæ*, Juss.) is a biennial plant, a native of Britain, (*Eng. Bot.* t. 976.) It is at once distinguished by the beautiful milky veins which form an irregular network on the leaves. Some readers may be surprized to find a native thistle ranked among our esculent plants; but it is certainly not more unpromising at first aspect than the artichoke or the cardoon. When very young, it is eaten as a salad; the tender leaves stripped of their spines, are sometimes boiled and used as greens; the young stalks peeled, and soaked in water to extract a part of the bitterness, are said to be excellent; early in the spring of the second year, the root is pretty good, prepared like salsify or skirret; the receptacle is pulpy, and eats like that of the artichoke. The young plants are sometimes blanched like endive, and used in winter salads: for this purpose the seeds are sown in spring, and the plants are allowed to remain about a foot and a half distant from each other; in autumn, the leaves are tied together, and the earth drawn up close to them, till they be whitened. The plant, however, is but rarely cultivated for any culinary purpose.

It grows naturally, or has been naturalized, near all the old castles or strongholds of Scotland, such as the castles of Edinburgh, Stirling and Dunbarton. From this circumstance, and the formidable spines of the calyx, many consider it as the "true Scots thistle," the national badge. But the way-thistle (*Carduus lanceolatus*) is incomparably more common in that country. The Gardeners Lodge of Edinburgh, it may be remarked, generally adopts the cotton-thistle (*Onopordum acanthium*) as its emblem; but apparently without any good reason, that plant existing only in one or two parts of the country. It may be added, that the representations of the Scots thistle, whether carved on ancient buildings, impressed on the coins of the realm, or emblazoned on armorial bearings, as seen in seals or in old engravings, bear equal resemblance to all of these, or, to speak more correctly, are equally unlike any thistle described by Linnæus, as they are dissimilar to each other.

Burnet.

Burnet.

394. Burnet (*Poterium Sanguisorba*, L.; *Monœcia Polyandria*; *Rosaceæ*, Juss.; *petite pimprenelle* of the French,) is a perennial plant, growing naturally in some parts of England, in dry upland pastures. It is figured in "English Botany," t. 860. The leaves are pinnated; they form a tuft next to the root, but are alternate on the stem; the leaflets are partly round-shaped, partly pointed, and much serrated on the edges. The stem rises fifteen inches high, and the flowers form small greenish or purplish heads.

Burnet leaves are sometimes put into salads, and occasionally into soups; and they form a favourite ingredient for cool tankards. When slightly bruised, they smell like cucumber, and they have a somewhat warm taste. They continue green through the winter, when many other salad plants are cut off, or in a state unfit for use. The plant is easily raised by sowing the seeds in autumn, soon after they are ripe; or it may be increased by parting the roots. A few plants are sufficient, as it is not much in use. To promote the production of young leaves and shoots, the stems are two or three times cut over during the summer.

Rape.

Rape.

395. *Rape, or Coleseed,* (*Brassica Napus*) is sown thick as a salad herb, to be cut while in the seed-leaf, in the same way as mustard. A variety of this plant affords the small French turnip or navew, already treated of § 318. Some consider rape leaves as a good stomachic, and take them boiled.

In the same way, radish seed (*Raphanus sativus*, § 329.) is sometimes sown thick, and cut in the seed-leaf for use.

Horse-radish.

Horse-radish.

396. *Horse-radish* (*Cochlearia Armoracia*, L.; *Tetradynamia Siliculosa; Cruciferæ*, Juss.) is a perennial plant, growing naturally in marshy places and by the sides of ditches in some parts of England, and figured in "English Botany," t. 2223. The leaves are very large, and vary considerably in appearance; being sometimes entire, or only crenated, sometimes deeply pinnatifid; the flowers are white, and come in loose panicles. It has long been cultivated in gardens; the root scraped into shreds, being a well known accompaniment of the roast beef of Old England, and also used to give a zest to winter salads. The soil should be rich and deep, in order to induce the plants to strike their roots freely. Crowns having about two or three inches only of root attached to them, make very good plants; but cuttings of the knotty parts of the roots, provided always they be furnished with one or two buds or eyes, are often preferred, as they are to be planted entirely under the soil. They are generally planted, in February or March, in lines, leaving a foot and a half between each line; and for the first season therefore, a slight crop of spinach or lettuce may be taken between the lines. The sets are placed at the depth of at least a foot; if the soil be light, fifteen inches is not too deep. The roots are not dug for use till the second year; and they are raised only when wanted, the pungent quality escaping rapidly as the root dries. The bed lasts for four or five years; care being taken, in digging the roots, to leave the stock plant, or original set, untouched, removing for use only the upright straight root of twelve or fifteen inches in length, produced by planting at that depth.

Indian Cress.

Indian Cress.

397. *Indian Cress, or Nasturtium,* (*Tropæolum majus*, L.; *Octandria Monogynia*; *Gerania*, Juss.) is a native of Peru: it was introduced into England near the close of the 17th century. It is the *capucine* of the French. The stalks, if supported, will rise six or eight feet high; the leaves are peltate, or have their petiole fixed to the centre of the leaf; the flowers are very showy, of a brilliant orange colour, and continue in succession from July till destroyed by frost. In its native country it endures several seasons; but here, being unable to sustain our winter, it is treated as an annual plant and sown every year. The flowers and young leaves are frequently eaten in salads; they have a warm taste like cresses, and from this circumstance the name of *nasturtium* has been bestowed. The flowers are also used as a garnish to dishes, and form a beautiful contrast with the flowers of borage. The seeds when green, form a favourite pickle; they are often called capers, and substituted for them.

Indian cress.

If the seeds be sown in April in drills about two inches deep, in places where the stalks can have support, no other care is necessary. A fresh but poor soil is better than a rich one, which last makes them too rampant and less fruitful. The plant is often employed as a temporary hedge or screen, to hide any disagreeable object, stakes being fixed which it soon completely covers. Although destitute of proper tendrils, the petioles or leaf-stalks make a peculiar bend, by which they attach themselves to any small body coming in the way, and support the plant. The seeds ripen freely in September, and may then be gathered for pickling, keeping some of the largest and ripest for next year's sowing.

There is a variety with double flowers, which is continued by cuttings, and sheltered in a hot-house, or the warmer part of a green-house, all winter. It is both highly ornamental as a flower, and forms a still more beautiful garnish than the single.

Dwarf Indian cress.

398. *Dwarf Indian Cress,* (*Tropæolum minus*, L.) is also a Peruvian plant, and an annual; it is cultivated in the same way, and for the same purposes as the other. It is generally sown on borders, and allowed to spread on the ground. There is likewise a double variety of this, which forms a very pretty greenhouse ornament.

Marigold.

Marigold.

399. *Marigold, or pot marigold,* (*Calendula officinalis*, L.; *Syngenesia Polygamia necessaria; Corymbiferæ*, Juss.) is an annual plant, a native of France and Spain; but one of the oldest and best known inhabitants of our gardens, its flowers having formerly been much in repute, as "comforters of the heart." Though little faith is now placed in its virtues, it still keeps its place; it is to be found in most cottage gardens both in England and Scotland; and Mr Marshall observes, that "the flower is a valuable ingredient in broths and soups, however it may have got into disuse." The flowers are dried in autumn, and kept in paper bags for use. The single-flowered orange marigold is most aromatic, and the most proper for keeping. There is a pale flowered variety, called the Lemon-coloured marigold; and there are double-flowered varieties both of the orange and lemon colour. The most curious variety is the childing or proliferous, which sends out small flowers from the margins of the calyx of the large central flowers; but this sort is very apt to degenerate; to give a fair chance of preserving it, seed should be saved only from the large central flowers. The common marigold sows itself abundantly, and the seedlings may be transplanted in May; so that, when the plant has once established itself, there is seldom any need for sowing.

Borage.

Borage.

400. *Borage* (*Borago officinalis*, L.; *Pentandria Monogynia;* nat. ord. *Asperifoliæ*) is an annual plant, either a native or completely naturalized in many parts of Britain; (*Eng. Bot.* t. 36.) The lower leaves are oblong and spread on the ground; the flower-stems rise near two feet high; both they and the leaves are rough with white bristly hairs; the bright blue flowers make a beautiful appearance, and are produced for several months in succession. Borage was

Borage.

formerly high in estimation as a cordial plant, for driving away sorrow; but "very light surely (says Sir J. E. Smith) were those sorrows that could be so driven away." It is still sometimes used when young as a pot-herb, and in salads; the spikes of flowers form an ingredient in cool tankards, and the blossoms are occasionally employed as a garnish. The juice of the plant affords nitre, and the withered stalks have been observed to burn like match-paper. Borage will sow itself, and come every year. There is a variety with white flowers, and another with flowers of a pale red or flesh colour; but neither is common.

Angelica.

Angelica.

401. This is the *Angelica Archangelica* of Linnæus, (*Pentandria Digynia; Umbelliferæ*): it is a biennial plant, with very large pinnate leaves, the extreme leaflet three lobed. The roots are long and thick; and they, as well as the whole plant, are powerfully aromatic. It is truly a northern plant, being common in Lapland and Iceland. It was cultivated in Britain in 1568, and probably more early. The stalks of it were formerly blanched, and eaten as celery. Now they are used only when candied; and the young and tender stalks are for this purpose collected in May. Though the plant is only a biennial, it may be made to continue for several years, by cutting over the flower-stem before it ripen seed; in which case it immediately sets out below. It is easily raised from seed, which should be sown soon after being gathered. It grows best in a moist soil, and thrives exceedingly by the side of a ditch.

Love-apple.

Love-apple.

402. *Love-apple*, or *Tomato*, (*Solanum Lycopersicum*, L.) is an annual plant, a native of South America; it was cultivated by Gerarde in 1596. The stem, if supported, will rise to the height of six feet or more. The leaves are pinnate, and have a rank disagreeable smell. The flowers are yellow, appearing in bunches in July and August, and followed by the fruit in September and October. The fruit is smooth, compressed at both ends, and furrowed over the sides; it varies in size, but seldom exceeds that of an ordinary golden-pippin. The common colour is yellow; but there is a red-fruited variety, which is now the sort principally cultivated; and there is also a small variety called the cherry-shaped. When ripe, it is put into soups and sauces, to which it imparts an agreeable acid flavour. The green fruit is frequently pickled; and sometimes also the ripe. A preserve is likewise made of the fruit.

The seed is sown on a hot-bed in March; when the seedlings are two inches high, they are transplanted into a slight hot-bed till they acquire a little strength. They are then placed near a wall, paling, or reed hedge, to which they can be trained, in a sheltered place, with a full south exposure. The fruit, after all, ripens only in favourable seasons. In dry weather the plants require regular watering. Two or three of the ripest and best of the berries are selected for seed; the pulp being taken out, and the seeds separated by washing.

Love-apples have by many been considered as the *Aurea mala* spoken of by Virgil: but the plant scarcely deserves the title of "arbor silvestris," and would hardly receive it from a poet who was a naturalist; and on this account probably, Dr Duncan, sen. has suggested, that Virgil's plant might really be an apple-tree, such as the oslin or original pippin, the fruit of which is of a fine yellow colour. In this view, the Doctor is supported by the authority of Sir William Temple. (*Miscell.* vol. ii.)

Egg-plant.

403. Allied to the love-apple is the *Egg-plant*, (*Solanum melongena*, L.) It is a tender annual, rising about two feet high, with reclining branches. The flowers are of a pale violet colour; they are followed by a very large berry, generally of an oval shape and white colour, much resembling a hen's egg, or in large specimens a swan's egg. There is likewise, however, a variety with globular berries; and the fruit is sometimes of a violet colour. In southern countries the fruit is eaten; here the plant is often cultivated as an ornament for the hot-house and the greenhouse; but the fruit is seldom made use of. It is sometimes transplanted to successive hot-beds, and planted out in June in a warm border; where, if the autumn prove fine, the fruit makes a beautiful appearance.

Capsicum.

Capsicum.

404. *Capsicum*, or Guinea pepper, (*Capsicum annuum*, L.; *Pentandria Monogynia*; *Solanaceæ*, Juss.), is an annual plant, rising about two feet high; a native of both the Indies. It has been long known, being mentioned by Gerarde. It is raised principally for the sake of the young pods, or to speak more correctly, inflated berries, which make a favourite pickle. They are sometimes also used in the ripe state, when they form a spice of the hottest quality. The seed is sown in the spring, on a gentle hot-bed; and the seedlings are transplanted into another bed, where they are nursed till June, when they are planted out in a sheltered border. The berries vary much in shape, producing many subvarieties of the plant. They are long or short, heart-shaped or bell-shaped, and angular. They vary likewise in colour; being generally red, but sometimes yellow. In Scotland, capsicum plants are often potted and kept under glass, the climate being seldom sufficient to ripen the berries in the open border.

Cherry-pepper. Bell-pepper.

A small-fruited annual species, called Cherry-pepper, (*Capsicum cerasiforme*, Hort. Kew.) is sometimes raised; and occasionally the true Bell-pepper (*C. grossum*, L.) is cultivated. This last is a biennial species, of humble growth, but producing large berries. These are better for pickling than the others, the skin being pulpy and tender; while in the others, it is thin and tough. This biennial species must of course have a place in the stove.

Caper.

Caper.

405. The *Caper-bush* (*Capparis spinosa*, L.; *Polyandria Monogynia; Capparides*, Juss.), though common in the south of France, and growing in the open air even at Paris, seldom withstands our winters, even though placed in the most sheltered situation. Trained, however, against any spare piece of wall in a stove, it grows luxuriantly, and produces its flower-buds freely. Sometimes it effectually establishes itself in crevices of old hot-house walls; this sort of situation resembling its native one. The use of the flower-buds for pickling is familiar. Perhaps a hardier variety might be obtained by repeatedly raising it from the seed, at first in Guernsey or Jersey, and thus gradually inuring the progeny to cold. It may be mentioned, that in the garden at Campden House, Kensington, a caper-tree stood alive in the open air for near a century. It had a south-east aspect, and was well sheltered from the north. It had no covering, and was generally much

injured by the frost during winter; but it made strong shoots, and produced flower-buds every year.

A species of spurge common in our gardens (*Euphorbia Lathyris*, L.) is vulgarly called Caper-bush, from the resemblance of its fruit to capers; but it is acrid, like the other spurges. The flower-buds of marsh-marigold (*Caltha palustris*, L.) form a safe substitute for capers; and likewise the young seed-pods of the common radish.

Rhubarb.

Rhubarb.

406. Of Rhubarb (*Rheum*, L.; *Enneandria Trigynia; Polygoneæ*, Juss.) two species are commonly cultivated.

Rheum rhaponticum, L. with the leaves blunt and smooth, veins somewhat hairy underneath, petioles grooved above, and rounded at the edge. This is the species most commonly cultivated in the kitchen garden for the footstalks of the leaves, which are peeled, cut down, and formed into tarts, in the manner of apples. They are best when young and succulent, in April and the early part of May.

Rheum palmatum, L. with leaves palmate, acuminate, somewhat rugged, petioles obscurely grooved above, and rounded at the edge. This has by many been considered as the officinal species, and its cultivation has been greatly promoted by the Society for the Encouragement of Arts. In the Transactions of that Society may be found accounts of the different modes which have been followed in this country in cultivating the plant and drying its root for use; or a very distinct abstract of these accounts may be seen in the last edition of Miller's Dictionary, art. *Rheum*. There is still, however, a degree of uncertainty concerning the species which yields the true Turkey or Russian Rhubarb; and the Edinburgh Faculty, in their Pharmacopœia, therefore adopt the popular name of Rheum Russicum. The probability is, that the roots of several species are used. In many places the leaf-stalks of this species are employed in making tarts, and when young they are scarcely inferior to the other. A few plants are commonly kept in gardens for curiosity. They are highly ornamental, and particularly remarkable for the rapidity of their growth, rising to the height of perhaps nine or ten feet in seven weeks, and sometimes growing five or six inches within twenty-four hours.

Sweet Herbs, and Medicinal Plants.

Thyme.

Thyme.

407. *Thyme* (*Thymus vulgaris*, L.; *Didynamia Gymnospermia; Labiatæ* or *Verticillatæ*) is a perennial plant, indigenous to Spain. It has been cultivated in our gardens from the earliest times. It is a larger and more woody plant than our native species, *T. Serpyllus*, but the flowers are smaller. Sprigs of thyme are used for giving flavour to soups. There are several varieties, particularly the broad-leaved or green thyme, and the narrow-leaved thyme. The plant is propagated either by parting the roots or planting slips in the spring, or by sowing the seed at the same season. It grows best on light dry soil, which has not been recently manured. A very small bed of the green thyme is enough for kitchen use. Sometimes it is planted as an edging to a border, in which case it must be cut close. It is often admitted to the flower-garden, and varieties with variegated leaves are to be met with. If the plants be allowed to ripen their seeds, numbers of seedlings will appear the following year, when they may be transplanted. In autumn, some of the bushes of thyme are cut over, and hung up surrounded with paper, to dry for winter use.

The Lemon-scented thyme is a variety of our native species above mentioned. It is sometimes also cultivated, being in request for flavouring particular dishes.

Sage.

Sage.

408. *Sage* (*Salvia officinalis*, L.; *Diandria Monogynia; Labiatæ*, Juss.) is a native of the south of Europe, which has very long been an inhabitant of our gardens. It is a branched shrub, about two feet high; the leaves are wrinkled, green, cinereous, white, or tinged with dusky purple; flowers terminal, in long spikes; of a blue colour. Several varieties are cultivated: Red or purple sage, and Green sage; and each of these with variegated leaves, forming ornamental plants in the flower-border. There is a small-leaved green variety called Sage of Virtue; and there is a Broad-leaved balsamic sage. The red is the sort preferred for culinary purposes, but the green is also employed. The leaves are used in stuffings and sauces for many kinds of luscious and strong meats. Of sage of virtue the decoction called Sage-tea is usually made; but it is equally good from the broad-leaved or the common green. The plants do not endure in good condition for more than three or four years; but they are easily propagated by slips in the spring, or by cuttings when the summer is advanced. The cuttings should be five or six inches long, stripped of all the lower leaves, and plunged nearly to the top in the earth, being at the same time well watered. The lighter and poorer the soil, the better is the sage, and the more surely do the plants stand the winter. In July or August some parcels of sage twigs are commonly collected, and hung up in papers for winter use; but the leaves on the plants remain green through the winter, and a few may occasionally be gathered without doing injury.

Clary.

Clary.

409. *Clary* (*Salvia sclarea*, L.) being of the same genus with sage, may here be noticed. It is a biennial plant, a native of Italy. The lower leaves are very large, the stem is about two feet high, clammy to the feel; the flowers are in loose terminating spikes, composing whorls, and of a pale blue colour. Clary was very early cultivated in English gardens, having been accounted medicinal. It is sometimes used in soups, but its very strong scent is not agreeable to many. A considerable bed of clary is seldom to be seen in gardens, excepting when it is intended to make clary wine. For this purpose, in dry weather, the flowers are gathered; some employ the whole spikes, and others carefully separate the blossom from the calyx. Most generally, clary flowers are used only for giving flavour to home-made wines, being thought to impart something of the frontignac zest. The plant is propagated by seeds sown in the spring, and transplanted in the summer months at fifteen inches apart. Next year they yield their flowers; and if a few plants be left, plenty of seed may be procured.

Mints.

Mints.

Several species of *mint* (*Mentha*, L.; *Didynamia Gymnospermia*; nat. ord. *Labiatæ*) are cultivated in gardens; all of them indigenous to Britain, and hardy perennials. The principal kind is,

Spearmint.

410. *Spearmint*, (*M. viridis*, L.) This is not a common native plant; it is figured in "English Botany," t. 2424. The young leaves and tops are a good deal used in spring salads in England; they also form an ingredient in soups, or, more frequently, are employed to give flavour, being boiled for a time and withdrawn. They are also shredded down, and mixed with sugar and vinegar as a sauce to roasted meat, particularly lamb. A narrow-leaved and a broad-leaved sort are cultivated in gardens; and some variegated kinds are considered as ornamental plants, particularly a reddish variety called Orange-mint

Peppermint.

411. *Peppermint*, (*M. piperita*, L.) is likewise a rare native, figured in *Eng. Bot.* t. 687. A few plants are sufficient in a garden, it being scarcely used but for distilling.

Pennyroyal.

412. *Pennyroyal*, (*M. pulegium*, L.) figured in *Eng. Bot.* t. 1026, is sometimes cultivated; but a few plants are sufficient.

All of these mints delight in a moist soil. Spearmint and peppermint are readily propagated, by patring the roots in autumn, by making slips in spring, or by means of cuttings during summer. Pennyroyal is easily increased by its creeping and rooting stems. Stalks of spearmint are often dried in the latter end of summer, when the plant is coming in flower, and kept for winter use; but unless the drying be gradually accomplished, and in the shade, much of the flavour escapes. Young mint leaves, however, may be had at any time of the winter or early spring, by setting a few roots in flower-pots in the autumn, and removing some of these into the corner of a hot-bed, or of the stove, some short time before the leaves be wanted.

Balm.

Balm.

413. *Balm* (*Melissa officinalis*, L.; *Didynamia Gymnospermia*; *Labiatæ*, Juss.) is a hardy perennial, with square stems, which rise two feet high or more; leaves large, growing by pairs at each joint; a native of Switzerland and the south of France, and very early cultivated in our gardens. It is readily propagated by parting the roots, preserving two or three buds to each piece, or by slips, either in autumn or spring. The roots or slips being placed about a foot and a half asunder, and watered, soon establish themselves; and the balm plantation does not require to be renewed oftener than every third or fourth year. In order to have young leaves and tops all the summer, it is proper to cut down some of the stalks every month, when new shoots immediately spring. As the remaining stalks approach the flowering state, they are cut over at full length for drying. They should be cut as soon as the dew is off in the morning; for in the afternoon, at least in bright sunshine, the odour of the plant is found to be much diminished. The stalks and leaves are carefully dried in the shade, and afterwards kept in small bundles, pressed down, and covered with paper. The *primum ens melissæ*, by which Paracelsus was to renovate man, is now quite forgotten, and the plant is used only for making a simple balm tea, which affords a grateful diluent drink in fevers, and for forming a light and agreeable beverage under the name of Balm Wine.

Marjoram.

Marjoram.

Marjoram, (*Origanum*, L.; *Didynamia Gymnospermia*; *Labiatæ*, Juss.) Of this, three species are cultivated.

Pot marjoram.

414. *Pot Marjoram* (*O. Onites*, L.) is a perennial plant, a native of Sicily. The stem is somewhat woody; it rises more than a foot high, and is covered with spreading hairs; the leaves are small and acute, almost sessile, and tomentose on both sides. Though it seldom ripens its seeds in this country, it is sufficiently hardy to withstand our winters. It is easily propagated by cuttings or slips. It is now little used by the cook.

Sweet marjoram.

415. *Sweet Marjoram* (*O. Majorana*, L.) is a native of Portugal. It resembles pot marjoram, but the leaves have distinct petioles, and the flowers are collected in small close heads; from which last circumstance it is often called Knotted Marjoram. Being only a biennial, a little of the seed should be sown every year. The seed seldom ripens in this country, and is therefore commonly imported from France. It flowers in July, and is then gathered and dried for winter use.

Winter marjoram.

416. *Winter sweet marjoram* (*O. heracleoticum*, L.) is a perennial species, a native of Greece, and which requires a sheltered border and a dry soil. The leaves resemble those of common sweet marjoram, but the flowers come in spikes. The plant is propagated by parting the roots in autumn.

Both the kinds of sweet marjoram are a good deal employed to give relish to soups, broths, stuffings, &c. They are used fresh in summer; and, for winter use, are drawn by the roots, and dried slowly in the shade, being afterwards kept hung up in a dry place.

Savory.

Savory (*Satureja*, L.; *Didynamia Gymnospermia*; *Labiatæ*, Juss.) Two species are cultivated, the winter and the summer savory.

Winter savory.

417. *Winter savory* (*S. montana*, L.) is a native of the south of France and of Italy, which has been very long cultivated in gardens. It is a small shrubby evergreen perennial plant, with two narrow stiff leaves, an inch long, opposite at each joint, and from the base of these a few small leaves in clusters. It is propagated by slips or by cuttings of the young roots, and also by seeds. It is hardy, and continues good for several years, especially on poor soils. Some plants having established themselves on an old wall, have been observed to continue for many years.

Summer savory.

418. *Summer savory* (*S. hortensis*, L.) is an annual plant, a native of the south of Europe, with slender erect branches about a foot high; leaves opposite, about an inch in length. This is propagated only by seed, which is sown in the spring time, thinly in shallow drills, eight or nine inches apart. When it is to be stored for winter use, it should be drawn up by the root, as in this way it retains its flavour better.

Basil.

Basil (*Ocimum*, L.; *Didynamia Gymnospermia*; *Labiatæ*, Juss.) Two species are cultivated, both natives of the East, and both annual plants.

Sweet basil.

419. *Sweet Basil* (*O. basilicum*, L.) is generally sown on a hot-bed in the end of March, and planted out in May, at eight or ten inches square. If raised from the

hot-bed in small tufts with a ball of earth attached, it is sure to succeed. In dry weather, liberal watering is proper. In a sheltered situation, sweet basil, thus treated, rises to about a foot in height. If sown at once in the open border, the plants are late and small. The leaves and small leafy tops are the parts used. On account of its strong flavour of cloves, basil is often in demand where highly seasoned dishes are in use: a few leaves are sometimes introduced into a salad, and not unfrequently into soups.

Bush basil.

420. *Bush Basil,* (*O. minimum,* L.) is little more than half the size of the common basil. It forms a round orbicular bushy head. It is raised on a hot-bed in the same way as the other; but should be planted out in a richer soil, and in a warmer situation. The same parts of the plant are used, and for the same purposes.

In very favourable seasons, and in the south of England, both species sometimes ripen their seed; but in general, Italian seed may be depended on.

Tarragon.

Tarragon.

421. *Tarragon,* (*Artemisia Dracunculus,* L.; *Syngenesia Polygamia æqualis; Corymbiferæ,* Juss.) is a perennial plant, a native of Siberia, which was cultivated in gardens in the time of Gerarde. It rises a foot and a half high, is branched, and has narrow leaves, green on both sides. The leaves and tender tips are used as an ingredient of pickles, for the sake of their fragrant smell and warm aromatic taste. A simple infusion of them in vinegar makes a pleasant fish-sauce. In France, tarragon is often added to salads, that its agreeable pungency may correct the coldness of other herbs; and it is frequently put in soups.

In a dry loamy soil, tarragon proves quite a hardy plant; but it is apt to perish in a wet situation. It is easily propagated by parting the roots, or by planting in the spring young shoots with only two or three fibres. During the summer months, even cuttings will grow; but both the shoots and cuttings must be plentifully watered till they strike root. The plant is therefore seldom raised from the seed. The stems containing the leaves and tops are sometimes dried for winter use; and if fresh young tops be wanted at that season, they can soon be procured by keeping some roots in pots, and placing these in a hot-bed or stove.

Wormwood.

422. *Common Wormwood,* which is another species of Artemisia, (*A. absinthium,* L.) was formerly kept in gardens, being much used as a vermifuge. It is a native plant, figured in "English Botany," t. 1230, and wild specimens are more powerful than cultivated ones. It is easily propagated by slips or cuttings. The growth of this plant, it may be remarked, should be encouraged in poultry walks, it being found beneficial to them. The distillers of great still whisky in Scotland sometimes employ it in place of hops, and for their use small fields of it are occasionally sown.

Rosemary.

Rosemary.

423. *Rosemary* (*Rosmarinus officinalis,* L; *Diandria Monogynia; Labiatæ,* Juss.) is a native of the south of Europe, but if planted on a dry soil in a sheltered garden, it withstands our ordinary winters. When its roots enter the crevices at the base of an old wall, the plant is not injured by the severest frosts. It is an evergreen shrubby plant, rising sometimes six or eight feet high; the leaves are sessile, linear, dark green above, greyish or whitish underneath; the blossoms, of a pale blue colour. As it is a highly aromatic, and a medicinal plant, a few bushes should be in every garden. An infusion of the leaves is grateful to many people. The flowers and calyces form a principal ingredient employed by the makers of what is called Hungary water. A rosemary sprig is the emblem of remembrance. "There's rosemary; that's for remembrance," says the distracted Ophelia, in Shakespeare. In some parts of the west of England, the sprigs are still distributed to the company at funerals, and often thrown into the grave upon the coffin of the deceased. Abercrombie, in his *Practical Gardener,* alludes to this practice, but supposes the motive to be the "preventing of contagion." There are varieties with white-striped, and with yellow-striped leaves; the former rather tender. The plant is easily propagated by slips or cuttings in the spring.

Lavender.

Lavender.

424. *Lavender,* or *Spike Lavender,* (*Lavandula Spica,* L.; *Didynamia Gymnospermia; Labiatæ,* Juss.) is a native of the south of Europe, and has been cultivated in our gardens since the middle of the 16th century. The plant is shrubby, rising from two to four feet high; the leaves linear, hoary, slightly rolled back at the edges; the flowers forming terminating spikes. There is a narrow-leaved and a broad-leaved variety. Lavender is rather a medicinal plant than one used by the cook. In every garden, however, a few plants are kept. The spikes of flowers being very fragrant, the ladies often make imitation scent-bottles of them. Frequently they are put in paper bags, and placed among linens to perfume them. In physic gardens, the plant is extensively cultivated for the sake of the flowers, from which lavender water is distilled. It is propagated by cuttings, or young slips, any time in the spring months. In large gardens it is sometimes used as an edging, but it is too bulky. If lavender be planted in a dry, gravelly or poor soil, its flowers have a powerful odour, and the severity of our winters has little effect on it; while, in a rich garden soil, although it grows strongly, it is apt to be killed, and the flowers have less perfume. In common garden soil, new plantations should be made every four or five years.

Coriander.

Coriander.

425. *Coriander* (*Coriandrum sativum,* L.; *Pentandria Digynia; Umbelliferæ,* Juss.) is a native of the East, but has naturalized itself in Essex, near places where it has long been cultivated for druggists and confectioners, and is therefore figured in *English Botany,* t. 67. It rises about a foot high, with doubly pinnated leaves. It is not often raised in private gardens. Formerly the young leaves were used in salads, and in soups; but they have a strong and scarcely agreeable scent. The seeds are now chiefly in request for medicinal purposes. If these be wanted, the seed should be sown in autumn, and the plants afterwards thinned out to five or six inches asunder.

Caraway.

Caraway.

426. *Caraway* (*Carum carui,* L.; *Pentandria Digynia; Umbelliferæ*) is a biennial plant, a native of

Caraway.

some parts of England, and figured in *English Botany*, t. 1503. The plant rises a foot and a half high, with spreading branches; the leaves are decompound; the leaflets in sixes. In former times, the tapering fusiform roots were eaten like parsnips, to which Parkinson gives them the preference. In the spring time, the under leaves are sometimes put in soups. But the plant is now principally cultivated for the seeds; these are used in making cakes, and are incrusted with sugar for comfits; they are likewise distilled with spiritous liquors, and for this purpose large quantities are raised in fields in Essex. Nicol and others direct its being sown in the spring; but it is much better to sow in autumn, soon after the seed is ripe; the seedlings quickly rise, and, the plant being biennial, a season is thus gained. A moist rich soil answers best. The seed is generally sown in rows; and in the spring, the plants are thinned out to four or six inches apart. In the end of summer, when the seeds appear to be nearly ripe, the plants are pulled up, and set upright to dry, the seed being then more easily beat out.

Tansy.

Tansy.

427. *Tansy* (*Tanacetum vulgare*, L; *Syngenesia Polygamia superflua; Corymbiferæ*, Juss.) is a well known perennial plant, a native of most parts of Britain, generally growing on the banks of rivers; it is figured in *English Botany*, t. 1229. In a cultivated state, it rises to the height of three or four feet; the stem leafy, the leaves alternate, deep green, finely divided; the flowers appear in terminating corymbs, and are yellow. It has long had a place in the garden, partly on account of its medicinal virtues, being in high estimation as a vermifuge, and partly for the sake of its young leaves, which are shredded down, and employed to give colour and flavour to puddings. There is a variety with curled leaves, which is rather ornamental; this is often called Double tansy. There is likewise a sort with variegated leaves, which is sometimes admitted into shrubberies. Tansy is extremely hardy, and will grow in any soil or situation. A few plants are sufficient; and it is very easily propagated at any time by parting the roots. Tansy leaves may be procured very early in the spring, by laying two or three tufted roots of the plant upon a slight hot-bed about mid-winter, arched with hoops and covered with mats in severe weather. The young leaves may also be had throughout the summer, by cutting down the flower-stems close, so as to encourage a new growth.

Costmary.

Costmary.

428. *Costmary*, or *Ale-cost*, (*Balsamita vulgaris*, Hort. Kew.; *Tanacetum Balsamita*, L.; *Syngenesia Polygamia æqualis; Corymbiferæ*, Juss.) is a native of Spain, Italy, and the south of France: it is however a hardy perennial, and has been cultivated in our gardens from the earliest times. The lower leaves are large, ovate, of a greyish colour, and on long footstalks; the stems rise two or three feet high; they are furnished with leaves of the same shape, but smaller and sessile. The flowers are of a deep yellow colour, and appear in loose corymbs in August and September; in indifferent seasons or in cold situations, they scarcely expand, and the seeds very seldom come to maturity in this country. The whole plant has a pleasant odour. Costmary was formerly more used in the kitchen than it is at present. In France it is an ingredient in salads. It was also put into ale, and hence the name Ale-cost. The other name, cost-Mary, intimates that it is the *costus* or aromatic plant of the Virgin. A few plants are enough in a garden. They do best in a dry soil, and will remain good for several years. It is readily propagated by parting the roots in autumn. There is a variety with deeply cut and very hoary leaves, but this sort is less fragrant.

Hyssop.

Hyssop.

429. *Hyssop* (*Hyssopus officinalis*, L.; *Didynamia Gymnospermia; Labiatæ*, Juss.) is a perennial evergreen undershrub, a native of the south of Europe, and has been long cultivated in our gardens. The stems rise a foot and a half high; the leaves are lanceolate, narrow like those of lavender, but shorter. There are several varieties, blue, red, and white flowered, and hairy leaved; but the first is the most commonly cultivated. The whole plant has a strong aromatic scent. The leaves and young shoots are sometimes used for culinary purposes, in the way of a pot-herb; and the leafy tops and flower-spikes are cut, dried, and preserved for medicinal uses. It is sometimes planted as an edging in the kitchen garden, the plants being set only about ten inches distant from each other: in a separate bed, they should be two feet asunder. It may be propagated by seeds, by rooted slips, or by cuttings, in the spring months. In a poor dry soil it is not only more hardy, but more aromatic, than in a rich soil. It often grows on old walls; but the "hyssop that springeth out of the wall" of Solomon, is supposed by Hasselquist to have been a small moss, which he observed covering the ruins of Jerusalem.

Rue.

Rue.

430. *Rue* (*Ruta graveolens*, L.; *Decandria Monogynia; Rutaceæ*, Juss.) is a perennial evergreen undershrub, a native of the south of Europe. It was early cultivated in our gardens, and was in former days called Herb of Grace, from the circumstance of small bunches of it having been used by the priests for the sprinkling of holy water among the people. There is a tall growing and a small kind; the latter is now chiefly cultivated. Formerly border edgings were frequently made with it; but it is now seldom employed for that purpose. It ought, however, to be occasionally pruned down, and kept from flowering too much; in this way it continues in a fresh bushy state for a number of years. It is easily propagated by slips or cuttings in the spring; and a few plants are generally thought sufficient in a garden. Like rosemary, lavender, hyssop, and other similar aromatics, it does best in poor dry soils. The leaves are sometimes used as a medicine, and often given to poultry afflicted with croup.

Chamomile.

Chamomile.

431. *Chamomile* (*Anthemis nobilis*, L.; *Syngenesia Polygamia superflua; Corymbiferæ*, Juss.) is a well known perennial plant, which grows naturally in Surrey, Cornwall, and some other parts of Britain, and is figured in *English Botany*, t. 980. Few gardens are without a chamomile bed: it is certainly a highly aromatic plant, and an infusion of the dried flowers makes a safe bitter and stomachic, much used under the name of Chamomile-tea. The double-flowering variety is ornamental, and is generally kept in gardens; but the

Chamomile.

single-flowered sort is preferable for use; the useful principle not residing in the floscules of the ray, which are multiplied in the double flower. The flowers are gathered when in their prime, dried slowly in the shade, and preserved in paper bags till wanted. The plant is easily propagated by slips or rooted shoots in the spring months. It delights in a poor soil: the plants may be placed ten inches or a foot apart, and should be watered in dry weather till they be established. It is sometimes employed to form rustic green seats, and it answers very well, if the seats be not very much used.

Scurvy-grass.

Scurvy-grass.

432. *Scurvy-grass* belongs to the same Linnean genus as the horse-radish, § 396, although in general habit the plants have no resemblance. It is the *Cochlearia officinalis*, L. an annual or at most a biennial plant, indigenous to most of our sea-shores, and, like the plant called thrift or sea-pink, growing also on many of our mountains, particularly in Scotland. It is figured in "English Botany," t. 551. A thick-leaved variety, called Dutch Scurvy-grass, is sometimes cultivated in gardens for medicinal purposes. The smaller leaves are occasionally eaten between slices of bread and butter. It is sown in July, or as soon as ripe seeds can be gathered; it requires little attention, needing only to be thinned and kept clear of weeds. If the seeds be not wanted, the flower-stems may be cut over, and the plants will thus continue for two or more years. Common scurvy-grass thrives uncommonly well on the top of an old wall, where it will sow itself and remain many years.

Elecampane.

Elecampane.

433. *Elecampane* (*Inula Helenium*, L.; *Syngenesia Polygamia superflua; Corymbiferæ*, Juss.) is a native of different parts of the south and west of England, and figured by Sowerby in "English Botany," t. 1546. It is a perennial plant, with a thick fusiform aromatic root; it rises from three to five feet high, being one of our largest herbaceous plants; the lower leaves are a foot long, and perhaps four inches broad in the middle; the yellow flowers appear in large heads in July and August. In former days the root had many virtues ascribed to it; the plant was therefore cultivated in village-gardens throughout Europe: now, it is much less in repute, but it still keeps its place in the physic-herb corner. As a few plants only are wanted, they are generally procured by offsets in the autumn. The root is fit for use the second year: and roots of this age, it may be noticed, are better than those of old plants.

Anise.

Anise.

434. *Anise* (*Pimpinella Anisum*, L.; *Pentandria Digynia*; nat. ord. *Umbelliferæ*) is an annual plant, a native of Egypt, but cultivated in Malta and Spain, for the seeds, which are medicinal, and a good deal in demand. In this country the plant requires a warm border. The seed is sown in April, where the plants are to remain; and they are thinned as they come up. It is only in very favourable seasons that the seeds are perfected. Mr Lysons mentions it as one of the plants raised by the physic gardeners near London, probably by mistake: for it is certainly too tender to be cultivated in this country for profit.

Blessed Thistle.

Blessed thistle.

435. *Blessed Thistle* (*Centaurea benedicta*, L.; *Carduus benedictus* of the older writers; *Syngenesia Polygamia frustranea; Cinarocephalæ*, Juss.) is an annual plant, growing naturally in the Levant. It was formerly cultivated with care in our gardens for its supposed extraordinary virtues. An infusion of it is still sometimes used; and a few plants are therefore raised from the seed, which is generally sown in autumn.

It seems unnecessary to swell the list of these simples, or medicinal plants; but it may be proper slightly to mention a few esculents or herbs, principally native, the cultivation of which is either seldom attended to in this country, or has fallen into disuse.

Garden rocket.

436. *Garden Rocket* (*Brassica Eruca*, L.) is an annual plant, a native of Switzerland, which was in former times used as a salad herb, but is now seldom to be met with unless in botanic gardens. When in flower it has a strong peculiar smell, which some would not hesitate to call fetid; but in a young state the flavour is just perceptible, and the leaves then form a very tolerable salad ingredient. It is still cultivated in some parts of the continent.

Wild-rocket.

437. *Wild-rocket*, or Hedge-mustard, (*Sisymbrium officinale*, Hort. Kew.; *Erysimum officinale*, L.; English Botany, t. 725.) has been sometimes sown and used as a spring pot-herb. When young, it has a warm and not disagreeable taste.

Winter-cress.

438. *Winter-Cress* (*Barbarea vulgaris*, Hort. Kew.; *Erysimum Barbarea*, L.; English Botany, t. 443.) is a well known perennial plant, which has long been occasionally used as an early spring salad. Some still consider the American cress of gardeners as merely a variety of this; but after cultivating both for several years, we have found those to be right who regard them as distinct. (See § 382.) It may be remarked, that a double-flowered variety of Barbarea vulgaris is admitted to the flower-border, under the name of Yellow rocket.

Sauce alone.

439. *Sauce alone*, or Jack by the hedge, (*Erysimum Alliaria*, L.; English Botany, t. 796.) is sometimes used, either in sauce, as a salad, or boiled as a pot-herb. When gathered as it approaches the flowering state, boiled separately, and then eaten to boiled mutton, it certainly forms a desirable pot-herb. To any kind of salted meat it will be found an excellent green. Being not unfrequent by the sides of hedges, in a natural state, it has seldom been raised in gardens.

Samphire.

440. *Samphire* (*Crithmum maritimum*, L.; English Botany, t. 819.) is well known as forming a very good pickle, and also a piquant addition to a salad. It grows among rocks on the precipitous shores of some parts of England, particularly Kent and Cornwall, and of Galloway in Scotland. It is the plant alluded to by Shakespeare in his celebrated description of Dover cliffs:

> ——"Half way down
> Hangs one that gathers samphire; dreadful trade!"

It is a perennial plant, and is propagated by parting the roots, or by seed sown in the spring. It is not easily cultivated. It seems to succeed best on a rich light soil, having sand and gravel mixed with it. It must be in a well sheltered situation, and requires to be freely watered in dry weather, till the roots have struck deep among the soil and gravel. Mr Marshall mentions, that it has been found to do well in pots, set for the morning sun only. If a few plants can be got to take deep root in an old wall, or on an artificial rock-work, they will have a much better chance to remain. The name samphire is a corruption of *sampier*, and this again is derived from the French name of the plant *Saint Pierre*. It may be observed, that what is called *golden samphire* in Covent Garden market, is the Inula crithmifolia, Eng. Bot. t. 68; and that the *Marsh samphire* of the same market, is the Salicornia herbacea, Eng. Bot. t. 415.

Buck's-horn Plantain.

441. *Buck's-horn Plantain* (*Plantago coronopus*, L.) was formerly cultivated as a salad herb, but is now neglected, the smell being to many rank and disagreeable. It is still, however, regularly sown in French gardens as a salad herb, under the name of *Corne de Cerf*.

Ox-eye daisy.

442. The young leaves of the *Ox-eye Daisy* (*Chrysanthemum leucanthemum*, L.) are noticed by Dr Withering as fit to be eaten in salads; and John Bauhin mentions that they were much used for that purpose in Italy.

Cotton-thistle.

443. The *Cotton Thistle* (*Onopordum acanthium*, L.; English Botany, t. 977.) is a biennial, growing naturally in different places, and remarkable for its large downy leaves and lofty stem. It was formerly cultivated and used like the artichoke and cardoon; the receptacle, and the tender blanched stalks, peeled and boiled, being the parts used.

Alexanders.

444. *Alexanders* (*Smyrnium Olusatrum*, L.; English Botany, t. 230.) is a biennial plant, rising about two feet high, and flowering in the spring; the leaves of a pale green colour, and the flowers yellowish. It grows naturally near the sea in several places, and may often be observed to be naturalized near old buildings. It was formerly much cultivated, having been used as a pot-herb and salad. In flavour it has some resemblance to celery; by which it has been entirely supplanted.

Water-cress.

445. *Water-Cress* (*Nasturtium officinale*, Hort. Kew.; *Sisymbrium Nasturtium*, L.; English Botany, t. 855.) is a well known perennial inhabitant of our ditches and slow running streams. It forms an excellent spring salad; and it is easily cultivated in any marshy spot, or by the side of a garden pond, by introducing a few plants from ditches where it grows wild. The popular remedy called *spring juices* consists of its juices, with those of brooklime, scurvy-grass, and Seville oranges: it is therefore cultivated by a few market gardeners for the supply of Covent Garden. In France, the sprigs are used as a garnish to roast fowl.

Brooklime.

446. *Brooklime* (*Veronica beccabunga*, L.; English Botany, t. 655.) is a perennial plant, growing in wet places near springs, and in slow running streams or ditches, very generally associated with the water-cress. The leaves are mild, or have only a slightly bitterish taste, and form a very tolerable salad ingredient in March and April. In Scotland the plant is called *water-purpie*, and the sprigs are gathered for sale along with *wall-cresses* (well or water cresses.)

Nettle.

447. The young tops and leaves of the *Great Nettle* (*Urtica dioica*, L.; English Botany, t. 1750) are gathered in early spring, about February, as a pot-herb, and form a tolerably good one. *Nettle-kail* is an old Scottish dish, now known only by name. If nettle-tops be wanted, they can readily be had without cultivating the plant.

Sow-thistle.

448. *Sow-thistle* (*Sonchus oleraceus*, L.; English Botany, t. 843.) is a common annual weed in our gardens. There is a prickly and a smooth variety. The latter is in some countries boiled and eaten as greens; hence the Linnean trivial name *oleraceus*. The tender shoots boiled in the manner of spinach are very good, superior perhaps to any greens not in common use.

Dandelion.

449. *Dandelion* (*Leontodon taraxacum*, L.; English Botany, t. 510.) is a well known perennial, generally despised as a troublesome weed: yet the leaves, in early spring, when they are just unfolding, afford a very good ingredient in salads. The French sometimes eat the young roots, and the etiolated leaves, with thin slices of bread and butter. Blanched dandelion loses its disagreeable flavour, and considerably resembles endive in taste.

Bladder campion.

450. *Bladder Campion*, or Spatling Poppy (*Silene inflata*, Hort. Kew.; English Botany, t. 164.; *Cucubalus behen*, L.) is a hardy perennial, growing naturally by the sides of our corn-fields and pastures. Its young tender shoots, when about two inches long, are excellent when boiled, having something of the flavour of peas. The plant sends forth a great number of sprouts, and when these are nipped off they are succeeded by fresh ones.

Hop-tops.

451. The *Hop* (*Humulus Lupulus*, L.; Eng. Bot. t. 427) is well known as being cultivated for the sake of its flowers for preserving beer; but for use as a kitchen-herb it is little regarded. The young shoots, however, which, early in the spring, rise abundantly from old stocks, are not much inferior to asparagus. They are sometimes, but not often, sent to market, and sold by the name of *hop-tops*.

For further particulars regarding esculent plants which have fallen into neglect, the reader may be referred to the "Flora Diætetica" of Bryant.

Fungous Plants.

Of the tribe of Fungi several esculent species occur in this country, belonging to the genera Agaricus, Tuber, and Phallus. Only one is cultivated, the Common Mushroom, *Agaricus campestris* of Linnæus, *A. edulis* of Bulliard and others.

Common Mushroom.

Mushroom.

452. This is well known. It is most readily distinguished, when of middle size, by its fine pink or flesh-coloured gills, and pleasant smell: in a more advanced stage the gills become of a chocolate colour, and it is then more apt to be confounded with other kinds, of dubious quality; but the species which most nearly resembles it, is slimy to the touch, and destitute of the fine odour, having rather a disagreeable smell: further, the noxious kind grows in woods or on the margins of woods, while the true mushroom springs up chiefly in open pastures, and should be gathered only in such places.

The uses of the mushroom are familiar; it is eaten fresh, either stewed or broiled; and preserved, either as a pickle, or in powder. The sauce commonly called *ketchup* (supposed from the Japanese *kit-jap*) is, or ought to be, made from its juice, with salt and spices. Wild mushrooms from old pastures are generally considered as more delicate in flavour and more tender in flesh, than those raised in artificial beds. But the young or button mushrooms of the cultivated sort are firmer and better for pickling; and in using cultivated mushrooms, there is evidently much less risk of deleterious kinds being employed.

Mushrooms are most speedily and certainly propagated, by placing the germinating seeds,—or rather the white fibrous radicles, which produce tubercles in the manner of potatoes, called the *spawn*,—in a situation proper for the developement of the plants. Without at all abetting the doctrine of equivocal generation, we may assert our power to produce this spawn at pleasure. Some long stable dung, which has not lain in a heap or undergone any degree of fermentation, is mixed with strong earth, and put under cover from rain: the more the air is excluded, the sooner does the spawn appear: a layer of old thatch, or any kind of litter that has lain long abroad, and so is not apt to ferment, is proper for excluding the air. In about two months the white threads of the spawn will be found penetrating the dung and earth. When spawn is once procured, it may be extended or propagated, as spawn, without producing mushrooms. A mode of doing this, practised by Mr John Hay, may here be mentioned. A quantity of cow droppings is to be gathered from the pastures; some rotten wood, or spray from the bottom of a hedge, is to be collected, with a little strong loam. These are mixed, and formed into a moist ductile sort of mortar or paste, of such consistence that it can be cut into pieces like bricks. When these are so far dried that they can conveniently be lifted, a row is laid in some dry place, under cover, perhaps in a shade at the back of a hot-house; a little spawn is placed upon the layer; then another layer of the spawn bricks, and so on. In a few weeks the whole mass is penetrated by the spawn. The spawn bricks may then be laid aside for use; they will keep many months; and the drier they are kept, the more certainly do they afford a crop of mushrooms when placed in favourable circumstances for doing so.

The usual mode of raising mushrooms in beds prepared with layers of horse-droppings and fine mould, is generally understood, and has been fully described in a preceding part of this work, (art. FUNGI, vol. x. p. 57.) It may be proper, however, in addition to what is there said, to give an account of what is called Oldacre's plan, this being generally considered as an improvement on the culture of mushrooms.

Oldacre's mode.

453. Mr Isaac Oldacre is an Englishman who for many years held the office of chief gardener to the Emperor of Russia at St Petersburgh. In 1814, he visited his native country; and on that occasion, at the desire of Sir Joseph Banks, put in practice at Spring Grove, his improved mode of raising mushrooms. In forming the compost for the beds, he prefers fresh short dung, from a stable or the path of a horse-mill. The dung must neither have been exposed to wet nor to fermentation. About a fourth or a sixth part of cow or sheeps droppings is added, and the whole ingredients are well mixed and incorporated. The beds, if they may be so called, are formed on shelves, or in drawers or boxes, in the mushroom-house, or in any out-house, where a slight increase of temperature can be commanded. A stratum of the prepared mixture, about three inches thick, being deposited, is beat together with a flat wooden mallet. Another similar layer is added, and beat together as before; and this is repeated, till the beds be six inches thick, and very compact. A degree of fermentation soon takes place in this mass; but if the heat arising from this process be not quickly perceptible, another layer must still be added, till sufficient action be excited. When the beds are milk warm, (or between 80° and 90° Fahr.), some holes are dibbled about nine inches apart, for receiving the spawn. These are left open for some time; and when the heat is on the decline, but before it be quite gone, a lump of spawn is inserted into each opening, and the holes are then filled up with the compost. Ten days afterwards, the beds are covered with a coating of rich mould, mixed with a fourth or sixth part of droppings, to the depth of an inch and a half. This is beat down with the back of a spade, and the bed may then be accounted ready for producing. The mushroom-house is now kept as nearly and equally at 55° Fahr. as circumstances will allow. When the beds become very dry, it is occasionally found requisite to sprinkle over them a little water, taken from a pond or river; but this must be done with great circumspection.

Beds thus prepared, we are assured, yield abundant crops of mushrooms. If a number of shelves or drawers be at first prepared, a few only, at a time, may be covered with mould, and brought into bearing; the rest of the shelves or drawers being cropped in succession, as mushrooms may happen to be in demand. It is evident that they may thus be procured at all seasons. The more that free air can be admitted into the mushroom-house, the flavour of the mushrooms will be found to be improved.

In what particulars the advantage of Mr Oldacre's plan over former modes chiefly consists, does not very clearly appear. Beds made up in the usual way are much less compact, and are more damp: compactness and dryness may therefore be considered as important. Indeed, the beneficial effects of keeping the spawn dry, were long ago noticed by Miller, in his Dictionary, who found, that spawn which had lain for four months near the furnace of a stove, yielded a crop in less time and in greater profusion than any other.

In some old authors, a very sage advice is given for promoting the fecundity of mushroom beds constructed on the ordinary plan, viz. to take a few full grown mushrooms from pastures, and, breaking them down in the watering-pot, to water the beds with the infusion. This is plainly nothing else than sowing mushroom seed, the minute seeds lodged in the gills being thus suspended in the water, and introduced along with it into the bed.

454. Although the Agaricus campestris is the only species cultivated, it is not the most delicate of the tribe as to flavour, nor perhaps the best deserving of culture. Some of the others should be tried, and there seems no reason to doubt of ultimate success. A. aurantiacus possesses excellent qualities; the flesh is tender, and the flavour delicate: it is in high repute on the Continent, where it is gathered in pine forests, about the end of summer. It is the *orange* of the French, and is distinguished from another species, called the false orange, by having a complete volva. A. solitarius is remarkable for its fine flavour. A. procerus is a great favourite in France, where it is known by the name of *grisette*. A. deliciosus is much used in Germany and Italy; but though it is not uncommon in our fir plantations, it is scarcely ever eaten in this country. The Champignon (*A. pratensis*) is used in soups, and is therefore occasionally brought to market; but, as remarked by Mr Sowerby, in "English Fungi," it is apt to be confounded, by the common mushroom gatherers, with A. virosus, one of those most to be avoided. A. violaceus is sometimes sold in Covent Garden, under the name of Bluets: it is a harmless kind, but has no other merit. The species which most commonly forms the circles and semicircles on downs near the sea-shore, called *fairy-rings*, is A. oreades. This Mr Lightfoot, in

his *Flora Scotica*, considers as the *mousseron* of the French; but their mousseron is A. virgineus of Persoon, a fleshy species, nearly of a pure white colour, while our plant is coriaceous and buff-coloured.

Truffles and Morels.

These have already been described under the article Fungi, and are figured in Plate LXXV. of this work.

Truffle.

455. The *Truffle*, or subterraneous puff-ball, (*Tuber cibarium*,) is one of the best of the esculent fungi. It grows naturally in different parts of Britain, but is most common in the downs of Wiltshire, Hampshire, and Kent, where dogs are trained to scent it out; the plant growing and coming to perfection some inches below the surface. The dogs point out the spot by scraping and barking, and the truffles (for several generally grow together) are dug up with a spade. They are principally sent to Covent Garden market. No attempt, it is believed, has hitherto been made to cultivate truffles; but of the practicability of the thing, there seems no reason to doubt. In their habits of growth, indeed, they differ essentially from the mushroom; but it is certainly possible to accommodate the soil and other circumstances to the peculiar nature of the fungus. It has been said, that the tubercles on the surface of truffles are analogous to the eyes or buds of potatoes, and that they have been propagated, like potatoes, by means of cuts furnished with tubercles: it may however be suspected, that the pieces thus planted contained ripe seeds. Truffles, we may add, seem to delight in a mixture of clay and sand; and a moderate degree of bottom heat, such as is afforded by a spent hot-bed, might probably forward their vegetation.

Morel.

456. The *Morel* (*Phallus esculentus*, L.; *Helvella esculenta* of Sowerby, and *Morchella esculenta* of Persoon) rises, in the spring months, generally in woods, but sometimes on commons. It frequently appears for sale in Covent Garden market in May and June; but it has never been cultivated. The cultivation of morels, however, would probably be more easily accomplished than that of truffles. Morels are used either fresh or dried, commonly as an ingredient to heighten the flavour of gravies or ragouts. If intended for keeping, they should not be collected when wet with dew, nor soon after rain; if gathered in a dry state, they may be kept for many months.

Having treated at great length of the Kitchen Garden and of culinary plants suited to our climate, we now turn to the Flower Garden; and here we shall study brevity as much as possible.

FLOWER GARDEN.

FLOWER GARDEN.

457. The flower garden, it has been already observed, § 55. has a separate situation, generally at some distance from the fruit and kitchen garden. It should indeed form an ornamental appendage to the mansion, and be easily accessible in all kinds of weather. There is no objection to the flower garden being seen from the windows of the house: on the contrary, this is sometimes considered as desirable. In some places, the flower garden consists of parterres of various shapes, generally curved, separated from each other by little grass lawns. Such insulated parterres look very well from the windows of the house; the turf, in our moist climate, being always of a lively green, and forming a fine contrast with the dressed ground, and with the gay hues of the flowers. But for many days in the year these grass-girt parterres are inaccessible to the proprietors, more especially to ladies, it being impossible to pass along the turf without getting wet, at times when well made gravel walks are comfortably dry. Wherever, therefore, this kind of flower garden amidst turf is formed, there should be another, which may be considered as the winter garden, and which may contain one or more of the glazed houses for preserving plants.

In many cases the flower garden is defended by low walls or by close pales, covered by shrubs. If there be little room, they may be concealed by a single row of some evergreen, such as phillyrea, alaternus, pyracantha, laurustinus, or tree-box. The wall on the north side of the garden, however, is in some places used for a double purpose; the more tender kind of shrubs being trained against it on the south aspect. In situations where a wall would be unsuitable, an "invisible fence" of wire is employed, this proving sufficient to exclude hares and rabbits, while it nowise offends the eye, and scarcely interrupts the view. Evergreen hedges, of laurel, yew or holly, make excellent fences, especially if united with a sunk fence.

458. The shape and size of the flower garden can be regulated only by the taste and the means of the owner. If the eye embrace the whole at once, the garden should evidently be of some regular figure. But if the size be considerable, it is advantageous that the ground should be unequal in surface, and irregular in shape. In general, a greenhouse, conservatory and stove, should form prominent objects in different parts of it: it should abound with evergreen trees and shrubs, so as to maintain its verdure even at midwinter; the principal borders should be destined for mingled perennial flowers, of the most ornamental kinds; a few may be devoted to showy annuals; and particular beds should be appropriated for the different kinds of flowering bulbs, as well as for pinks, polyanthuses, and auriculas. These borders and beds, it may be remarked, should be so placed, that from the windows of the house, or from the principal entrance of the garden, they may be seen across or laterally, so that the colours of the flowers may appear in mass, without being broken by the alleys.

A rock-work is generally formed; and if the situation admit of it, or if curiosity in plants be indulged in, a small piece of water for aquatics is proper. A circular or oval plat is commonly devoted to a collection of roses; and a damp border with peat soil is set apart as an "American ground." One of the walks is often arched over with strong wire or with slight spars, on which climbing shrubs may be trained, so as to form a berceau. Covered seats of various kinds are constructed, under the names of heath and moss houses, arbours, and grottoes. If, however, the garden be regular in surface, bowers of light lattice-work, covered with climbing plants, are to be preferred. In very few places do fountains or statues now enter into the composition of the flower garden; and urns, busts, or inscriptions, are not to be introduced without caution.

Taking it for granted that the flower garden should have a ready communication with the principal gravel-walks near the house, and also with those leading to the shrubberies; and likewise that it is extremely desirable to have the walks at all times dry, we shall first make some remarks on the formation of such walks in general, and shall then consider some of the principal constituent parts of the garden more in detail.

Garden Walks.

Garden Walks.

459. Formerly grass walks were common in gardens; but the inconveniences attending them, especially dampness, and liability to wear bare in the middle, have caused them to be in a great measure relinquished; and they are now to be seen only in a few old gardens. Walks, at the present day, are principally made with gravel. If gravel walks be properly formed at first, much future labour is saved. If judged necessary, a drain should be made to pass below them; but at all events a quantity of lime-rubbish or very coarse gravel should form the foundation. In the flower-garden it is not necessary to have a fine permeable bottom of earth, such as is proper under gravel-walks next to fruit-tree borders. Lime-rubbish prevents the lodging of earth worms, which are so apt to disfigure walks, and also tends to drain the walks and keep them dry. Over the rubbish is laid screened gravel. In some places *gingle* from the sea-shore is used; but this does not bind without the addition of a little clayey matter. Good gravel may often be got from some inland pit, where there is naturally a slight mixture of clay. The gravel pits of Kensington and of Blackheath have long been celebrated. If gravel be liberally laid on at first, the face of the walk may afterwards be more easily refreshed, by turning over the surface gravel, and then using the roller.

If the walk be five or six feet broad, it should rise about an inch and a half in the centre. It is often made to rise considerably more; but the appearance is thereby impaired, and the walker is annoyed. If the walk be of large dimensions, the height in the centre may increase in proportion: so that in ten feet of breadth, a rise of two or three inches is quite allowable. The walks of the flower garden should scarcely be less than five or six feet wide; nor can there in general be any good reason for their exceeding eight' feet. They should be two or three inches lower in level than the flower-borders, otherwise these last would look flat and mean.

The rollers used for levelling and smoothing the walks, are formed sometimes of wood, sometimes of stone; but the largest and best are of cast iron. Rolling immediately after rain is practised, the gravel binding readily at that time.

460. In many places only the principal walks are covered with gravel; all the subordinate ones, and the paths through woods or large shrubberies, being merely laid with sand. Gravel walks are much injured by the drip of trees in rainy weather, and are not easily repaired; while sand walks require only to have their surface stirred with a Dutch hoe, and to be raked smooth again. It is, however, of importance to have a foundation of very coarse gravel, broken field stones, or lime rubbish, below the sand. Sand from an inland pit, having commonly a tendency to bind, is preferable to pure sea or river sand. In places near the sea, and where banks of shells occur on the beach, sea-shells when broken will be found to form a very neat walk, also susceptible of binding to a certain degree. The utility of the binding quality is manifold; it gives the walk a neat appearance; it renders it more pleasant for walking on: and it permits of sweeping, without deranging the surface.

Walks.

461. If the flower garden is to consist of parterres separated by grass-turf, the first formation of these little lawns requires particular attention. When the ground is delved over and levelled, a stratum of sand or very poor sandy earth, perhaps three inches thick, is laid on, and over this an equal depth of good earth, on which to sow the grass seeds. The use of the poor soil below is to prevent the grass from getting rank. This is particularly necessary where a mixture of rye-grass and brome-grasses (particularly *Bromus squarrosus* and *multiflorus*) is sown; and all the grass seed, it may be observed, sold in this country, consists of such a mixture. Were only fescue grasses sown (*Festuca duriuscula* and *ovina*), with perhaps crested dog's-tail (*Cynosurus cristatus*), there would be much less danger of over-luxuriant patches appearing, while their fine wiry leaves and slightly glaucous hue, would render the turf highly beautiful. The selection of grasses for lawns is too little attended to. The same kind of seed is sown indiscriminately in exposed and in shady situations. If white clover and rye-grass be sown under trees, it is little wonder that the ground should remain bare: if the seeds of *Poa nemoralis* were scattered in such situations, the bare spaces would soon be covered with a lively green sward. A judicious little essay on the employment of the gramina, and particularly of the species last mentioned, presented to the Highland Society by the late Mr George Don of Forfar, may be seen in the third volume of the Transactions of that Society, p. 194, *et seq.*

Soil.

Soil.

462. The *soil* of the flower-garden should of course be various. For the general borders a loamy soil is preferable. The surface earth from old pastures, taken along with the turf, is accounted excellent. There may be mixed with it a quantity of old hot-bed dung, or other rotten manure; a third or a fourth, according as the earth is naturally rich or poor. If the compost seem apt to bind, a small proportion of sea-sand is the remedy. If a poor soil be wished for, which at the same time is open, then half-rotten tan from the bark stove is substituted for dung.

It may here be remarked, that various composts should always be in readiness, and others in a state of preparation; and for this purpose a convenient spot, as much hid from view as possible, but near to the garden, should be set apart as a compost yard.

Peat-soil is very useful in the flower-garden. It is of two sorts, boggy peat, and sandy or surface peat; the former adapted only to the larger and more hardy kinds of American plants; the latter, to other American plants, to alpine plants, to Cape heaths, and to many greenhouse plants. The best sort of peat-turf is frequently to be found constituting a mere skin over a bed of sand. The turf or sod should be taken with what peat-soil adheres to it, and should be allowed to moulder in the compost yard. Spots where wild heath grows luxuriantly, or where it closely covers the surface, are likely to afford excellent light or sandy peat. It may be added, that at the points where mountain rivulets enter the flat country, accumulations of peat earth and sand may often be found, the peat being freed, by the washing of the rivulet, from the chief part of the salts and other principles likely to prove hurtful to vegetation. A mixture of nearly equal parts of peat soil and loam is suitable for very many kinds of plants. For the succulent tribe Miller recom-

Flower Garden. Soil.

mends a compost prepared of one-half earth from the surface of a common, where the soil is light; and the other half drift sea-sand and old lime rubbish screened, in equal parts. Decayed leaves of trees have long been considered as forming the most suitable ingredient in composts, where it is wished to imitate a vegetable soil. Large pits are dug in convenient parts of the woods, and into these the heaps of leaves and small spray are raked during winter; a slight sprinkling of the surface soil being thrown over all, to prevent the leaves from being blown about. After the lapse of a year, a very light vegetable soil is thus procured; while the half rotten spray forms an appropriate soil for some kinds of epidendrum, cultivated in the stove.

In the first forming of composts, considerable attention should be paid to the thorough mixing together of the ingredients. The heaps should not be round and of great bulk, but should rather be formed into long and narrow ridges, the sides of which may more effectually be exposed to the influences of the atmosphere. The compost should remain for at least a year before being used, and should be several times turned over and mixed in the course both of summer and winter.

The best kind of rich manure for the flower-garden is found in old hot-beds which have been formed of stable dung and litter; but even this should not be delved into the borders without being mixed with a portion of good loam; for there are few *flowers* to which very rich manures do not prove detrimental.

A quantity of pit sand should always be in readiness for mixing with other soils, or for *striking* cuttings of different plants. The purest and finest pit sand is preferred. However pure to appearance, it still contains a portion of very fine vegetable matter; sea-sand being destitute of this, is not nearly so proper.

To enlarge further on soils for the flower-garden seems unnecessary. In Cushing's *Exotic Gardener* may be seen a table of genera, shewing the peculiar soil most suitable, in a general way, to each genus; and the same little book contains some very useful remarks on the preparation and use of composts.

It may here be observed, that for all border plants, as well as for tulips, ranunculuses, and other flowers kept in beds, the earth or the compost should not be screened fine. It is enough if stones which the spade sensibly strikes against be cast out, and if clods be broken small at the time of delving. Screened earth is apt to bind after heavy and continued rains, and thus to impede the progress of the roots which it was meant to facilitate. For plants kept in pots, and particularly for seedlings and cuttings, the matter is quite otherwise; the soil for most of these should be made fine by passing it through a sieve.

Edgings.

Edgings.

463. In the formal style of gardening which prevailed in the 17th and the early part of the 18th century, *edgings* of various kinds were much more needed and more attended to than they now are. The compartments of parterres were generally divided by box, and on the margins of the walks were frequently small hedges of lavender, or rue. Thyme, savory and hyssop, were also in those days employed as ornamental edgings.

464. For the general gravel-walks in gardens, the best edging is without doubt the *dwarfish Dutch box* (*Buxus sempervirens* var.) A compact low hedge of this effectually keeps the walks clean, by preventing the earth of the border from falling down into them, or being washed into them by heavy rains. If the box be kept low and regularly clipped, it endures in good repair and beauty for several years. It is commonly clipped twice in the year, in April and July. It should be kept about three inches broad at the base, and tapering upwards to a sharp ridge. A linear and continuous edging of this kind pleases every eye. Box is planted either in the beginning of autumn, or in the spring about the month of April. If slips having few or no roots be used, watering is proper till the plants be fairly established.

Flower Garden. Edgings.

Next to box, the plant which forms the best retaining edging is perhaps *thrift* or *sea-pink* (*Statice armeria.*) In June and July, when in flower, it makes a showy edging; and it answers the purpose during the rest of the year with its dense tufts of leaves. It should be replanted every year, or at farthest every second year.

The double-flowered *daisy* (*Bellis perennis*, var. fl. pl.) has very long been used in this way. When kept in repair, it forms an edging very pleasing to the eye. The plants should be separated and transplanted every season, in the beginning of September, and only one strong stem or bud left to each bunch of roots.

Double *catchfly* (*Lychnis viscaria*, fl. pl.) is sometimes employed; but it seldom makes a neat edging: the flowers are ornamental, but the stems are too tall. *Dwarf gentian* (*Gentiana acaulis*) of all other plants forms the most brilliant edging, while in flower in the spring; but it is necessary that a continuous azure line be kept up, and for this purpose the verge must be of some breadth: It is applicable therefore only to large or broad borders, and it succeeds best in a strong or clayey soil. *London-pride* (*Saxifraga umbrosa*) forms a loose and straggling verge, but is very pretty while the plants are in flower: It is fittest for a shrubbery walk. *Lady's cushion*, or Indian moss as it is sometimes called, (*Saxifraga hypnoides*) is occasionally planted as an edging, and makes a pretty enough appearance. Some other similar species of Saxifraga, such as *palmata* and *cæspitosa*, may be used in the same way.

For gay parterres, the large blue-flowered *pansy violet* (*Viola tricolor* var.) makes a beautiful slight edging. Although strictly speaking an annual plant, if it be parted every season, it endures for several years. It is very commonly used for adorning the margins of elegant flower-borders in the neighbourhood of Dublin.

Dwarf bell-flower (*Campanula pumila*, or *C. rotundifolia* var.) makes a fine edging for little borders where nicety and beauty are studied. Sometimes a few feet of the edging are formed alternately of the blue and of the white variety. For small borders also, a very ornamental edging may be formed of *Stone-crop* (*Sedum acre*), preferring the variety which has the tops of the shoots of a yellowish colour; this, even during winter or very early in the spring, having the appearance of being in flower.

It may be remarked, that patches of several of the different edging plants which have been enumerated, perhaps a few yards alternately of each, have an agreeable effect, especially in a long or extensive border.

Most kinds of edgings may be planted early in the spring. In planting them, it is more proper to use the spade than the dibble. The ground being slightly beat, a drill is cut by the garden-line, perpendicular on the side next the border; the plants are then placed against the perpendicular side, their roots spread out, and the earth closed upon them.

For edgings to square or oblong beds intended for tulips, ranunculuses, or similar plants, thin boards

Flower Garden. Edgings.

painted of a lead colour, are perhaps better than any other. Edgings to endure only for one season are sometimes formed of annual plants, sown in the spring; such as the dwarfish stock (*Malcomia maritima*, H. K.), or candy-tuft, purple or white, (*Iberis umbellata.*)

465. A simple and elegant edging may be formed of sheep's-fescue (*Festuca ovina*), the very fine foliage of the plant being highly ornamental. In the extensive nurseries at Gateside, Newcastle, this sort of verge has been adopted, F. duriuscula being mixed, however, in some places with the true sheep's-fescue. If very carefully sown or planted in a narrow straight line, it has a slender linear appearance, and does not occupy more space than a small box edging. For a temporary edging, another kind of grass, the large cow-quakes, (*Briza maxima*), is sometimes very happily employed, the loose racemes, with their nodding spikes, having a pleasing and uncommon effect. If sown in autumn, soon after the seeds ripen, the plants become larger and stronger than those sown in the spring. Common grass verges can scarcely be less than a foot in breadth, and are not therefore adapted for small borders: if formed of fine turf laid upon sand to keep the plants dwarfish, such simple verges are very proper for the margins of shrubbery borders.

Evergreens.

Evergreens.

466. Near the house, and about the flower garden, evergreen shrubs should abound. There should be at least one evergreen for two deciduous shrubs. The transplanting of evergreens requires some attention. It is often desirable to have them at once of considerable size; and fine large specimens may sometimes be found in public nurseries, or in market gardens. A year before these are to be removed, the roots should be cut, by passing a sharp spade all around and below them; thus encouraging the setting out of new and tufted roots, and greatly facilitating the subsequent removal of the plant. The roots of any kind of evergreen should be as little as possible exposed to the air. Nicol, in his Calendar, makes some judicious observations on the best time for transplanting of evergreens; He prefers the middle or end of April, or rather the precise time when the plant begins to grow for the season, when the buds swell, and the new leaves are about to be unfolded: the roots are then also in an active state, and if the transplanting be speedily accomplished, no check is sustained. Next to this late period of the spring, the beginning of August is a good time; for a second growth then takes place, as careful observers must have remarked, occasioned perhaps by the showery weather which generally occurs at that season.—Only a very few of the principal hardy evergreens can here be noticed.

467. Of the Alaternus (*Rhamnus alaternus*) there are several varieties, particularly the jagged and the plain leaved, and the gold and the silver variegated. Resembling this is the *Phillyrea*; but the genera may at once be distinguished, without seeing the flowers, by observing, that in the former the leaves are alternate, while in the latter they are opposite. Of phillyrea there are three species, privet-leaved (*P. media*), narrow leaved (*P. angustifolia*), broad-leaved (*P. latifolia*), and several varieties of each of these: these were, in former days, among the most favourite tonsile evergreens.

The Chinese Arbor vitæ (*Thuja orientalis*) and the American (*T. occidentalis*) are large, and rather suited for extensive shrubberies. The same may be said of the common laurel (*Prunus laurocerasus*), and the Portugal laurel (*P. lusitanica*).

Flower Garden. Evergreens.

468. The Sweet Bay (*Laurus nobilis*), which is a considerable tree in the south of Europe, appears but as a shrub in this country, producing its flowers only in sheltered situations and good seasons. The common laurel above mentioned, we may remark, is often mistaken for the bay, and regarded as the plant which furnished crowns for the Roman heroes. The error is perhaps fortunate, our bays thus escaping mutilation on occasions of public rejoicing. There is no doubt, however, that it was the sweet bay which furnished the wreath worn on the brow of the victor, and of the priestess of Delphi. The mistake has arisen from the bay having formerly been called laurel, and the fruit of it only named *bayes*. The Alexandrian Laurel (*Ruscus racemosus*) has also been mistaken for the heroic plant; but although destitute of this honour, it is a most elegant shrub, worthy of a prominent station.

The different varieties of Laurustinus (*Viburnum tinus*) are very ornamental, as they not only enliven the winter scene with their green leaves, but delight us with their flowers at that dead season. These last, however, are produced only in sheltered situations.

469. The Strawberry-tree (*Arbutus unedo*) is an elegant plant at all times; but when at once covered with fruit and flowers, the appearance is not only beautiful, but curious. In Ireland, about the Lakes of Killarney, this species, which ranks as a shrub in Scotland and the north of England, attains the size of a lofty tree. In the Transactions of the Dublin Society for 1806, a gigantic specimen is described by Mr J. T. Mackay as growing in Rough Island, an islet in the lower lake, entirely composed of limestone. In 1805, this tree measured nine feet in circumference at two feet from the ground; at the height of five feet it branches off into four limbs, each of which then measured two feet and a half in circumference; from the base of the trunk to the extremity of the branches, the length was 36 feet; and the tree has a fine spreading head. The *andrachne* (*A. andrachne*) is a beautiful shrub or small tree, but liable to be injured by severe frosts, and suited only to the milder counties of England and Ireland.

The superb Yucca, or Adam's needle, (*Yucca gloriosa*) may here be mentioned, as it retains its leaves at all times. When in flower it makes a magnificent appearance. Young plants are at first rather tender; but when fairly established, they prove sufficiently hardy for the open border. A fine specimen has stood for about a century in the pleasure-grounds of Kilochan, belonging to Sir Andrew Cathcart in Ayrshire; and it flowers every second or third year.

The Aucuba, or gold plant, (*Aucuba Japonica*) was formerly kept in the green-house; but it now ornaments the flower-garden with its fine spotted yellow leaves; and in a sheltered situation it sustains no injury from our ordinary winters.

470. Rhododendrons of different species are highly ornamental, particularly R. maximum, Ponticum, hirsutum, and ferrugineum. These grow well in any loamy soil, although they no doubt flourish more among sandy peat. If a rivulet pass the flower garden, the banks of it should be planted with them. *Kalmias* may also be introduced, particularly K. latifolia, angustifolia, and glauca; together with *Ledum* palustre and L. latifolium, or the Labrador tea plant; likewise different species of *Vaccinium*, and of *Andromeda*, particularly pulverulenta and cassinefolia; and *Gaultheria* procumbens.

Flower Garden.

Evergreens.

471. Among low evergreens for the front of the borders, different species of Cistus or rock-rose are excellent; and several hardy exotic Heaths, which shew their flowers early in the spring, particularly Erica mediterranea and carnea. E. arborea, the flowers of which are fragrant, sometimes attains the size of a considerable shrub, and is very ornamental, but it succeeds only in the milder parts of England. Even our four native species deserve a place. The most common is E. vulgaris, of which there is a white-flowered variety, and one with double flowers. E. cinerea, fine-leaved heath or *bell-heather,* is the next in point of abundance; it is more showy than the former, and there is a variety with white flowers. E. tetralix, or cross-leaved heath, is the third species; it is an elegant plant, distinguished by the leaves growing in fours, and by the flowers coming in clusters on the tops of the stalks. E. vagans is a native of the south of England, found indeed scarcely any where but in Cornwall. These native heaths grow perfectly well in any poor soil; but the ground should not be delved close by them, as their roots are generally extended very near the surface. *Pittosporum tobira* is a beautiful glossy-leaved Chinese evergreen, which succeeds in a well sheltered border, but unless it be situated in a dry soil, is apt to be cut off by the damp at the surface of the earth. Several species of *Daphne* are very ornamental as evergreens, and produce their flowers in the spring months, particularly D. cneorum, collina and pontica; and although the mezereon (*D. mezereum*) is a deciduous shrub; yet as it displays its blossoms very early in the spring, generally in February, it deserves a place; there are three varieties, dark red, pale red, and white. The Periwinkles (*Vinca major* and *minor*), when regularly cut over every year, form neat evergreen bushes.

472. The Musk rose (*Rosa moschata*) may be considered as approaching to an evergreen; and there is an almost evergreen variety of the sweet-briar (*R. rubiginosa*). But of all others, *R. Indica* is the greatest acquisition to our gardens, being not only always in leaf, but flowering both late and early, in November and in March. The *Ayrshire Rose,* a species not well ascertained, deserves a place, especially for covering any wall, pale, or winter seat; it grows very rapidly, and always retains some of its leaves. It is said to be from America, and to have received the name of Ayrshire rose, from having been first cultivated at Fairfield, near Kilmarnock. A rampant native species (*R. arvensis*) has likewise obtained among nurserymen the name of Ayrshire rose, and is often sold instead of the other, to which it bears a considerable resemblance.

Autumn, Winter, and Spring Gardens.

Autumn garden.

473. It now very commonly happens, that the autumn and early part of winter are the only seasons in which families, swayed by the fashionable world, reside at their country mansions. The forming of an autumnal and a winter garden is therefore important. In the former, many late-flowering perennial plants, such as asters, solidagos, rudbeckias, hollyhocks, and many kinds of annual flowers, may render the borders gay till the frost prove too severe. The carnation shed may with propriety be situated in the autumn garden.

Winter garden.

474. Addison, in one of his Spectators (No. 477.) sets forth the pleasures and beauties of a winter garden. "In the summer season," he observes, "the whole country blooms, and is a kind of garden, for which reason we are not so sensible of those beauties that at this time may be every where met with; but when nature is in her desolation, and presents us with nothing but bleak and barren prospects, there is something unspeakably cheerful in a spot of ground which is covered with trees that smile amidst all the rigour of winter, and give us a view of the most gay season in the midst of that which is most dead and melancholy. I have so far indulged myself in this thought, that I have set apart a whole acre of ground for the executing of it. The walls are covered with ivy instead of vines. The laurel, the hornbeam, and the holly, with many other trees and plants of the same nature, grow so thick in it, that you cannot imagine a more lively scene." A winter garden of much smaller dimensions than here suggested, would in general be found sufficient. The idea was taken up also by Lord Kames, in his "Elements of Criticism," (vol. ii. p. 448). "In a hot country," he remarks, "it is a capital object to have what may be termed a summer garden, that is, a space of ground disposed by art and by nature to exclude the sun, but to give free access to the air. In a cold country, the capital object should be a winter garden, open to the sun, sheltered from the wind, dry under foot, and having the appearance of summer by a variety of evergreens." All the evergreens which have already been mentioned would enter with propriety into the composition of such a garden. The *hornbeam,* it may be noticed, however, must have crept into the Spectator's list by inadvertency, it being a deciduous tree. Besides evergreen trees and shrubs, there are a good many humble herbaceous plants which retain a greenness in their foliage over winter; such are common daisies, thrift, pinks, none-so-pretty, burnet, and several others. These may also be admitted; and plants which flower in winter or very early in the spring, may be scattered over the borders; such are Christmas rose and winter aconite (*Helleborus niger* and *hyemalis*); dog's-tooth violet, white and pink, (*Erythronium dens canis*); bulbous fumitory (*Fumaria bulbosa* and *solida*); and others. To the winter garden a Conservatory may be considered as an appropriate appendage.

Spring garden.

475. A part of the winter garden may be appropriated as a spring garden, and planted chiefly with the early flowering shrubs, such as the common and the double dwarfish almond (*Amygdalus nana* and *pumila*), and the sweet almond (*A. communis.*) On the borders, the different species of narcissus, particularly the poetic, the daffodil, jonquil, and polyanthus-narcissus, may appear; these, even when rising through the ground, produce a lively appearance. And other early spring flowers might be added, such as the spring bitter-vetch (*Orobus vernus*); comfrey-leaved hound's tongue (*Cynoglossum omphalodes*); snowdrop, (*Galanthus nivalis*); the puccoon, (*Sanguinaria Canadensis*); and red, blue and white hepaticas (*Anemone hepatica.*) The *heathery* or heath-house might very properly form the principal object in the spring garden, many of the exotic ericæ flowering early in the year. The auricula frame might likewise be situate here.

Border Flowers.

Hardy perennial plants.

476. The principal borders are of course dedicated to mingled perennial plants, sufficiently hardy to endure our ordinary winters. A very few only can here be specified: those mentioned shall be the most showy and desirable of their kinds. They are arranged in the borders partly according to size, and partly according to colour. The tallest are planted in shrubbery bor-

Border flowers.

ders, or in the back part of broad flower-borders. Those of middling size occupy the centre; and those of humble growth are placed in front. The beauty of a flower-border when in bloom depends very much on the tasteful disposition of the plants in regard to colour, or on mingling the reds, the purples, the blues, the yellows, and the whites in due proportions. To increase the variety of colours, some biennial plants, and even a few annual kinds, are occasionally introduced. By intermixing plants which flower in succession, the beauty of the border may be prolonged for some weeks. In a botanic garden the same plant cannot with propriety be repeated in the same border; but in the common flower-garden, a plant, if deemed ornamental, may be often repeated with the best effect; nothing can be finer, for example, than to see many plants of double scarlet lychnis, double wallflower, double sweet William, or double purple jacobæa.

Shrubbery border.

477. For the shrubbery border the following are a few of the fittest tall-growing herbaceous plants. Hollyhocks (*Althæa rosea*) of different varieties and colours; these shew their flowers in October, when other plants are fading, and they continue till the frosts cut them off; they are properly biennial plants, but if some of the stems be cut over, before flowering, the roots continue for several years. Herb Christopher (*Actæa spicata*) a native of the north of England, and *A. racemosa* from North America, with the goat's-beard Spiræa (*S. aruncus*), are plants which succeed in the shade, and are therefore very fit for the shrubbery, or for any shady situation. The white-flowered Fox-glove (var. of *Digitalis purpurea*) is ornamental; it is only biennial, but rises freely from seed sown by itself. Several species of Aconite or monk's-hood, with blue and with yellow flowers, may here be planted; but the most common kind (*Aconitum napellus*) it is to be remembered, is a poisonous plant. With the monks-hoods may be united several species of perennial Larkspur, particularly Delphinium grandiflorum, and exaltatum; and the stavesacre, (*D. staphisagria.*) The common Columbine (*Aquilegia vulgaris*) when very double, and of good colours, makes a pleasing variety. All the large species of *Iris*, particularly the Germanica, sambucina and Sibirica, here deserve a place. The common and the white-flowered Willow herb (*Epilobium angustifolium*), and the double and double fistular varieties of Feverfew (*Pyrethrum parthenium*) are showy when in flower. Several tall species of Aster and of Solidago are also proper for the shrubbery, as well as some of the perennial Sunflowers, particularly Helianthus decapetalus, and the single and the double flowered H. multiflorus. To these may be added Rudbeckia laciniata, and Thalictrum aquilegifolium or columbine-leaved meadow-rue.

Besides tall plants, some of humble growth may with propriety be placed in the shrubbery or shrubbery border. Patches of sweet Woodruff (*Asperula odorata*), for instance, have a pleasing effect; the stalks and leaves gathered when the plant is coming into flower in May, and kept in small bundles in paper under some degree of pressure, retain their fragrance for a long time. Patches of the double wood Anemone (*Anemone nemorosa*) are likewise very ornamental; and this is the appropriate place for the Lily of the Valley (*Convallaria majalis*), of which there is a double and a red flowered variety.

Mingled flower border.

478. The borders for perennial flowers are seldom less than four or five feet in breadth. The plants are not placed immediately behind each other, but in the quincunx order; the distance between each plant varying, according to the size of the border, and in some measure according to the nature of the plant, whether it be apt to spread or to form a compact tuft. In regard to soil, it may be sufficient to observe, that most of the hardy herbaceous plants grow very well in a soil that is moderately light and mellow, such as a sandy loam. For certain plants, strong loam, turf mould, or vegetable earth, are proper; and this circumstance is generally noticed when treating of the particular plant.

Tall-growing plants.

479. Of the tall-growing perennials, one of the most ornamental is the double-flowered Scarlet Lychnis already mentioned (*Lychnis chalcedonica*, fl. pl.) The large heads of flowers have a most brilliant appearance in the back part of a flower-border. Every attention should be paid by those fond of fine flowers to the propagating of this plant. Several stems should with this view be cut down before the flower appear: these are to be divided into pieces five or six inches long, which are stripped of leaves except at the top, and sunk up to the leaves in the earth; they are covered for a few weeks with a hand-glass, and may either be planted out in the autumn, or allowed to remain under the glass till the spring. There is a white-flowered single variety, which is also deserving of a place.

480. The hyssop-leaved Dragon's-head (*Dracocephalum Ruyschiana*,) and the great-flowered (*D. grandiflorum*,) are elegant blue flowers. The Silver-rod, or branched asphodel (*Asphodelus ramosus*,) is a good border plant, with fine white flowers. Two species of Mullein, the rusty-flowered and the purple (*Verbascum ferrugineum* and *phœniceum*,) may be admitted; together with the fine branched Lythrum (*L. virgatum*), which is covered for about three months with purple flowers. Two or three species of the extensive genus *Centaurea*, deserve to be cultivated; such as, C. orientalis, with yellow flowers; C. Caucasica, with white flowers, and C. montana, with blue flowers; all of them hardy perennials. The double Siberian Larkspur (*Delphinium elatum*) has flowers of a fine dark azure colour. *Phlox pyramidalis* and *P. paniculata* are handsome showy flowers, of a pale bluish purple colour; of the latter there is also a white variety. The linear-leaved Willow-herb (*Epilobium angustissimum*) is worthy of a situation in the border, the foliage being fine, and the flower large, of a beautiful purplish red colour. Black Masterwort (*Astrantia major*) being of a singular appearance, may perhaps also merit a place. *Coreopsis verticillata* is an ornamental plant, and produces flowers of a fine deep yellow colour. Different species of Speedwell are elegant; particularly *Veronica Virginiana*, with blush coloured and with white flowers; and *V. longifolia* (formerly *maritima*) with blue, white, and flesh-coloured flowers. The variegated Wolf's-bane (*Aconitum variegatum*) is a very pretty plant; and the large flowers of *Rudbeckia purpurea* make a good appearance. *Liatris spicata* deserves a place in every collection.

The *Acanthus mollis* grows best when its roots get into the crevices of an old wall, near to the foot of which it may happen to be planted. In such a situation it will flower every year; while in a rich border soil, flowers seldom appear. The leaves of this plant accidentally surrounding a basket, are supposed to have given rise to the Corinthian capital.

Of the fine genus *Spiræa*, which is partly herbaceous and partly shrubby, two species are common natives, S. ulmaria or queen of the meadow, and S. filipendula or dropwort. Double flowered varieties of both these

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are kept in gardens; but it is worthy of remark, that while the single queen of the meadow is exceedingly fragrant, the double-flowered variety is quite destitute of odour. S. trifoliata is very elegant; it grows best in a peat soil, such as is generally prepared for American plants.

481. In the extensive genus *Campanula* or bell-flower, of which Persoon enumerates more than a hundred species, there are several showy perennials. Such are the peach-leaved or C. persicifolia, with single blue and single white flowers, and with double flowers of both colours: a very large flowered variety of the single blue, deserves particular attention; it has been figured in the *Botanical Magazine*, as a distinct species, under the title of C. maxima. The nettle-leaved bell-flower, (*C. trachelium*), when double, forms a showy border flower. The pyramidal or steeple bell-flower (*C. pyramidalis*) is highly prized as an ornament in halls, being for this purpose often kept in pots. In the open border the plant requires a sheltered warm situation; and when seeds are wanted, it is found useful to fix in the ground four stakes with niches at top, to receive a hand-glass to cover the plant during heavy rains.

Middle-sized plants.

482. The ornamental plants which are of middling size are so numerous, that it is somewhat difficult to make a selection.

Several species of Achillea are ornamental, particularly the Sweet maudlin (*A. ageratum.*) A double-flowered variety of our native sneezewort (*A. ptarmica*) very well deserves a place in the border. The spring Adonis (*A. vernalis*) is a perennial species, producing large yellow flowers in the beginning of April, when flowers are scarce. A double variety of Rose-campion (*Agrostemma coronaria*) is a highly elegant plant; it is properly only a biennial, but it may be continued for several years by parting the roots in autumn. The perennial flax (*Linum perenne*) is a very pretty native plant, deserving of a situation in the border. The round-headed Rampion (*Phyteuma orbicularis*) is another native, not less worthy of a place.

A curious variety of the common Toad-flax (*Linaria vulgaris,* H. K.), with five nectaries and five stamina to each corolla, is cultivated in some gardens, and much admired, it not being without reason that Miller styles it a "beautiful monster." It was first described in the "Amœnitates Academicæ" under the title of Peloria, and it is figured under the same name in "English Botany."

483. Several species of *Dianthus,* besides the carnation and pink, are much cultivated in gardens. D. barbatus, or bearded pink, more generally known by the name of Sweet William, is very common. It is a perennial, and may be increased by slips; but it is generally raised from seeds, seedling plants producing the strongest flowers: in this way, too, a great variety in the colours of the flowers is procured. When a very good kind occurs, it should be planted apart, at a considerable distance from all others, and the seed should be saved. The principal variations of colour are, deep red, pale red or rose-coloured, bluish purple, purple and white, white spotted; red with a white border, called Painted Ladies; purple with a white border, and pure white. Double flowers of several of these varieties are carefully preserved by the curious, and propagated by offsets and by cuttings; the double crimson and rose coloured are particularly esteemed. The narrow-leaved bearded pink is called Sweet John. A very remarkable and beautiful variety is the Mule Pink, supposed to have proceeded from the flower of a carnation acted upon by the pollen of the narrow-leaved bearded pink.

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484. Two species of *Eryngium* are very ornamental, E. alpinum and E. amethystinum. In the former, the fine azure blue, with streaks of green and white, of the large involucrum, never fail to attract admiration. It generally ripens its seeds in this country, and seedling plants may be observed near the parent plant, frequently under the shelter of the box edging. The other species has the upper part of the stem, as well as the head of flowers, of the richest amethystine colour, and therefore produces a very fine effect on the border. It is only in good situations, and in favourable seasons, that the seeds of this species come to maturity. Our native species, E. maritimum, or sea-holly, is admired for the glaucous hue of its leaves and stems: it may be planted in a mixture of sand and gravel: it is not easily dug up on the sea-shore, the roots running very deep into the sand: it should be removed in autumn. The roots of this species were formerly candied. Along with these eryngiums, may be classed several species of *Statice* or Thrift, in particular S. latifolia, scoparia, tatarica, and speciosa, all natives of Russia or Siberia.

485. Fraxinella or *Dictamnus albus* is a plant which merits a place, being both beautiful and curious. When gently rubbed, the plant emits an odour like that of lemon peel. The pedicels of the flowers are covered with glands of a rusty red colour: from these a viscid juice or resin exudes, which is exhaled in vapour, and is said occasionally to produce a slight explosion: this phenomenon is to be observed in a warm, dry, and clear night in June, by approaching a lighted candle to the flower of the plant. The usual colour of the fraxinella is white; but there is a red variety.

486. The Cardinal's Flower (*Lobelia cardinalis*) is a very elegant plant: But it is now in a great measure supplanted by another species of the same genus, of still greater brilliancy, *L. fulgens.* The flower of this last is among the brightest scarlets of the vegetable kingdom. The plant is readily propagated by offsets, but it will scarcely endure our winters without protection. A few plants may be left to their fate, while others may be covered with hand-glasses in the borders; but it is safest to pot a number of plants, and keep them under a frame during winter.

487. *Catananche cœrulea* requires a dry soil and sheltered situation; it is often indeed kept in pots, and placed under glass in winter. Its flowers are of a very fine blue; and there is a double variety, which however is not common. The Canadian Columbine (*Aquilegia Canadensis*) is a delicate looking flower, highly ornamental. Garden Wall-flower, (*Cheiranthus cheiri*) when double and of dark colour, is much prized; there is also a pretty variety of the native species, *C. fruticulosus,* with double flowers. The Red and the Scarlet Chelone (*C. obliqua* and *barbata*) make a pretty appearance in autumn, when flowers are beginning to grow scarce. A new species of chelone, (*C. major*) has of late been introduced, being figured in the "Botanical Magazine" for November 1816. It is, like the others, an American plant, and perhaps more hardy than them: it is at the same time the most showy of the genus, producing fine peach-coloured flowers in large and close spikes. German Goldilocks (*Chrysocoma linosyris*) has bright yellow flowers in the form of an umbel; when handled, the plant gives forth an aromatic agreeable scent. *Tritoma media,* although a native of the Cape of Good Hope, endures our winters, with a very slight degree of protection, and produces

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its beautiful spikes of orange flowers either in November or in March. Two species of *Monarda* should be admitted; the Oswego tea or M. didyma, which has scarlet flowers, and M. fistulosa, the flowers of which are purple. The perennial Lupine (*Lupinus perennis*) is now a rare plant; but a more showy species, from Nootka Sound, (*L. Nootkatensis*) has received the name, and is generally and deservedly cultivated. Of the Poppy genus two perennial species are worthy of attention; the Oriental (*Papaver orientalis*) with large bright orange flowers, and the Welch, (*P. Cambricum*) with flowers of a deep yellow. Red Valerian (*Valeriana rubra*), when of a dark colour, is highly ornamental, and there is a white variety which forms a fine contrast. Several kinds of Peony, particularly the double dark red and double blush (varieties of *Pæonia officinalis*), and the white-flowered, (*P. albiflora*), are magnificent border plants. The smooth-leaved Bell-flower (*Campanula nitida*) is very ornamental, appearing for some weeks completely covered with its blue flowers: the Dutch, it may be observed, have a double variety of this, which has not yet found its way into our gardens. Of the numerous genus *Aster*, three species are of proper size for the middle of a border, and shew fine lively blue flowers; the Italian starwort, or A. amellus; the alpine, or A. alpinus; and the A. spectabilis.

Ragged-Robin, or *Lychnis flos cuculi*, a native of our meadows, when double-flowered, makes a beautiful appearance, and is of course perfectly hardy. The varieties of L. dioica with double red and with double white flowers, are also very showy: In England, these often get the name of red and white Bachelors' Buttons, while in Scotland this name is more commonly given to the double varieties of Ranunculus aconitifolius and acris. The plantain-leaved crowfoot (*Ranunculus amplexicaulis*) may be mentioned as a desirable spring plant, displaying its pure white flowers in April and May: it succeeds best in a strong loam.

Of the Garden Rocket or dame's violet (*Hesperis matronalis*), there are double white and double purple varieties; the former is the kind generally seen in gardens, the latter being rare. They are both excellent border flowers, being at once showy and fragrant. If the stock-plants be allowed to remain long without transplanting, they are apt to die off; a supply should therefore be prepared by slips or cuttings every year.

The Virginian Spiderwort (*Tradescantia Virginica*) with fine blue flowers, and the varieties with red and with white flowers, should not be omitted; they grow best in a mixture of loam and peat-earth. The bell-flowered Pentstemon (*P. campanulata*) is a fine peach-coloured flower; the *Uvularias* are uncommon looking yellow flowers, particularly U. grandiflora and sessilifolia; and some species of Solomon's-seal, particularly Convallaria polygonatum and multiflora, afford greenish-white blossoms.

If the Asiatic Globe-flower (*Trollius Asiaticus*) be not planted in a bed by itself, it may be introduced into the border, where its rich orange flowers are very brilliant; it requires a strong loam. The common globe-flower of our upland meadows (*T. Europæus*) may also have a place, the flowers being handsome and of a fine yellow, and being the *lucken gowans* mentioned by Burns in his poems.

In any moist and rather shady situation, the American cowslip (*Dodecatheon Meadia*) will grow, and freely display its very elegant flowers in the month of May. If some peat earth be mixed with the soil, the plant becomes more strong. Barrenwort (*Epimedium alpinum*) is a plant of considerable beauty, which thrives in similar situations.

Low-growing plants.

488. Among *low-growing flowers* for the front of the border, the double purple Jacobea (*Senecio elegans*) holds a distinguished place. It is, strictly speaking, only an annual; but the double variety is continued by cuttings. If a few small plants be preserved in the green-house during winter, they will afford cuttings in the spring, which, as soon as they are well established, are to be planted out in the borders. There is also a variety with double white flowers, which is not uncommon in gardens in the vicinity of London.

Several Phloxes are very ornamental, particularly the common Lychnidea (*P. suaveolens*) with variegated leaves; the early flowering, P. divaricata; P. subulata or awl-leaved, and P. setacea or fine-leaved; with P. ovata, and P. stolonifera or creeping. Phlox subulata should be allowed to form a large patch on the ground in front of the border, being in this way extremely brilliant when in flower; in this way, too, the plant suffers less during winter. This species and the P. setacea are best propagated by cuttings; the others, by parting the roots in autumn.

The great-flowered Siberian Fumitory (*Fumaria nobilis*) is very handsome, and continues long in flower. *F. formosa*, remarkable for its delicate blush coloured blossoms, may also be noticed; and the yellow species (*F. lutea*) is valuable, as affording a patch of this colour in the border from April to November.

Our common Bloody Crane's-bill (*Geranium sanguineum*) is not unworthy of a place; and the same may be said of the striped variety, commonly called Geranium Lancastriense. The streaked crane's-bill (*G. striatum*) is a delicate looking flower, which generally pleases.

The yellow species of Monkey-flower (*Mimulus luteus*) introduced about 1812, is an acquisition, as it is rather pretty, and continues several months in flower: Though a native of Chili, it proves quite hardy. Different species of *Œnothera* are of humble growth, and produce fine yellow flowers, particularly Œ. Fraseriana, fruticosa, and pumila. Patches of the purple Alyssum (*Farsetia deltoidea*) are very beautiful in the spring and early part of summer, when covered with flowers. A common native plant, Marsh-marigold (*Caltha palustris*) is likewise very showy in the early part of the year; a large patch of it makes a brilliant appearance for several weeks; being naturally a marsh plant, it grows best in a moist border. Feather-grass (*Stipa pennata*), when its long and delicate awns are displayed in August and September, is justly admired for its light and airy appearance.

Violets of different kinds are well known ornaments; the Canadian (*Viola Canadensis*) is particularly elegant; and the Sweet, or March violet, (*V. odorata*) is not only desirable for its fragrance, but the large flowered double variety is beautiful.

Different species of Anemone, chiefly with blue flowers, may adorn the front of the border; such as the splendid Pasque-flower (*A. pulsatilla*); different varieties of the star anemone, (*A. hortensis*); the blue mountain and the meadow anemone (*A. apennina* and *pratensis*). Some of the Gentians are also fine border plants, especially Gentiana asclepiadea and cruciata, both with blue flowers.

489. Among the flowers which have now been enumerated, a good many are natives of North America, such as all the species of the elegant genera Phlox and Chelone. A separate *American Garden* is, however, a

desirable thing. Into this the trees, shrubs, and herbaceous plants of the New World only are to be admitted; so that, on entering the garden door, a person possessed of a botanical eye will find himself transported, as it were, across the Atlantic. One of the most complete American gardens in this country is at Milburn Tower, near Edinburgh, the seat of Sir Robert Liston, Bart. formerly British ambassador to the United States.

Florists' flowers.

490. Flowers which are cultivated in beds by themselves are now to be considered. These are in a peculiar manner distinguished by the title of *Florists' flowers.* The principal are the tulip, ranunculus, anemone, iris, dahlia, pink, carnation, polyanthus, auricula, hyacinth, polyanthus-narciss, and crocus.

Tulip.

Tulips.

491. The tulip (*Tulipa Gesneriana*, L.) is a native of many parts of Turkey and of Persia, where the flower is principally of a red colour, each petal having a black mark at its base. It was not brought into the north of Europe until after the middle of the 16th century; and it was first cultivated in this country by a Mr Garret, an apothecary of London, about the year 1577. A hundred years after its introduction, the *tulipomania*, or rage for fine tulips, attained its height: it prevailed chiefly at Haarlem, and other parts of the Netherlands. High sounding and bombastic names were bestowed on the favourite varieties, a practice which is still continued by florists. The Viceroy and Semper Augustus were two sorts, the bulbs of which sold at the most extravagant prices, or rather gave occasion to the most foolish gambling speculations. Twelve acres of land were covenanted to be given by one person, and 4600 florins, besides a new carriage, with horses and harness, by another, for a single tulip bulb, the flowers of which should possess certain almost ideal perfections. In the present day, tulip collectors possess a few sorts on which they place a high value; but in general the very finest varieties may be procured at 5 guineas a bulb; and a great many of what are reckoned prime kinds at perhaps 5s. a piece.

Tulips were formerly divided into *præcoces*, or early flowering; *mediæ*, or middle-timed: and *serotinæ*, or late flowering. One of the præcoces, it may be noticed, is a distinct species, T. suaveolens; this is the early dwarfish sweet-scented tulip, or Duke Van Thol of the catalogues: when planted in a small bed by themselves, these Van Thol tulips, when in flower in April, form one of the most resplendent scenes presented by the flower garden. Parkinson, so long ago as 1629, enumerates 140 varieties of tulips, and hints that there were many more. Maddock, in his catalogue, gives the names of 665 choice late tulips, independent altogether of early sorts, double flowered, and what are called parrot tulips.

492. Late tulips are the only kind now attended to by florists, the double and parrot sorts being in little esteem with them. They are divided into six families, distinguished by barbarous titles, a mixture of French and Dutch. 1. *Primo baguettes*, very tall, (the term *baguette* inferring that they resemble a small walking-stick, or switch), cups with a white ground broken with fine brown; and all from the same breeder. 2. *Baguettes rigauts* (or *rougeaudes*), with strong stems, though not so tall, very large cups with a white ground, likewise broken with fine brown, and all from the same breeder. 3. *Verports*, (or, as they are more commonly called in this country, Incomparable Verports, or simply Incomparables), with very perfect cups, having a beautiful white ground, or bottom, well broken with shining brown approaching to rose colour, and all from the same breeder. 4. *Roses*, allied to the verports, the petals streaked with cherry and rose colours, on a white ground. 5. *Bybloemens*, sometimes contracted into *bybloems*, with the ground white or nearly so, from different breeders, and broken with variety of colours. 6. *Bizarres*, (probably a corruption from *bigarée*), with a yellow ground, from different breeders, and broken with variety of colours.

Tulips.

The terms *breeders, whole blowers*, and *seedlings*, are all applied to such flowers, raised from seed, as are plain or of one colour, have a good bottom or ground colour, (visible at the base of the petal), and are well shaped. They may thus be either bybloemens or bizarres. The petals of these, in the course of time, break into various elegant stripes, according to the nature of their former self-colour. In correct language, the term *breeders* would mean plants, from the seed of which young tulips are to be raised.

493. The florist's criterion of a fine flower is frequently at variance with that of the world at large. Many tulips which would excite the admiration of thousands, are rejected by the connoisseur. The properties of a fine tulip, as set forth in the Florist's Directory, are the following. The stem should be strong and tall, two feet or more. The flower should be large, with six petals; the petals at the base proceeding for a little way almost horizontally, and then sweeping upwards, so as to form an elegant cup, with a rounded bottom, and somewhat wider at top than below. The three outer petals should be rather larger, or broader at the base, than the three inner ones; all the petals should have the edges perfectly entire; the top of each should be broad, and well rounded; the ground colour at the bottom of the cup should be clear white or yellow, free from stain or tinge; and the various rich stripes, which are the principal ornament of a fine flower, should be regular, bold, and distinct on the margin, terminating in fine broken points, elegantly feathered or pencilled; while the centre of each petal should contain one or more bold blotches or stripes of colour, mixed with small portions of the original or breeder colour, broken into irregular obtuse points; this last character, however, of central stripes or blotches, not being indispensable, and any trace of the breeder colour displeasing many florists.

494. The raising of tulips from the seed is a tedious process; but in this way alone are new varieties and vigorous bulbs to be expected. Seed is collected only from flowers of one uniform colour, or which are self-coloured, and are at the same time of good shape; for, contrary to what might naturally be expected, experience, it seems, has shewn that the seed of the most beautiful striped tulips does not yield so fine a produce as is got from the plain coloured. The tulips intended for seeding are planted deeper than usual, perhaps eight or nine inches deep, in order that the stem may be kept longer in a vigorous state; and they are placed in a border where they may enjoy the full benefit of the sun. Towards the end of July the pods begin to open; they are then cut off, and kept, with the seeds in them, in a dry place, till the beginning of September, when the seed is sown. This is generally done in shallow boxes containing fresh light earth; a covering of about half an inch thick, of the same light or sandy earth, is sifted over them. These boxes are placed in a sheltered situation for the winter. By the middle of March the seedling tulips shew their grass-like first

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Tulips.

leaves; these continue green for about two months, and then gradually decay, so that they entirely disappear in June. After another year, the small bulbs are raised, and transplanted into a nursery bed, two inches deep, and at two inches apart. If the bed be in an exposed situation, haulm or mats are placed over it during the severity of winter. In this bed the bulbs remain for the third and fourth years. They are then raised, kept some short time out of the earth, and transplanted to another bed, in which they are placed four inches separate. Here they remain other two years; and in this interval many of them begin to show flowers. Such as have tall stems and rounded petals are now transferred to a separate bed, and treated like full grown bulbs; and after they have flowered for two or three years, their real value may be pretty nearly ascertained: If they be very promising, that is, tall, well shaped, with clear bottoms, and self-coloured, they are retained for a longer time, in expectation of improvement. A few come finely striped at once, and are of course retained; but these are apt quickly to degenerate. Those that appear with short stems and sharp-pointed petals are rejected without hesitation.

The tendency to break is promoted in the breeders, by shifting the bulbs every season into different kinds of soil, and placing them in different situations. The soils preferred are such as are fresh, but poor, dry and sandy. The compost recommended by Miller consists of a third part fresh earth from old pasture land, having the sward rotted with it; a third part sea-sand; and a third part old lime rubbish sifted, all well mixed and frequently turned. The beds are made two feet deep, and the bulbs are planted in drills about four inches deep, and six or seven inches from each other in every direction. When a breeder breaks completely, losing all traces of its self-colour, and continuing till the petals decay without shewing any tendency to return to its former colour, it is marked, named and enrolled among the choice tulips, and its offsets are carefully preserved. A tulip when it breaks never attains the height or size of the breeder; if a breeder be three feet high, its variegated progeny does not exceed two, and the flower is proportionally less. Whether the breaking is the cause or the consequence of debility, does not appear; but it seems to be a general fact, that variegated flowers or plants are more tender than such as are plain.

The directions for the planting and management of breeders are applicable to striped tulips in general. A practice not uncommon with gardeners must here be condemned, it is the planting of tulip bulbs with a dibble. This ought never to be done. The pressure of the dibble renders the earth compact where it ought to be loose, and in many cases a partial hollow must remain below the bulb, which is particularly injurious when wet weather follows, and moisture lodges about the root. It is better when drills are formed, six or seven inches deep, and the bulbs covered in with the loose earth. A still more proper way is, to prepare the bed some inches lower than it is intended ultimately to be; to put the bulbs in their places on the surface; and then to add the necessary quantity of soil. The bed is improved by being made to slope a little from the centre to each side; the stronger bulbs should be situated in the middle, as they thus receive the thickest covering of soil, which they ought to have. In all the modes of planting, it is a good rule to put a little dry and fine sand around each bulb.

495. The bed of choice tulips is, by the true florist, at first protected by hoops and mats, from hail showers and storms, and afterwards, when the season of flowering arrives, covered by an awning of thin canvas. In this way only can the delicate colours be fairly brought out; even half an hour's full exposure to the sun's rays has been known to alter them; besides, the enjoyment of the fine sight is prolonged for near a month. Though the scent of the tulip is so slight as scarcely to be perceptible in single specimens, the united odour of so many, confined in some measure by the cover, becomes quite evident. Watering is scarcely ever necessary for tulips. The seed-pods of all fine tulips are cut off as soon as they appear; for these, as already said, are by no means the best from which to procure seed, and the bulbs exhaust themselves in forming them. The bulbs are lifted in the course of the month of June, the proper time being ascertained by observing when the foliage has decayed, and two or three inches at the top of the stem begin to acquire a purple tinge. If they be left longer in the earth, the flowers are apt to become foul the next season. The bulbs are cleaned, and laid in a dry place till October. The offsets, chives, or babies, are taken off and marked, in September; these are planted in a separate bed, not so deep as the parent bulbs, and about a month earlier. It may be remarked, that all young bulbs or offsets that are of a round shape, though small, may be considered as likely to produce flowers. The general time of planting old bulbs is the end of October or beginning of November. At this time the outer brown skin is carefully stripped from the bulb, which is committed to the ground in a bare and clean state. By the end of February most of the tulips appear above ground: the surface is at this season gently stirred with the fingers, aided perhaps by a little bit of stick; this stirring tending greatly to promote their health and growth.

The finest and most extensive collections of tulips in this country at present, are probably those of Davy, nurseryman, King's Road, and of Milliken, florist at Walworth, both near London. Some private collectors, however, principally near the metropolis, have small beds of very fine and select kinds.

Ranunculus.

Ranunculus.

496. This well known flower (*Ranunculus Asiaticus*) is a native of the Levant and of the Greek Islands. It was cultivated by Gerarde in the end of the 16th century. Very many new varieties of singular beauty have been raised from semi-double flowers, both in this country and in Holland: some of these possess also considerable fragrance. A judicious and industrious cultivator of this plant near Edinburgh (Mr John Fletcher, superintendant of experiments to the Caledonian Horticultural Society) has excelled many of his cotemporaries in the number of his distinct and well marked varieties, and the beauty of his flowers, many of which have been raised from seed by himself during the last thirty years. He plants each variety in a row, or sometimes in two rows, by itself, in narrow beds, divided by small paths; each distinct variety has a numbered tally, and the number of choice sorts exceeds 180; the proper contrast of colours is studied, and the whole, when in full flower, produces a very brilliant effect. By some florists the varieties are split down till they extend to many hundreds, so that it has been found difficult to invent names for them. Mr Maddock divides the colours into twelve families: Dark and dark purple; light purple and grey; crimson; reds; rosy; orange; yellow and yellow spotted; white and

white spotted; olive; purple and coffee-coloured striped; red and yellow striped; and red and white striped. The Turquoy, or turban-shaped ranunculus, is a very distinct sub-variety.

497. The qualities of a fine double ranunculus, as described by him, consist in the flower being of a hemispherical form, at least two inches in diameter, the numerous petals gradually diminishing in size to the centre; the petals broad, with entire, well rounded edges; their colours dark, clear, rich, or brilliant, either of one colour, or variously diversified on an ash, white, sulphur, or fire-coloured ground, or else regularly striped, spotted or mottled. The stem should be strong and straight, and from eight inches to a foot in height.

The root is composed of several thick fleshy fangs or claws, uniting at top into a head. When the plant becomes strong, several subordinate or lateral heads are formed, and each of these may be taken off with their proper claws, to form a new plant. These offsets, it may be observed, form better flowering plants than the central head, which is exhausted by flowering.

The soil preferred for the ranunculus bed is fresh rich loam, inclining to clayey. It should be deep, perhaps little short of three feet; for it is surprising to what a depth the fine fibres from the tubers penetrate downwards. Some gardeners raise the bed a few inches above the surrounding ground. If manure be at any time added, it should be well rotted, and must be introduced at the very bottom of the bed at least two feet and a half below the tubers. Miller mentions three feet as the proper depth of soil for the beds, adding, that on such beds plants will produce forty or fifty flowers, which in a shallow soil would not afford a dozen. The beds are kept flat on the surface, not raised in the middle as for tulips. Miller directs, that the roots should be planted six inches apart each way; but this is too wide: Five inches between the rows, and three or four inches between each plant in the rows, are sufficient. In some situations, the plants grow stronger than in others; and a good general rule is, to observe the size which the leaves commonly acquire, and then, in that garden, to plant so close as that the grass or foliage of contiguous rows may just meet; the ground being kept in a desirable state of moisture by this close covering of leaves. The tubers should not be more than an inch and a half deep in the earth; and they should be placed with the claws pointing downwards or the bud upwards. It is not right to plant ranunculuses year after year in the same bed. If a little fresh soil be introduced, they may do twice; but after this, the earth of the bed should be entirely changed, or a new bed should be made in a different part of the garden.

The time of planting is either the latter end of October, or the first mild and dry weather in February. When put in in October, the buds sometimes appear above ground in November; in this case, a thin covering of half an inch of light soil, is cast over them before severe weather set in. Autumn planted ranunculuses also require attention in the spring; if hard frosts occur when the flower-stems appear, a covering of hoops and mats may be proper for a few days.

The beds are weeded with the hand, and by careful cultivators the earth between the rows is stirred up only with the fingers, a hoe being very apt to cut and injure the tubers, or break too many of the fine roots. When the flowers begin to expand, the florist does not fail to guard equally against nightly frosts and scorching sunbeams, by means of a canvas awning, or at least of mats laid over large hoops. When drought occurs, liberal watering proves very beneficial to the ranunculus bed.

When the flowering is over, and the leaves have begun to decay, the tubers are carefully lifted on a dry day; being thoroughly cleared of earth, they are dried in the shade, and then deposited in separate drawers or boxes, or in paper bags, till wanted for replanting.

When it is wished to raise seedling ranunculuses, the seed is collected from flowers having not fewer than five or six rows of petals, of good colour. It is sown in August, in boxes or pots, on the very surface of the earth, and a little very fine mould is sifted over it, so as hardly to cover the seeds. The young plants are kept under a glass frame during winter; and most of them flower the second year.

Anemone.

Anemone.

498. The garden anemone is of two kinds, the broad-leaved (*A. hortensis,*) and the narrow-leaved (*A. coronaria.*) The former is the more hardy, being a native of Italy and the south of France; the latter grows naturally in the islands of the Archipelago, where it appears of all colours.

499. A fine double anemone should have a strong upright stem, eight or nine inches high; the flower should be from two to near three inches in diameter; the outer petals should be firm, spreading horizontally, except that they turn up a little at the end, and the smaller petals within these should be so disposed as to form an elegant whole. The plain colours should be brilliant and striking; the variegated ones, clear and distinct. The flowers are generally divided by florists into red and pink, rosy and crimson, white and white spotted, dark and light blue.

In preparing an anemone bed, the surface soil of some old pasture, with the turf itself, is to be mixed with some well rotted cow-house dung, and allowed to lie for a year in heap, but occasionally turned over. Large stones are to be cast out, but the soil should not be screened, or at least should not be made too fine.

The roots are tuberous, and very irregular in shape. They are commonly planted six inches apart in each direction, and about two inches deep, taking care to place the bud uppermost. The best season for planting is considered to be the month of October; but some roots are generally kept back till December; and others are not put in till February, in order to render them later in coming into flower, and thus to prolong the anemone show. Where the flowers are prized, the beds are sheltered during the severity of the early spring, by mats laid over hoops; for it is remarked by practical men, that double flowers often become single, by "the *thrum* (collection of narrow thread-like petals) that is in the middle of the flower being destroyed." In April and May, if the weather prove very dry, they are regularly refreshed with water.

In July, when the leaves decay, the roots are taken up, but always in dry weather. They are cleared of earth, either with the fingers, or by washing. They are then packed in baskets or drawers till the planting season recur. Of choice sorts, the smallest offsets are valuable; and as these are minute, and very much of the colour of the soil, great attention is requisite to have them all picked up at the time of lifting.

500. New varieties are raised from the seeds of

Anemones.

single garden anemones commonly called Poppy Anemones, preferring those of good colours. Some care is necessary towards the separating of the seeds, which stick together like those of carrots; it is most effectually done by rubbing them among dry sand. The seedlings require attention and protection for the first year, particularly in the spring months, when the frost is apt to throw them out of the ground. In the second year, many of them flower; and the rest probably in the third year. The most promising are then selected.

The poppy anemones themselves, of bright red and blue colours, are highly ornamental in the garden borders. They require little attention, being only taken up every second year. They generally flower in February, and form the gayest parterre ornament at that chill season. Double anemones likewise, if left in the border all the year, come very early into flower.

Iris.

Iris.

503. The genus *Iris* or Flower-de-luce is extensive, containing about fifty species, many of which make very handsome flowers for moist and shady borders; but when a bed of irises is formed, only a few species enter into it. Different varieties of what are called the English or bulbous iris (large rooted and small rooted, or *Iris xiphioides* and *I. xiphium*) form a principal part. The seed of these is gathered and sown by florists, and in this way new and sometimes curious varieties are obtained. The most common colour is blue, deeper or lighter; but the colour is often yellow, or white; sometimes blue, with white or yellow shades, or violet with blue shades; and it is variegated in many other ways. I. pallida or pale Turkey iris, with I. variegata and cristata, are sometimes admitted into the bed. I. tuberosa or snake-head iris, is a singular species both in regard to foliage and flower, and is likewise occasionally planted.

The soil of the iris bed should be a light loam, with a mixture of sandy peat. The loam should if possible be procured from an old pasture, and the sward should be taken along with it. No manure should be added. On an east border, the flowers make a finer appearance than if fully exposed to the south.

The Chalcedonian Iris (*I. susiana*) is yearly imported from Holland, and produces its magnificently rich and large flowers the first summer, but seldom shews flower till three years afterwards. It too agrees with a light loamy soil, but must have a warm sunny situation; and it is to be observed, that moisture, which agrees well with most of the species, is hurtful to this one. In severe winters it is apt to perish: the best roots should therefore be placed in pots, and kept under a frame during winter.

Dahlia.

Dahlia.

504. There are two species of *Dahlia* mentioned in *Hortus Kewensis*, D. superflua and D. frustranea. Of the former there are purple and rose-coloured varieties; and of the latter, scarlet and yellow varieties. Seeds have repeatedly been ripened in this country; and the plants from these have become so far acclimated to Britain, that in a few years they are likely to be ranked as hardy perennials.

Till Mr R. A. Salisbury published his observations on the cultivation of Dahlias, they were little known in this country. Being natives of Mexico, they come into flower in October and November, the period corresponding to their usual time in their native country. They may, however, be brought to shew their flowers more early. This is accomplished by checking the luxuriance of the herbage, by means of planting the roots in very poor soil, sometimes even in screened gravel. Water is supplied only till the flower-bud be discernible in the heart of the leaves; after which none is given.

The roots, which are large and tuberous, like those of peony-rose or yellow asphodel, are taken up every year, and kept for some weeks in sand. Some cultivators always plant them in pots, the restraint thus imposed on the roots having the same effect as planting in gravel. The growth in the spring may, in this way, be forwarded, by placing them under a frame; and the pots may be sunk in the dahlia bed in June. If the bed be situate close to a south-east or south wall, the flowering of the plants is greatly promoted. The more tender sorts, such as the scarlet variety of D. frustranea, may be placed next to the wall, and have its branches nailed to it, in the way practised with love-apple. All secondary branches are pinched off while young and tender, and even some leaves are removed, if the plant shew a disposition to be very luxuriant.

Pinks.

Pinks.

505. The common pink and the carnation, though considered as distinct kinds of flowers by the florists, have originated chiefly from one and the same species of plant, the Dianthus Caryophyllus of Linnæus, or Clove Pink. It grows naturally in rocky situations in some parts of Germany; and Sir J. E. Smith has even given it a place (*English Botany*, t. 214.) as a native of Britain. Carnations and pinks seem to have been entirely unknown to the ancients; for Pliny does not describe them, and the classic poets make no allusion to them.

Pinks were not held in much esteem by our own ancestors; indeed they seem to have risen to distinction with florists only in the 18th century. They are divided by them into several classes; such as damasks, cobs, and pheasant's-eyes. The first are white, and flower early; the cobs are red, and flower late. Both of these kinds are considered as originating from D. caryophyllus; but the pheasant's-eye, of which there are numerous varieties, is regarded as having sprung from D. plumarius.

When it is wished to propagate good kinds of pinks, this is readily done either by layering or by using cuttings or pipings. This last mode is the most commodious, the pink growing freely in this way. The difference between a cutting and a piping consists in this, that in the former a joint is cut through horizontally, while a piping is drawn from its socket, leaving a pipe-like hollow. The proper time for gathering cuttings or pipings is when the plants begin to come into flower. They are best when between two and three inches in length; and they should be firm and compact, not *drawn*. Some part of a bed or border having been worked fine, or the surface soil having been screened by means of a sieve, the pipings are stuck into it at three inches square, and the earth is firmly applied to them with the fingers. A copious watering is then given, and hand-glasses are firmly pressed down over the plants: if the weather be bright, these may have some dry earth thrown against them while the glass is moist, in order to produce a degree of shade, or some large leaves may be laid on them for a few days. These hand-glasses are not removed till the new growth of the pinks be distinctly perceived, which happens generally in the course of a month or five weeks; water is however occasionally applied around the covers. The plants are afterwards transferred to a larger bed, or to a garden border, in time to permit them to become well rooted before winter. Slips of pinks, four or six inches long, drawn from the sides of main shoots, and planted any time in the spring, seldom fail to grow.

New varieties are procured by raising plants from seed: for this purpose the seed of the best sorts only is saved; it is produced sparingly in such flowers as are not perfectly double; it is procured more plentifully from semi-double flowers, and if these be of good colours, the offspring is frequently very promising. It is sown in the spring, and the plants are nursed up in beds, and afterwards planted out. From a considerable bed, only a few can be expected worthy of being preserved; and these are likely to be found among the weakest plants.

506. Those flowers the petals of which are elegantly laced with colours, while the edges are scarcely notched, or are as nearly as possible rose-leaved, are considered the finest. Being very double, and at the same time opening fairly or without bursting, are qualities highly prized. A clear white for the body of the flower is always desirable. In the lacing, a rich black, shaded toward the centre with red, is much esteemed. Scarlet lacings are most rare, and much in request. A purple lace is greatly admired, as in the variety known by the name of Davy's Duchess of Devonshire, which may be considered as the model of a perfect pink. Pinks are carefully tended by the zealous florist. When the flower-stalks rise, they are tied to a small stick to keep them up; and when the petals begin to appear in the pod, those pods which seem apt to burst on one side are restrained by a small piece of slit card-paper. The finest flowers when expanded are covered with pieces of tinned iron in shape of inverted funnels or little umbrellas, equally to save them from rain and from the sun's rays.

Carnations.

Carnations.

507. Formerly these were divided into *Carnations*, often called Bursters, having very large leaves and flowers, and into *Gillyflowers* (*girofliers*, F.), the leaves and flowers of which are smaller. The former are now called Tree-carnations; the latter, Common carnations. The florists of the present day distinguish carnations into four classes. 1. *Flakes*, having one colour only, on a white ground, the stripes large, and the colour extending through the substance of the petal: when the stripe is pink, and of high colour, the flower is called a Rose flake. 2. *Bizarres*, flowers with two colours, on a white ground: they are called scarlet, purple, or pink bizarres, as these colours happen to abound; when deep purple and rich pink occur together, the flower is accounted a crimson bizarre. 3. *Piquettees*, with a white, and sometimes a yellow ground, spotted with scarlet, purple, or other colours, the edges of the petals generally notched or serrated. 4. *Painted ladies*, with the petals red or purple on the upper side, but white below. This last class is often associated with the pinks.

508. According to florists, the following are the chief properties of a good carnation. The stem should be strong and straight, nearly three feet high; the flower should expand freely and equally, and should not be less than three inches in diameter; the outer circle of petals, or the guard leaves, should be strong, so as to support the interior petals; these should be numerous, but not crowded; they should regularly decrease in size as they approach the centre; the petals should be rose-shaped, or the edges should be entire, without notch or fringe; the colours should be bright and distinct, the stripes narrowing gradually to the base of the petal; and almost one half of each petal should be of a clear white.

In the culture of carnations, the preparing of a proper compost or soil is of some importance. For producing strong flowers, Maddock recommends a compost consisting of one half well rotted stable dung, one third fresh sound loamy earth, and one sixth sea or river sand; the ingredients to be thoroughly mixed by repeated turnings at intervals of several weeks. If, however, it is wished to preserve entire and brilliant the colours of the flowers, a compost containing much less dung and more loam is greatly to be preferred.

The finest carnations are planted in pots a foot wide at top, and are placed on the shelves of a stage at the time of flowering: they are hence often called Stage-flowers. The potting is performed toward the end of March. The plants are then placed in an open airy part of the garden, under an arch of hoops, so that they may be protected by a covering of mats in case of need. Watering is carefully attended to; the water is not sprinkled over the whole plant, but is applied only to the root. The stems are tied to stakes as they advance. In this situation the plants continue till their stems become too tall for remaining under the hoops. They are then placed on the stage for flowering. Here slender stakes, four feet in length, and sometimes painted, are employed, and the stems are neatly tied to them at the distance of every six inches. As the flower-buds advance, they who are nice watch any appearance of irregular bursting, and prevent it by slight ligatures, as already mentioned in the case of fine pinks. Only three or four principal flower-buds are allowed to come forward; the smaller lateral ones being cut off as they appear. When the earliest flowers begin to expand, tinned iron or common paper covers, such as those above described, § 506, are placed over them. When the flowering becomes general, a canvas awning is resorted to. A tulip-bed frame answers perfectly well for covering carnations; and tulip bulbs are raised and stored, before carnations come into flower: every one therefore who delights in tulips, should also cultivate carnations, that his canvas frame may thus be occupied with vegetable beauties twice in the year.

Earwigs prove very injurious, sometimes almost destructive to carnations. They should be daily looked for, hunted out, and destroyed. Numbers may be entrapped in dried hollow stalks of rhubarb, reeds, or similar fistular plants. Some have been at the pains to insulate the raised stage, by setting its supporters in vessels filled with water; forgetting perhaps that earwigs occasionally take wing. When the flowers are heavy and apt to droop, bits of fine brass-wire are used as supports. Zealous carnation florists sometimes *dress* the flowers, by removing with a pair of pincers small or ill-coloured petals, and arranging the rest so as to hide the defect.

509. When the plants have passed the height of their

Carnation.

bloom, *layering* must not be neglected. The lower leaves of the layers being stripped off, and the terminal leaves cropped, an incision is made below the second or third joint, and continued through the joint; the loose portion of stem below the cut joint is removed, so that the layer may bend freely. It is kept down by a slight peg of wood, or, what is more convenient and neat, of the brake-fern or pteris; such fern pegs are naturally formed in the stalk of the frond, and they decay of themselves when no longer needed. If the weather be dry, watering proves useful. In about a month most of the layers are found to be rooted, and may be transplanted, taking care not to plant too deep. Carnations may also be propagated by pipings; but this is a more difficult mode. The pipings being dressed, by cutting about half a line below the *second* joint from the extremity of the shoot, and shortening the foliage as for layers, are placed in water for some time, to *plump* them as florists speak. They are then pricked into an exhausted hot-bed, and covered with hand-glasses. The soil is kept moist till fibres be sent out; but it is proper to observe, that after watering, the glass should not be replaced till the leaves of the pipings be dry. When they begin to shoot upwards, air is regularly but cautiously admitted. Layers or pipings, when properly rooted, are removed, and, if choice kinds, generally planted in pots, three or four in each pot. For the winter season, carnations, whether young plants, or surviving mother plants, are best preserved in a repository similar to that commonly used for auriculas. Here they remain till after the middle of March, when they are placed in pots singly for flowering, as already mentioned.

It is of course only by means of seed that new varieties can be obtained. When it is wished that carnation plants should perfect their seeds, they are removed from the canvas awning to a place completely exposed to the sun; or, in the northern part of the island, into an airy greenhouse; and the plant is not mutilated, by making layers or pipings. It may be remarked, that plants recently raised from the seed, are themselves most productive of seed, and that varieties which have long been propagated by layers and cuttings, scarcely produce any. In flowers approaching to the double state, but few seeds can in any case be expected, and these few often require to be fostered; the withered petals are drawn out from the pod, leaving the styles or stigmata, which proceed from the top of the germen or seed-pod; an incision is also sometimes made in the calyx down to the base of the germen, so as to prevent any water from lodging there. The seed ripens in September, but it is kept in the pod till April, when it is sown in pots. The young plants are afterwards transplanted into a bed, where they are allowed to show flower; such as prove single-flowered, are cast out; and the best of the double flowers are layered.

It may here be noticed that carnations are susceptible of the operation of grafting. A good double-flowered sort may be grafted on the stem of a healthy single kind; the most woody part of the stalk is to be preferred, and whip-grafting is best.

Polyanthus.

510. Of the fine genus *Primula*, several elegant species are natives of Britain. Every one is delighted with the appearance of the common primrose (*P. vulgaris*) on our banks in the spring time, and many are the varieties cultivated in gardens under the name of Polyanthus. The well known cowslip or paigle (*P. officinalis*) decks the pastures and margins of corn fields, particularly in the south and west of England, and the gathering of the pips for the making of wine furnishes in many places a pleasing employment for children. The oxlip (*P. elatior*) is much less common than the cowslip, and is found chiefly in woods, and by the margins of woods. It seems to be the parent of several of the small-flowered polyanthuses. The bird's-eye primrose (*P. farinosa*) is certainly one of the prettiest natives we can boast, and it grows on the poorest moors. Of the exotic species, the auricula or bear's-ear (*P. auricula*) is a well known favourite, of which we shall speak after treating of the polyanthus.

Polyanthus.

511. According to the florist, the properties of a good polyanthus are the following: The tube of the corolla above the calyx should be short, well filled at the mouth with the anthers, and terminate fluted rather above the eye. The eye should be circular, of a bright clear yellow, and distinct from the ground colour below. The ground colour is most admired when shaded with a light and dark rich crimson, resembling velvet, with one mark or stripe in the centre of each division of the limb or border, bold and distinct from the edging down to the eye, where it should terminate in a fine point. The petal should be large, quite flat, and round, excepting the minute indentations between each division, which divide it into five (sometimes six) heart-like segments. The edging should resemble a bright gold lace; it should be bold, clear, and distinct, and nearly of the same colour as the eye and stripes.

Endless are the varieties of polyanthuses; and as they are easily raised from seed, they are generally the first kind of flower that a young florist cultivates. Seed is kept in the shops for sale; but by sowing this, very few good varieties may be expected. The seeds should be saved only from flowers with large upright stems, producing many flowers upon a stalk, which are large, finely shaped, which open flat, and are not pin-eyed; and all ordinary flowers near to these should be cut over, to avoid any intermixture of pollen. The seed is ready in June, and the pods should be gathered as they successively ripen. The seed is commonly sown in boxes in January. The seedlings are regularly watered in dry weather, and shaded from the forenoon sun. They are fit for pricking out in the end of May; and they are transplanted, in August and September, to the borders where they are to flower, which should be somewhat moist and shady, and exposed only to the east. A loamy soil answers best. Most of them will flower in the succeeding spring, and then those that are indifferent may be cast out, or transferred to the shrubbery. The select plants being again transplanted, will bloom in full strength the second year; and, if the kinds be very good, will, in collective beauty and brilliancy, be little inferior to a show of auriculas.

After this, they must be yearly removed, and the roots must be parted, else the flowers will inevitably degenerate. The truth is, that seedling plants produce stronger and more brilliant flowers than offsets; and they who would have polyanthuses in perfection, must save seed from their finest plants, and sow annually. The best way is to raise two or three of the finest plants with a ball of earth attached, and to plant them in another part of the garden, where they may be free from intermixture of pollen, and may be regularly watered, attention to watering being found very conducive to the production of vigorous and healthy seed. The plants which thus yield seed are much weakened, and often perish. In some gardens, the choice flowers are always kept in pots.

Snails and slugs infest polyanthuses in the spring of the year, and should be watched in the morning. In summer the red spider often forms its webs on the rough under side of the leaves, which is indicated by their becoming yellow and spotted. If the plants thus attacked be not removed, the whole polyanthus bed will be destroyed. An effectual cure is found in soaking the foliage of the diseased plants for two or three hours in an infusion of tobacco leaves, and planting them at a distance from the others.

Auricula.

Auricula.

512. The Auricula is a native of the Italian Alps; and there the most common colour is yellow, but it occurs also purple and variegated, with a white powdery eye. The varieties raised by florists are innumerable; many of them are of great beauty, and some extremely curious. Parkinson, in 1629, names twenty varieties, and mentions that there were then many more. Rea, in his Flora, 1702, describes several new sorts raised by himself and cotemporary florists. A century afterwards, Maddock's catalogue enumerates nearly 500 varieties.

513. The properties of a fine auricula are the following. The stem should be strong, upright, and of such a height that the umbel of flowers may be above the foliage of the plant. The peduncles or foot-stalks of the flowers should also be strong, and of a length proportional to the size and number of the blossoms or pips: these should not be fewer than seven, in order that the umbel may be close and regular. A pip or single flower consists of the tube, eye, and border; these should be well proportioned; if the diameter of the tube be one part, that of the eye should be three parts, and that of the whole flower or pip six parts nearly. The circumference of the border should be round, or at all events not what is called starry. The anthers ought to be large, and to fill the tube; the tube should terminate rather above the eye; and this last should be very white, smooth, and round, without cracks, and distinct from the ground colour. The ground colour should be bold and rich, equal on every side of the eye, whether it be in one uniform circle, or in bright patches; it should be distinct at the eye, and only broken at the outer part into the edging. Black, purple, or bright coffee-colour, form excellent contrasts with the white eye; a rich blue or a bright pink are pleasing; and in a deep crimson or glowing scarlet, edged with bright green, are concentred the hopes and wishes of the florist, which however are seldom realised. On the green edge much of the fine variegated appearance of the auricula depends, and it should be nearly in equal proportion with the ground colour. The dark grounds are generally strewed with a fine white bloom or powder, which gives a rich appearance: the leaves of many sorts are thickly covered with the same kind of powder, which seems destined by nature to save them from the scorching effects of the sun's rays.

Mr Maddock considers the forming of a proper compost for auriculas, to be of great importance. The ingredients and proportions recommended by him are these: One half well rotted cow-dung; one sixth fresh sound earth, of an open texture; one eighth vegetable earth, from tree-leaves; one twelfth coarse sea or river sand; one twenty-fourth soft-decayed willow wood, from the trunks of old willow-trees; the same proportion of peat or bog earth; and a like proportion of the ashes of burnt vegetables, to be spread on the surface of the other ingredients. This compost is to be kept for at least a year, exposed to sun and air, several times turned, and passed through a coarse sieve. Mr Curtis properly remarks, that if the compost be rich and light, it is not necessary to adhere rigidly to the above prescription. He mentions, that two-thirds of rotten dung from old hot-beds, and one-third containing equal parts of coarse sand and of peat-earth, form a very suitable compost.

514. Choice auriculas are always kept in pots. The inner diameter of these at top may be six inches, at bottom four inches, and they should be about seven inches deep. A little gravel in the bottom is proper as a drain below the roots of the plants. Auriculas are annually repotted in May, soon after the bloom is over. The balls of earth are to be preserved around the roots, and only a certain portion of new mould given: Mr Maddock, indeed, advises the shaking of the earth from the roots; but this necessarily gives a check, from which the plant does not recover in the course of a year. At the same time offsets are taken, and planted in separate pots. The whole auriculas are then placed in an airy but rather shaded situation, not however under the drip of trees. The place is generally laid with coal-ashes, to prevent the earth-worm from entering the pots, and the pots are often set on bricks, to allow a freer circulation of air about them. Here they remain till October. They are then placed under a glass frame, or other repository, to shelter them for the winter months, giving as much air as circumstances will permit. In February they are earthed up; that is, the superficial mould, to the depth perhaps of an inch, is removed, and replaced by fresh compost, mixed with a little loam to give it tenacity. This is found greatly to aid the flowering. When several flower-stems appear in one pot, a selection is made of one or two of the strongest, and the others are pinched off. As the flowers advance, the plants are arranged in the covered stage, which contains four or five rows of shelves rising one above another. The roof is generally of glass; and the front, which is placed facing the north or the east, is furnished with folding doors, which may be shut when desired. Here the plants are regularly watered two or three times a week, care being taken not to touch the flowers or foliage with the water. A good collection of auriculas treated in this way, forms, when in flower, a very captivating sight. Sometimes the richness of the scene is increased, by introducing mirrors into each end of the frame, and by having a bed of hyacinths, and perhaps a row of fine polyanthuses, both of which flower at the same period, in front of the stage, and covered with a thin awning. The soft light passing through the awning, heightens the effect of the auriculas. It may be mentioned, that, in order to secure the filling of the stage with good flowering plants, which alone ought to appear there, it is necessary that the collector possess at least twice as many plants as the stage is calculated to hold.

The interest of the florist's pursuits receives in this, as in all other cases, a great increase when he attempts the raising of new varieties from seed. To purchase auricula seed in shops is a bad plan. It is much better to encourage the ripening of the seeds of a few very good flowers, which may be done merely by exposing them fully to sun and air, and saving them by hand-glasses from heavy rains. The seed ripens about the end of June; but it should be kept in the umbels till sown. This may be done, either in autumn or early in spring, in boxes; and the seed should be very slightly

Flower Garden. covered with willow earth, or any light vegetable mould. The boxes are of course to be kept under shelter during the winter; but in good weather the seedlings should have plenty of air; they must not, however, be exposed directly to the sun's rays, which would destroy them in a short time,—at least the more weakly, which are always of the greatest promise. When of a proper size, they are transplanted into other boxes, and nursed till they be fit for pots. If one plant in thirty prove worthy of a place in the collection, the success is great; the rest may be planted out as border flowers, where they continue very ornamental for a few years.

Hyacinth.

Hyacinth. 515. The garden Hyacinth (*Hyacinthus orientalis*, L.) is one of the flowers to the culture of which florists have particularly devoted themselves. It is originally from the Levant, but has been brought to its present improved state in the Low Countries. Double hyacinths are now the only kind prized, though formerly these were as little sought after as double tulips are now, the beauty of the flower being then regarded as consisting in the regularity of the shape and disposition of the blossoms, and in the richness of the colour. Whole acres of nursery ground are covered with this flower near Haarlem and Utrecht in Holland. Here new varieties are annually produced from the seed, which is collected from multiplicate or semi-double flowers, and from very fine single flowers. When a new variety of good qualities is procured, it is named and enrolled in the select list. The choice flowers are divided into classes, according to their colours. John Kreps and Sons of Haarlem enumerate near 1000 varieties in their catalogue, classed in this way: Reds; rosy and flesh-coloured; white, with rosy and flesh coloured eyes; yellow; white with yellow eyes; white with red eyes; pure white; white with violet and purple eyes; dark blackish blue; dark blue; porcelain and pale blue. The names of the finest and newest kinds are, as usual, high-sounding, and calculated to attract English curiosity,—the Monarch of the World; the Honour of Amsterdam; the Princess Charlotte; the Earl of Lauderdale, &c. &c.

516. The properties of a fine hyacinth are the following: the stalk tall, strong and upright; the blossoms numerous, large, well filled with petals, so as to appear rather convex, suspended in a horizontal direction; the whole flower having a compact pyramidal form, with the uppermost blossom quite erect; the plain colour should be clear and bright, and strong colours are preferable to pale; when the colours are mixed, they should blend with elegance.

The hyacinth grows best in a light sandy, but fresh earth. If manure of any sort be given, it must be placed far below the bulb. The time for planting is from the middle to the end of September. Old tanners-bark is kept spread over the beds during winter, unless when mild weather seems to set in for some days. When the plants come into flower, a slight awning, which can easily be removed, is placed over them; and by this means they continue a month in glory. Hyacinths in beds never require any watering. When the flowering is over, the Dutch move their hyacinths with the spade, so as to break the root-fibres, and prevent farther nourishment, but do not raise them completely from the ground for a fortnight. Even then, they are laid in a bed nearly in a horizontal position, with their leaves and stems lying outwards; in this way, a great part of the juice in their thick succulent leaves and stems evaporates, instead of returning into the bulbs. This is called "ripening the roots." When choice hyacinths are cultivated in pots, as is commonly the case in this country, the pots are laid on their sides after the flowering till the leaves decay. Bulbs four or five years old, flower most strongly in Britain, and they then gradually fall off; but in Holland they endure a great number of years. It is remarked that they succeed best in situations near the sea. It is curious that bulbs imported from Holland flower more beautifully in this country the first year, than they ever do afterwards.

Polyanthus-Narcissus.

Polyanthus-Narcissus. 517. The Polyanthus-narcissus (*Narcissus tazetta*) is a native of Spain and other parts of the south of Europe. The flowers are very ornamental, and come early. The plant has long been a favourite with the florists of Holland and Flanders. There are several principal varieties: Some have yellow petals, with cups or nectaries either orange or sulphur coloured,—others have white petals, with orange, yellow or sulphur coloured nectaries; in a third set, both the petals and the nectaries are white; and there are double flowers of all the varieties. The subordinate varieties are more than a hundred in number. A double variety called the Cyprus Narcissus, is curious and beautiful; the outer petals are white; those in the middle partly white and partly orange; and it has a very agreeable scent. A pure white variety is called the Paper Narcissus.

The florists of this country generally depend on the supply of bulbs imported from Holland. The seed, however, often ripens in good seasons here, and there is no peculiar difficulty in raising the plants in this way. The seed is sown in shallow vessels in the manner of tulip seed. The seedling bulbs are not raised or transplanted till the third year; in other two years, the flowers make their appearance. The beds containing young bulbs require to be defended from severe frost by means of a covering of peas-haulm, straw, or fern.

Full grown bulbs are planted in the beginning of September. They do not require to be raised every year; it is better indeed not to remove them oftener than once in three years. They flower in April and May; and if they be choice kinds, they should be saved from sun and rain by an awning, as practised in the case of tulips.

Crocus.

Crocus. 518. The crocus, though a well known flower, has only of late years been accurately studied as a genus. Miller admits only two species, the autumnal or saffron (*C. officinalis*), and the spring crocus, (*C. vernus*). Sir J. E. Smith mentions three species as natives of Britain, C. vernus, nudiflorus, and sativus. Of the former there are several varieties, blue and purple, yellow and white, and striped; and besides these, the following species are cultivated in crocus beds: C. versicolor, or party-colour crocus, a kind which requires a light loam, while most of the others grow best in sand; biflorus, or yellow bottomed; mœsianus, or common yellow; susianus, or cloth of gold; and aureus or true gold. The Scots crocus is a beautiful striped variety.

The bulbs may be planted in any light soil; but they succeed best in sand; and some cultivators to the westward of London have been at the pains to carry sea-sand fifty miles for this purpose. They should not be planted deep, not being covered more than an inch. In February the flowers begin to appear; in March they are in glory; and by the end of April the seeds begin to ripen. In good seasons these are produced plentifully, and by means of them new varieties may be procured. The leaves of most of the species grow chiefly after the flowering is over: these should not be cut, as is often done, the bulbs being thereby deprived of much of their nourishment; they may, however, very properly be tied up.

Annual Flowers.

Annual flowers.

519. Many of these are very beautiful; and in fine flower-gardens, they not only appear in patches on the borders, but some of the elegant sorts are cultivated in beds in a separate compartment, called the Annual Flower-garden.

They are commonly divided into Hardy, Less hardy, and Tender. The hardy are sown in the spring, in the natural ground, where they are to remain; the less hardy are raised on a slight hot-bed, and planted out in April and May; and the tender require to be passed through two nursery beds before planting in the open border, and in the northern parts of Britain they are kept almost always under glass. In this place only a few of the most beautiful or curious of each of these divisions can be named. Pretty ample and correct tabular lists of them may be found in Abercrombie's *Practical Gardener*, under the head *Flower-garden.*

Hardy annual flowers.

520. Of the *Hardy Annuals*, different species of *Adonis* are showy, none more so than the Pheasant's-eye, A. autumnalis: this, if not a native, has become completely naturalized in fields near London, and quantities of the flowers are every summer sold in the city by the name of Red Morocco. Several species of Snapdragon (*Antirrhinum*); white and purple Candytuft (*Iberis umbellata*); Lobel's Catchfly, red and white (*Silene armeria*); Venus' Looking glass (*Campanula speculum*); with the purple and the red topped Clary (*Salvia horminum*), are very ornamental. Varieties of the Convolvulus major and minor, and of the Bluebottle (*Centaurea cyanus*), with the Sweet Sultan (*C. moschata*); the Fennel-flower (*Nigella damascena*), with many sorts of Scabious (*Scabiosa*), and the well known Stock Gillyflower (*Mathiola incana*), deserve cultivation. The Yellow Balsam (*Impatiens noli tangere*) is remarkable for its ripe capsules exploding the seeds upon being touched; it thus sows itself, and should therefore be placed in a by-corner. The yellow blossoms of the Bladder Ketmia or Flower of an hour, (*Hibiscus trionum*) are extremely perishable if the sun be bright, but they are produced in long succession. Many varieties of Larkspur (*Delphinium Ajacis*), single and double, branched or with simple stems; with several kinds of Lupine (*Lupinus*), and of Sweet Pea (*Lathyrus odoratus*) are well known, and very ornamental. The varieties of Carnation Poppy (*Papaver somniferum*) are very showy; they are generally allowed to sow themselves. Strawberry Blite (*Blitum capitatum*) is a curious plant, the fruit resembling strawberries, only however in appearance. Belvedere (*Chenopodium Scoparia*) is a handsome plant, resembling in its close pyramidal shape a dwarfish cypress-tree; from which circumstance it is often called Summer cypress. The Caterpillar (*Scorpiurus vermiculata*), Hedgehog, and Snail plants (*Medicago intertexta* and *scutellata*) have no beauty, but are remarkable on account of their vermiform pods. The Eternal Flower (*Xeranthemum*) is excelled by none, and there are red, white, purple, and blue varieties of it. Mignonette (*Reseda odorata*) is universally liked; it is generally sown in large patches, or an entire border is filled with it, commonly in front of the conservatory or green-house.

Hardy annual plants are generally sown in circular patches, traced with a hand-trowel, with which, at the same time, the earth is broken small. A bit of stick is placed as a mark in the centre of each patch. Usually two or three successive sowings are made, from the middle of March to the middle of May, the season of flowering being thus prolonged. The plants must afterwards be thinned, according to the nature of their growth, the belvedere, the sunflower, and some others standing quite detached. After thinning, a plentiful watering is proper, in order to settle the earth about those that remain; and in dry weather, frequent watering will ensure the production of much finer and stronger plants. Most of the kinds bear transplanting in dull and showery weather. The tall-growing plants should of course be placed in the back part of the border; the low-growing in front. When the flowering is nearly over, some of the earliest and strongest plants should be marked for affording a supply of seed, and should, if tall, be tied to stakes to prevent their being broken, or falling down. It often happens that some of the kinds spring up in the borders from seeds sown naturally the former year; from these the best and ripest seed may be expected.

Less hardy annual flowers.

521. The list of *Less hardy* annual plants embraces many fine flowers, such as different varieties of the African Marigold (*Tagetes erecta*), and of the French Marigold (*T. patula*); the Amaranth or Love lies bleeding (*Amaranthus caudatus*), and Prince's Feather (*A. hypochondriacus*); the rich and elegant Balsams, many varieties, (*Impatiens balsamina*); different kinds of Chrysanthemum, particularly C. tricolor, and also of Zinnia; with the Indian corn (*Zea mays*), and Tobacco plant (*Nicotiana tabacum*), which are curious. For these and others a moderate hot-bed is necessary, on which they may be sown in March or April, so as to be ready for transplanting into the borders in May or June. It is better, however, instead of removing the seedlings at once to the open border, to prick them into a nursery border, covered with a canvas awning, or hooped over and protected by mats at night: here they may be allowed to establish themselves and get hardy, for some weeks. In dry weather, frequent watering is essential, especially at the times of transplanting.

Tender annual flowers.

522. The list of *Tender* annual plants is not numerous, unless the balsam and some others from the less hardy list be included, which in the northern part of the island is always the case. Many varieties of Cock's-comb (*Celosia cristata*), with scarlet, purple, and yellow heads, some of the plants dwarfish, others three or four feet high, are exceedingly ornamental. The Globe-amaranth (*Gomphræna globosa*) of various sorts, with the Amaranthus tricolor, having each leaf composed of three colours, bright red, yellow and green, are likewise among the more showy of the tender annual flowers. The Egg-plant deserves the same character; not on account of its flower, but of its singular and elegant berry, which has much of the shape and appearance of a large egg, as already noticed (§ 403). The Ice-plant (*Mesembryanthemum crystallinum*), remarkable for its stalks and leaves being covered with crystalline globules like small icicles, and the well-known Humble plant (*Mimosa pudica*), may also be mentioned. These are raised, in March, in a small

hot-bed that is in a pretty strong state of fermentation, and afterwards transferred to one that is larger and of more moderate warmth. In general the plants are subsequently kept in flower-pots, and are placed near the green-house plants, or perhaps in the green-house, the shelves of which they may thus decorate, while the proper inhabitants are abroad. Here too, if properly attended to in regard to watering, they will ripen their seeds, which they seldom do in our climate without the protection of glass. A few cockscombs, globe-amaranths, and egg-plants, likewise make a fine appearance on the back shelves of a hot-house.

Biennial Flowers.

Biennial flowers.

523. Some flowers which are, strictly speaking, *biennial*, are often cultivated among the annual kinds: Such are the Indian pink, (*Dianthus Chinensis*); the Palma Christi, (*Ricinus palma Christi*); and the Sensitive plant, (*Mimosa sensitiva*). Others are always treated as biennial plants, being kept in nursery rows for the first season, and planted out the next. Some of the most common are Honesty or satin-flower (*Lunaria annua*), white and purple flowered; French Honeysuckle (*Hedysarum coronarium*), red and white; Yellow Horned Poppy (*Glaucium luteum*); tree-primrose, several species, (*Œnothera biennis, &c.*); and Mullein of different kinds (*Verbascum*), particularly the Moth-mullein (*V. blattaria*), yellow and white flowered.

Rock-work.

Rock-work.

524. In forming a piece of rock-work, it is found very useful to have at least the two or three outward layers of stones composed of *moor-stones*, that is, of such as have long lain exposed to the action of the weather. At the bases of greenstone and basalt hills very suitable masses may generally be found: those should be selected which have cavities in them, or are unequal on the surface; keeping in view also that they must be of such shape as to be capable of being piled on each other in a sloping direction without cement. If such weather-worn stones be selected, and mossy earth be used in place of cement, many kinds of ferns, and various cryptogamous plants, will be found to thrive, which would not succeed on sandstone, or on masses of any kind of rock fresh dug from a quarry. Besides, some part of the stones being always seen, the appearance of these is to be considered. Masses covered with lichens, especially Lichen atro-flavus, geographicus, ventosus, perellus, and stellaris, are therefore desirable. Pieces of plum-pudding stone and of serpentine have likewise a very good effect; some joints of columnar basalt are in some places introduced, and large petrifactions, or casts in sandstone or limestone of the trunks and branches of trees. Large shells, too, particularly valves of the Chama gigas, are occasionally placed in the rock-work; and among sand in these, some plants will thrive, such as Cotyledon umbilicus. All plants which grow naturally in a dry soil, may be accounted fit for the rock-work. Several species of Dianthus, particularly D. deltoides, armeria, and cæsius, are highly ornamental. Red Valerian (*Valeriana rubra*), and a white variety of it, grow very readily among stones. If peat-earth be used, Erinus alpinus is a desirable plant. It forms close tufts, and produces its pretty purple flowers from April to July; and when well established, it often ripens its seed, and sows itself. Different species of Madwort are suitable, particularly Alyssum saxatile and deltoideum. Cerastium repens grows freely, but is apt to overrun the other plants: indeed, if it be wished at any time entirely to hide a heap of rubbish with garden plants, this is one of those to be selected for the service. To those already mentioned may be added, Erigeron alpinum; Cyclamen Europæum and herderæfolium; the spring Gentian, Gentiana verna; Soldanella alpina; purple Saxifrage (*Saxifraga oppositifolia*) and double Sengreen, (*S. granulata*, fl. pl.); the borage-leaved Mullein (*Verbascum Myconi*); alpine Lychnis (*Lychnis alpina*); and different species of Primula, P. nivalis, integrifolia, helvetica and marginata. The basil-leaved Soapwort (*Saponaria ocymoides*) is one of the most beautiful little plants that adorns the flower-garden, and it is peculiarly well suited for rock-work. All the smaller species of hardy Stone-crop deserve a place, in particular Sedum album, glaucum, rupestre, aizoon, and sexangulare; as well as several species of House-leek, especially the cobweb kind, (*Sempervivum arachnoideum*). In small flower gardens, the rock-work is often constructed on the margin of a little pond for hardy aquatic plants.

Aquarium.

Aquarium.

525. The shape of the pond is generally either circular or oval. Its dimensions must be regulated by the size of the neighbouring parterre or lawn, and by the taste of the owner for the cultivation of aquatic plants. If it be wished to have the white and yellow Water-lily (*Nymphæa alba* and *Nuphar lutea*) in perfection, it must be at least three feet deep. If the ground be open, especially if the subsoil be sandy or gravelly, the bottom should be well laid with puddled clay, and the sides should also be lined with the same material, in order to prevent the escape of the water. On the margin a kind of small terrace or shelf is formed, immersed only a few inches under water, and commonly laid with channel; on this are placed pots containing various marsh plants, such as the Marsh Calla, (*Calla palustris*,) a native of Lapland and other northern parts of Europe. In some gardens, (as formerly noticed, § 191.) the margin is occupied with the American cranberry.

Several of our native aquatic plants are very ornamental; particularly the yellow and the white fringed Bog-bean, Menyanthes nymphoides and trifoliata; the Flowering-rush (*Butomus umbellatus*,) and the Water-violet or Feather-foil (*Hottonia palustris*) which grows in deep ditches near London. The Cats-tail or Reed-mace (*Typha latifolia* and *angustifolia*) has a singular appearance, especially when in flower, but it is apt to overrun a small pond.

Rosary.

Rosary.

526. The rose has always been deservedly a favourite; and at no period was it ever more high in repute than at present. Every hardy species is now carefully cultivated, and many new varieties raised from seed, have of late years been introduced. The catalogue of Lee and Kennedy, of Hammersmith, enumerates no fewer than 315 varieties; but the *species* are not distinguished. Many of the finest varieties have been beautifully figured by Miss Lawrence, in her splendid collection of Drawings of Roses. Most of the species throw out suckers. These should be annually removed in October, and in this way abundance of plants may soon be procured. Still better plants however may be prepared by laying down branches; and this is the chief

way of propagating adopted by the dealers in roses. Few of the kinds need any other pruning than shortening some of the strongest shoots, to cause them push new buds and bear more flowers.

The following are the species generally preferred, but a few only of the varieties can be enumerated.

Hundred-leaved rose, (*Rosa centifolia.*) Of this there are many varieties, as the Dutch, blush, velvet, and Burgundy, the latter an elegant little plant, sometimes not more than a foot in height.

Red rose, or Crimson rose, (*R. Gallica.*) This is the kind the unexpanded petals of which are used for making conserve of roses. A sort with variegated flowers is called Rosa Mundi.

Damask rose, (*R. Damascena.*) Of this there are some pretty variations, as the blush damask, the York and Lancaster, and the red and the white monthly roses, these last continuing to flower in succession during most of the summer.

Provence rose, or Cabbage rose, (*R. provincialis,*) is one of the most beautiful of the tribe, and perhaps the most fragrant of all the roses. Of it there are likewise some favourite varieties, as the scarlet, the blush, and the white Provence; the rose de Meaux, and the pompone or dwarfish rose de Meaux. It may be remarked, that if the new wood be in a great measure cut down every year, after the flowering is over, the plants throw out more vigorous shoots, and yield a greater profusion of flowers.

The Moss rose (*R. muscosa*) is well known in gardens in a double state; but it is curious that the single moss rose is quite unknown to us. The double is often propagated by budding on other stocks; but better and more durable plants are procured by laying down the branches. A white moss-rose has lately appeared in the London nurseries; but it is still scarce and high priced.

The common White rose (*R. alba,*) both single and double, deserves a place; as well as the varieties called, large, small, and cluster maiden blush.

Single yellow rose, (*R. lutea.*) The Austrian rose, with the petals orange or scarlet at the base, is considered as a variety of this. Both kinds grow better in upland places than in the richest and warmest situation.

The Double yellow rose (*R. sulphurea*) is remarkable for the flowers seldom opening fairly. It should be planted in a cool and rather shady situation, or at least it does not succeed against a south wall. It is quite a distinct species from the single yellow; the leaflets, for example, are simply serrated, not glandular, and they are glaucous underneath; while in the single yellow, they are doubly serrated, glandular, and of a shining green.

Of the Cinnamon rose, (*R. Cinnamomea,*) a variety with double flowers is usually cultivated. It is the smallest and the earliest of the double roses, often coming into flower in the beginning of May.

Scots rose, or Burnet rose, (*R. spinosissima.*) Of this species, which, as a native plant, is more common in Scotland than in England, several varieties have long been known, particularly the red, the semi-double white, and the semi-double red. Messrs Brown of the Perth nurseries, have of late years raised several new and very beautiful varieties of this rose. The Rosa Ciphiana, celebrated in a Latin ode by Sir Robert Sibbald, the earliest illustrator of the natural history of Scotland, was a variety of this species. Professor Martyn says it was found on his " Ciphian farm;" but the fact is, that the name of Sir Robert's estate was the unpoetical one of *Kips*, from which, *euphoniæ gratiâ*, Ciphia was formed.

Sweet-briar rose, (*R. rubiginosa.*) Of this well known species, the Eglantine of the poets, there are several varieties,—the common double flowered, mossy double, marbled double, and red double. A single flowered yellowish variety is kept in some gardens, but it is very scarce.

The Musk rose (*R. moschata*) is a climbing kind, flowering late, and continuing till the end of October. It varies with double flowers.

The deep red China rose (*R. semperflorens*) if placed against a south wall, or in front of a green-house, flowers for the greater part of the year. There is a pale China rose, by some considered as only a variety of R. semperflorens.

The Indian rose, (*R. Indica*, already noticed, § 472.) is a very great acquisition to our gardens, being perfectly hardy. Although but lately introduced, it has now become very common; and by means of it we possess, in the open air or against a wall or paling, full blown red roses in March and April, and in November and December. The common sort has very little smell; but a fragrant variety has been raised, thus uniting all the excellent properties of the rose.

In order to have a continued succession of roses, for instance of the common moss rose, the best plan is, to cut off in May the tops of shoots produced the same spring. In this way new shoots are elicited, which come into flower late in autumn.

Beds of roses, of different shapes, are now commonly formed in the lawn near the mansion-house, or by the sides of the approach to the pleasure garden; when of an oval form, they are often called *baskets* of roses. The surface of the circle or oval is made to rise in the middle; the shoots are layered, and kept down by means of pegs till they strike roots into the ground; the points only, with a few buds on them, appear above the earth. By this sort of management, in two or three seasons, the whole surface becomes covered with a close and beautiful mixture of flowers and leaves. Sometimes only the moss rose is employed for this purpose; but frequently several kinds are intermixed. Even a single plant, particularly of the moss-rose, may, by continued attention, be made in this way to cover a large space, and to afford at once perhaps several hundred flowers. Plans for rosaries of different shapes, circular, oval, square, and octagonal, have been published by Lee and Kennedy, and circulated along with their list of roses.

Climbing Plants.

Climbing plants.

527. In many gardens a walk is arched over with trellis work, either of wood or wire, principally for the purpose of affording a proper opportunity of cultivating the finer kinds of climbing shrubs, and enjoying the beauty and fragrance of their flowers, which render such a berceau walk extremely delightful in the warm weather of July and August. The finest of them, however, flourish only in the milder counties of England, and are planted in vain to the northward of Yorkshire.

The Kidney-bean tree (*Glycine frutescens*), shews elegant clusters of purple flowers; and the Virginian silk-tree (*Periploca Græca*) produces bunches of flowers of the same colour. *Smilax aspera*, sometimes called Rough Bindweed, and *S. excelsa*, although their flowers are not showy, are desirable climbing plants, as they retain their verdure during winter. Of the honey-

Flower Garden.

suckles, besides different varieties of the common Woodbine (*Lonicera Periclymenum*), the trumpet-honeysuckle (*L. sempervirens*) particularly deserves a place. The yellow and the white Jasmine (*Jasminum fruticans* and *officinale*) are well known plants. Three species of *Atragene* are now cultivated; the Austrian (*A. austriaca*), the Siberian (*A. Sibirica*), and the American (*A. Americana*): the two former were long confounded under the name of A. alpina; they resemble each other, but the Austrian comes into leaf and flower two months before the other; the American species is also early. Several kinds of *Clematis* or virgin's-bower are highly ornamental, particularly the purple (*C. viticella*), and the double-flowered variety of it, with red and blue varieties of the single; the Virginian (*C. virginiana*) with white flowers; and the evergreen (*C. cirrhosa*), which produces its greenish flowers about mid-winter. The common Traveller's-joy (*C. vitalba*) is too rampant to be trusted near to delicate climbers. The common Passion-flower (*Passiflora cærulea*) succeeds in some sheltered places, but in general it flowers better when trained against a wall.

528. For covering walls, some other plants are well suited. If the exposure be good, *Bignonia radicans* or ash-leaved Trumpet-flower, is highly ornamental, being covered with orange flowers in the autumn: this is a plant, however, which requires some management as to pruning; all small weak shoots must every year be removed, and when the plant has filled the space allotted to it, a quantity of new or young wood for flowering is procured, by annually shortening a number of strong shoots. Common Ivy (*Hedera helix*), with the silver-striped and gold-striped varieties, and the large-leaved or Irish, are very desirable; as is likewise the Virginian Creeper or five-leaved ivy, (*Vitis hederacea*). The double Pomegranate has been already mentioned (§ 180.) as admirably adapted for covering a wall, or the end of a house, especially if it have a south aspect.

529. It has been more than once noticed, that the most effectual way of *acclimating* the plants of warmer countries, is to endeavour to bring such plants to ripen their seeds in the open air in this climate with as little assistance as possible, and then to sow these seeds, from which a more hardy progeny is likely to spring. Some plants, however, seem gradually to become inured to our climate, even without being reproduced by seed; or perhaps these plants were at first accounted more delicate than they really are. Several Japan shrubs have of late years become common ornaments of our gardens, particularly the Loquat or Mespilus Japonica; the Japan apple, (*Pyrus Japonica*) which requires a south wall; the Sophora Japonica; and the Corchorus Japonicus. This last was introduced only about 1804; yet it may now be seen growing like a willow in our borders; and, if kept near to an east or a west wall, to save the buds from severe frost, producing a profusion of its yellow blossoms early in the spring. Trained to the back of a hot-house at the Botanic Garden at Edinburgh, and of course with a northern exposure, it has for several years past stood remarkably well, and has been regularly clothed with flowers in March and April. The Tea-plants (*Thea bohea* and *viridis*), which are natives of the north of China, stand in the open border in the southern counties of England; but in severe winters, they require some degree of protection. Edwardsia grandiflora and microphylla are natives of New Zealand, which flower in February, in our sheltered borders, or trained against a wall. Several natives of the south of Europe now inhabit our borders; such are, Jupiter's-beard, Anthyllis barba Jovis; Coronilla glauca; and Moon trefoil, Medicago arborea. Two species of Leptospermum or South Sea myrtle, L. juniperinum and baccatum, succeed in the milder parts of England, if trained against a wall; and Metrosideros lanceolata, likewise from New South Wales, has already been noticed as trained on the open wall in the College Botanic Garden at Dublin, § 28. Rhamnus glandulosus from Madeira, is an addition to our evergreens. Some perennial species of *Convolvulus*, formerly accounted tender, are now trained against the border walls; particularly C. bryoniæfolius from China, and C. althæoides from the Levant. Of the common myrtle (*Myrtus communis*) there are several varieties, some of which are more hardy than others: a single-flowered sort, resembling the double-flowered, but with narrower leaves than the Dutch broad-leaved, is the most hardy; and a variety of the narrow-leaved, called the bird's-nest myrtle, seems also to be more hardy than the Dutch broad-leaved kind.

Framed Borders.

Framed borders.

530. They who are curious in flowers frequently have a border covered with glazed frames, which can be easily removed during the warm season of the year, from the middle of June to September. Many plants, particularly of the bulbous kind, grow much better when planted in a large border than when confined to flower-pots. Bulbs in general require a deep soil; for they commonly send their fibrous roots, by which they draw their nourishment, to a considerable depth in the earth. Some of the bulbous plants which succeed well in such covered borders are, several species of Ixia, of African Gladiolus, of Hæmanthus or blood-flower; and the Tigridia pavonia, or Tiger-flower, equally remarkable for its gorgeous beauty and its transitory nature. Tuberoses (*Polyanthes tuberosa*), after having been fostered on a slight hot-bed, may be sunk in pots in a framed border, in order to their flowering. Several species of the splendid genus *Amaryllis* might be added to the list, particularly the Belladonna lily (*A. belladonna*), the Jacobea lily (*A. formosissima*), and the Guernsey lily (*A. Sarniensis*). Concerning this last, it may be observed, that a few plants only can be expected to flower every year; for, as noticed by Miller, the same plant does not flower in two successive years, nor probably till after the lapse of several years. Dr Macculloch (*Scottish Hort. Mem.* vol. ii. p. 60.) has given an account of the cultivation of this favourite lily in Guernsey. Even there, the Doctor informs us, "scarcely five flowers are produced among a hundred healthy roots." Boxes containing parcels of the bulbs, generally with the flower-stems formed, are annually sent from the Channel Islands to the nurserymen of London, and by them distributed through Britain. Miller has justly remarked, that this lily may more properly be cultivated in a bed on a south border than in pots; it is therefore peculiarly well adapted to the framed border. For the soil, he recommends a third part fresh earth from some light pasture ground; about an equal part of sea-sand; and the remaining third to be composed equally of rotten dung and sifted lime-rubbish.

The different species of Cyclamen or sow-bread are humble plants, likewise well adapted to the framed border, where they make a very beautiful appearance.

In many gardens, where fine bulbous plants are much attended to, as at the Botanic Garden at Liverpool, all the borders immediately in front of the various hot-houses are covered with moveable frames. In these framed borders, it may be added, many alpine plants may likewise be preserved during winter; for such plants being accustomed, in their native place of growth, to the protection of a thick covering of snow during that severe season, are impatient of intense cold.

Green-house.

Green-house.

531. The proper situation for the Green-house has been already pointed out (§ 55.) as being somewhere in the flower garden. Its aspect ought of course to be towards the south. In fixing on the plan and elevation of a green-house, there is great scope for fancy and taste; for, the indulgence of these is quite consistent with the production of a house which shall afford shelter during winter to plants which require little more than to be saved from the effects of frost. It is scarcely ever wished that the temperature should exceed 45° Fahrenheit; and when the weather is such that air can be given, it is enough if the thermometer indicate from 38° to 42°. To every part of the house, however, light ought to be freely admitted, else some of the plants will necessarily become *drawn up* and distorted: a great part of the front of the roof should therefore be of glass. Nicol observes, that a green-house may have two straight sides, but should have circular ends; he is better pleased, however, with an octagon whose sides are not equal, but which has two opposite longer sides, forming as it were an "angular oval." In some gardens the green-house forms a complete circle; in others it is of an oval shape: in these cases, and indeed in general, it is now constructed of glazed frames on every side. The roof is not made nearly so lofty as formerly; indeed, it seldom exceeds in height ten or twelve feet from the paved walk. The furnace and stock-hole are of course as much concealed as possible; and if the house be circular or octagonal, the smoke is carried by a flue under ground to some distance, and then discharged by a small chimney, hid by shrubbery. The interior is fitted up with stages and shelves for holding the plants. These are arranged according to their sizes, the shape of the leaves, and the general tint of colour: the smaller plants are chiefly placed in front, and those that are likely to flower during winter have conspicuous stations allotted to them: the taller plants occupy principally the back shelves: in this way a symmetrical mass of varied foliage is presented to the eye, interrupted only by projecting clusters of variously coloured blossoms. Several of the sashes, or perhaps each alternate sash, should be made moveable for the admission of air; and ventilators are also proper, for promoting a circulation, when the state of the weather prevents the admitting of air by the roof. Very little water is given to the plants during winter; and they are cleared of dust rather by means of a bellows than by the application of the syringe.

The roots of green-house plants are generally examined twice in the year, by turning the plants gently out of the pots. Many kinds only need repotting once in the year; and this operation is commonly performed in August: but others require it twice in the year, and the other period is usually March. It is not always necessary that the plants should be shifted into larger pots; on the contrary, it is often better to retrench the matted roots, and keep to pots of the same size. It is always proper that some small gravel or shivers of broken flower-pots be put in the bottom of the pots, to drain off moisture. And here a very common error in the manufacture of that earthen-ware article may be pointed out: the hole in the bottom is frequently made so as to have a small unintended rim on the inside, which necessarily retains a portion of water; whereas the sides of the hole ought to have a slope from the interior, so as to allow every particle of water to escape.

Flower-pots.

532. In the course of this treatise, the different sizes of flower-pots have more than once been mentioned in the tecnichal style employed by gardeners, such as "eights," "sixteens," &c., or "No. 1," "No. 3," &c. These terms it may be proper here to explain. The meaning of them will be rendered obvious by a tabular view; but it may first be observed, that potters usually make seven *sizes*, also called *numbers*, of pots; that the pots of each particular size are sold in what are called *casts*; and that the number of pots in a cast increases proportionally as the size of the pots decreases. Of No. 1., which is the largest kind of pot in common use, there are eight in the cast, and a pot of this class is called either a "No. 1." or an "eight."

No. 1.	first size,	has 8 in the cast, called	Eights.
— 2.	second size,	12	Twelves.
— 3.	third size,	16	Sixteens.
— 4.	fourth size,	24	Twenty-fours.
— 5.	fifth size,	32	Thirty-two's.
— 6.	sixth size,	48	Forty-eights.
— 7.	seventh size,	60	Sixties.

Pots larger than eights, or of extra size, such as 4 in the cast, are often made, for the accommodation of large plants; and, on the other hand, pots of a smaller size than sixties are sometimes manufactured, particularly for holding small seedling plants, or very young Cape heaths. These very small pots are among gardeners called *thumbs*.

533. Plants suited to the green-house are extremely numerous, and constantly on the increase: the selection of them must depend on the taste of the owner, and the size of the house. To give any enumeration seems unnecessary: it may be sufficient to refer to those excellent lists, the Epitome of Hortus Kewensis, and the Cambridge Catalogue; in these the plants suited to the green-house are marked G; and their duration or character are indicated by the marks usually employed by botanists and gardeners; ☉ for annual; ♂ for biennial; ♃ for perennial; and ♄ signifying that the plant is shrubby or arboreous. In the first mentioned catalogue, the plants which require a black heath mould, or peat soil, have an asterisk * prefixed to them. In the Botanical Magazine, edited by Sims, (formerly mentioned § 18.), all new and curious green-house plants are figured and described as they come into notice.

534. To keep up the show of plants actually in flower in the green-house, especially in the early spring months, a usual and very proper expedient is to plant a number of the common ornamental bulbous plants, in pots, in the month of October; to forward these in the stove, and to place them, as the flowers appear, upon the shelves of the green-house. For this purpose some of the many varieties of hyacinth, with single and double jonquil, white and yellow polyanthus-narcissus, Per-

sian iris, and the early sweet-scented tulips, are well adapted. The jonquil bulbs, it may be observed, must be two years in the pots before they can be expected to flower properly.

Flower-[illegible]

535. We may take this opportunity of noticing the mode of bringing these bulbous plants into flower by means of water alone. It was described by Miller in a communication published in the 37th vol. of the Philosophical Transactions, for 1731. November is the usual season for beginning this sort of chamber forcing. The flower-glasses are filled up to the bottom of the bulb with fresh soft water; and it is kept up to this point by adding to it as often as necessary. The water should be entirely changed once in the week or ten days. The glasses should be situated in a light room where a fire is kept, and, if possible, near to windows exposed to the forenoon sun. If they be placed in a hot-house for a few weeks, they are greatly forwarded, and appear in perfect flower in January. The numerous varieties of hyacinths raised by the incredible industry of the Dutch florists, answer extremely well for this purpose; likewise the different sorts, white and yellow, of the polyanthus-narcissus. The jonquil, also, is pretty well adapted; but to many its fragrance is too powerful in a room. The small tulips called Duc de Vanthol, Claremont, and Pottebakker, may be treated in this way; and the Persian iris is sometimes brought to flower, but is rather apt to fail. The common poetic narcissus, and the common daffodil, may be made to bloom in the same way.

Conservatory.

Conservatory.

536. The Conservatory is distinguished by its interior being laid out in beds and borders, in which exotic trees, shrubs and perennial plants are cultivated as in the natural soil. The sides and roof are of glass; and not unfrequently this last is so formed that it can be removed during the summer months. The parapet wall should be arched, in order to allow the roots of plants in the border next to it, to penetrate to the exterior border in quest of food. In general the flue passes under the walk, and has cavities at each side, to let heated air escape through holes in the earthen tiles with which it is covered. The side borders are occupied with some of the smaller ornamental shrubs of New Holland, and with some others which, though occasionally placed in the open border, are apt to perish during winter; such as the scarlet Fuchsia of Chili, and the fragrant Vervain of the same country (*Verbena triphylla*); the Dutch double-flowered myrtle, and the tea plants. To these may be added some of the showy species of Polygala, Hermannia, and Gnidia. The bed in the middle of the house should be formed of compost soil to the depth of at least two feet; the bottom being laid with some hard material, to prevent the roots from penetrating, particularly if the subsoil be indifferent. For the general soil, Nicol recommends a perfectly homogeneous compost of 3-4ths brown loam, being the sward of an old pasture, and 1-4th vegetable earth, preferring that resulting from decayed tree-leaves. The earth should not be screened; indeed it is the better for having small stones mixed with it. This middle bed is occupied by some lofty New Holland plants, such as different species of *Acacia*, particularly A. decurrens and longifolia; the dwarfish fan-palm, Chamærops humilis; Clethra arborea, one of the ornaments of Madeira: Olive-trees, and frequently one or two of the Citrus genus. The different varieties, red and white, single and double, of the Japan rose (*Camellia Japonica*) deserve a place; with Daphne odora; the red-flowered Anise-seed tree, Illicium Floridanum; the Malabar nut, (*Justicia Adhatoda*); the Camphor-tree (*Laurus camphora*); several of the elegant genus Protea, and one or two of the no less pleasing and curious genus Banksia. Where the house is of an oval or oblong square shape, and is composed of glass only on three sides, the back is covered with a trellis, to which several of the arborescent Cranes-bills, (such as *Pelargonium inquinans*, different varieties, *P. peltatum*, *cuculatum*, and *lateripes*) are trained; and these, when in flower, have a very brilliant appearance. In some conservatories, a small *aquarium* is formed, where several of the foreign species of Nymphæa and Menyanthes may be brought to flower.

537. Sometimes the characters of the greenhouse and the conservatory are to a certain extent combined in one house. In particular, some ornamental climbers are planted in the borders, trained against the rafters and pillars, and often led in festoons from place to place. Several species of Passiflora, such as cœrulea, aurantia, and incarnata, and of Glycine, become in this way very elegant, and the large bell flowers of Cobbea scandens make a fine appearance; with different species of Convolvulus, and the Maurandia semperflorens. The Caper-bush, already noticed, § 405. is at once showy and in some measure useful.

Heathery.

538. In a few fine gardens, where the cultivation of curious plants is much attended to, a separate *heath-house* is erected, and appropriated to the numerous Ericæ from the neighbourhood of the Cape of Good Hope. This tribe of plants, it is justly remarked by Professor Martyn, has within these few years "risen from neglect to splendour." Miller, in the edition of his Dictionary published in 1766, mentions only five sorts, four of which are indigenous to this country, and the fifth a native of the south of Europe. The stores of the Cape were then nearly unknown. In 1775, Mr Francis Masson, travelling botanist to the king, sent home many new species from Southern Africa; and the same botanist revisited that country in 1787, and was equally successful in his researches. More lately Mr Niven of Edinburgh, by extending his travels, made a rich harvest among the same tribe of plants. The Cape ericæ are now about two hundred in number, and many of them both beautiful and fragrant. In construction, the heath-house differs in no respect from a small greenhouse with a low roof. The plants thrive best in a light, rather poor soil; such as a mixture of bog-earth, light loam and sand. They are propagated chiefly by cuttings; the cuttings preferred are very small, inserted closely together in fine soil, sifted over with very pure and fine sand, and covered with small crystal glasses, so as to prevent evaporation; the pots are kept in a moderate heat, but shaded. Cuttings of E. retorta, articularis, and several others, do not grow without great difficulty: such species are therefore often layered. Several kinds ripen their seeds in this country; and by sowing these, great numbers of plants are frequently raised.

Hot-houses.

Hot-houses.

539. The hot-houses for exotic plants have already been mentioned under the title of Dry Stove and Bark Stove, (§ 199, 200). It was there observed, that in the latter some of the more delicate kinds of grape vines are often trained along the rafters, and that pots with kidney-beans and strawberries are sometimes placed on the side shelves. In first rate gardens, where the stove is entirely appropriated to ornamental plants from tropical climates, the house is sometimes formed of glass

on all sides, those plants which naturally grow in shady woods in their own country being placed on the north side of the house. It may here be mentioned, that a book, in folio, on the Construction of Hot-houses, Green-houses, &c. has been published by Mr George Tod, including plans and elevations of some of the fine stoves for exotics at Kew gardens, which were executed by Mr Tod, under the direction of the late distinguished Mr Aiton.

Many curious and beautiful plants might be mentioned as deserving a place in the bark stove, but only a very few can here be named. Among the curious may be noticed, the Date-palm tree (*Phœnix dactylifera*); the Sago-palm (*Cycas revoluta*); the Cyperus Papyrus of Egypt, which afforded the scrolls of bark on which the ancients wrote with the stylum; the Coccolobo pubescens, remarkable for producing the largest round-shaped leaves in the world; Hernandia sonora, or the whistling tree of the West Indies; Musa paradisiaca, the plantain tree, and M. sapientum, the banana; several of the larger species of Acacia, which yield gum arabic; with others which, in our Eastern or Western possessions, afford well known commodities, such as the sugar-cane, the coffee-tree, the pimento and the clove-tree, the indigo plants; and the Ficus elasticus, from which the substance called Indian rubber is procured.

The Papaw-tree (*Carica papaya*) deserves a place in every large hot-house, on account of its possessing a remarkable property, which has been long known to those who have resided in the West Indies, but which has only of late been particularly described in this country by Dr Holder,—that of intenerating butchers-meat or poultry. This singular property is not even hinted at in the last edition of Miller's Dictionary. The juice rubbed on beef or mutton has the effect of rendering the meat as tender as veal or lamb, without injuring its other qualities. Indeed it is affirmed, that if a fowl be hung against the trunk of a papaw-tree, it becomes intenerated in a short space of time, by mere proximity; and that the oldest poultry may thus be rendered as tender as chickens. In stoves in England, the papaw-tree has been known to attain the height of twenty feet in three years, and to produce its flowers and fruit: it is not however a durable plant.

Among the more showy stove plants, may be mentioned, the different species of Strelitzia, Limodorum Tankervilli, Plumbago rosea, Canarina campanula, and Lantana odorata. Along the rafters may be trained Passiflora quadrangularis, which in the West Indies affords the fruit called Granadilla, but which in this country requires the utmost heat of our stoves to induce it to shew its brilliant and fragrant flowers. P. alata is also highly deserving of a place.

Diseases of Plants.

Disease.

540. In treating of the different kinds of fruit-trees and esculent plants, several of the maladies to which they are subject have already been noticed, as well as the usual means adopted either for prevention or cure. The diseases of plants shall therefore be only very slightly touched in this place. Any extensive discussion of the subject, indeed, could not be attempted: Our knowledge of it is yet in its infancy. Some authors have no doubt given us lists of diseases of the vegetable race, drawn up in the formal style of nosological nomenclature; but they are in general destitute of the requisite permanence and precision of type and character. We shall therefore continue to use the popular terms, such as *Canker*, confessing at the same time that they are sometimes much too indefinite.

Canker.

541. *Canker* is by far the most prevalent and the most fatal disease incident to fruit-trees in this country. It may be described as a sort of gangrene which usually begins at the extremities of the branches, and proceeds towards the trunk, killing the tree in two or three years. It seems, in different situations, to arise from different causes; very often from bad subsoil, trees planted over a ferruginous and retentive soil being observed to be very liable to it. Sometimes it appears to take its origin merely from some external injury, or from injudicious pruning, and leaving ragged wounds and snags. In other cases, it makes its first appearance after exudations of gum; and Mr Spence of Hull has remarked, that the foundation of canker in full grown trees is often laid by the attacks of insects, particularly the larvæ of Tortrix Wœberana. It frequently happens that cions for grafting have been taken from infected trees; and the young trees produced in this way, are, as might be expected, peculiarly obnoxious to the disease. Among apple trees, those which come soonest into a bearing state, such as the nonsuch and Hawthorndean, are observed to be most subject to canker. Trees trained as standards or against espalier rails are more liable to it than wall-trees; the more tender and finer sorts of fruits, than those that are hardy,—the reasons of which seem to be, that the young wood not being thoroughly ripened, is killed in the course of the winter, or the buds and early shoots are incurably injured from the same cause.

In order to guard against canker, if the subsoil be indifferent, the trees should be planted as much on the surface as possible. (See § 78. and 110.) If certain varieties of fruit seem peculiarly liable to the disease in any particular garden, other varieties should be introduced by means of grafting. The greatest care should be taken, in pruning, to make the cuts quite clean, and to cover with a plaster any accidental wound. Where the extremities of unripe shoots are nipped by the frost, they should be carefully removed with a sharp knife. Mr Forsyth, as is well known, was remarkably successful in overcoming the ravages of canker, in the Royal Gardens at Kensington, by means of heading down the trees, and thus procuring new branches; an example which may in similar cases be followed. Mr Knight seems to consider canker as principally affecting those varieties of fruit-trees which are in an advanced stage of existence, or which have long been propagated by means of grafts or buds; and the observation is probably well founded. Mr Sang of Kirkcaldy (*Scottish Hort. Mem.* i. 339.) very justly insists on the importance of grafting only on healthy *stocks*, and mentions a case which occurred in his own experience, where many stocks became diseased with canker, apparently from having been raised in an unpropitious soil. For further information regarding canker, the reader may be referred to a paper on that subject by Mr James Smith, gardener at Hopeton House, published in the first volume of *Scottish Horticultural Memoirs*, p. 221, *et seq.*

Blight.

542. *Blight* commonly means the effects of cold winds or of hoar-frosts, on the foliage and blossom of trees. In this country, easterly winds, accompanied with fogs, often produce blight; the buds are nipped, and the tender vessels burst; innumerable minute insects soon appear, feeding on the extravasated juices, and these are often erroneously supposed to have been

wafted hither by the wind, or "engendered by the hazy" *east*. When some fine weather has induced the blossom to expand itself prematurely, and frost supervenes, blight very often ensues. It is not therefore desirable, especially in the northern parts of Britain, that fruit trees should come early into flower: on the contrary it would be advantageous if the flowering were retarded. Various devices are resorted to for protecting early blossom, some of which have already been described, § 84.

Suffocation.

543. What is called *suffocation* is very commonly induced by the stems and branches being overgrown with lichens and mosses; an evil to which the trees in old orchards, where perhaps the bottom is naturally moist, and has not been drained, are peculiarly liable. The remedy is simple, consisting in rubbing off the parasitical plants, an operation which is much more easily and effectually performed in wet than in dry weather. A round-mouthed iron scraper is sometimes used for this purpose; but one of hard wood answers perfectly well. The trunk and larger branches are afterwards hard swept with a birchen rubber, and it is found very useful, even after both these operations, to wash the branches with old soap-suds or any penetrating liquid, or to apply a coating, of the consistence of paint, of a mixture of equal parts of quicklime, cow dung and clay.

Blotches.

544. Sometimes *blotches* or dark spots appear, terminating in ulcers. If these occur on old branches, the best remedy is to cut off the diseased parts, if practicable, and to apply a plaster. This may be composed of horse-droppings and clay wrought together, these ingredients being found to answer every useful purpose. Many however prefer a mixture of cow dung and old lime; and where the wounds are small, this is more easily applied. This last, indeed, is very nearly Forsyth's "composition," the specification of which, the reader may like to see. It is as follows: Take one bushel of fresh cow-dung, half a bushel of lime-rubbish of old buildings, half a bushel of wood-ashes, and a sixteenth part of a bushel of pit or river sand; the three last articles to be sifted fine before they be mixed; then work them well together with a spade, and afterwards with a wooden beater, until the stuff is very smooth, like fine plaster used for the ceilings of rooms. Chamber-lye and soapsuds are to be added, till it be reduced to the consistence of a pretty thick paint, which may be applied to the trees with a painter's brush. The application of such plasters or paints, it may here be remarked, is proper wherever any accident has occurred to fruit trees, or where large branches are lopped off.

Forsyth's composition.

In some cases, especially in peach-trees, blotches appear on the young shoots, which must of course be entirely removed. Mr Kinment, gardener at Murie in Scotland, has assigned some reasons for believing that such blotches on the young wood of the peach-tree, are induced by the gross feeding of the tree; in other words, he observed, that blotches always occurred on trees where the borders were manured with simple dungs, but that where fresh soil or well prepared compost only was added to the border, the trees continued in a healthy state.

Hide-bound bark.

545. When a tree becomes *hide bound*, or when the stem swells too fast for the bark, the usual remedy is, with a knife, to score or divide the outer bark longitudinally in various places.

Decortication.

546. In cases where the outer bark has become rough and full of chinks, so that small insects deposite their eggs and produce their larvæ below this bark, it is a good practice entirely to remove it. This sort of decortication is by no means a novelty in gardening; it is recommended by several of the authors mentioned in the introduction to this article. Thus, Le Gendre, (§ 10.) writing about 1650, says, "Those trees which have their bark base, you must with a bill take away the old bark to the quick; for the trees being thus cleared and discharged, do shoot forth with new strength, bearing fairer and better nourished fruit." (Translation, p. 136.) And Hitt (§ 14) who wrote in 1754, recommends for trees that have been neglected or ill dressed, "taking off the old rind, and cleansing cankered parts, thus destroying many insects, as also their eggs, concealed in these places." (*Treatise on Fruit Trees*, 3d edit. p. 271.) Of late years Mr Knight practised decortication on some old fruit trees, particularly red-streak apples, and found the new growth thus produced quite surprising, so that the growth of some trees deprived of their external bark in 1801, exceeded in the summer of 1802, the increase of the five preceding years taken together. (*Treatise on Apple and Pear*, 4th edit. p. 86.)

547. More recently, a zealous horticulturist at Edinburgh, Mr P. Lyon, surgeon, has called the attention of the public to the advantages of decortication. At first Mr Lyon recommended the removal of the bark only in cases where it was cracked and rugged, and chiefly with the view of destroying the *ova* of insects; but of late he has inculcated the stripping off the outer bark even of young trees, and of the new shoots of full grown trees, even where the bark is sound and healthy. The beneficial effects of the former practice we have repeatedly witnessed; old trees which usually bore very little fruit and produced little new wood, becoming, after the removal of the outer bark, fruitful and rather exuberant in the production of shoots: the fruit, however, though plentiful, has in general been of smaller size than usual. The depriving young trees and new shoots of their bark is quite a different thing: we know that it is the earnest endeavour of many excellent practical gardeners to keep the bark *on*, provided they can preserve it in a clean and healthy state. We shall only, therefore, for an explanation of this part of Mr Lyon's doctrines, refer to his book, entitled, "A Treatise on the Physiology and Pathology of Fruit-trees," 8vo. Edin. 1816,—warning the reader that he must make allowance for no small proportion of extraneous matter.

548. In order to clear trees, especially wall-trees, of insects and their eggs and larvæ, and to prevent the breeding of these, the trunk, branches and even twigs, are, by careful horticulturists, regularly washed with some penetrating liquid every winter. Some of the most experienced practical gardeners in Scotland have followed this plan, tedious and laborious although it may seem, for a number of years past, and have found the greatest benefit result from it. They have very generally adopted a mixture recommended by Mr Nicol, and from his writings, therefore, the recipe shall be given: "Take of soft soap, 2lb.; flowers of sulphur, 2lb.; leaf or roll tobacco, 2 lb.; nux vomica, 4 oz.; turpentine, a gill English measure. These ingredients are to be boiled in eight gallons English of soft or river water, down to six gallons." This mixture is applied, by means of a house-painter's brush and a sponge, generally when in a milk-warm state. All the branches in succession are loosened from the wall, and completely rubbed or anointed on every side, particular attention being paid to the cleansing of angles or cavities. If the trees have been much overrun with insects, even the wall should be anointed, or the trellis in the case of

Nicol's liquid.

espalier trees. This operation may be performed any time from the beginning of November till the middle of February.

Use of oil.

549. Sir George Mackenzie has lately communicated to the Caledonian Horticultural Society, the result of an extensive experiment of anointing the stems and branches of trees with oil, or oily matter, for the purpose of destroying the eggs and pupæ of insects. The experiment has succeeded beyond expectation; but care must be taken not to touch the buds, particularly those which are to produce blossoms. Apricot and cherry trees are the only kinds which seemed to suffer injury from oil, every other kind having made vigorous shoots, and the bark of those which had a diseased appearance, having sloughed, and shown the advance of new healthy bark; and aphides, &c. seeming to have been banished.

The same gentleman has discovered a nocturnal enemy in a Curculio, supposed to be C. vastator, whose ravages have been attributed to caterpillars. This kind of weevil conceals itself during the day about the foot of the stems of trees in the earth, from which, owing to its brownish-grey colour, it is difficult to distinguish it; and at night, it crawls up and attacks the young shoots and blossoms. It is very destructive to young grafts. The method which Sir George Mackenzie took to destroy them was, to tread the earth about the foot of the stems of the trees, at night when the weevils were on the trees, and putting small flat stones, pieces of slate, or the like, on the trodden space. In the morning the enemy having retreated under these, were destroyed. The trees and grafts should, however, occasionally be examined by candle light, and the insects picked off. They have been found sometimes to harbour also in the clefts of branches, and about portions of dead or decayed and rugged bark.

Mildew.

550. *Mildew* consists in a thin whitish coating, investing the leaves especially of peach-trees and the finer kinds of fruits. It is observed that it commonly appears in the warm months, when the ground is dry, the weather calm, and when hazy vapours or slight fogs appear in the evenings. It is a remark of experienced gardeners, that trees washed during winter with such a liquid as that above described, are scarcely ever known to be affected with mildew, probably owing to the leaves being perfectly healthy and able to withstand the immediate cause of the evil, whether it be minute fungi or the slime of aphides. Washing the foliage with the garden-engine is found very useful in removing the mildew or in stopping its progress.

The scale.

551. What is called the *scale* seems to be the nidus of an insect, or a collection of its minute eggs, covered with a thin pellicle. It very much resembles a drop from a spermaceti candle. The hatching of the eggs and consequent bursting of the pellicle, have been observed and described by Mr Thomas Thomson, an excellent Scottish gardener. It generally appears in August, and it continues in the state of a scale during the winter. The larvæ usually emerge about the time when the trees are in blossom, and they immediately begin to devour the tender parts of the flower. Afterwards, as they acquire strength, they attack the young leaves and even the new shoots of the trees. When about to undergo their transformation, they involve themselves in leaves drawn together with fine silky threads: from this retreat they come forth in the form of small moths, but the species has not been ascertained. The most effectual method of destroying these scales consists in removing them with the nail of the finger at the time of winter dressing. In rainy weather they are most discernible, being of a lighter colour than the wet bark. Another simple method of overcoming them, is to make a paste of fine clay of the consistence of thick paint, and with a coarse brush completely to anoint the branches of the tree. This should be done in March; and if heavy rains do not immediately wash away the coating of paint, the breeding of the insects at the proper season is prevented, and their destruction thus ensured.

Several of the diseases of plants, we have thus seen, arise from the attacks of insect assailants. Some more of these remain to be mentioned, and also a few enemies of larger size.

Enemies to Garden Productions.

Aphides.

552. *Aphides* or green-flies, of many species, very much annoy wall-trees in the spring and early part of summer, attacking the leaves while just expanding, and preying much about the points of the young shoots. A fumigation with tobacco is the common cure, and it very generally proves effectual. In the case of wall-trees, a large cloth, preferring one that is waxed or oiled, is placed over the tree, and the tobacco smoke applied under it with bellows; the wall and the tree are previously wetted with the garden engine, the moisture having a tendency to detain the smoke. The tree is then briskly washed with the force-pump, and the border is delved over, so as to bury the stunned aphides. In the same way gooseberry or currant bushes may be freed from them. In hot-houses the fumigation is easily performed, while the doors and sashes are kept close. It is likewise very readily accomplished in melon or cucumber frames, the crops in which are sometimes infested. In the kitchen-garden, kidney-beans are subject to the attacks of aphides; and in the flower-garden, rose-bushes are peculiarly obnoxious to them.

Apple-aphis.

The Apple-aphis (*A. lanigera*), sometimes called American blight, which has of late proved exceedingly destructive to young apple-trees, first appeared in the neighbourhood of London only about the year 1795. It is a minute insect covered with a long cotton-like wool; it breeds in chinks and rugosities of the bark, and at length almost covers the infected tree. It is said that the application of the spirit of turpentine to the bark proves an effectual remedy; and we know that it has been wholly banished from a garden where it had spread, by merely smearing the infested branches with oil, as recommended by Sir George Mackenzie. Sir Joseph Banks extirpated it from his own apple-trees, by the simple means of removing all the rugged old bark, and then scrubbing the trunk and branches with a hard brush. Mr William Salisbury, in his "Hints to the Proprietors of Orchards," published in 1816, gives it as his opinion, that this is the same insect which has of late infested larch-trees. He supposes it to have been brought to this country by the Protestant refugees in the reign of Louis XIV.; but he has assigned no reason for this extraordinary opinion, nor has he attempted to explain why so destructive an insect had lain dormant for so many years, and at length suddenly extended its ravages in so striking a manner. He observes, that some of the insects descend during winter to the upper roots, and lodge there; in cleansing the trees, therefore, these should be examined, as well as the trunk and branches.

Gooseberry-caterpillar.

553. There are several distinct kinds of *gooseberry-caterpillar*. One species, of a whitish colour, becomes a longish fly, with golden-tinged wings, a yellow body, and yellow thighs; probably the Tenthredo capreæ. Another, of a greenish hue, which becomes T. flava, often proves quite destructive to the foliage of the plant, and consequently to the fruit. A third, of a larger size, and sometimes very common, is the larva of the magpie-moth (*Phalæna grossulariata*, Lin. *Abraxas* of Leach). The young of this last haunt during winter about the crevices of the bark; and this is considered as the best time for destroying them. Their destruction may be effected merely by hard rubbing of the stems and branches, or by pouring boiling hot water over these parts, which at this season does not injure the bushes. The larvæ of the saw-flies or teuthredines penetrate about an inch under ground in July, and, passing into the chrysalis state, remain there till the following spring, when they come forth in the form of flies. For destroying these, one of the most effectual means consists in delving the ground about the bushes very deep during winter, taking care to bury the surface-soil in the bottom. In this way the chrysalids are placed beyond the genial influence of the atmosphere, or if the transformation be accomplished, the fly is unable to gain the surface.

Coccus.

Different species of *Coccus*, particularly C. hesperidum, often called *scaly insects*, infest the plants of the green-house and the conservatory, particularly the myrtle, the orange, and the olive. A thorough washing with soap and water, rubbing the leaves with a woollen rag or bit of sponge tied on a small stick, is the remedy usually resorted to, the plants being afterwards well syringed with pure water. Coccus vitis infests vines placed in stoves, and is often very injurious, covering their stems, as it were, with little tufts of white cotton. The means of freeing pine-apple plants from the coccus, have already been adverted to, § 223.

Red spider.

554. The *red spider* (*Acarus telarius*) infests not only the pine-stove, vinery, and melon-frames, but often proves very injurious to ornamental stove plants. Water applied with the syringe is destructive to it. Some persons recommend the use of lime-water; but it is not commonly employed, being found hurtful to the folinge; nor does any addition to the water seem necessary.

Wasps.

555. The finer kinds of fruits, as they approach ripeness, are subject to the attacks of different insects. Among these *wasps* (*Vespa vulgaris*) may be first mentioned. Various expedients are resorted to for destroying them. In some places, phials half filled with honey and water, or any sweet liquid, are hung in different parts of the tree; and great numbers are thus ensnared. The most effectual means, however, of keeping down the numbers of this formidable enemy, is to destroy the females in the early part of the season, and the nests in the autumn. From hot-houses they are, in some places, excluded by employing temporary doors, and temporary frames below the sashes, covered with thin muslin or gauze: both kinds of doors are never allowed to be open at the same time, and the gauze or muslin does not prevent the access of sufficient light and air. Where their exclusion is not thus effected, it is found very useful to have a plant of Hoya carnosa established. This is an ornamental climber (named in honour of Mr Thomas Hoy, a distinguished botanist, who has for about half a century been head-gardener to the Duke of Northumberland at Syon House), and may be trained along any spare parts of the house. It flowers freely; and as long as the blossoms continue, which they do for several weeks, the wasps give a decided preference to the sweet exudation they afford, leaving grapes and peaches untouched.

Earwigs.

556. *Earwigs* (*Forficula auricularia*) attack all sorts of ripe fruit. No remedy is known but ensnaring and killing them. Short cuts of reeds, or of strong wheat-straw, or hollow stalks of any kind, are placed here and there among the branches, and also at the roots of the trees. Into these the earwigs take refuge in great numbers; and from the tubes they are blown into a bottle containing water.

Woodlouse.

557. The *woodlouse*, called *sclater* in Scotland (under which name are included the Oniscus asellus and Porcellio scaber of naturalists) is often entrapped along with the earwig. It is almost equally injurious to ripe fruit as that insect.

Flies.

558. *Flies* of many different species, and belonging to various genera, may be numbered among the enemies of ripe fruit. The wasp, the earwig, and the woodlouse commence the attack, and "sap the blushing rind;" the flies enter the openings made by these more powerful insects, and extend the devastation. Several *muscæ* are very frequently to be observed, particularly M. tenax, Cæsar, and canicularis. Wherever the juices begin to corrupt, the large blow-fly (*M. vomitoria*) is to be found in every hollow.

Caterpillars.

559. The *caterpillars*, which devour the leaves of cabbages, savoys, and broccoli, are principally the larvæ of Noctua brassicæ, and N. oleracea. The completely green caterpillar, which frequently preys on cauliflower and broccoli plants, is the larva of *Papilio rapæ*, Lin. (*Pontia*, Fabr.) The cabbage tribe is observed to be most subject to the attack of caterpillars in the neighbourhood of towns and in long cultivated soils, where much crude manure has been applied. The best and simplest remedy consists in turning up the soil in ridges in the autumn, and leaving it exposed to the action of the winter's frost; but the application of quicklime is also useful.

Wire-worm.

560. The *wire-worm* is an indefinite sort of name for any small thread-like grub, which lodges in the roots of culinary plants, particularly such as are of a bulbous or tuberous nature. These grubs appear to be principally the larvæ of different species of Elater. They sometimes attack also the roots of ornamental plants kept in pots: The remedy, in this case, consists in repotting, shaking the roots clear of the old earth, and using fresh soil brought from some old pasture at a distance.

The *maggot* which infests onions and shallots (§ 335 and 344), is a small larva, the transformations of which have not yet been traced by naturalists.

For further information concerning the natural history of the insect enemies of fruits and culinary vegetables, we may refer to the first volume of a very entertaining and instructive work, entitled, "An Introduction to Entomology," by Messrs Kirby and Spence, 8vo. London, 1815; and to the article ENTOMOLOGY in the 9th volume of this work.

561. The other enemies of garden productions can only be very slightly noticed here.

Slugs.

Slugs, meaning principally Limax cinerarius and L. flavus, are often very mischievous to wall-trees, which they ascend in the spring months, cutting off the fruit at the time of setting. Inverted flower-pots are sometimes placed as decoys at the bottom of the trees, the slugs being induced to take shelter within them. Ducks are very good destroyers of slugs; and a few are often turned into gardens for this purpose; they must be kept in it for two or three days, and get no food but what they cull for themselves.

Snails. *Snails* (meaning chiefly *Helix aspersa* of Montagu, or *H. hortensis* of Pennant) often abound, especially where the garden-walls are old or rugged. In well kept gardens they are looked for in the mornings, particularly after showers, when they never fail to appear, and are destroyed.

Moles. *Moles* (*Talpa Europæa*) are sometimes very injurious in gardens, and must be extirpated wherever they appear. Traps are set for them by persons who have studied their habits: and the expertness of some of these in taking them is wonderful. The moles seem to be social animals, keeping together in families or societies. The great art in catching them depends on ascertaining their recent and frequented galleries or subterraneous roads, and in placing the traps neatly in these.

Mice. *Mice* (principally the field-mouse, *Mus sylvaticus*) frequently devour newly sown peas and beans, if these have not been duly covered with soil; and they sometimes likewise attack the beds of tulips, ranunculuses, and crocuses. They may soon be subdued by placing a number of *fourth-figure* traps (as they are called, from resembling in shape the Arabic 4) in the garden: this kind of simple but effectual trap is figured and described both in Nicol's "Calendar," and in Abercrombie's "Practical Gardener."

Birds. Many kinds of *birds* may be numbered among the enemies of gardens. Even the beautiful bulfinch (*Loxia pyrrhula*) destroys many blossoms of fruit-trees, scooping them clean out; but whether the bird feeds on the blossom, or only nips it off for the sake of caterpillars contained within it, is not known. The jay (*Corvus glandarius*), the black-bird (*Turdus merula*), and the mavis (*T. musicus*), make great havock among the best kinds of cherries, where means are not resorted to for saving them. Rooks (*Corvus frugilegus*) often attack pear-trees, and destroy vast quantities of the fruit; and jack-daws (*C. monedula*) are sometimes also guilty of this sort of trespass. The common sparrow (*Fringilla domestica*), and the chaffinch (*F. cœlebs*), likewise commit great depredations. For the protection of large standard trees, dead birds are occasionally hung up, so as to wave with the wind; and such scares are of considerable service in deterring depredators. In the case of espalier and wall-trees, nets are generally employed, being hung over them, and fixed close to the ground. It may be remarked, that different species of tit-mouse (*Parus cæruleus* and *ater*) with the common creeper (*Certhia familiaris*), and all the Motacillæ or warblers, may be considered as useful in destroying insects or their larvæ, which are their principal food, and should therefore be winked at in gardens, although they may possibly destroy a certain quantity of the blossom.

Implements of Gardening.

Implements of Gardening. 562. The principal tools employed in horticultural operations have already been mentioned incidentally; but it may be proper in this place to enumerate them together.

Tools. The spade may be first named, as the oldest and most indispensable garden tool. Besides common sized spades for delving, small spades are required for working in the flower-borders. The manufacture of spades is carried on to a great extent at Dalston near Carlisle; at Gateshead, Newcastle; Bedburn, near Durham; Burton upon Trent; and Ulverstone in Lancashire; and of late years, some Scots forges, particularly those at Cramond, near Edinburgh, and Dalnottar, near Glasgow, have disputed with those mentioned, the palm of excellence in this useful and important article of our iron manufacture. Shovels of different sorts are made at the same manufactories. Forks are necessary for pointing over ground where it is improper to use the spade: They are of different sizes, and some have flat and others rounded tines: asparagus-forks have been already mentioned (§ 353.) Hoes of different sizes are indispensable, with small weeding and thinning hoes, and also the sort called the Dutch hoe. Rakes of different sizes are necessary: for large ones, those in which the teeth are of iron, and the head of well-seasoned ash, are best; and for small ones, those in which the teeth and head are formed of one solid piece of iron, are to be preferred. Shears for clipping hedges, and a kind with bent handles for dressing grass verges, are not to be forgotten. A flat faced hammer, with large headed nails, both of wrought iron and of cast iron, and a stock of lists or *roonds* are requisite for the nailing of wall-trees: as well as a proper wall-ladder, such as is described, § 245. Pruning, grafting, and budding knives, with hand-bills, chisels, and small saws, are indispensable. Some recently invented pruning instruments might here be noticed. One called the Averuncator has a handle from 5 to 8 feet in length; by means of a cord and pulley, a lever connected with a cutting blade is acted upon; so that a person standing on the ground may prune the greater part of ordinary sized trees. The Pruning-shears are more easily managed, and are found very useful on many occasions, making the cuts more clean and neat than can be done with any kind of knife. Both instruments take off branches an inch and a half in diameter with great ease. The form of the averuncator is given at Fig. 6. of Plate CCCXII., and of the pruning-shears at Fig. 7. of the same Plate. Trowels of different sizes and shapes, with planting irons and dibbles, are all very useful implements. These, with scythes and paring-irons, and similar instruments, are manufactured to a great extent at Sheffield; and from the subdivision of labour there established, they are furnished at rates so cheap as cannot fail in a great measure to command the market: but it is not to be disputed, regarding hoes and rakes in particular, that the blacksmiths of some towns not distinguished as manufacturing places, such as Edinburgh, produce these instruments of better materials, if not of neater workmanship. A garden reel and line is constantly needed. Sieves of iron or of brass wire of different degrees of closeness, are required wherever attention is paid to the raising of exotic seedlings. Fumigating bellows are useful for green-houses, vineries and melon-frames. Where forcing is practised, or where a collection of stove-plants is kept, thermometers are necessary: those graduated to the scale of Fahrenheit are universally in use: what is called the botanical thermometer differs in no respect from another, excepting that some terms, such as "Ananas," are inscribed at the proper degrees on the sides of the scale. One thermometer is placed in the open air; and in the centre of each of the hot-houses there is another: by comparing these, the propriety of increasing or diminishing the fire-heat or the quantity of fuel, is regulated. Watering-pots are made by tinsmiths, with pipes of different lengths, and with roses more or less closely perforated; for watering delicate seedlings, pots with brass nozles finely perforated are used, producing an extremely light or minutely divided shower.

Garden engine. 563. The *garden engine* has been repeatedly mentioned, and its use recommended, (§ 92, 205, &c.). Con-

Implements of Gardening.

siderable improvements having been made on this instrument at Edinburgh, a few words additional concerning it, may be excused. The engine consists of a force pump or barrel, commonly two inches and a quarter in diameter, to the bottom of which, above the valve, is connected an air-vessel: into this the water is forced; and it is emitted from it, by the action of the compressed air, through the directing pipe in a continued stream. This pipe is attached to the top of the air-vessel by means of a swan-neck swivel joint, with double screws, which are water tight: in this way the pipe can be moved in any direction. Formerly, leathern valves and a leathern flexible director-pipe were in use; but from occasional exposure to drought, the seams of the leather were very apt to open, and allow water to escape; well executed brass work, on the other hand, is of all others least liable to derangement. The pump and air-vessel are fixed in a copper cistern, sixteen inches deep, and capable of containing about twenty-two gallons of water, wine measure. The cistern has likewise a strong wooden bottom, to which are attached two rollers, an improvement of Mr John Hay's, which greatly facilitate the moving of it when taken into hot-houses or vineries. The engine is, at the same time, fitted to a barrow with wheels, for the conveniency of wheeling it through the garden; and to this the rollers form no obstacle, as they pass between the *steels* of the barrow. The pump is worked by a lever, and requires very little exertion. The water can be projected about fifty feet; so that wall-trees of any height may be washed, while the engine remains on the gravel walk.

The best writers on the various branches of horticulture, particularly British authors, have been mentioned either in the introduction to this article, or in the course of treating the different parts of the subject; but it may be useful to recapitulate them here, in alphabetical order. (P. N.)

LIST OF AUTHORS AND WORKS QUOTED OR REFERRED TO.

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Hospital || Hot-bed.

HOSPITAL. See INFIRMARY.

HOT-BATH. See BATHING.

HOT-BED. The common hot-beds in use in this country are composed of new or fresh stable dung in the following manner. The dung is collected in a heap, under cover if possible, and kept for about a week in this situation, when the heat arising from fermentation becomes considerable. It is then turned over, well mixed, and again formed into a heap, to remain for five or six days more, in order that the heat may be equally distributed. It is now transferred to the site of the intended hot-bed. Here it is again very completely intermixed by means of the dung-fork, in the course of making up the bed; at the same time every layer is settled compactly, and beat smooth. The bed is usually five or six feet in breadth, according to the size of the glazed frames, beyond which it ought to extend on every side about eight or nine inches; and it is from four feet to two feet and a half thick or deep,—the thickest beds being used in winter, and the thinner in the spring months. The part of the dung which is *shortest*, or freest from litter, is placed on the top, forming a close covering, through which steam or vapour may not readily pass; sometimes a layer of cow-dung is placed on the surface, with the same view. After the bed is made up, it is allowed to remain for a few days, during which it sends off a good deal of vapour, and acquires an equal temperature throughout. When the heat declines, it is revived by adding *linings* on the outside; but for information re-

Hot-bed.

specting these, as well as concerning the use of tanners-bark and decayed tree leaves in forming hot-beds, see Horticulture, § 257, 355, &c.

HOT-HOUSE. See Horticulture, *Index*.

HOTTENTOTS, an extraordinary people in the southern extremity of Africa, originally occupying the territories around the Cape of Good Hope. They are altogether an insulated tribe, confined to a small corner of the African Continent, and bearing no resemblance either to the Negro race along the western coast, or to the Caffre nation to the eastward.

Origin.

Various conjectures have been proposed, but nothing very satisfactory has yet been established respecting their origin, or affinity. Kolben, in full consistency with his multitude of marvellous stories on the subject, affirms that they have a tradition among themselves of having been thrust upon the promontory of the Cape out of some narrow passage; and, as a narrow passage might signify a door-way or window, he forthwith concludes, that it could be nothing else than the window of Noah's ark, out of which they crept. Mr Barrow considers them as approaching nearest in colour, and in the construction of the features, especially in the shape of the eye, to the Chinese or Tartar race; and accounts for this relation by supposing them to have proceeded from the Egyptians, who have been not improbably represented as originally the same people with the Chinese. In support of this opinion, he adduces the strong resemblance between the physical character of the Bosjesmans or real Hottentots, and the descriptions given by ancient writers, particularly by Diodorus Siculus, of the Egyptians and Ethiopians, especially of the Pigmies and Troglodytes, who are said to have dwelt in the neighbourhood of the Nile. The early Portuguese writers, also, mention a colony of Chinese in the vicinity of Soffala; and the natives in the interior of Madagascar are described as a small race of Tartars, resembling the Hottentots in stature, colour, and countenance.

Name.

The name Hottentot, though frequently represented as their native appellation, is now ascertained to be of modern fabrication, and has no place or meaning in their own language. They take it to themselves, under the idea of its being a Dutch word; and it is conceived to have been applied at first as a term in some degree imitative of the remarkable clacking made by them in speaking, which is said to sound like *hot* or *tot*. Each horde had formerly its particular name, as the Attaquas, Hessaquas, Houtiniquas, Namaquas, and Coranas; but the designation by which the whole nation was distinguished, and which they still bear among themselves in every part of the country, is Quaiquæ.

Country occupied by the Hottentots.

The whole of the Hottentot country, comprehending all the different tribes of the race, extends along the east coast to the 32° of S. Latitude, and to the 25° on the West.

First notices of by Europeans.

None of the first discoverers of the Cape of Good Hope, nor of the early Portuguese navigators, had much communication with the natives; and the Hottentots were scarcely known to Europeans till about the year 1509; when Francisco D'Almeyda, Viceroy of India, returning home after his quarrel with Albuquerque, landed at Table Bay, and was killed, along with seventy of his people, in a scuffle with the natives. A Portuguese captain, having touched on the coast, about three years afterwards, planned the following cowardly scheme of avenging his countrymen. He landed a piece of ordnance loaded with grape shot as a pretended present to the Hottentots; and while the unsuspecting natives were crowding around the engine, the brutal Portuguese fired off the piece by means of a rope which was attached to it, and viewed with savage delight the mangled carcases of the deluded creatures, who had trusted their professions of friendship. They were occasionally visited for refreshments by the English, Portuguese, and Dutch traders in their voyages to the East Indies, till the establishment of a colony among them by the last mentioned nation, in the year 1650. They made little opposition to the new settlers; and were soon induced, by their passion for brandy and tobacco, first to sell their country and cattle, and next to become themselves the servants of the purchasers, for the purpose of guarding those flocks and herds, which had so recently been their own property.

Condition under the Dutch colonists.

These wretched people, duped out of their possessions and their liberty, have entailed upon themselves and their offspring a state of subjection, which is comparatively worse than slavery; inasmuch as, in consequence of their not being transferable property, their immediate value is diminished, and their treatment less tempered by the self-interest of their oppressors. In the remoter parts of the colony especially, they are subjected to cruelties, which have not been surpassed in the worst of the West India islands. Instant death is not unfrequently the consequence of that brutal rage, to which they are exposed. To fire small shot into their legs or thighs is no unusual punishment. One of the gentler chastisements, which they endure, is to be lashed or rather bruised with thongs, cut from the hide of the sea-cow or rhinoceros, which are nearly as hard and heavy as lead. With these horrid instruments they are flogged at leisure, not by a number of blows, but by a period of torture; and the savage master makes it one of his favourite recreations to regulate the time of their suffering, by smoking as many pipes of tobacco as he deems proportionate to the offence.* These boors or Dutch farmers are authorised by an old law of the colony to claim as their property all the children of the Hottentots in their service, to whom they may have given in their infancy a morsel of meat; and, though the same regulation directs their emancipation at the

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* Among many instances of the cruel treatment to which the helpless Hottentots are daily exposed, the following are recorded by Mr Barrow as peculiarly striking: "We had scarcely parted from these people, when, stopping at a house to feed our horses, we by accident observed a young Hottentot woman with a child in her arms lying stretched on the ground in a most deplorable condition. She had been cut from head to foot with one of those infernal whips, made from the hide of a rhinoceros or sea-cow, known by the name of Samboes, in such a barbarous and unmerciful manner, that there was scarcely a spot on her whole body free from stripes; nor had the sides of the little infant, in clinging to its mother, escaped the strokes of the brutal monster." "The only crime alleged against her was the attempt to follow her husband, who was among the number of those of his countrymen that had determined to throw themselves upon the protection of the English." "The next house we halted at upon the road presented us with a still more horrid instance of brutality. We observed a fine Hottentot boy, about eight years of age, sitting at the corner of the house, with a pair of iron rings clenched upon his legs, of the weight of ten or twelve pounds; and they had remained in one situation for such a length of time, that they appeared to be sunk into the leg, the muscle being tumified both above and below the rings. The poor creature was so benumbed and oppressed with the weight, that, being unable to walk with ease, he crawled on the ground. It appeared, upon inquiry, that they had been rivetted to his legs more than ten months ago." The fellow shrunk from the inquiries of the indignant general; he had nothing to allege against him, but that he had always been a worthless boy; he had lost him so many sheep, he had slept when he ought to watch the cattle, and such like frivolous charges of a negative kind," &c.

Probable extinction of the race.

age of twenty-five, this is a privilege which they are generally too ignorant to claim, or too feeble to enforce. At most, the poor wretches, after spending the prime of their strength in an unprofitable servitude, are turned adrift at last with no other earthly property except the sheep skin upon their back. Those who are apparently free, and engage themselves from year to year, are not much better protected and provided for. If they have families when they enter the service, their children are encouraged to run about the farm house, where they receive their morsel of food; and upon this ground, are often claimed as the property of the farmer when their parents are desirous to remove, or perhaps forcibly turned away. Those who are unmarried, as well as free, are doubtless the least wretched; but even their personal service is easily converted into the hardest bondage. Their paltry wages are stopped upon every frivolous pretext; and should any of the cattle entrusted to their care be missing, they must prolong their service without pay, till they have earned the value of what was lost. Or, should no damage of this nature be imputable to their negligence during the year, they may still have nothing to receive at the end of it, in consequence of a bill for brandy or tobacco, brought against them to the full amount of their wages. In such circumstances, they have little inducement to engage in marriage; and when they do enter into that state, they are frequently without any offspring, or at most have seldom more than two or three children. Their extreme poverty, scanty food, and constant dejection of mind, appear to exhaust the prolific powers of nature; and their practice of marrying only among their own limited horde is considered as an additional hindrance to their increase. Multitudes of the more independent tribes, also, have perished by the hostilities of the Caffres, and the ferocity of the wild beasts, as they receded towards the interior of the country.* From all these causes combined, the Hottentot race is rapidly diminishing, and in all probability will soon become wholly extinct. Many of their tribes mentioned by the earlier travellers, have entirely disappeared; and, at the commencement of the present century, not a kraal or village was to be found about Camtoos river, where, only 20 years before, hundreds of the natives were met in groupes. In the whole extensive district of Graaff Reynet, there is not a single horde of independent Hottentots; and the whole number within the limits of the colony does not amount to fifteen thousand. Much has been done since the colony came last into the possession of Great Britain, especially by the measures of Sir John Craddock, and the progress of missionary settlements, to protect and preserve this oppressed race of beings; but, though a little remnant may thus be collected, the nation, it is to be feared, is almost already extinguished. A mixed breed, called Bastaards, produced from Hottentot women and European fathers, or the slaves from other countries, are likely to supplant the original inhabitants. They are already a numerous race in the colony; and are a tall, stout, and active people.

Manners and customs.

Personal appearance.

The ancient manners and primitive character of the Hottentots are acknowledged to have been greatly changed during their connection with the colonists of the Cape; and it may not, therefore, be a sufficient proof of the inaccuracy of former accounts, that they do not correspond with the observations of recent travellers. At the same time, so many of the strange and ridiculous stories, published on the subject, have been discovered to have originated in ignorance, credulity, or deliberate fiction, that little dependence can be placed upon any of the narratives which preceded the enlightened enquiries and personal observations of Barrow, Truter, Somerville, &c. The Hottentots of one district, differ considerably, in the present day, from those of another, in consequence of their living together in particular clans, and mixing with different kinds of people; but from observing their manners in these parts of the colony, which have been most recently occupied, some approach may be made to a sketch of their original native character. The personal appearance of the Hottentots, though by no means prepossessing, is not nearly so revolting as has been often represented. Their countenance, indeed, is in general extremely ugly. Prominent cheek bones, and a narrow pointed chin, give to the face the form nearly of a triangle. The nose, in most of them, is remarkably flat, and rather broad between the eyes. The eyes are of a deep chesnut colour, long and narrow in their shape, and the eye-lids, at the extremity next the nose, instead of forming an angle as in Europeans, are rounded into each other, exactly like those of the Chinese. Their mouth is of the ordinary size, the lips thinner than those of the Negroes and Caffres, and the teeth beautifully white. The hair of their heads is of a singular nature, growing in small tufts at certain distances from each other, and extremely hard and frizzled, resembling, when short, the bristles of a shoe-brush twisted into round lumps about the size of a large pea, and, when suffered to grow, hanging about the neck in strong tassels like fringe. The colour of their skin is that of a yellowish brown or faded leaf. Their figure, especially when young, is not devoid of symmetry. They are erect, clean-limbed, and well proportioned; their hands, feet, and all their joints, remarkably small; and the muscular parts of their body delicately formed, so as to indicate rather feminine inactivity, than masculine exertion. Some of the women in their youth, and before child-bearing, are described as models of perfection in the human figure; every joint and limb being well shaped and turned; their breasts round, firm, and distant; their hands and feet small and delicately formed; and their gait not altogether deficient in grace. But, at an early period of life, and immediately after the birth of their first child, their beauty vanishes; their breasts begin to grow loose and flaccid, and at length become enormously distended; their bellies protrude, and their posteriors acquire immense masses of fat, so as to give to the spine an appearance of extraordinary curvature inwards. It is very rarely that a cripple or deformed person is seen among the Hottentots of either sex; and they are not subject to any particular diseases. Their health is generally sound; and their life, if not cut short by accident or violence, is usually terminated by a gradual decay. But they are not so long-lived as the natives of most other countries, which resemble their own in point of temperature; and it is a rare occurrence when any of them attains the age of sixty years.

Dress.

The dress of a Hottentot is very simple; and in summer is so trifling, as not to deserve the name of covering. It consists of a belt cut from the hide of some animal, and fastened round their body. From

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* One woman mentioned to Mr Campbell that she had born ten children, who had all been destroyed by lions, tygers, and serpents.

this strap is suspended in front a kind of case or bag made of the skin of a jackal with the hair outwards; and which is intended to receive those parts, which modesty requires to be concealed. From the back part of the girdle hangs a piece of stiff dried skin, shaped like an isosceles triangle, with the point uppermost, and reaching nearly to the middle of the thigh. Sometimes two of these pieces are used; but these straps, especially when the wearer is walking or running, entirely fail to answer the purpose of concealment; and are conjectured to have been originally intended rather as a kind of artificial tail, to fan the body by its motion, and to lash away troublesome insects. In the winter months, they wear cloaks made of skins, generally of sheep, which are worn, as the weather requires, either with the wool inwards or outwards; and which serve as blankets and bedding through the night, as well as for a garment through the day. The women suspend from their belt in front a kind of apron made of skin, but cut into threads, which hang in a bunch between the thighs, and reach about half-way to the knee; or they wear a smaller apron about seven or eight inches wide, not divided into threads, but ornamented with shells, metal buttons, and any of their most showy trinkets. In place of the tail worn by the men, they have a sheep's skin, which entirely covers the posterior part of the body from the waist to the calf of the leg, and makes a rattling noise as they walk. Instead of the thongs of dried skin, which formerly covered their legs from the ankle to the knee, as a protection against the bite of poisonous animals, they have substituted strings of glass beads and shells. These they wear also in great abundance around their necks and arms. Some of them have skin caps on their heads, differently shaped and adorned according to the fancy of the wearer; and they have sheep skin cloaks resembling those of the men. When these cloaks are laid aside, which is commonly the case in the warmer weather, both sexes may be said to be nearly naked; but their bodies are in some measure protected from the influence of the sun or air by the unctuous matter which they rub over the whole of their persons; and which, however filthy in itself, is a very natural and useful resource in hot climates, to prevent the skin from being parched and shrivelled by the scorching heat. It is supposed that a similar practice in parallel latitudes would prevent that disgusting and dreadful disorder, the elephantiasis, which is so common in many hot countries, but which, with most other cutaneous diseases, is wholly unknown among the Hottentots.* This greasy covering applied from time to time, and accumulating perhaps for a whole year, sometimes softening in the sun, or melting before a fire, catches up the dust and dirt, and gradually covers the surface of the body with a thick black coating, which entirely conceals the natural colour of the skin. This native hue is perceivable only on the face and hands, which are kept rather cleaner than the other parts of the body, not by washing them in water, which would have no effect upon the grease, but by rubbing them with the dung of cattle.

Food.

The Hottentots are often reduced, especially in their native state, to live upon gums, roots, and the larvæ of insects, and at times make a kind of bread from the pith of the palm tree; but their universal delight is to indulge in animal food. They are remarkably patient of hunger, and are able to fast a very long time; but are equally voracious when supplied with their favourite diet, and are described as the greatest gluttons on the face of the earth. Their manner of eating sufficiently indicates the voracity of their appetite. They cut a large steak from the carcase upon which they feed, and, passing the knife in a spiral manner from one edge till they reach the middle, form it into a string of flesh two or three yards in length. This they coil round and lay upon the hot ashes; and, when the meat is just warmed through, they grasp it in both hands, and, applying one end of the string to their mouth, proceed without intermission, and with considerable expedition, to the other extremity. They do not think of cleaning the meat from the ashes of the green wood, which serve as a substitute for salt; and they wipe their hands, when done with eating, merely by rubbing them on different parts of their body. They are passionately fond of ardent spirits and tobacco; and, to make as much as possible of the flavour of the latter luxury, they purposely employ a very short pipe.

Huts.

The Hottentot families, who engage in the service of the colonists, live in small straw huts around the farm house. In a more independent state, they horde together in kraals or villages, where the houses are commonly ranged in a circle with the doors opening towards the centre, and thus forming a kind of court, into which their cattle are collected at night, to preserve them from the beasts of prey. The huts are generally circular in their form, resembling a bee-hive, covering a space about twenty feet in diameter, but commonly so low in the roof, that, even in the centre, it is rarely possible for a man of middle size to stand upright. The fire place is situated in the middle of the apartment, around which the family sit or sleep in a circle; and the door, which is seldom higher than three feet, is the only aperture for admitting the light, or letting out the smoke. The frame of these arched habitations is composed of slender rods, capable of being bent in the desired form, some parallel with each other, some crossing the rest, and others bound round the whole in a circular direction. Over this lattice work, are spread large mats, made of reeds or rushes, which are about six or ten feet long, and sewed together with a kind of thread or rather catgut, made from the dorsal sinews of different animals. These materials are easily taken down, and removed on the backs of the oxen, when there is occasion to change the place of residence.

Weapons.

These free Hottentots depend for subsistence upon the milk and flesh of their cattle, and the produce of their skill in the chace. They are excellent marksmen with the musket, but still make use occasionally of their ancient weapons, the Hassagai or javelin, and bow with poisoned arrows. The Hassagai is an iron spear about a foot in length, fastened to the end of a tapering shaft about four feet long, which is thrown from the hand by grasping it in the middle, raising it above the head, and delivering it with the fore-finger and thumb. The bow is a plain piece of wood seldom much more than a yard long, and sometimes tapering to a point at each extremity. It is furnished with a string composed of hemp, or the fibres of animal-tendons

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* A similar practice prevails among the inhabitants of Tombuctoo, as observed by the American sailor Adams. "It is the universal practice of both sexes," says his Narrative, "to grease themselves all over with butter produced from goats milk, which makes the skin smooth, and gives it a shining appearance. This is usually renewed every day; and, when neglected, the skin becomes rough, greyish, and extremely ugly."

twisted into a cord. The arrows are short, and consist of a reed about a foot in length, with a piece of solid polished bone at one end about five inches long, the top of which is sometimes pointed to serve as the head, but generally cut square, and provided with a small sharp piece of iron in the shape of an equilateral triangle. This is bound tight to the bone with threads, along with a bit of pointed quill, turning to the opposite end of the arrow by way of barb, and intended at once to increase the difficulty of extracting the weapon from the wound, and by tearing the flesh to make the poison mix more readily with the blood. The poison is frequently taken from bulbous roots, or the most venomous serpents; but is also prepared by macerating the leaves or branches of poisonous plants, and thickening the juices, by boiling on the fire or evaporation under the heat of the sun. This preparation, in the consistence of varnish, is laid with a brush over the thread which binds on the tip of the arrow. Whenever an animal is killed with these arrows in hunting, the flesh around the wound is instantly cut away, and the blood squeezed out of the flesh. The quiver is made of a piece of wood hollowed out, frequently of the stem of an aloe, with a lid of skin or leather; and generally contains a dozen arrows, a brush for laying on the poison, and a sand stone to whet the points of the weapons.

Arts of life.

The Hottentots may be said to be entirely ignorant of arts and manufactures, except the formation of coarse earthen ware, the sewing of sheep skins for their winter garments, the preparation of poisons, and the making of bows and arrows.

They discover very little taste for music; but a few instruments of sound have been observed among them. One is a kind of guitar with three strings stretched upon a piece of hollow wood, which has a long handle, and is called in their language *gabowie*. Another consists of a piece of sinew or intestine, twisted into a small cord and fastened upon a hollow stick about three feet long, by a piece of quill at one end fixed into the stick, and by a small peg at the other, which is made to turn for the purpose of stretching the string to the degree required. This instrument is called the *gowra*, and is played by applying the mouth to the quill, and producing faint murmuring notes, by giving a vibratory motion to the string. A sort of flute made of the bark of trees is also used among them.

Intellectual acquirements.

The physical knowledge of the Hottentots is extremely limited. All their astronomy consists in having a name for the sun, another for the moon, and a third for the stars. Their reckoning of time scarcely extends beyond the period of a day, and expresses events past only by saying, that they were before or after some memorable occurrence. They indicate the time of the day when any thing happened, by pointing to the place in the heavens where the sun then was; and the seasons of the year by the number of moons before or after the time when the roots of the *iris edulis* (once a considerable article of their sustenance) are ready for use. None of those whom Mr Barrow saw in the more distant parts of the colony could reckon beyond the number five, or put two numbers together without the help of their fingers.

Language.

The language of the Hottentots is perhaps one of the most extraordinary forms of speech in use among human beings. Its principal peculiarity is a strong clacking of the tongue, in uttering every monosyllable, and every leading syllable of larger words. This sound is formed by suddenly retracting the tongue from the teeth or palate, according to the signification of the word to be uttered, and in some measure answering the part of inflexions, &c. The sound of the dental clack is said to be exactly the same as that, which is sometimes used to express impatience; and that of the palatial stroke is more full and sonorous, not unlike the clucking of a hen to her chickens. These sounds are thrown out at the same moment with the syllable, so that they cannot be said to precede or follow, but rather to accompany it. Though the difficulty of uttering and appropriating these sounds appear to Europeans extreme, yet it is not insurmountable; and most of the Dutch colonists are able to speak the Hottentot language with great fluency. Many vocables in the language seem to have been originally exact imitations of nature, and many of the names of animals, especially, are obviously suggested by their distinguishing cry; such as, *kraak*, a frog; *mnoo*, an ox; *meau*, a cat; *hahœ*, a horse; *hurroo*, the sea; *kaboo*, a gun. This last word particularly is so pronounced as to imitate the report of a musket. The syllable *ka* is thrown out with a strong palatial stroke of the tongue expressing the stroke of the flint; while the last syllable *boo* is uttered with a full mouth, outstretched lips, and prolonged sound, descriptive of the report. We add a few of the common vocables; and a Hottentot version of the Lord's prayer, as a slight specimen of the language.

Surrie,	the sun.	*Hoonooci,*	Lightning.
Kā,	the moon.	*Qũa*	Wind.
Kōro,	the stars.	*Tōōkai,*	Rain.
Kōo,	the earth.	*Quaina,*	a man.
Kom,	air, or light.	*Queisha,*	a woman.
Ei,	Fire.	*Toona,*	a dog.
Ham,	Water.	*Hasai,*	To-day.
Hō ōroo,	Thunder,	*Quãtrie,*	To-morrow.

NUMERALS,

Qũæ,	One.
Kām,	Two.
Góna,	Three.
Haka,	Four.
Gose,	Five.

Cita eip - ne nanoop na - sa ons
Our father - the heaven in - thy name
anooke - sa koop ha - sa ei i -
hallowed be - thy kingdom come - thy will be done -
koop ei - ne nanoop na koommi - cita
earth on - the heaven in as - our
cecorobe bersp mata - neei - i cita
daily bread give us - this day - and our
soorootikoo oobekata - cita soorooti
debts forgive us - our indebted
aukoo citee oobeka koommi - i
men we forgive as - and
ta oowa keikata - gawe coreta
not temptation lead in us - but deliver us
eip ga - o sa ne koop ke - i de
evil from - for thine the kingdom is - and the
keip - i de isa - i amo.
power - and the glory - in eternity.

Customs.

Few ancient usages are retained among the scattered tribes of the Hottentots; and all traces even of their religion, if they ever had any knowledge or observances on the subject, are now lost. No particular ceremonies are observed either at their marriages or funerals; and they are more like a people, who have never been formed into any kind of communities, than the remains of a tribe or nation who had once possessed any laws or customs common to them all. The truest specimens of the unmixed Hottentot people and practices are probably to be found among the Bosjesmans, (see BOSJESMANS); but, whether that wretched race existed in their present condition before the dispersion of the Hottentots, or in consequence of that event, must remain a subject of mere conjecture. A few detached customs and practices of the Hottentots may be briefly stated. One of the customs still generally prevalent, is to shave the heads of young girls as soon as the first symptoms of maturity appear, to remove all their ornaments, and wash the whole body thoroughly; and to restrict them to a milk diet, and seclude them from the company of men during the continuance of the periodical symptoms. Though they inter their dead without any ceremony, it is a common practice to pile a heap of stones over the grave; and it is firmly believed among them, that some misfortune would soon befal the individual who should pass the place without adding a stone to the heap. This custom is supposed to have originated in a wish to secure the bodies of the deceased from being dug up and devoured by wild beasts. The Hottentots in drinking from a pool or stream, throw the water into their mouths with their right hand in a very expert and expeditious manner, seldom bringing the hand nearer the mouth than the distance of a foot. They generally wash their poisoned wounds with a mixture of urine and gun-powder, besides frequently using the actual cautery; and, for the most part, recover easily unless wounded severely. They kill their cattle, by thrusting a sharp-pointed instrument into the spinal marrow immediately behind the horns; and the animal being thus instantaneously deprived of life, the throat is cut to let out the blood. Among the Hottentots who reside at the mouth of the Orange river, a superstitious practice prevails, similar to what has been observed among the South Sea islanders, of cutting off the first joint of their little finger, as a remedy for a particular disease to which they are subject when young.

Customs.

Character.

The most prominent point in the habits and dispositions of the Hottentots is their extreme indolence, which even the urgent calls of hunger are scarcely able to overcome. Provided they are allowed to sleep, they would willingly fast the whole day, rather than undergo the trouble of digging the ground for roots, or procuring food by the chace; and Mr Barrow particularly relates, that in the course of his journies, the Hottentot servants frequently passed the day without a morsel of food, rather than walk half a mile for a sheep. They are habituated from their infancy to a life of sloth; and, having obtained what is barely sufficient to support nature, contentedly spend the day as well as night in sleeping under a bush upon their sheep-skin. Even in the service of the Dutch colonists, they are rather confirmed in their laziness, than cured of it; as, in every farm-house there is so great a multitude of servants, that little work falls to the share of each individual. It is not uncommon to see twenty or thirty, where there is not employment for more than four or five; so that one of the domestics, during the space of a whole day, may have only to bring his master's whip from the next apartment; another to fetch his mistress's fire-box and place it under her feet; and a third to supply some of the family, three or four times in the day, with lighted wood to kindle their tobacco pipes. They are by no means, however, a stupid people. They are uncommonly expert in finding out a passage over a desert uninhabited country. They are remarkably quick-sighted, and can discover the game in the chace at a very great distance. They will follow with the eye the flight even of a bee to an incredible distance, watching its motions, and tracing out its nest. They are able to distinguish the prints of the feet of whatever animal they chance to pursue, if they be at all acquainted with it; and would single out among a thousand foot-marks those of their companions. They learn the Dutch language with great facility; and though seldom employed as domestic servants by the colonists at the Cape, they can be taught to do every kind of work with as much propriety as Europeans. They are a mild, quiet, and rather timid people; but endure pain with extraordinary patience, and, when led on by superiors, will encounter danger with sufficient alacrity. They are honest and faithful, and have little of that cunning which savages generally possess; but are ready to divulge the truth, when charged with crimes of which they have been guilty. They seldom quarrel among themselves, or make use of provoking language; but are kind and affectionate to one another, and ready to share the last morsel with their companions. Though extremely phlegmatic, they are not incapable of strong attachments, and are particularly sensible to any act of kindness. These are sensations, however, which they have, unhappily, few opportunities of indulging. In the state of hard bondage and cruel oppression, under which they spend their miserable existence, the muscles of their countenance are rarely seen to relax into a smile, but are constantly overspread with the deepest melancholy. It has been sufficiently proved, that under humane treatment they are capable of being rendered active, industrious, and useful members of society. About 500 of them had been embodied by the Dutch in a corps called the Cape Regiment; and, though unsupported, had acted with considerable spirit in opposing the British troops at the capture of the colony in 1795. General Sir James Craig found it expedient to take them into the British service, and to increase their numbers. They became excellent soldiers, orderly, tractable, and faithful, ready on all occasions to obey the commands of their officers with cheerfulness and alacrity. "Never," says the above-mentioned officer, "were people more contented, or more grateful for the treatment they now receive. It is with the opportunity of knowing them well, that I venture to pronounce them an intelligent race of men. All who bear arms exercise well, and understand immediately and perfectly whatever they are taught to perform. Many of them speak English tolerably well. We were told, that so great was their propensity to drunkenness, we should never be able to reduce them to order or discipline; and that the habit of roving was so rooted in their disposition, we must expect the whole corps would desert the moment they had received their clothing. With respect to the first, I do not find they are more given to the vice of drinking than our own people; and, as to their pretended propensity to roving, that charge is fully confuted by the circumstance of only one man having left us since I first adopted the measure of assembling them, and he was urged to this step from having accidentally lost his firelock."—"Of all the qualities, it will little be expected I should expatiate upon their cleanliness; and yet it is certain, that at this moment our Hottentot parade would not suffer in a comparison with that of some of our regular regiments. Their clothing may perhaps have suffered more than it

Hottentot regiment.

ought to have done in the time since it was issued to them, from their ignorance of the means of preserving it; but those articles which are capable of being kept clean by washing, together with their arms and accoutrements, which they have been taught to keep bright, are always in good order. They are now likewise cleanly in their persons; the practice of smearing themselves with grease being entirely left off. I have frequently observed them washing themselves in a rivulet, where they could have in view no other object but cleanliness." These men shewed themselves highly deserving of this favourable testimony, during three years service in the distant district of Graaf Reynet, where they were required, by an unfortunate train of events, to act against their own countrymen and comrades; yet, during all that time, according to the testimony of Mr Barrow, they never shrunk from their duty, and only one man deserted in the whole corps. They became so attached to the British government, that, after the evacuation of the colony, they refused to enter again into the service of the Dutch; and most of them, upon being disbanded, fled into the interior to join their oppressed countrymen.

Missionary settlements.

The labours of Christian missionaries, particularly of the Moravian Brethren, have not been less successful in forming the Hottentot race to live under the influence of religious principle, and to fulfil the duties of civilized society. The progress of their disciples at Bavian's Kloof, so far back as the year 1798, is thus described by Mr Barrow:—"Early in the morning I was awakened by the noise of some of the finest voices I had ever heard; and, on looking out, saw a group of female Hottentots sitting on the ground. It was Sunday; and they had assembled thus early to chaunt the morning hymn. They were all neatly dressed in printed cotton gowns. A sight so very different from what we had hitherto been in the habit of observing, with regard to this unhappy class of beings, could not fail of being grateful; and at the same time, it excited a degree of curiosity as to the nature of the establishment."—"These missionaries have succeeded in bringing together into one society more than six hundred Hottentots, and their numbers are daily increasing. These live in small huts dispersed over the valley, to each of which was assigned a patch of ground for raising vegetables. Those, who had first joined the society, had the choicest situations at the upper end of the valley near the church; and their houses and gardens were very neat and comfortable; numbers of the poor in England not so good, and few better. Those Hottentots, who chose to learn their respective trades, were paid for their labour as soon as they could earn wages. Some hired themselves out by the week, month, or year, to the neighbouring peasantry; others made mats and brooms for sale. Some bred poultry; and others found means to subsist by their cattle, sheep, and horses."—"On Sundays, they all regularly attend the performance of divine service; and it is astonishing how ambitious they are to appear at church neat and clean. Of the three hundred, or thereabouts, that composed the congregation, about half were dressed in coarse printed cottons, and the other half in the ancient sheep skin dresses; and it appeared on inquiry, that the former were the first who had been brought within the pale of the church; a proof that their circumstances at least had suffered nothing from their change of life."—"The deportment of the Hottentot congregation during divine service was truly devout. The discourse, delivered by one of the fathers, was short, but replete with good sense, pathetic, and well suited to the occasion: tears flowed abundantly from the eyes of those, to whom it was particularly addressed. The females sung in a style that was plaintive and affecting; and their voices were in general sweet and harmonious." This establishment is described by Lichtenstein, little more than six years afterwards, as containing two hundred houses and huts, built in regular streets, and occupied by nearly 1100 Hottentots; several of whom had become very expert in various kinds of iron work, particularly in the manufacture of knives. "The men are clothed in linen jackets and leather small clothes, and wear hats; and the women have woollen petticoats, cotton jackets with long sleeves, and caps. Other missionaries have collected the wilder Hottentots in the more distant parts of the colony; and have succeeded in instructing and civilizing them in various degrees, proportioned to the duration and circumstances of the different establishments. Even the Bosjesman Hottentots have been found in places beyond the limits of the colony to be a docile and tractable people, inoffensive in their manners, and extremely grateful to their benefactors. The recovery of the colony by the British has at least secured to these defenceless tribes a protection from cruel oppression, and an encouragement to every benevolent exertion for their benefit, which they never enjoyed under the Dutch government. See Sparrman's *Voyage to the Cape of Good Hope.* Paterson's *Journies into the Country of the Hottentots.* Barrow's *Travels into the Interior of Southern Africa.* Campbell's *Travels in Africa.* Lichtenstein's *Travels in Southern Africa.* (*q*)

HOUNDS. See Dog, Hunting, and Mammalia.

HOU-GANG, or Hoo-Quang. See China, vol. vi. p. 214.

HOURS. See Chronology, vol. vi. p. 402.

HOUSSA, or Haoussa, the capital of a kingdom of the same name in Africa, is supposed to be situated two days journey south from the Niger, and about 200 miles south east from Tombuctoo. As it appears to have been unknown to the African geographer Leo, it is suspected to be of modern date; and, as Park could hear nothing of Tokrur or Tekrur, mentioned by Edrissi and Abulfeda as the metropolis of a great central empire of Africa, it is conjectured that Houssa must have superseded that ancient capital as the seat of government. Former accounts represented it as almost equal to London or Cairo in population, and its inhabitants as acquainted with the art of writing, and other civilized attainments. The country along the banks of the Niger, between Houssa and Tombuctoo, was also described as fertile, and well inhabited. All the native travellers, with whom Park conversed, assured him that Houssa was larger and more populous than Tombuctoo; and that the state of trade, police, and government, were nearly the same in both places. The recent Narrative of Adams the American sailor enables us to estimate the amount of this comparison, and to form some idea of Houssa, when he tells us, that Tombuctoo, to which it bears so near a resemblance, covers about as much ground as Lisbon with houses irregularly scattered; that it contains no shops for its boasted commerce, but that the imported goods are deposited in the king's palace, till they are disposed of; that this royal residence and warehouse is constructed of mud, and altogether mean in its appearance; and that the principal food of the king and queen consists, like that of the people, of Guinea corn, boiled like burgoo, and eaten with goat's milk, to which, in the case of their majesties, is added the luxury of a little butter. See Park's *Travels* and *Appendix*; Adams' *Narrative*; and TOMBUCTOO. (*q*)

HOWARD, JOHN, the celebrated philanthropist, was born at Enfield, about the year 1727. His father was originally an upholsterer in Long-lane, Smithfield; but, having acquired a handsome fortune, had retired from business several years before his death. He was a strict Protestant dissenter; and, wishing that his son should be educated in the same principles, placed him under a preceptor at some distance from London, who seems to have been more distinguished by his religious character than literary qualifications. Under the tuition of this person, young Howard continued for the space of seven years, without being thoroughly instructed in any one branch of knowledge; and, though he was afterwards removed to the academy of Mr Eames, he never surmounted the deficiencies of his early education. He was not able to write his native language with grammatical correctness; and, excepting the French, his acquaintance with other languages was very superficial. His father died when he was young, and directed, in his will, that his son should not come to the possession of his property till the twenty-fifth year of his age. In conformity, also, it is supposed, to the wishes of his parent, he was bound apprentice to a wholesale grocer in the city; but he found this employment extremely irksome; and, as soon as he came of age, bought up the remainder of his time, and set out on his travels to France and Italy. Upon his return to England, he lived in the style of other young men of fortune; but had acquired a taste for the arts, and an attachment to the study of nature. The delicacy of his bodily health required him to take lodgings in the country, and to follow a rigorous regimen of diet, which laid the foundation of his future extraordinary abstemiousness. About the 25th year of his age, he married Mrs Sarah Lardeau, as a return of gratitude for her kind attention during his invalid state while he lodged in her house at Stoke-Newington; but she was twice as old as himself, as well as of a sickly habit, and died at the end of three years after their marriage, in the year 1756. After the death of his wife, he set out upon another tour, which he designed to have commenced with a visit to Lisbon, which had been recently overthrown by an earthquake; but the packet, in which he sailed, was taken by a French privateer, and he endured for some time all the hardships of a prisoner of war in France. The sufferings of his countrymen in the same situation made a strong impression on his mind, and first directed his attention to the condition of those unhappy persons who are doomed to inhabit the cells of a prison. Having remained abroad only a few months, he fixed his residence, after his return, on his estate at Cardington, near Bedford; and, in 1758, was united in marriage to the eldest daughter of Edward Leeds, Esq. of Croxton in Cambridgeshire. In this connexion and situation he spent the most tranquil and happy years of his life, occupying his leisure and his wealth in executing plans of beneficence for the more indigent part of mankind. But his domestic felicity was fatally interrupted by the death of his wife in the year 1765, soon after the birth of her only child; and, for many years afterwards, he cherished her memory with the most affectionate sorrow. For some time he was attached to his home, by an anxious attention to the education of his son; but the child was sent to school at an early age, and Mr Howard began to assume a more public character. In 1773 he was nominated High-Sheriff of the county of Bedford; and entered upon his office with a resolution to perform its duties with his accustomed punctuality. In the inspection of the prisons within his jurisdiction, his humanity became deeply engaged by the distresses which he witnessed; and, in the progress of his enquiries, he was led to extend his investigation to all the places of confinement and houses of correction throughout the kingdom. He pursued his object with so much assiduity, that, in the beginning of 1774, he was desired to communicate his information to the House of Commons; and, in consequence of his representations, two bills were brought forward for the relief and health of prisoners. Being desirous, before he should publish his account of English prisons, to suggest remedies, as well as to point out defects, he resolved to examine personally the practice of the continental kingdoms in this branch of police. For this purpose, in 1775, he visited France, Flanders, Holland, and Germany; repeated his visit in 1776, extending his tour to Switzerland; and, during the intervals of these travels, made a journey to Scotland and Ireland, and most of the counties of England. In 1777, he published the information which he had collected with so much risk, toil, and expence, and dedicated his work to the House of Commons. Anxious to diffuse the knowledge of facts so interesting to humanity; and, at the same time, desirous to obviate any suspicion of his wishing to repay his benevolent labours by the profits of book-making, he not only presented copies of his work to the principal persons in the kingdom, and his particular friends, but insisted upon fixing the price of the volume at a lower rate than the original expence of publication. In the conclusion of the work, he pledged himself, if a thorough parliamentary enquiry were instituted for the improvement of prisons, to undertake a more extensive journey into foreign countries, for the purpose of obtaining additional information. The House of Commons having zealously entered upon the business of regulating places of confinement, Mr Howard, agreeably to his promise, which he was well inclined to fulfil, began a new tour in 1778. In his progress, he revisited the establishments of a penitentiary kind in Holland; directed his course through Hanover and Berlin to Vienna; went to Italy by way of Venice; proceeded as far south as Naples, returning by the western coast to Switzerland; pursued the course of the Rhine through Germany; and, crossing the Low Countries, returned to England in the beginning of the year 1779. During the spring and summer of the same year, he made another complete tour of England and Wales, besides taking a journey through Scotland and Ireland. In the year 1780, he published the results of this extensive research, as an appendix to his former work; and also a new edition of that publication, in which all this additional matter was incorporated. Still intent upon the farther improvement of his plans, he resolved to explore those countries of Europe which he had not yet visited; and, in 1781, he set out on a tour to Denmark, Sweden, Russia and Poland, from which he returned about the end of the year. In the year following, he made another complete survey of the prisons in England, and another journey into Scotland and Ireland. In 1783, he examined the prisons of Spain and Portugal, and returned through France, Flanders, and Holland. In the summer of the same year, he again travelled into Scotland and Ireland, and visited many of the English prisons. In 1784, he communicated to the public the fruits of the preceding three years investigations, in the form of another appendix, with a new edition of the main work, comprising all the additions. With the view of acquiring information respecting the means of preventing contagion in general, and the formation of establishments for guarding against pestilential infection, he resolved to visit the principal Lazarettos in Europe, and to extend his researches to those countries which are most subject to the ravages of the plague. Aware of the hazards which he should have to encounter in this most perilous of all his journeys, he would not permit any of his servants to partake of these dangers, but determined to travel without attendants. About the end of the year 1785, he entered upon this tour, taking his way through Holland and Flanders to the south of France. His former visits, however, had so much alarmed the jealousy and excited the displeasure of the government in the last mentioned country, that he was apprehensive of his personal safety; and travelled with the greatest secrecy under the character of an English physician. From Nice, he went to Genoa, Leghorn, and Naples; thence to the islands of Malta and Zante; and next to Smyrna and Constantinople. Determined to obtain, by personal experience, the fullest information of the mode of performing quarantine, he returned to Smyrna, where the plague then was, for the purpose of going to Venice in a vessel with a foul bill of health, which would necessarily subject him to the utmost rigour of the process. In the course of his voyage, the ship in which he was a passenger, was attacked by a corsair from Tunis, which was beaten off after a smart skirmish, in which he rendered essential service, by pointing some of the guns. After leaving his quarters in the Lazaretto of Venice, in which his health and spirits suffered considerably, he proceeded, at the close of the year 1786, to Vienna, where he had a private conference with the Emperor Joseph II.; and, returning through Germany and Holland, arrived safe in England, in the beginning of the year 1787. During his absence on this journey, he received the afflicting intelligence of his son having fallen into a state of decided insanity; his only child of whom he used to speak with all the pride and affection of a parent, and whose hopeless calamity it required all the fortitude of his mind, aided by the consolations of religion, to sustain. At the same time, he was informed of a public subscription having taken place among his countrymen, to express their esteem and veneration for his character, by erecting a statue or monument to his honour. This design, instead of tending to console his wounded spirit, only added to his distress; and he instantly exerted himself to prevent its being carried into execution. In corresponding with his friends, he expressed, in the strongest terms, his aversion to the proposed honour; and, in a letter to the subscribers, while he acknowleged his grateful sense of their approbation, he displayed so determined a repugnance to the measure, that the matter was dropped during his life. In 1787 and 1788, he made several visits to the prisons, bridewells, infirmaries, &c. of England, Ireland, and Scotland, and, in 1789, he put to the press an account of his observations in these various journeys, abroad and at home; containing an account of the various Lazarettos in Europe, papers relative to the plague, with additional remarks on prisons and hospitals. After the printing of this work, he remained but a short time at home; and prepared to revisit Russia and Turkey, and to extend his tour to Asia Minor, Egypt, and the coast of Barbary. In this new journey, he is understood to have had no peculiar object in view; and to have been actuated chiefly by a conviction, that, in such researches, he was pursuing the path of his duty; that, in those countries where he had formerly travelled, he might be still farther instrumental in relieving human suffering; and that, in exploring new regions, he might discover farther subjects of observation connected with his main pursuit. He had resolved to undertake this journey also without an attendant; and it was only in consequence of most urgent intreaties, that a faithful servant obtained permission to accompany him. Arriving in Holland, in the beginning of July 1789, he proceeded through the north of Germany, Prussia, Courland, and Livonia, to Petersburg; thence to Moscow, and finally to the extremity of European Russia, on the shores of the Black Sea, where he fell a lamented victim to one of those infectious diseases, the ravages of which he was exerting every effort to restrain. While residing at Cherson, he was earnestly requested to visit a young lady, about sixteen miles from that place, who had caught a contagious fever; and it was his own opinion, that from her he received the disease. During his illness, which from its commencement he considered as likely to prove fatal, he received a letter from a friend in England, containing favourable accounts of his son. He was greatly affected by the intelligence; and often desired his servant, if ever his son should be restored to reason, to tell him how much he had prayed for his happiness. Except during the fits, with which he was occasionally seized in the course of the distemper, he retained his faculties till within a few hours of his death, which took place on the 20th of January 1790. He was buried, according to his own request, at the villa of M. Dauphiné, about eight miles from Cherson; where, instead of a sun-dial, which he had desired to be erected over his grave without any inscription,* a rude pyramid, surrounded by posts and chains, was raised by the inhabitants of the neighbourhood.

Mr Howard, though frequently requested, would never consent to sit for his picture; and the various portraits, which have been given of him, are said by his intimate friends to be totally unlike. The nearest resemblance, is said to be a head sketched by an artist in London, and copied for Dr Aikin's *View of his Character*; which, though considered as somewhat of a caricature, is said to have exactly the expression of his countenance, when in a very serious and attentive mood. His eye was lively and penetrating, and his features strong and prominent; his gait quick, and his gestures animated. In his youth, his constitution was delicate, and his habit supposed to be consumptive; but he afterwards attained (probably in consequence of his abstemiousness in diet and application to exercise) a power of enduring, without inconvenience, the greatest corporeal privations and fatigues. The strict regimen in point of food, which he had originally adopted from a regard to health, he afterwards continued from choice. He made no use of animal food,

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* He had a strong dislike of monumental honours, and had once given directions before he set out on a journey, that in case of his death his funeral expences should not exceed ten pounds; that his tomb should be a plain slip of marble placed under that of his wife in Cardington church, with this inscription, "John Howard died ———, aged ———. My hope is in Christ."

or of fermented and spirituous drinks. Water and the plainest vegetables sufficed for his ordinary diet, and milk, tea, butter and fruit, were his luxuries. He was sparing in the quantity of his food, and indifferent as to the stated times of taking his meals. He was equally tolerant of heat, cold, and all the vicissitudes of climate; and could without difficulty dispense with the ordinary seasons and proportions of sleep. When he travelled in England or Ireland, it was generally on horseback, and he rode regularly about forty English miles a day. He was never at a loss for an inn; but, in Ireland or the Highlands of Scotland, could accommodate himself with a little milk at any of the poor cabins in his way. When he came to the town, where he was to sleep, he bespoke a supper like other travellers, but made his servant remove it, while he was preparing his bread and milk. When he travelled on the continent, he usually went post in his own chaise, in which he slept as occasion required; and has been known to travel twenty days and twenty nights without going to bed. He used to carry with him a small tea-kettle, some cups, a little pot of sweet-meats, and a few loaves. At the post-house he would get some water boiled, send out for milk, and make his repast, while his servant went to the inn. He was remarkably attentive to the perfect cleanliness of his whole person; and water was always an indispensable necessary for his ablutions. His peculiar habits of life, and his exclusive attention to a few important objects, made him appear more averse to society than he really was. He assiduously shunned all engagements, which would have involved him in the irregularities of general intercourse; but he received his select friends with the truest hospitality, and was often extremely communicative in conversation, enlivening a small circle with the most entertaining relations of his travels and adventures. He was never negligent of the received forms of polite life; and, however much he might be charged with singularities, no one could refuse his title to the character of a gentleman. He was distinguished especially by his respectful attention to the female sex; and nothing afforded him so much pleasure as the conversation of women of good education and cultivated manners. His own voice and demeanour were so gentle as to be almost denominated feminine; and furnished a striking contrast to the energy of his mind and the extent of his exertions. His language and manners were invariably pure and delicate; and it must have been no small triumph of duty over inclination which brought him to submit, in the prosecution of his benevolent designs, to such frequent communications with the most abandoned of mankind. Yet the nature of his errand appears to have inspired the most profligate with respect; and he has himself recorded, that he never met with a single insult from the prisoners, in any of the jails which he visited. He possessed an elegant taste for neatness in his house and furniture; and employed much of his leisure time in the cultivation of useful and ornamental plants. In the course of his various travels, he brought home many curious vegetables; and his garden became an object of curiosity, both for the elegant manner in which it was planned, and for the excellent productions which it contained. He was elected a Fellow of the Royal Society in 1756; and contributed a few short papers which have been published in its Transactions.* His philosophical researches were chiefly directed to meteorological observations, and he seldom travelled without some instrument for that purpose. He applied himself, likewise, with considerable assiduity, to the prosecution of experiments on the effects of the union of the primary colours in different proportions. In his intellectual character, he discovered less of the faculty of extensive comprehension than of laborious accuracy. By his talent of minute examination and detail, he was peculiarly qualified for the patient investigations in which he engaged; and in his modest estimates of his own abilities, he was used to say of himself, "I am the plodder, who goes about to collect materials for men of genius to make use of." His liberality with respect to pecuniary concerns, was early and uniformly displayed; and he appears never to have considered money in any other light than as an instrument of procuring happiness to himself and others. Contented with the competence, which he inherited, he never thought of increasing it; and made it a rule with himself to lay up no part of his annual income, but to expend in some useful or benevolent scheme the surplus of every year. Moderate in all his desires, and untainted by the lust of growing rich, he was elevated above every thing mean and sordid. He expended much in charities, and displayed in all his transactions a spirit of the utmost honour and generosity. He imbibed from his earliest years a devout principle of religion, which continued steady and uniform through every period of his life. The body of Christians, to whom he particularly attached himself, were the Baptists; and the system of belief, to which he adhered, was what has generally been called moderate Calvinism. But he was always less solicitous about modes and opinions, than the internal spirit of piety and sincerity; and though always warmly attached to whatever interests he espoused, he possessed that true spirit of catholicism, which led him to honour virtue and religion wherever he found them. It was his constant practice to join in the service of the established church, when he had not the opportunity of attending a dissenting place of worship; and he often dwells in his works, with great complacency, on the pure zeal and genuine Christian charity, which he frequently discovered among the Roman Catholic clergy. But the peculiar feature of his character certainly consists in that decisive energy, and unshaken perseverance, with which he prosecuted the great work of benevolence, to which he seemed to have devoted his life. He was distinguished by decision and dispatch in all his proceedings; and this was rather the predominant habit of his mind, than the occasional result of any excited feeling. "At no time of his life," says his friend and biographer Dr Aikin, "was he without some object of warm pursuit; and, in every thing he pursued, he was indefatigable in aiming at perfection. Give him a hint of any thing he had left short, or any new acquisition to be made; and, while you might suppose he was deliberating about it, you were surprised with finding it *was done*." Nor was it during a short period of ardour, that his exertions were thus awakened. He had the still rarer quality of being able, for any length of time, to bend all the powers and faculties of his mind to one point, unseduced by every allurement, which curiosity or any other affection might throw in his way, and unsusceptible of that satiety and disgust, which are so apt to steal upon a protracted pursuit."—"Impressed with the idea of the importance of his

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* See the *Phil. Trans.* vols. liv. lvii. lxi.

designs, and the uncertainty of human life, he was impatient to get as much done as possible within the allotted limits. And in this disposition consisted that enthusiasm, by which the public supposed him actuated; for, otherwise, his cool and steady temper gave no idea of the character usually distinguished by that appellation. He followed his plans, indeed, with wonderful vigour and constancy, but by no means with that heat and eagerness, that inflamed and exalted imagination, which denote the enthusiast." Neither was he moved, as some supposed, by mere sternness of principle, or rigidity of habit, or insensibility of feeling. "I have equally," says the last quoted author, "seen the tear of sensibility start into his eyes on recalling some of the distressful scenes, to which he had been witness, and the spirit of indignation flash from them, on relating instances of baseness and oppression. Still however his constancy of mind, and self-collection never deserted him: He was never agitated, never off his guard." His coolness and intrepidity proceeded both from nature and principle; and, when marching in the path of duty, he was fearless of consequences. This resolute temper neither originated in any idea of his being moved by an irresistible impulse, or a persuasion of his being secured from the natural consequences of the dangers which he encountered; but from a steady sense of religious obligation and pious confidence, which rendered him superior to mere worldly considerations. His own testimony sufficiently expresses the sentiments by which he was actuated. "My medical acquaintance," he says in a letter during his last journey, "give me but little hope of escaping the plague in Turkey. I do not look back, but would readily endure any hardships, and encounter any dangers, to be an honour to my Christian profession." So heroic a philanthropist, (though not devoid of some singularities and foibles, which have sometimes drawn the sneer of contempt from trivial and selfish minds, unworthy and incapable to pronounce upon a character so far above their sphere of judgment,) could not fail to attract the admiration of every friend of humanity. The sublimest strains of poetry and eloquence have been frequently devoted to the celebration of his exertions; and his name is become indissolubly associated with every idea of pure and elevated benevolence. The following tribute to his fame, which burst, in all the enthusiasm of genius, from the lips of Mr Burke, though probably familiar to the reader, can bear to be reperused, and may suitably close our feeble sketch of this extraordinary character.* "I cannot name this gentleman without remarking, that his labours and writings have done much to open the eyes and hearts of mankind. He has visited all Europe,—not to survey the sumptuousness of palaces, or the stateliness of temples; not to make accurate measurements of the remains of ancient grandeur, nor to form a scale of the curiosity of modern art; nor to collect medals, or collate manuscripts;—but to dive into the depths of dungeons; to plunge into the infection of hospitals; to survey the mansions of sorrow and pain; to take the gauge and dimensions of misery, depression, and contempt; to remember the forgotten, to attend to the neglected, to visit the forsaken, to compare and collate the distresses of all men in all countries. His plan is original: it is as full of genius as it is of humanity. It was a voyage of discovery; a circumnavigation of charity." See *various lives and anecdotes of Howard;* and particularly Dr Aikin's *View of his Life and Character.* (*q*)

HOWDEN, or HOVEDEN, a town of England, in the east riding of Yorkshire, is situated upon an inlet of the Ouse, named Howden Dike, which may be considered as the harbour of the town. Howden consists principally of two considerable streets, extending in the direction of north-east and south-west, intersected by three or four lesser ones. The town has of late years undergone very considerable improvements; and, though the houses are ancient, yet they are neatly built and commodious. The principal public buildings are the moot-hall, a large edifice in the market, where the courts, &c. are held; a work-house, built by subscription in 1791, which contains from 20 to 30 paupers, who are maintained at an annual expence of £300; and the old Gothic church. This church is a large building in the form of a cross, and, excepting the chancel, which is of more recent date, it appears to have been built during the first period of the pointed arch style. The tower, which is quadrangular and well proportioned, is 135 feet high, and is said to have been built in 1390 by Walter Skirlaw, Bishop of Durham, as a place of refuge from the inundations of the Ouse and the Derwent, which were formerly very frequent. The chapter-house, which is now unfortunately in ruins, is reckoned a most beautiful specimen of the pointed style. The chancel, particularly the east end of it, is greatly admired. A peal of eight bells was cast for this church in 1775. The ruins of the palace of the bishops of Durham are situated almost close to the church-yard, and are now converted into a farm-house. One of the greatest horse fairs in the kingdom, is held here on the 25th of September, and continues till the 3d of October. Besides the church and its two chapels of ease, there is an Independent and Methodist meeting-house. The celebrated historian Roger de Hoveden, who was monk of the abbey, and chaplain to Henry II. was born here.

The township of Howden contained in 1811,

Inhabited houses	314
Families	409
Do. employed in trade and manufactures	230
Total population	1812

See Savage's *History of Howden Church;* Hutchinson's *Durham;* and the *Beauties of England and Wales,* vol. xvi. p. 562.

HOWITZERS. See ORDNANCE.

HOY. See ORKNEY ISLES.

HUAHEINE. See SOCIETY ISLANDS.

HUDDERSFIELD, or HUTHERSFIELD, a town of England in the west riding of Yorkshire, is situated on the river Colne, and on the Huddersfield canal. This town is chiefly celebrated for its woollen manufactures, which consist of narrow and broad cloths, serges, kerseymeres, frize, &c. The buyers and sellers of these goods formerly met in an open square; but in the year 1765, Sir John Ramsden, who possesses all the land which the town covers, and also a great many of the houses, built a commodious cloth-hall. It is a circular building of two stories, and is divided by a diametrical range into two semicircular courts, into which all the windows open. It is subdivided into ranges like streets; and the cloths are laid close together upon their edge on benches or stalls. Over the entrance, is a bell pla-

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* See also Darwin's *Botanic Garden;* Cowper's *Poem on Charity;* Hayley's *Ode to Howard;* and Foster's *Essay on Decision of Character.*

Hudson's Bay.

ced in a handsome cupola. The Huddersfield canal (see Inland *Navigation*) extends 8 miles to the river Calder. Ruins, supposed to be the ancient city of *Canbodunum*, are to be seen on the castle hill, about two miles south of the town, and west of Almonsbury; but Mr Watson thinks they are of Saxon origin. The Roman road, however, passed near Almonsbury. There are several medicinal springs in the neighbourhood.

In 1811, the township of Huddersfield contained,

Inhabited houses	1871
Families	1881
Do. employed in trade and manufactures	1842
Males	4824
Females	4847
Total population	9671

See the *Beauties of England and Wales*, vol. xvi. p. 767.

Extent and description.

HUDSON'S Bay, lying between 55° and 65° of North Latitude, is about 250 leagues in length, and 200 at its greatest breadth. It is 140 fathoms deep in the middle, and is navigable during four months in summer, but is filled, all the rest of the year, with shoals of ice. Numerous rocks, sand-banks, and small islands, are dispersed through it, of which may be mentioned; Southampton island, in 64° north latitude, stretching about 100 leagues from north to south, but of very inconsiderable breadth; Marble island, in 62° north latitude, about 6 leagues long and two broad, composed of white marble, variegated with green, blue, and black patches; Carleton isle, in the south-east corner of the bay, covered with trees, moss, and shrubs. The entrance of the bay is a strait, of dangerous navigation, more than 200 leagues in length, and in some places of considerable breadth. It stretches from south-east to north-west, in 62½° north latitude, bounded on the north by the isle of Good Fortune, and on the south by Labradore. Its eastern extremity is formed by Cape Elizabeth on the north, and Cape Chudley on the south, between which is situated Resolution island, about 15 leagues in length, and a little westward Savage and Grass islands, almost uninhabited. In the north-west extremity, between Point Anne on the north, and cape Walsingham on the south, are several small islands named Salisbury, Nottingham, Mill Diggs, and Mansfield. The principal bays of this inland sea are, James's Bay in the south-east corner, containing many islets; Button's Bay on the western coast; Chesterfield Inlet on the north-west coast, stretching far inland, and terminating in a large fresh water lake; Roe's Welcome, a deep inlet of the sea on the north coast; and Repulse Bay still farther north. The most remarkable rivers which flow into it, are Great Whale river, East Main or Slude; Rupert's, which has its origin in lake Mistassins; Abbitibbe flowing from a lake of the same name; Moose, and Albany, which all empty their streams into James's Bay; the Severn, which is supposed to proceed from lake Winipig; Nelson or Bourbon river, from a lake of the same name; and Missin-ni-pi,* or Churchhill river, which loses itself in the bottom of Button's Bay. The north coast of Hudson Bay is yet imperfectly explored. The country on the east is part of Labradore, called East Main. The tract which stretches southwards below Button's Bay, is called New South Wales, bounded on the south and east by Canada. The regions to the north-west are in like manner called New North Wales, and very little known. And, on the west, is a vast tract of country extending across the American continent to the Pacific Ocean, separated from the territories of Canada by a mountainous ridge in 49° north latitude, which covers the sources of the rivers flowing north and south.

Hudson's Bay.

History.

Hudson's Bay was discovered in 1610 by Henry Hudson, who had been sent out by the English Russia Company in quest of a north-west passage round the American continent; but his crew having mutinied, left him with his son and other seven persons to perish in those seas, which now bear his name. It was afterwards more thoroughly explored by successive navigators employed by the same enterprizing Company, particularly by Button in 1612; by Lucas Fox, and Thomas James, in 1631, the former equipped by government, and the latter by a company of Bristol merchants; and by Zacharias Gillam, in 1668, who was sent out by Charles II. at the solicitation of Prince Rupert, and was assisted by two French merchants of Canada named de Grosseliers, who had previously made a voyage from Quebec to the scene of the present expedition. Gillam passed the winter in Rupert's river, where he built the first stone fort erected in the country, which he named Fort Charles, and provided it with a sufficient garrison. Before his return, the king had granted to Prince Rupert, and divers lords, knights, and merchants, associated with him, a charter, dated May 2d 1669, in which he styled them "The Governor and Company of Adventurers trading from England to Hudson's Bay;" and, in consideration of their having, at their own costs and charges, 'undertaken an expedition to Hudson's Bay, in the north-west parts of America, for the discovery of a new passage into the South Sea, and for the finding of some trade for furs, minerals, and other considerable commodities, and of their having already made by such their undertakings, such discoveries as did encourage them to proceed farther in pursuance of the said design; by means whereof, there might probably arise great advantages to the king and his kingdom,'—absolutely ceded to the said undertakers the whole trade and commerce of those seas, &c. in whatsoever latitude they might be, which are situated within the entrance of Hudson's Straits, together with all the countries upon the coasts and confines of the said seas, straits, &c. so that they alone should have the right of trading thither; and whosoever should infringe this right, and be found selling or buying within the said boundaries, should be arrested, and all their merchandize be confiscated, so that one half should belong to the king, and the other half to the Hudson's Bay Company." Of this extensive grant the Company have enjoyed uninterrupted possession from the year 1669 to the present day, except during the space of 17 years, from 1697 to 1714, when the settlement was occupied by the French; but the charter, instead of promoting the progress of discoveries, is understood to have produced the opposite effect. The Company have been charged with having rather endeavoured to conceal as much as possible the situation of the coasts and seas connected with their territories; and even to influence those who had any knowledge of these quarters, to withhold it from the world. The few feeble attempts which they did make, to save appearances, between 1720 and 1730, rather excited the displeasure than satisfied the expectations of the public; and, by the exertions of Mr Dobbs, Capt. Middleton was sent out by government in 1741, and Capt. Moor

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* A word signifying "Great waters."

in 1746, the former of whom discovered Repulse Bay, and the latter explored Wager's Strait and Chesterfield Inlet, so as to ascertain with sufficient certainty, that no passage existed in that direction. *

Settlements of the Company.

The Company's settlements around the whole extent of Hudson's Bay are only four, viz. Prince of Wales, or Churchhill Fort, the most northern of the factories, situated at the mouth of Churchhill river, in 59° N. Lat.; York Fort, formerly called Bourbon by the French, a square building, flanked with bastions, standing on an island between two branches of Nelson's river, in 57½° N. Lat.; Albany Fort, called by the French St Anne, or the river Albany, in 52° 18′ N. Lat.; and Moose Fort, or Monsipi, or St Louis, at the mouth of a small river on the south border of James's Bay, in 51° 28′ N. Lat. Besides these, are several smaller establishments, particularly Severn House, dependent on York Fort, in 56° 12′ N. Lat. and East-main, or Prince Rupert's, in 53° 24′, connected with Moose Fort.

Climate.

The climate around the Bay is extremely severe, especially at Churchhill Fort. From the middle of October to the middle of May, the country is buried under frost and snow. In the year 1775, one of the severest seasons remembered by the oldest residents, the snow at the latter end of May lay level with the wall of the west curtain of the fort; and the ice in the river and bay did not break up till the end of June. Even at York Fort, though two degrees farther south, Fahrenheit's thermometer has frequently stood at 50° below zero in the month of January; and brandy, or strong brine, exposed to the air for a few hours, will freeze to solid ice. In the cellars eight or ten feet deep, and below the guard rooms, where a daily and almost perpetual fire is kept up, London porter has been so frozen that only a few gallons could be got out of a whole hogshead; and the remainder, converted to ice, was found, upon being thawed, to have no strength remaining. The lakes and rivers, which are not above 10 or 12 feet deep, are frozen to the ground; and the springs are uniformly bound by the frost to the greatest depth that has been dug. The most piercing cold is felt at sun-rising; and is particularly intolerable during the prevalence of the north wind. The air is frequently filled with particles of ice, sharp and angular, and sufficiently perceptible to the eye, which, in blowing weather, occasion a most painful sensation of cold; and, if driven upon the face or hands, raise the skin in little, hard, white blisters, which, if not immediately rubbed, or warmed, are apt to break out into hot watery issues. The utmost precautions against the effects of the cold are necessarily employed by the European residents. The windows of the factories are very small, and provided with thick wooden shutters, which are closely shut 18 hours of the day in winter. As soon as the wood in their large fires is burnt down to a coal, the tops of the chimnies are stopped with an iron cover to keep the heat within the house; and, three or four times a day, red hot iron shot of 24 pounds are suspended in the windows of the apartments. Yet all this will not preserve the beer, wine, and ink from freezing; and after the fires go out, the insides of the walls and bed-places are found covered with ice two or three inches thick, which is every morning cut away with a hatchet. For a winter dress, they use three pair of socks of coarse blanketing or Duffield for the feet, with a pair of deer-skin shoes over them; two pair of thick English stockings, and a pair of cloth stockings over them; breeches lined with flannel; two or three English jackets, and a fur or leather gown; a large beaver cap, double to come over the face and shoulders, and a cloth of blanketing under the chin; yarn gloves, and a large pair of beaver mittens, hanging down from the shoulder, ready to receive the hands as high as the elbows. Yet, with all this covering, they are frequently severely frost bitten, when they stir abroad during the prevalence of the northerly winds; and many of the natives even fall victims to the severity of the climate. Watery vapours, ascending from the open sea-water, and condensed by the cold, occasion thick fogs, which are carried to a considerable distance along the coast, and which obscure the sun completely for several weeks together. But, during the intense cold of winter, the atmosphere is commonly remarkably clear and serene; and the stars shine during the night with extraordinary lustre. The aurora borealis particularly is seen almost every night during winter, darting with inconceivable velocity over the whole hemisphere, exhibiting the greatest variety of colours, and often completely eclipsing the stars and planets by its brightness. Parhelia and paraselenæ, or mock suns and moons as they are commonly called, appear very frequently during the colder months; and, at the same time, coronæ of different diameters and various colours are seen around the sun for several days together from his rising to his setting. † The frost is never out of the ground; and even in summer, when the heat is oppressive, and the thermometer frequently at 90 degrees of Fahrenheit, the earth is thawed only to the depth of three or four feet below the surface. The climate, nevertheless, is extremely salubrious throughout the whole year; and Europeans, with the exception of accidental injuries from exposure to the cold, enjoy in general an excellent state of health in the country.

Soil.

On the eastern coast of Hudson's Bay, the soil is completely barren; and about Lat. 60° vegetation entirely ceases. The surface of the country is extremely rugged, covered with enormous masses of stone; and in many places are seen the most frightful mountains of an astonishing height. Its barren vallies are watered by a chain of lakes, which are supposed to be formed merely by rain and snow, and of which the water is so cold, as to be productive only of a few small trout. A little moss, or a blighted shrub, may be seen here and there on the mountains, and a few stunted trees in the lower grounds. The soil about Churchhill Fort is extremely rocky and barren, and bare of vegetable productions. There are no woods within seven miles of the shore; and those which are found at that distance consist only of a few stunted junipers, pines, and poplars, scarcely capable of affording a sufficiency of winter's fuel to the Factory. Upon advancing northward from that settlement, the earth becomes gradually more unproductive and desolate, till at length not the least herb is to be seen, nor any trace of human step observed in the frigid waste. The produce of a few garden seeds, put into the ground about the middle of June, and shooting up with surprizing rapidity, is all that the residents are able to gather from the adjoining soil. At York Fort, the soil, which is of a very loose and

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* The recent history of the Hudson's Bay Company, particularly as connected with its disputes with the North-west Company, will be found in Lord Selkirk's pamphlet, entitled, *A Sketch of the British Fur Trade in North America, with Observations relative to the North-west Company of Montreal*. London, 1816.

† See our article GREENLAND, vol. x. p. 487; and HALO, vol. x. p. 612.

Hudson's Bay.

clayey nature, is nearly equally unfit for agriculture, even though the climate were favourable. Cresses, radishes, lettuce, and cabbage, are raised by careful culture, and, in some propitious seasons, peas and beans have been produced, but they rarely come to perfection. The face of the country is low and marshy; and the trees, though superior to those at Churchhill Fort, are still very knotty and diminutive; but, after proceeding inland towards the south, about Moose and Albany Forts, the climate is more temperate, and the trees of considerable size; potatoes, turnips, and almost every species of kitchen garden produce, are reared without difficulty; and it is supposed that corn also might be cultivated by proper attention. Upon advancing inland towards the west, the climate becomes still milder, and the soil more productive. Wild rice and Indian corn are produced in considerable quantities in the plains; various kinds of animals abound in the woods; the rivers and lakes are stored with the most delicious kinds of fish; and iron, lead, copper, and marble have been found in the mountainous parts. In the woods of the more northern tracts, the only trees are pines, junipers, small scraggy poplars, creeping birch, and dwarf willows. The ground is covered with moss of various sorts and colours, upon which the deer principally feed. Grass is not uncommon; and some kinds, especially rye-grass, are so rapid in growth, as frequently to rise, during the short summer at Churchhill Fort, to the height of three feet. Another species of grass, adapted for the support of the feathered tribes, is very abundant on the marshes and banks of lakes and rivers. Vetches, burrage, sorrel, coltsfoot, and dandelion, one of the earliest salads, are plentiful in some parts around Churchhill river. A herb called Wee-suc-a-pucka grows abundantly in most parts of the country, of which the leaves, and especially the flowers, make a very agreeable kind of tea, much used both by the Indians and Europeans, not only for its pleasant flavour, but also for its salutary effects. It is of an aromatic nature, and considered as serviceable in rheumatism, for strengthening the stomach, and promoting perspiration. It is likewise applied outwardly in powder to contusions, excoriations, and gangrenes; but in this view does not appear to possess any medicinal quality. Another herb, named by the natives jackashey-puck, resembling the creeping boxwood, is mixed with tobacco, to make it milder and pleasanter in smoking. Several small shrubs are found in the country, which bear fruit; of which the chief are, gooseberries of the small red species, which thrive best in rocky ground, and spread along the ground like the vine; currants, both red and black, are plentiful around Churchhill river, and grow best in moist swampy soils. The black berries particularly are large and excellent; but in some persons both kinds occasion severe purging, unless when mixed with cranberries, which completely correct that tendency. Hips of a small size are found on the coast, but large and abundant in the interior of the country. Upon a bush, resembling the creeping willow, grows a berry similar in size and colour to the red currant, but of very unpleasant taste and smell. Cranberries are very abundant every where; and, when gathered in dry weather, and carefully packed with moist sugar, may be preserved for years. Heath-berries are also produced in great quantities, and their juice makes a pleasant beverage. Juniper berries are frequently seen, chiefly towards the south, but are little esteemed either by the natives or the Europeans, except for infusion in brandy. Strawberries and raspberries, of considerable size and excellent flavour, are found as far north as Churchhill river, and are often most plentiful in those places where the underwood has been set on fire. The eye-berry, resembling a small strawberry, but far superior in flavour, grows in small hollows among the rocks at some distance from the woods. There are also the blue-berry, which grows on small bushes, and resembles the finest plum in flavour; the partridge-berry, growing like the cranberry, but of a disagreeable taste; and the bethagotominick, or dewater-berry, which grows abundantly in swamps on a plant like the strawberry, with a high stalk, each bearing only one berry, and is accounted an excellent antiscorbutic.

Animals.

The principal animals around Hudson's Bay are the Moose-deer, rein-deer, buffaloes, musk oxen, and beavers; polar or white bear, black bear, brown bear, wolves, foxes of various colours, lynxes or wild cats, wolverins, which are remarkably fierce and powerful animals, able to withstand the bear itself; otters, pine-martins, ermines, a smaller otter called jackash, which is very easily tamed, but, when angry or frightened, apt to emit a most disagreeable smell; the wejack and skunk, the last of which is remarkable for its insupportably fœtid smell; musk beavers, porcupines, hares, squirrels, castor-beavers, and mice of various kinds, one species of which, the hair-tailed mouse, is nearly as large as a common rat, and capable of being speedily tamed even after they are full grown. Amphibious animals frequenting the coasts of the Bay, are the walrus or sea-horse, some of which have been killed of so enormous a size as to exceed the weight of two tons; seals of various sizes and colours; and sea-unicorns in the northern parts. Of the feathered race, there are eagles and hawks of various kinds, white and grey owls, ravens, cinereous crows, which are very familiar and troublesome birds, frequenting the habitations of the natives, and pilfering every species of provision; woodpeckers, ruffed grouse, pheasants, partridges, pigeons, thrushes, gros-beaks, buntings, finches, larks, titmice, swallows, martins, cranes, bitterns, curlows, snipes, plovers, gullemels, divers, gulls, pelicans, goosanders, swans, geese of different kinds, and ducks in great variety, particularly the mallard, long-tailed, wigeon, and teal. There are several kinds of frogs, as far north as the latitude of 61°, which in winter are generally found in a completely frozen state, yet capable of reviving when thawed. Grubs, spiders, and other insects, are found in the same icy condition, from which they can be recovered by exposure to a gentle heat. Several kinds of shell fish are found on the shores of the Bay, particularly muscles, periwinkles, and small crabs. The empty shells of cockles, wilks, scallops, and other sorts, are frequently thrown upon the beach; but none of these have been seen with the fish in them. There are few fish in Hudson's Bay. White whales are found in considerable numbers at the mouths of the principal rivers; and the Company's servants, in the settlements on the west coast of the Bay, have been known to send home in some years from eight to thirteen tons of fine oil. A small fish called kepling, about the size of a smelt, and very excellent for eating, resorts in some years to the shore in great numbers, but at other times is extremely scarce. No other salt water fish is found in the country, except salmon, which are also very plentiful at some seasons, and equally rare at other times. It has been observed, in short, that every species of game, whether quadruped, fowl, or fish, is remarkably variable at different periods; and it thus becomes necessary to provide in plentiful seasons a quantity of such provisions as are most capable of being preserved. The geese are said to be particularly useful for this purpose, when properly salted; and it is nothing uncommon for 10,000 to be killed during a winter at the factories.*

Natives.

The natives who inhabit the countries around Hudson's Bay, may be distributed under these three general denominations,—the Southern Indians, the Northern Indians, and the Esquimaux.

Southern tribes.

The Southern Indians occupy the country lying between the south coast of Hudson's Bay and the territories of Canada, and that part of the western coast of the Bay which is situated to the south of Churchhill river, and extends inland to the lake of Athabasca or Athapuscow. They are the same as the Indian tribes who occupy the regions to the north of Upper CANADA; and we refer to the account of that country for a general description of the leading nations. The principal tribes who reside in the interior to the south-west of Hudson's Bay, and who used formerly to repair to the Company's forts, but now find their wants supplied at the trading houses nearer their own homes, are the Ne-heth-a-wa, and Assinne-poetuc Indians. The latter are the same as the Assinipoils or Stone Indians, originally a branch of the Naudowessies, but latterly incorporated with the Knisteneaux or Killistinoes. They are a numerous tribe, who extend over a considerable tract of country, and bring many peltries to the traders. The former, the Nehethawas, or Neheaways, are supposed to spring from the same stock as the Chipawas or Chepewyans. From being scattered over an immense extent of country, they appear to be less numerous than they are in reality. They have been longest acquainted with the fur traders, and are the most debauched and corrupted of the southern tribes. The Southern Indians, in general, who have become known to the Hudson Bay traders, are of a middle size and copper complexion; their persons generally well formed, and their features regular and agreeable. Their constitutions are strong and healthy; and they are subject to very few diseases. They are chiefly affected with dysentery and a violent pain in the chest, which is ascribed to the intensity of the cold, but which is said rarely to prove fatal. The venereal disease is also common among them, but generally mild in its symptoms. They seldom live to a great age; but are observed to enjoy all their faculties to the last. They are capable of travelling on foot with great expedition, and for many days in succession, patiently enduring the utmost degree of cold, hunger, and fatigue. They excel in hunting, which is their sole mean of subsistence; and, though long used to firearms, they are still remarkably expert in the use of their original weapons, the bow and arrow. When employed to procure provisions for the factories at the rate of the value of a beaver skin for every ten geese, they frequently bring in 50 or 60 of these fowls a day, which they shoot readily on the wing. They are extremely artful, addicted to every species of fraud and pilfering, and ready to boast of their thefts when successfully executed, so as to escape detection. At the same time, nothing can exceed their honesty and fidelity when entrusted with a charge. They are frequently employed by the Hudson Bay traders to take packages into the interior parts, and to bring down the articles which are procured in return. An Indian with his wife will embark in his canoe packs of 60 or 70 lbs. each, containing articles which would enable him to live in affluence for many years, and with which it would be easy for him to abscond, without the possibility of being traced. Yet this valuable property, so completely in their power, they will convey hundreds of miles, through unfrequented lakes and rivers, and deliver at the place appointed with the utmost punctuality, for the reward of the value of six beaver skins for each pack. They are humane and charitable to the widows and children of their departed relatives, and are naturally mild, affable, and friendly in their manners; but, in their moments of intoxication, they are invariably roused by the slightest provocation to the fiercest quarrels, and most barbarous murders. Even when the women have taken care to remove their weapons, they rarely fail, on such occasions, to mutilate one another with their teeth and nails. They are also extremely licentious in their sexual intercourse, and give themselves up without restraint to every species of incestuous debauchery, with mothers, sisters, and daughters. They have no manner of regular government or subordination; but choose a temporary leader when they go to war, or form a party for trade. By the use of spirituous liquors, which they drink to the greatest excess, and with which they are too readily supplied by the Europeans as the most alluring article of traffic, they are debased in their minds, enervated in their bodies, dejected in their spirits; and are daily becoming a more emaciated, puny, indolent, and worthless race.

Northern Indians.

The Northern Indians occupy the extensive tract of country which reaches from the 59th to the 68th degree of North Latitude, and which is upwards of 500 miles from east to west. Their territories are bounded by the Churchhill river on the south, by the country of the Athabasca Indians on the west, by Hudson's Bay on the east, and by the country of the Dog-ribbed and Copper Indians † on the north.

The Northern Indians are generally above the middle size, robust, and well proportioned; but have less of that activity of body and liveliness of disposition, which commonly distinguish the Indian tribes of the western coast of Hudson's Bay. Their features are of a peculiar cast, and different from those of any other race in those countries. Their foreheads are low, their eyes small, their cheek bones high, their noses aquiline, their cheeks fleshy, and their chins generally long and broad. Their complexion is of a copper colour, but rather inclining to a dingy brown; and their hair, like that of the other tribes, black, straight, and strong. Few of the men have any appearance of a beard till they arrive at middle age, and then it is very small in quantity, but exceedingly bristly. They endeavour to pull out the

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* A French governor at Fort Bourbon affirmed, that his garrison of 80 men consumed in one winter 90,000 grouse and ptarmigans, and 25,000 hares; which, for 200 days, allows about 5½ grouse and 1½ hares to each man per day.

† These are, in every respect, the same people as the Northern Indians, and speak a dialect of the same language. They never visit the Hudson's Bay factories; but used to supply the Northern Indians with the greater part of the furs, which these last bring to the Company's traders. They appeared, when visited by Mr Hearne, to be a hospitable and harmless tribe; and a gainful traffic might have been opened between them and the factories; but, about the end of the last century, a war broke out between the Dog-ribbed and Copper Indians, which terminated in the destruction of the latter people, except a small remnant, who found their way to the Canadian houses among the Athabasca tribes, where they are cheaply supplied with the European articles which they require, and for which the Northern Indians used to make them pay almost a thousand per cent. dearer than the Company's rates.

hairs by the root, though they seldom effect this very completely. They have no hair under their arm pits, or on any other part of the body, except in those places which nature directs them to conceal. The skins of the women are soft, smooth, and polished; and, when they are dressed in clean clothing, they are entirely free from any offensive smell. All the tribes of the Northern Indians have three or four parallel black strokes on each cheek, which are produced by introducing an awl or needle under the skin, and rubbing powdered charcoal into the wound after the instrument is drawn out. As almost the whole of their country is little better than a mass of rocks and stones, scarcely producing any other vegetable food than moss for the deer, they have few opportunities of collecting furs; and subsist chiefly by hunting and fishing. A few of the more active or restless among them, who have acquired a taste for European articles, collect the furs from the rest, or from the Dog-ribbed and Copper Indians, or from their own hunting excursions towards the inland districts, where the proper animals abound; and, after carrying these to the factories with great risks and fatigues, barter, on their return, the fruits of their traffic with their less ambitious countrymen for necessary food and clothing. But the greater part, though they may have visited the factories once in their lives, lead a happier life, and enjoy a more comfortable subsistence in their own country. Their real wants are easily supplied; and a hatchet, ice-chisel, file, and knife, are almost all that is requisite to enable them, with a little industry, to procure a plentiful supply of food and clothing. They subsist chiefly on venison, and generally spend the whole summer in hunting the deer on the open plains, or catching fish in the rivers and lakes.

Hunting.

As they have no dogs trained to the chace like the Southern Indians, and as they seldom have powder and ball in sufficient abundance for the purpose, they make use of their bows and arrows in killing the deer, as they pass through the narrow defiles, into which they drive the herds in the following manner. Upon seeing the deer, they betake themselves to leeward, lest they should be smelled by the animals; and then search for a convenient place for concealing the marksmen. They next collect a number of sticks, like large ramrods, with a small flag at the top of each, and these they fix upright in the ground above fifteen or twenty yards from each other, so as to form two sides of a very acute angle, terminating in the defile, where the huntsmen are concealed behind loose stones, heaps of moss, &c. The women and boys then divide into two parties, and going round on both sides, till they form a crescent behind the herd, drive them straight forward between the rows of sticks into the place of concealment, where they are shot as they run along. The same mode is employed in the winter season, to drive the deer into a pound or inclosed space fenced round with brushy trees. These pounds are of various sizes according to circumstances, and are sometimes about a mile in circumference. The door or entrance is not wider than a common gate, and the inside of the space inclosed is so crossed with hedges as to form a kind of labyrinth, at every opening of which also are placed snares made of thongs. As soon as the deer are driven into the pound, the gateway is blocked up with trees and brushwood, prepared for the purpose; and, while the women and children walk round the outside of the fence, to prevent the imprisoned animals from breaking through or leaping over, the men are employed in shooting those which run loose, or in spearing those which have been entangled in the snares. About the end of March or beginning of April, when the snow, slightly thawed during the day, is frozen during the night into a thin crust, which easily bears the Indian on his snow shoes, but sinks under the hoof of the deer, it is a common practice to kill the moose deer, by literally running them down. The hunters, lightly clothed, and armed only with a bow and arrows, a knife, or broad bayonet, generally tire the deer in less than a day, though sometimes they continue the chace for two days before they can come up with the game. These animals, however, when incapable of running farther, make a very desperate defence with their head and forefeet, and unless the Indians are provided with a short gun, or with bows and arrows, they find it necessary to fasten their knives or bayonets to the end of a long pole, in order to stab the deer, without coming within reach of their feet. The flesh of the animals killed in this manner is so overheated by the long run, that it is never well tasted.

Fishing.

In taking fish, they make use of nets and hooks at all seasons of the year. Their fishing nets are made of thongs cut from raw-deer skins, (much inferior to those of the Dog-ribbed Indians, which are made of the inner bark of the willow tree) and are furnished with various appendages, such as the bills and feet of birds, toes and jaws of otters, &c. which they superstitiously consider as essential to their success. These nets are always used separately, and placed at a distance from each other; and on no account would they unite them together for the purpose of stretching across the channel of a narrow river; because they imagine that one net would become jealous of its neighbour, and would not catch a single fish. In fishing with hooks they are equally influenced by superstitious notions; and all the baits which they use are compositions of charms, inclosed within a piece of fish-skin, so as to resemble a small fish. These charms are bits of beavers' tails, otters' teeth, musk-rats' entrails, squirrels' testicles, curdled milk taken from the stomachs of sucking fawns and calves, human hair, &c.; and almost every lake and river is supposed to require a peculiar combination of different articles. A net or hook, that has taken many fish, is valued accordingly; and would be taken as an equivalent for a number of new ones, which had never been tried, or which had not proved successful. In winter the hooks are let down through round holes cut in the ice, and are kept in constant motion, both to allure the fish, and to prevent the freezing of the water.

Food.

From want of fuel, they are frequently obliged to eat their victuals in a raw state; and this they occasionally do from choice, especially in the case of fish, which they seldom dress so far, (even where fire is at hand) as to warm it thoroughly. A few of them purchase brass kettles from the European factories; but the greater part still prepare their food in large upright vessels made of birch bark. As these vessels will not admit of being exposed to the fire, the water is made to boil by a succession of hot stones being introduced; a method which effects the purpose very expeditiously, but mixes much sand with the victuals, in consequence of the stones frequently mouldering down in the kettle. They employ also the ordinary methods of broiling their food, or roasting it by a string. They make a favourite dish, by boiling in a deer's paunch or stomach a mixture of minced meat, blood, and fat; but the fat is chewed by the men and boys, to prepare it for mixing more intimately with the other ingredients, and the half-digested food, found in the animal's stomach, is carefully added to the mess. In winter, when the deer feed upon a species of fine white moss, the contents of their stomach is accounted so great a delicacy, that the Indians frequently eat it warm out of the paunch, as soon as the animal is killed. In like manner, they pull out the kidneys of the deer or buffalo, and eat them warm from the newly slaughtered animals, without any dressing. They often drink the blood, as it flows from the wound in the carcase, and account it a most nourishing sort of food, as well as an excellent quencher of thirst. They are remarkably fond of the womb of the buffalo, elk, deer, &c. even when they are some time gone with young; and are not desirous of cleansing the bag very completely before boiling it for use. The young calves, fawns, beavers, &c. taken out of their mothers' bellies, are reckoned most delicious articles of food; and all the parts of generation, belonging to any animal which they kill, whether male or female, are carefully eaten by the men and boys, partly as a dish which they relish, and partly as a superstitious observance which they consider essential to their success in the chace. The deer skins also, freed from the hair, and well boiled, are frequently used as food. Even the worms, which infest them after the rutting season, are squeezed out and eaten alive as great delicacies. When animal food is scarce, the natives boil a kind of hard crumply moss which grows upon the larger stones, and which forms a very palatable gummy preparation, sometimes used to thicken other kinds of broth, and particularly esteemed when cooked in fish liquor. All the Indians around Hudson's Bay, Southern, Northern, and Esquimaux, constantly swallow the secretion which comes from the nose; devour the maggots which are produced by the flesh fly; and delight in a handful of lice as much as a European epicure is known to relish the mites in a decayed cheese.

lothing.

ents.

edges.

Snow shoes.

The clothing of the Northern Indians consists chiefly of deer skins, with the hair inwards; but, for summer use, they prepare from these skins a fine soft leather, with which they make their stockings, jackets, &c. To make a complete winter dress for a grown person, requires the principal parts of eight or ten deer skins; and all these must, if possible, be procured in the month of August, or beginning of September, when the fur is thickest, and the skin least injured by worms. Each person is calculated to require annually ten more of these skins for the lighter parts of summer clothing, for thongs, lines, and other domestic purposes, besides what is needed for tents, bags, &c. The coverings of the tents are always formed of skins with the hair; and by the Northern Indians are commonly composed (differently from the practice among the Southern tribes) of separate pieces, containing about five skins in each. At the commencement of the winter season, they frequently sew a few of the skins of the deer's legs together in the shape of long portmanteaus, which they use as a kind of temporary sledge, till they reach a situation where wood can be procured. They then construct proper sledges of thin boards of larch fir; and make them of various sizes, according to the strength of the persons by whom they are to be dragged. In general they do not exceed eight or nine feet in length, and twelve or fourteen inches in breadth; but sometimes they are not less than twelve or fourteen feet long, and fifteen or sixteen inches wide. The boards, of which they are made, are only about a quarter of an inch thick, and five or six inches broad. They are sewed together with thongs of parchment deer skin, and several cross-bars are fastened on the upper side to strengthen the vehicle, and secure the ground lashing. The head or fore part of the sledge is turned up, so as to form a semicircle of fifteen or twenty inches diameter, to prevent the carriage from diving into light snow, and enable it to rise over the inequalities of the surface. The trace is a double line or slip of leather fastened to the head of the sledge, and attached to a collar, which is put across the shoulders of the person who hauls it, so as to rest upon the breast. They are sometimes dragged by dogs, but too commonly by the women. The snow shoes of the Northern Indians differ from all others in that country, in being made so as to be worn always on the same foot, having a large sweep or curve on the outside, but nearly straight in the inside. The frames are usually made of birch wood, and a netting of thongs from deer skin fastens the toes and heels to the bottom or sole. They are four feet and a half in length, and about thirteen inches broad.

Canoes.

Instruments.

Tanning.

Women.

The canoes of the Northern Indians are smaller and lighter than those of the Southern nations, so as to be carried by a single person on the longest journies; and are chiefly employed for crossing the rivers and lakes, with which they meet in their progress. These canoes are flat bottomed, and sharp at each end, so as to bear some resemblance to a weaver's shuttle. They seldom exceed twelve or thirteen feet in length; and are from twenty to twenty-four inches broad at the widest part. The forepart is unnecessarily long and narrow, and is all covered over with birch bark, so as to admit of nothing being laid into it. The hinder part is much wider, for receiving the baggage, or a second person, who must lie along the bottom, that the vessel may not upset, while the rower sits on his heels in the middle space, impelling the vessel with a single paddle. A hatchet, a knife, a file, and an awl, are all the tools which these Indians employ in making their canoes, snow-shoes, bows, arrows, and other kinds of wooden work. These few instruments they use with the utmost dexterity, and execute every thing in the neatest manner. In tanning their leather also, they use a very simple, yet efficacious process. The skins are first well soaked in a lather made of the brains, marrow, and soft fat of the animal; then dried before the fire, and even hung in the smoke for several days. They are next thoroughly steeped and washed in warm water, till the grain of the skin is perfectly open and moistened; after which they are carefully wrung, and dried before a slow fire, being in the meantime repeatedly rubbed and stretched as long as any moisture remains. Last of all, they are scraped smooth with a knife, and are extremely soft and beautiful, almost equal to shamois leather. The women of the Northern Indians, as in most other tribes, are more the slaves than the companions of the men; and are held in a state of unmitigated subjection. They are commonly rather of low stature and a delicate shape; but being inured to labour from their infancy, they are able to sustain all kinds of drudgery, and to carry very heavy loads on their journies. It is nothing unusual to see them bear on their backs a burden of eight or ten stone of fourteen pounds each, or haul in a sledge a much greater weight. They are expected also to dress the deer skins, make the clothing, cook the victuals, pitch the tents, carry home the game when killed, and perform all the work of splitting, drying, and preserving it for use. When the meal is prepared, they are not allowed to partake, till all the males, even the servants of their fathers or husbands, have eaten what they think proper; and, in times of scarcity, it is not unfrequently their lot to be left without a single morsel. They possess little beauty even in youth; and become old and wrinkled before they reach the age of thirty. But they are remarkably chaste, mild, and obliging creatures, making the most faithful servants, affectionate wives, and indulgent mothers. A plurality of wives is customary among all these Indians, and every man takes as many as he is able to maintain, or has occasion to employ in his service. It is not uncommon to see six or eight in one family; and they are changed or increased in number, at the pleasure of the husband. From the early age of eight or nine years, the girls are kept under the greatest restraint, and are not permitted to join in any amusements with the children of the other sex; but are obliged to be constantly beside the old women, learning their domestic labours. They are betrothed at an early period of life, without any choice of their own, but entirely at the will of their relations, who are chiefly anxious to connect them with men able to maintain them. No ceremonies attend their marriages, or divorces; and they are taken or dismissed as the husband chooses. When he suspects any of them of incontinency, or is not pleased with her accomplishments, he administers a beating and turns her out of doors, telling her to go to her lover or relations, as the case may be. It is also a daily occurrence among them to take by force, the wives of others, whom they may happen to fancy; and all that is necessary to decide the claim, is to vanquish the former husband in wrestling. On these occasions, the by-standers never attempt to interfere; nor will one brother even offer to assist another, except by giving his advice aloud, which being equally heard, may be equally followed by both the parties engaged. In these contests, there is properly nothing like fighting; and it is very rarely that either of the combatants receives any hurt. The whole affair consists in pulling each other about by the hair of the head, or, if they should have taken care to cut off their hair and grease their heads before beginning the contest, they endeavour to seize each other around the waist, and struggle to prove their superior strength and title, by throwing their antagonist to the ground. When one of them falls or yields, the other is entitled to carry of the woman, who was the cause of contention; but as the children usually go with the mother, it is chiefly for the younger wives, that these contests take place. It is a common custom among them to exchange wives for a night, as one of the strongest ties of friendship between the two families; and, in case of the death of either husband, the other considers himself bound to support the children of the deceased. The women among the Northern Indians are less prolific than the females of more civilized nations; and their children are commonly born at such intervals, that the youngest is usually two or three years old before another is brought into the world. The wife, when taken in labour, is removed to a small tent erected for her separate accommodation, at such a distance from the other tents, that her cries cannot be heard; and no male above the age of childhood approaches the place. No assistance is offered by the other women to facilitate the birth, which is generally easy, and the recovery of the mother not less speedy. A woman after delivery, however, is accounted unclean for a month or more, and continues to occupy a separate tent with one or two female acquaintances; nor does the father, during all that time, even see the child, in the apprehension that he might dislike its appearance, before its countenance is duly formed. At certain monthly periods, also, the women are not permitted to remain in the same tent with their husbands, and are obliged to make a small hovel for themselves at a little distance from the rest. When these periods arrive, they creep out of the tent at the side where they happen to be sitting, as on such occasions they are not permitted to go out or in by the door; and it is said, that, upon any disagreement with their husbands, they often make a pretence of being in that situation, as a reason for a temporary separation. During these periods, a woman is restricted from walking on the ice of rivers or lakes, or where a fishing net is placed, or from crossing a path where the head of any animal has been carried, or from eating of any part of the head; and all this from a superstitious notion that by so doing she would impede their success in hunting. The children are not put in cradles as among the Southern Indians, but merely have a small bundle of dry moss placed between their legs, and are thus carried on the mother's back next her skin, till they are able to walk. Though managed in this awkward manner, very few deformed persons are seen among them. The children are named by the parents or near relatives; and the names of the boys are generally taken from that of some animal, place or season. Those of the girls are most frequently expressive of some quality or part of the martin, such as White Martin, Black Martin, Summer Martin, Martin's-head, Martin's-foot, Martin's-tail, &c. The men, though very indifferent about their wives, express much affection to their children, especially to the youngest; apparently actuated by no other principle than mere natural instinct.

Children.

Salutations.

When two parties of these Indians chance to meet, their mode of salutation is rather singular, and quite different from all European practices. When about twenty or thirty yards distant from each other, they make a full halt; and sit or lie down upon the ground without speaking for some minutes. At length the oldest on one side breaks silence by relating to the other party all the misfortunes which have befallen him or his companions, since they had last seen or heard of each other, and also all the deaths or calamities of any of their countrymen, as far as may have come to his knowledge. A similar communication is made in reply; and, should any of the two companies be nearly affected by any of the bad news announced, they begin to sob and cry, in which all the rest unite with the utmost vehemence. They then advance by degrees, and mix together, the two sexes, however, always associating separately. The pipes are passed freely, if any tobacco can be found among them; conversation becomes general; the good news circulate; cheerfulness appears on every countenance; and small presents of provisions, ammunition, or other articles, are made, sometimes as gifts, but more frequently as speculations to draw forth a greater present in return. Their principal amusements are shooting at a mark with the bow and arrow; playing a game resembling that of quoits, in which they make use of short clubs sharpened at one end; or shifting a button, or small bit of wood from hand to hand, as in "which hand will you take?" in which the player, whenever he guesses rightly, receives a counter or chip of wood from his antagonist, and he who first gains all the sticks, is winner of the stake, which is usually an arrow, or a single load of powder and shot, or something of inconsiderable value. At times they amuse themselves with dancing, which is always performed during the night; but in which they have nothing peculiar to their own nation, and always imitate the songs and dances of the Southern tribes, or more commonly of the Dog-ribbed Indians. These

Amusements.

dances are very simple, and are performed by three or four persons at a time, who stand up naked, or nearly so, close to the musician; and, with their hands close upon the breast, their heads inclining a little forwards, and their bodies kept quite stiff, lift their feet alternately in quick succession, and as high as possible. The music is produced by a drum or tabor, and sometimes a rattle made of buffalo's hide, shaped like an oil-flask, and filled with pebbles or small shot. These instruments are accompanied with the voice, repeating, in a monotonous kind of tune, the words *hee, hee, hee, ho, ho, ho,* &c. The women are never allowed to join in these diversions, but sometimes dance by themselves, out of doors, to the music which serves the men within the tent. Their mode of dancing has still less meaning and motion than that of the men; and is performed by a number of them crowding close together in a straight line, shuffling themselves a little from right to left and back again on the same ground, without lifting their feet; and making, when the music stops, a kind of awkward curtsey, with a shrill cry of *he-e-e, ho-o-o-e.*

Diseases.

Few of the Northern Indians live to a great age; and the extreme fatigues which they undergo from their youth in procuring their subsistence, is supposed to have no small effect in shortening their lives. Their most fatal disorders are fluxes and consumptions, which carry off great numbers of both sexes and of all ages. But the most prevalent disease, is a kind of scurvy resembling the worst stage of the itch. It is seldom known to prove fatal, unless when conjoined with some internal affection; but it is extremely troublesome and obstinate, resisting all the medicines, which have yet been applied at the Company's factories; and, when left to the power of nature, as is always the case among the natives, seldom removed in less than twelve or eighteen months. They make no use, indeed, of medicine, either for external or internal diseases, and attempt to cure them solely by charms. The modes most commonly employed are sucking the part affected, blowing and singing to it, laughing, spitting, and uttering a multitude of unmeaning sounds and vocables. In the case of some internal complaints, such as colic, strangury, &c. the operator frequently blows into the anus or the adjacent parts, whatever be the sex of the patient, and continues the process as long and as violently as his lungs can act. The consequence of such an accumulation of wind is not unusually precisely the same as the effect of a clyster; and the reaction is sometimes so sudden as to lodge the contents full in the face of the doctor; a scene which, however ludicrous to Europeans, never discomposes the gravity of any of the Indian parties or spectators. The medical practitioners are a class of conjurors, who no doubt impose upon the credulity of their countrymen, but who seem to have themselves a real belief in the efficacy of some of their operations. In cases of great danger, besides the usual modes of cure, they pretend to appease the power of death, and to procure a respite for the sufferer, by swallowing hatchets, ice-chisels, broad-bayonets, knives, &c.; and these feats they are described as performing, or rather appearing to perform, with wonderful dexterity. Some of their exertions are sufficiently real and laborious, as particularly described in a case witnessed by Mr Hearne. After one of them had performed the feat of swallowing a long board, he took with him other five men and an old woman into the house where the patient lay; and, having stripped themselves completely naked, began to suck, blow, sing, and dance around the sick man, "continuing so to do for three days and four nights, without taking the least rest or refreshment, not even so much as a drop of water. When these poor deluding and deluded people came out of the conjuring-house, their mouths were so parched with thirst, as to be quite black, and their throats so sore that they were scarcely able to articulate a single word, except those that stand for *yes* and *no* in their language. After so long an abstinence, they were very careful not to eat or drink too much at one time, particularly for the first day; and, indeed, some of them, to appearance, were almost as bad as the poor man they had been endeavouring to relieve. But great part of this was feigned; for they lay on their backs with their eyes fixed as if in the agonies of death, and were treated like young children. One person sat constantly by them, moistening their mouths with fat, and now and then giving them a drop of water. At other times, a small bit of meat was put into their mouths, or a pipe held for them to smoke. This farce only lasted for the first day; after which they seemed to be perfectly well, except the hoarseness, which continued for a considerable time afterwards." These conjurors profess to accomplish their cures by the aid of certain spirits or fairies, with whom they pretend to converse, and whom they often describe as appearing to them under the shapes of beasts, birds, clouds, &c. They are supposed to be equally able, by means of those supernatural allies, to take away as well as to prolong any one's life; and when they chose to threaten such a malign influence to any individual or family, the imaginations of their victims are so possessed by the conviction of their power, that the consequence is affirmed to have often proved fatal, without any apparent molestation being offered to the objects of their vengeance. Indeed, when any of their principal people die, their death, in whatever way it has taken place, is usually ascribed to some conjuring influence, either of their own countrymen, or of the Esquimaux, or of the Southern tribes.

Dead.

They never bury their dead, but always leave the bodies on the spot where they expire. They are understood to be generally devoured by beasts and birds of prey; and for this reason these Indians will not eat the flesh of foxes, wolves, ravens, &c. unless they be pressed by absolute necessity. Though thus neglectful of the mortal remains of their friends, they are deeply affected with grief for their loss; and express their sorrow by tearing off their clothes, and wandering about naked, till their neighbours or relatives come to their relief. After the death of a father, mother, husband, wife, son or brother, they mourn for the space of a whole year, indicating their affliction, not by any particular dress, but by cutting off their hair, and crying almost perpetually. But the greatest calamity that can befal any of these Indians is old age. When any one is incapable to labour, he is treated, even by his own children, with the greatest neglect and disrespect, being always last served at meals, and then only with the worst of the victuals; being clothed in the clumsiest manner, with what the rest of the family despise to wear; and finally, when no longer able to walk, deliberately abandoned to perish of want. This practice is so general, that one half at least of the aged people of both sexes are supposed to die in this miserable manner. The absolute necessity of moving from place to place in quest of subsistence, and the want of any easy mode of conveyance among them, may be considered as the original causes of this unnatural custom.

The notions which these Indians entertain in religion

Religion. are so extremely vague and limited, that they may almost be said to have no ideas at all on that subject. With regard to the origin of the world, they have a tradition, that the first person on earth was a woman, who, after being some time alone, found an animal like a dog, which followed her to the cave where she lived, and transforming itself during the night-time into the shape of a handsome youth, rendered her the mother of a family. Some time afterwards, a person of such gigantic stature as to reach the clouds with his head, came to level the land, which had been hitherto a confused heap, and this he effected merely with the help of his walking stick, marking out, at the same time, the lakes, ponds, and rivers. He then took the dog, and, tearing it in pieces, threw its intestines into the waters, commanding them to become fishes; dispersed its flesh over the land, with a similar charge to form the different kinds of beasts; threw the pieces of its skin in the air, to give origin to the feathered tribes; commanded the woman and her offspring to kill, eat, and never spare, as he had charged these creatures to multiply for her use; and then returning to the place whence he came, has never been heard of since. They believe in the existence of several kinds of spirits, whom they suppose to inhabit the different elements, and to whose influence they attribute every change in their lot, whether favourable or adverse. They have no fixed creed, however, in these matters; but are continually receiving new fables from their conjurors, who profess to receive intimations in dreams from these invisible beings. They have no practical religious observances whatever, except perhaps speaking with reverence of certain beasts and birds, in which they imagine these spirits to reside. But they restrict the influence of these beings upon their welfare entirely to the present life, and have no idea whatever of a future state.[*] They have indeed a multitude of superstitious customs, some of which have already been mentioned, respecting success in hunting, fishing, &c. but which seem to partake more of the nature of civil than religious institutions. One of the most remarkable of these is that which they observed after having put to death any of their enemies in war. All those who have shed blood are, for many months afterwards, in a state of uncleanness, and obliged to perform a number of strange ceremonies. They are prohibited from cooking any kind of victuals for themselves or others; required to paint their faces with red earth before every meal; restricted to the use of their own pipe and dish; forbidden to eat various parts of animals, particularly the head, entrails, and blood; precluded from having their food prepared in water, so that, if they could not have it broiled on the fire or dried in the sun, they must eat it in a raw state; and finally denied the privilege of saluting any of their wives and children. When the appointed time is expired, they kindle a fire at some distance from the tents, into which they throw all their ornaments, pipe-stems, and dishes; and then partake of a feast, consisting of all those articles of food which they had been prohibited from using.

Character. The Northern Indians are an indolent, improvident race; and are frequently in danger of starving from mere want of exertion and foresight, especially in their trading excursions to Prince of Wales Fort, the only one of the factories which they frequent. They are seldom guilty of stealing from one another, but are ready to pick up every kind of iron work which falls in their way at the Company's settlements. They excel in all the arts of defrauding and overreaching, and especially in playing the part of feigned want and distress. They are continually pleading poverty even among themselves; and, at the factory, they may be said to practise begging more then traffic. They are generally of a morose and covetous disposition, and remarkably deficient in gratitude. They are by no means a warlike people, and are not inclined to acts of cruelty, except towards their enemies the Esquimaux. Whatever losses or injuries they may sustain from one another, their revenge rarely extends beyond a wrestling match with the offender. Murder is almost unknown among them; and the perpetrator of such a crime would be treated by universal consent as an outlaw from their tribe. At the same time, they testify little humanity to the sufferings of others beyond the circle of their immediate relatives; and are known rather to ridicule, in the most unfeeling manner, the most afflicting cases of distress. They are not at all addicted to the use of sprituous liquors; and, though some, who have intercourse with the factory, may learn to take them freely enough, when given gratis, they never think of them as an article of purchase. They are thus always sober, and are guilty of no greater rioting, than what consists in abusive language. They are apt to become insolent and uncomplying when treated with indulgence; but nevertheless are by far the mildest tribe of Indians to be found on the borders of Hudson's Bay.

Esquimaux. The Esquimaux who inhabit the northern coasts of Hudson's Bay,[†] (to whom alone the following particulars apply,) seldom approach the Company's fort at Churchhill River; but a sloop is regularly sent to trade with them at Knapp's Bay, Navel's Bay, and Whale Cove. It is only since the middle of last century, that the Company's servants could venture to land among them, (partly perhaps because they were considered by the Esquimaux as the allies of their most inveterate enemies, the Northern Indians,) but they have of late become so much civilized, and reconciled to the Europeans, as readily to welcome their arrival, and to treat them with every mark of hospitality. They have long been persecuted by their more powerful neighbours the Northern Indians with the most savage barbarity. No quarter is ever granted on either side; and the strongest party never fails to massacre every creature of the vanquished, without sparing even the women and children. Of late years, however, the company's servants have extended their protection to the oppressed Esquimaux, and have succeeded in establishing a peace between the two nations, so far at least that parties and individuals of both tribes can meet each other in a friendly manner, or rather without any disposition to plot each other's destruction. But the more distant Esquimaux, who reside so far to the north as to have no intercourse with the Europeans, are still exposed and often fall a sacrifice to the fury of their enemies. They are tolerably well protected in winter by their

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[*] The Southern Indians consider the aurora borealis as the assembled spirits of their departed friends dancing in the clouds; but the Northern Indians have no belief of this nature, and merely speak of that phenomenon by the name of Deer, in consequence, it is said, of observing, that a hairy deer-skin, when briskly stroked with the hand in the dark, emits electrical sparks like these lights in the atmosphere.

[†] For an account of the other tribes of that people, see GREENLAND and LABRADORE.

remote situation; and, in summer, they guard as much as possible against surprise, by residing chiefly on islands and peninsulas; but with all these precautions, they are often so harassed and closely pressed by their pursuers, as to be obliged to leave behind them those goods and utensils upon which they depend for procuring subsistence, and the loss of which they cannot replace without a great expence of time and labour. These more northern Esquimaux are of low stature and broad figure, but neither strong nor well proportioned. Their complexion is of a dirty copper colour, but some of their women are considerably fairer. They have a singular custom which distinguishes them as a peculiar tribe, namely, that all the men have the hairs of their heads pulled out by the root; but in most other respects, they resemble the Esquimaux of Hudson's Straits and Labradore. Their arms and utensils, from the want of proper tools, are very inferior in workmanship to those of the more southern tribes of their nation; yet even with the imperfect instruments in their possession, many of their articles of furniture are formed and ornamented with wonderful ingenuity, especially their stone kettles. They are made of a grey porous stone, of an oblong square shape, wider at the top than the bottom, with strong handles of solid stone left at each end for the purpose of lifting them more conveniently, and are sometimes large enough to contain five or six gallons. They are all ornamented with neat mouldings around the rim, and occasionally with a kind of fluted work at the corners; and all this is executed with no other instruments than such as are made of a harder kind of stone. Their arrows, spears, darts, &c. are generally pointed with a triangular piece of black stone, or sometimes a piece of copper. Their tools for wood work are entirely of this metal, namely, hatchets, broad bayonets, and women's knives. The hatchets are made of a thick piece of copper, about five or six inches long, and from one and a half to two inches square, bevelled away at one end like a mortice chisel, and fastened at the other to a wooden handle about twelve or fourteen inches in length, so as to resemble an adze; but they have neither weight nor sharpness to act like an adze or hatchet, and are generally applied in working like a chisel, being driven into the wood with a heavy club. The bayonets resemble an ace of spades, and are fastened to a handle of deer's horn about a foot long. During summer, they live in circular tents covered with deer skins, and employ themselves principally in fishing; but, in winter, they occupy small huts, the lower half of which is sunk below the surface of the earth, and the upper part formed with poles which meet at the top in a conical form. Those who reside near Churchhill river travel, in winter, from lake to lake, or from river to river, where they have magazines of provisions, and heaps of moss for fuel; but as those stations are often far distant from each other, they frequently pitch their tents on the ice, and cut holes in the ice within the tent, where they sit and angle for fish, which, for want of fire, they eat in a manner alive as they come out of the water, and are altogether a miserable starving race of beings.

Commerce.

The original Hudson's Bay Company appear to have acted upon the most liberal and benevolent principles. Their instructions to their factors contain the most explicit directions, to use every mean in their power for reclaiming the Indians from a state of barbarism, and inculcating on their minds the principles of Christianity. They were, at the same time, admonished, to trade with them equitably, and to take no advantage of their native simplicity; to explore the country, and to study to derive such benefit from its soil and produce, as might redound to the interest of the mother-country, as well as to their own emolument; to watch over the behaviour of the European servants, especially as to sobriety, temperance, and veneration for the services of religion. The chief person in command at each settlement is called the governor of the fort, and sometimes there is one appointed to act under him termed the second. These, with the surgeon and the master of the sloop attached to the place, constitute a council, who deliberate together in all matters of importance, or cases of emergency. The governors are appointed for a period of three or five years, and have from £50 to £150 per annum as fixed salary, with a premium upon the trade, which consequently fluctuates according to its amount.* The labouring servants, who are chiefly procured from the Orkney islands, are generally engaged for three, four, or five years, and, about twenty years ago, received £6 per annum as wages, independent of maintenance. Their employments consist principally in carrying fuel, sledging the snow out of the avenues of the factory, and hunting. The company export muskets, pistols, powder, shot, brass and iron kettles, hatchets, knives, cloth, blankets, baize, flannels, gun-worms, steels, and flints, hats, looking-glasses, fish-hooks, rings, belts, needles, thimbles, glass-beads, vermilion, thread, brandy, &c. with which they purchase from the natives skins, furs, whalebone, train oil, ivory, eider-down, &c. The trade was understood, in its original flourishing state, to be the most profitable in the world; and the proprietors of the stock were generally supposed to gain about 2000 per cent. It has been denounced, however, as proportionably detrimental to the mother-country; and it has been affirmed, that, if laid entirely open, the number of persons employed, and the quantity of wares exported, might easily be increased ten-fold. The company are charged, at the same time, with transacting all their affairs with the greatest secrecy, and always shewing the utmost reluctance to expose the details of their trade to public view. On the other hand, during a parliamentary inquiry into their proceedings in 1749, they produced documents to prove, that their profits were sufficiently limited, as appears from the following summary of their expenditure and returns, in the space of ten years, from 1739 to 1748 inclusive:

Charges of shipping, factories, &c. in ten years	£157,432	14	4
Exports during that period . . .	52,463	9	0
Total expences . .	£209,896	3	4
Amount of sales .	273,542	18	8
Clear profits from the trade in ten years	£63,646	15	4
Dividends in one year among 100 shares of £100 each	£6364	13	6
For each proprietor of £100 stock . .	£63	12	11

The following account of imports and sales for one year, from Michaelmas 1747 to Michaelmas 1748, may

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* The second has about £40; an assistant, £25; and a clerk, £15 per annum.

afford a more detailed view of the articles of the trade, and their respective values.

Articles.	Number.		£	s.	d.	
Beaver skins	52,716	at		7	6	per skin.
Martins	8,485	at		6	8	do.
Otters	1,445	at		9	7¼	do.
Cats	1,199	at		10	10½	do.
Foxes	527	at		8	1¼	do.
Wolverins	977	at		5	0	do.
Bears	371	at	1	2	7	do.
Wolves	1,663	at		9	6¾	do.
Woodshocks	32	at		10	7	do.
Elks	50	at		6	7	do.
Deer	105	at		2	3	do.
Bed-feathers	5,838 lbs.	at		1	2	per lb.
Castor	308	at		6	2¼	do.
Whale fins	226	at		2	0½	do.
Minks	33	at		3	1	per skin.
Racoons	26	at		1	7	do.
Goose quills	43,000	at		15	0	M.
Musquash	268	at		0	9¼	per skin.
Badger	80	at		1	1	do.
Total value			£30,160	5	11	

The Company's establishments in the Bay, in the year 1790, may be seen at one view in the following Table.

Settlements.	Number of Servants.	Indian Settlements.	Ships consigned to.		Sloops in the country.		Trade on average.
			Ships.	Tons.	Sloops.	Tons.	
Churchhill Fort	25		1 of	250	1 of	70	£10,000
York Fort Severn-house	100	4	1 of	250	1 of	60	25,000
Albany Fort	50	2					5,600
Moose Fort	40	2	1 of	280	1 of	70	7,000
East Main	25				1 of	70	
Total	240	8	3	780	4	270	£47,600

In forming a standard of trade with the natives, the beaver skin is taken as the universal measure; and a comparative valuation made of the other kinds of peltry, &c.

A full grown moose	skin 1	as	2 beavers.
Cub ditto	1		1
Old bears	1		3
Cub ditto	1		1
Foxes, black	1		4
Ditto, gray	1		3
Ditto, white	2		1
Ditto, red	1		1
Ditto, brown	2		1
Wolf	1		2
Wolverins	1		2
Cats	1		2
Otter, old parchment	1		1
Ditto, cub and drest	2		1
Martins, prime	2		1
Ditto, ordinary	3		1
Deer, buck	1		1
Ditto, doe	2		1
Musquash	6		1
Goose feathers	lb. 10		1
Ditto quills	No. 2000		1
Castor	lb. 2		1

With these the trading goods are bartered, or rather directed to be bartered, at the following rates:

Glass beads	lb. 1	as	1 beaver.
China ditto	1		6
Kettles, brass	1		1¼
Coarse cloth	yard 1		3
Blankets	No. 1		7
Tobacco, Brazil	lb. ¾		1
Ditto, leaf	1		1
Ditto, English roll	1		1
Shirts, check	No. 1	as	2 beavers.
Ditto, white	1		2
Stockings, yarn	pair 1		2
Powder	lb. 1		1
Shot	4		1
Duffels	yard 1		2
Knives	No. 4		1
Guns	No. 1		14
Combs	1		1
Flints	16		1
Vermilion	lb. 1		16
Pistols	No. 1		7
Small burning glasses	1		1
Gartering	yard 1⅛		1
Orrice lace	1⅛		1
Rings, brass	No. 3		1
Files	1		1
Tobacco boxes	1		1
Awl blades	8		1
Boxes, barrel	3		1
Hawks-bells	pair 12		1
Sword blades	No. 1		1
Ice chisels	1		1
Gun worms	4		1
Hats, coarse	No. 1		4
Trunks, small leather	1		4
Needles	12		1
Hatchet	1		1
Brandy, English	gallon 1		4
Medals	No. 12		1
Thimbles	6		1
Collars, brass	1		2
Fire steels	3		1
Razors	2		1
Thread	lb. 1		1

Out of this standard, however, which is in itself sufficiently hard upon the Indians, the factors are allowed, for their own emolument, to raise a surplus-

Hudson's Bay.

trade; so that the natives often pay at the rate of one-third, or even one half, more than the preceding rates. In consequence of this griping traffic, and the alleged supineness of the company, the trade has been gradually decreasing, though the articles procured have been bringing a higher price at home. This is partly ascribed to the competition of the Canadian traders since 1773, who penetrate into the interior, and establish trading ports nearer the abodes of the natives, who often collect more skins than they are able to convey to the settlements on the coast, and are glad also to find a market without needing to seek it through a long and laborious journey. By these enterprising competitors under Mr Joseph Frobisher, the company's trade suffered so severely, that, in 1775, it fell short nearly one half of what it had been in 1774. They immediately commenced pursuit of the retreating trade, by erecting trading houses in the interior. In 1775, they formed a settlement at Sturgeon Lake, in north latitude 53° 56', and west longitude 102° 15'; in 1793, their traders repaired to the south-east of Portage de Traite among the Knisteneaux, whom they term their home guards; and, about the beginning of the present century, to Athabasca river, in north latitude 56° 42', among the Chepewyans. Since the establishment of these trading houses, which are maintained at a great expence, the Indians have in a great measure ceased to visit the factories on the coast of Hudson's Bay, which have thus become little better than storehouses for the articles of the trade. Still, however, in spite of these endeavours to secure the *traffic* of the natives, they have found the adventurers from Canada in every respect an overmatch for their people in the business; a circumstance for which it is difficult to account, when it is considered how much nearer to the Indian hunters is the residence of the Hudson's Bay traders; and in how much shorter a time they can procure a return upon their goods. The directors of the Company appear to have readily authorised their agents to pursue the inland trade since the encroachments of the Canadians, of which a proof may be adduced from the following manuscript notes in a copy of Mackenzie's Voyages, by one of their factors at that period.[*] "When chief factor at York Fort, I sent inland several young men with the Indians to observe the movements of the Canadian adventurers. They found bands of them with servants and coureurs des bois pursuing the fur trade with more spirit than their predecessors the French. From that date, 1762 to 1764, I yearly sent inland, and repeatedly informed the directors of what was going forward. The Company's trade at York Fort increased for two or three years after the conquest of Canada; but decreased after Findlay, Currie, &c. penetrated to Saskatchiwine river. Anno 1774, I advised the directors to establish settlements inland, with which they readily complied; and have continued to do so at an enormous expence. I do affirm the Company spare no cost to promote trade in every branch. This I say from my own experience, having been 26 years in their service, greater part of that time governor and chief factor; and since I left the employment, have been highly honoured with their esteem, and application for advice on the subject. But our countrymen from Canada are bold adventurers, and far superior to the Company's servants; the former work for their own benefit, while the latter do not." "I repeatedly advised the Directors to prosecute the trade to Athabasca; but the servants never would venture, making as excuse, that they would be in want of food." The company, however, have been loudly and publicly charged with making only the most languid exertions, with failing from an ill-judged parsimony to animate their servants by adequate salaries, and with injudiciously employing in the carrying part of the inland trade the native Indians, who are so much less active than the Canadian servants, and who are thus withdrawn from their more profitable service as hunters. It has been affirmed, in short, that were they to prosecute the trade with spirit, the Canadian associations would be obliged to relinquish it entirely; and it has been consequently urged, that so inefficient a monopoly should be thrown open to the exertions of the public. These charges, however, are made chiefly, and rather inconsistently, by the rival fur-traders from Canada, who have certainly been the greatest gainers, by the remissness of those from Hudson's Bay; and who must be convinced, that, if the trade were thrown open, it would naturally be prosecuted rather through the more favourable stations on Hudson's Bay, than through the circuitous rout of the St Lawrence. See Foster's *History of Voyages and Discoveries in the North*; Hearne's *Travels to the Northern Ocean*; Mackenzie's *Voyages through the Continent of North America*; Umfreville's *State of Hudson's Bay*; and Long's *Travels in Canada*. (q)

Huet.

HUET, Peter Daniel, Bishop of Avranches in France, an eminent scholar, was born of a good family at Caen in Normandy, on the 8th of February, 1630. His parents died while he was but an infant, and left him to the care of guardians, who neglected him; but his natural abilities and innate love of learning overcame all disadvantages, and before he was thirteen years of age he had finished his studies in the *belles lettres*. Having entered into the study of philosophy, he found an excellent guide in father Maimbrun, a Jesuit, who directed him to begin by learning a little geometry. Huet, however, went farther than his tutor desired, and contracted such a relish for the mathematics as had almost induced him to abandon his other studies.

Having finished his elementary studies, it was his object to apply himself to the law, and to take his degrees in that faculty; but from this pursuit he was diverted by two books which were then published. These were, "The Principles of Descartes," and "Bochart's Sacred Geography." To the philosophy of Descartes, of which he was a great admirer, he adhered for many years; but afterwards abandoned it, when he discovered the fallacy of its principles. The immense erudition displayed in Bochart's work made a great impression on him, and inspired him with a strong desire to become conversant with Greek and Hebrew learning. To assist his progress in these studies, he contracted a friendship with Bochart, who was minister of the Protestant church at Caen.

At the age of twenty, he was emancipated, by the custom of Normandy, from the tuition of his guardians; and soon after made a journey to Paris, with the view of purchasing books, and becoming acquainted with the learned men of the times. About two years afterwards, he accompanied Bochart to the court of Christina, queen of Sweden; and had thus an opportunity of introducing himself to the learned in other parts of Europe. The queen, it is said, wished to have engaged him in her service; but owing to the jealousy and

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[*] The late Andrew Grahame, Esq. Prestonpans.

intrigues of Bourdel, another physician, Bochart's reception had not been very gracious; and Huet being aware of the fickle temper of Christina, declined all offers, and returned to France after an absence of three months. The principal advantage which he derived from this journey, besides the acquaintance he formed with the learned men in Sweden and Holland, consisted in the acquisition of a copy of a manuscript of *Origen's Commentaries upon St Matthew*, which he transcribed at Stockholm. While engaged in translating this work, he was led to consider the rules of translation, as well as the different manners of the most celebrated translators; and in 1661, he published his thoughts upon this subject at Paris, under the title *De interpretatione libri duo*; a work written with great vigour and elegance, in the form of a dialogue between Casaubon, Fronto Ducæus, and Thuanus. In 1664, he published, at Utrecht, an elegant collection of Greek and Latin poems, which was afterwards enlarged in several successive editions. At length, in 1668, he published at Rouen his *Origenis Commentarii*, &c. *cum Latina interpretatione, notis et observationibus*, in 2 vols. folio; to which was prefixed an ample preliminary discourse, containing all that antiquity relates concerning Origen.

In 1659, Huet was invited to Rome by Christina, who had abdicated her crown and retired thither; but he again declined the invitation. About ten years after, when Bossuet was appointed preceptor to the Dauphin, Huet was chosen for his colleague, with the title of sub-preceptor. He accordingly went to court in 1670, and remained there till 1680, when the dauphin was married. It is to this appointment probably that the learned world is indebted for the editions of the classics *in usum Delphini*; for although the first idea of the commentaries for the use of the dauphin was started by the Duke de Montausier, it was Huet who digested the plan, and directed the execution of this useful undertaking. Although necessarily much occupied with the duties of his situation, he found leisure, at this period, to compose his *Demonstratio evangelica*, which was published at Paris in 1679, in folio, and has since been reprinted in various forms. He was admitted a member of the French Academy in 1674.

At the age of forty-six, Huet entered into orders; and in 1678 he was presented by the king to the abbey of Aunay in Normandy, whither he retired every summer after he had left the court. In 1685, he was nominated to the bishopric of Soissons, which, with the consent of the king, he exchanged with the Abbé de Sillery for the see of Avranches. In 1689, he published his *Censura philosophiæ Cartesianæ*; and in 1690 his *Questionis Alnetanæ de Concordia Rationis et Fidei*, which work is written in the form of a dialogue, after the manner of Cicero's Tusculan Questions.

In 1699, he resigned his bishopric of Avranches, and was presented to the abbey of Fontenay, near the gates of Caen. Soon after, he removed to Paris, and lodged among the Jesuits in the Maison Professée, to whom he bequeathed his library, reserving to himself the use of it while he lived. Here he resided during the last twenty years of his life, and employed himself chiefly in writing notes on the vulgate translation of the Bible; for which purpose he is said to have read over the Hebrew text twenty-four times, comparing it, as he went along, with the other Oriental texts. In 1712, he was seized with a severe illness, from which, contrary to the expectation of his physicians, he gradually recovered, and applied himself to the writing of his life, which was published at Amsterdam in 1718, under the title of *Pet. Dan. Huetii, Episcopi Abricensis, Commentarius de rebus ad eum pertinentibus.* The critics have wondered how such a master of the Latin language as Huet should have been guilty of so great a solecism in the very title of his book, by using the pronoun *eum* instead of *se*. This performance, although composed in an amusing style, is by no means equal to his other works, his faculties being then a good deal impaired. He died on the 26th of January 1721, in the 91st year of his age. The Abbé Olivet relates a most remarkable singularity of Huet, viz. that for two or three hours before his death, he recovered all the vigour of his genius and memory.

Besides the works we have mentioned in the course of the preceding narrative, Huet published a variety of other treatises upon literary and philosophical subjects. He had been, throughout the whole of his long life, a hard student; and he left behind him the reputation of one of the most learned men of the age. See *Eloge Historique de M. Huet, par M. l'Abbé Olivet*, prefixed to his *Traité Philosophique de la foiblesse de l'Esprit humain*; Aikin's *Life of Huet*, London, 1810; and *Gen. Biog. Dict.* (z)

HUGUENOTS, a name of uncertain origin, given to the Protestants of France. A full account of their history will be found in our article France, Vol. IX. p. 563. *et seq.*

HULL, or Kingston-upon-Hull, is a seaport town of England, in the east riding of Yorkshire, situated on the west side of the river Hull, and on the northern side of the river Humber, about twenty miles from its mouth.

The town, which lies on a level tract of ground, extends nearly in a direct line along the river Hull, from the Humber bank to very near the church of Sculcoates, a space of about two miles. It stretches nearly as far in another direction, from the High Street on the river Hull towards Beverley, Anlaby, and Hessle. The dock, or artificial harbour, divides the town into two principal divisions. The one to the north of the dock belongs to the parish of Sculcoates, and is without the original boundaries of Hull. It consists of several very spacious streets, which have been built chiefly within the last thirty years. The principal streets of Hull are clean and spacious, and the whole town is paved, flagged, and lighted.

The public buildings of Hull are numerous but by no means elegant. The Trinity church, which was partly built about the year 1312, is a magnificent and beautiful structure, built in the Gothic style. It occupies a space of 20,056 square feet. It extends 279 feet from the west door to the east end of the chancel. The nave is 144 feet long, the breadth of the transept 28, and the length of the chancel 100. The breadth of the nave is 72 feet, and the breadth of the chancel 70 feet. St Mary's church, commonly called the Low church, was built a few years later than the preceding. Its length is 74 feet, and the height of the steeple 74 feet. St John's church, a neat and simple brick building, was erected at the sole expence of the Rev. Thomas Dikes, and finished in 1792. It is 86 feet long, and 59 broad. It is wholly built upon arches, raised seven feet above the surface, and contains more than 70 vaults for burying the dead. The town contains several places of worship belonging to the three denominations of dissenters, to the Methodists, and other sectaries. The Methodist chapel in Waltham Street is spacious and elegant.

Among the charitable institutions of Hull, that of the Trinity-house is the most ancient. It was established in 1369 for the reception of decayed seamen who have been admitted members of the institution; but it has, for many years past, been set apart for the widows of such seamen as have attained the age of fifty. In 1787, the Trinity-house built an hospital for decayed seamen and their wives; and in the same year, they founded a marine school, for preparing boys for the sea service. Thirty-six boys are now educated at this seminary, each member of the corporation appointing one. They continue at school three years, and are annually clothed in a neat uniform. The present house was erected in 1753, and is of a quadrangular form, inclosing a spacious area. The different apartments, and the curiosities which they contain, are well worthy of being examined.

The Charter-house Hospital was founded by Michael de la Pole in 1384, for the support of poor pensioners, under the superintendance of a master. It is a plain building, with two projecting wings, and is built of handsome brick covered with blue slate. It contains 44 apartments, well fitted up for the accommodation of the pensioners, who are allowed 3s 6d. per week each, besides coal, turves, and occasional payments. The chapel, which is spacious and neat, is in the body of the building. The minor charities are, Lister's Hospital, for the reception of 12 paupers; Gregg's Hospital; Crowle's Hospital, for 12 paupers; Watson's Hospital, for 14 poor; Gee's Hospital; Harrison's Hospital; and Ratcliffe's Hospital.

The Charity Hall or Work House was established in the reign of King William III. The house is decent and commodious, and has a house of correction adjoining to it.

The public charities supported by voluntary contribution are very numerous. The General Infirmary was established in 1782 upon the most liberal and humane principles. The building is of brick, ornamented with stone, and is neat and handsome. It is situated in a healthy spot, and can accommodate seventy in-patients. The ranges of wards open into a long, wide, and airy gallery, for the purpose of obtaining a perfect ventilation. The total number of patients admitted between 1782 and 1816 is 15,129, of whom 11,248 have been cured, and 193 greatly relieved. The total number of persons vaccinated up to January 1, 1816, is 5,569

The Lying-in Charity appears to have been established about 1802. More than 4,281 patients have been admitted since the 5th April 1802, and the number of children born 4,314. The Hull Female Penitentiary was opened in July 1811. More than 100 females have been admitted, and a great proportion of these have been restored to their friends. The Hull and Sculcoates Dispensary has been recently established, and a Humane Society for the recovery of persons apparently dead was founded in 1800.

The *Grammar School* of Hull was founded and endowed in 1136 by John Alcock, Bishop of Ely. The School Room is esteemed one of the best in England. The *Vicar's School* is a free institution, founded in 1734 by William Mason, vicar of the parish, and the father of the poet, for the education of 60 scholars. Coggan's Charity School educates 20 poor female children. Besides these, there are subscription schools in Salthouse Lane, which originated in 1786. They consist of two day schools for girls, each containing 30, and four Sunday schools for boys. The buildings are capacious, and no fewer than 250 boys and 150 girls are educated here on Bell and Lancaster's system.

The other public buildings at Hull, are the citadel, the exchange, the custom-house, the theatre, the gaol, the Hull subscription library, &c. The *citadel*, intended for the defence of the harbour and town, is situated on the east bank of the river. The ancient castle, called the Magazine, is a mere storehouse for arms and ammunition. A battery of 21 guns faces the Humber, and the embrasures on the mounds are well furnished with cannon. The citadel is surrounded with a ditch palisadoed in the middle. The garrison generally consists of a few companies of invalids. The exchange was opened on the 1st of January 1794. It is a brick building on a most substantial plan, with a spacious flagged area in front of it. The public subscription news room is above the exchange. The custom-house is a spacious and handsome building, situated in White Friar Gate. The theatre, erected in 1809, is a large building in Humber Street. The present gaol, which contains very healthful accommodations, was erected in consequence of an act of parliament passed in 1789. The Hull subscription library was instituted Dec. 6, 1775; and the foundation stone of the present building in Parliament Street, was laid on the 21st of June 1800. The library possesses a spacious reading-room, which is open to the subscribers every day. The collection of modern books is excellent, and the number of subscribers is nearly 500.

The avenue from the market-place to the Humber was widened some time ago, by removing the guildhall, on the site of which the most elegant and well ventilated shambles were erected in 1806. The east end of Trinity church is thus exposed to the market-place, in the centre of which is a beautiful equestrian statue of King William III. erected in 1734 by subscription, and executed by Mr Sheemaker.

Hull may be considered as one of the first commercial towns in the united kingdom. It carries on a great intercourse with the Baltic, and sends an immense number of ships annually to the whale fishery.

The wet dock, which was originally intended to receive all the ships engaged in the trade of Hull, was begun in virtue of an act of parliament passed in 1774. The foundation stone was laid on the 19th Oct. 1775, and the whole was completed in four years instead of seven, as required by the act. Government gave a grant of the ground, and of £15,000. It occupies the place where the walls and ramparts once stood, and it enters immediately from the river Hull, about 300 yards from its mouth. It is 700 yards long, 85 wide, 22 deep, and is capable of containing 130 vessels of 300 tons. Including the wharfs and quays, it covers an area of 13 acres, the area of the dock being 48,188 square yards, and that of the quay 17,479. The subscribers are incorporated under the title of the "Dock Company at Kingston-upon-Hull." The number of shares was originally 120; but acts were passed in 1802 and 1805, empowering the Company to raise them to 180. The money arising from this increase in the number of shares, amounting to £82,390, was appropriated to the construction of another wet dock, called the Humber Dock.

The foundation stone of the Humber Dock was laid on the 13th April 1807, and it was completed in 1809, at the expence of £220,000. The area of the dock is 7 acres and 13 perches, and that of the road and wharfs is 3 acres and 33 perches, amounting in all to 10 acres 1 rood and 11 perches. It opens into the Humber by a lock, which will admit a fifty gun ship, and which is crossed by an iron bridge. By extending the dock a little farther to the north, to the extremity of White Friar Gate, the old town may be completely insulated. Hull possesses also several dry docks for repairing vessels. The following Table, shewing the amount of the customs in different years, will exhibit a correct view of the progress of the trade of Hull.

1701	£26,287	1805	£386,070
1778	78,229	1806	374,907
1785	91,366	1807	340,825
1792	199,988	1808	198,487
1802	438,459	1809	276,811
1803	379,675	1810	311,780
1804	287,210		

The following Table exhibits the state of the Greenland fishery, from 1806 to 1811 inclusive.

Years.	Ships.	Whales.	Seals.	Unicorns.	Bears	Sea Horses.	Tons Oil.
1806	37	239	1804	10	3	6	3382
1807	35	377	722	24	9		4233
1808	27	467	552	13	4	2	4330
1809	26	419	311	9	7		4230
1810	34	449	1238	8	13		4912
1811	42	552	993	2	2		4782

The inland trade of Hull exceeds that of any other English port. In the year 1792, merchandise, stores, coals, &c. to the value of £5,156,998, were conveyed to and from the Aire and Calder navigation alone.

The following Table contains the number of ships that entered inwards and cleared outwards, from 1804 to 1810 inclusive.

Years.	With Cargoes.		In Ballast.		Coasting Vessels.	
	Inw.	Outw.	Inw.	Outw.	Inw.	Outw.
1804	728	279	51	380	1560	1547
1805	658	232	47	327	1626	1602
1806	513	226	29	272	1576	1636
1807	525	158	9	335	1484	1614
1808	207	67	109	135	1557	1733
1809	473	256	55	223	1806	1938
1810	622	193	30	427	1786	2033

Various manufactures are carried on in Hull. One of the principal is the expressing and refining oil from lintseed, and preparing the residue for feeding cattle. Many of the mills for this purpose, and for grinding corn, are from about 80 to 100 feet high, and contain excellent machinery. The other manufactories are an iron foundery, a large soap-work, two sugar-houses, several white lead manufactories, several breweries, and several ropeworks and ship-builders yards.

The civil authority of the county of Kingston-upon-Hull, which includes a district of more than 18 miles, comprehending the villages of Hessle, Anlaby, Kirk Ella, West Ella, Swanland, and North Ferriby, is vested in the corporation, consisting of the mayor, the recorder, the sheriff, two chamberlains, and twelve aldermen. The town sends two members to parliament, who are elected by the burgesses.

The following is an abstract of the population returns for the town of Hull in 1811:

Number of inhabited houses	4611
Do. of uninhabited houses	306
Do. of families	6541
Do. employed in agriculture	305
Do. employed in trade and manufactures	2608
Do. not included in any of these classes	3628
Males	11,998
Females	14,794
Total population	26,792

See the *Guide to Hull*, published by Mr Craggs, who has favoured us with the proof sheets of it before it was published; Tickhill's *History of Hull*; and the *Beauties of England and Wales*, vol. xvi. p. 447—537.

HUMBER, the *Abus* of Ptolemy, is a large river or estuary in England, which runs into the German Ocean after separating the counties of York and Lincoln. Below the confluence of the Ouse with the Trent, the former of which carries off almost all the waters of Yorkshire, the united streams receive the name of the Humber. It is gradually enlarged to the breadth of two or three miles, and below Hull it swells into an estuary about six or seven miles broad. The Humber has been compared to the trunk of a vast tree, spreading its branches in every direction, and commanding the navigation and trade of a very extensive and commercial part of England. See ENGLAND, Vol. VIII. p. 687, 688.

HUME, DAVID, an eminent historian, metaphysician, and general literary character, was the younger son of a very respectable Scottish family, and was born at Edinburgh on the 26th of April 1711. He lost his father when an infant, and the care of his education devolved on his mother, whom he describes as a woman of great merit, who performed in a most exemplary manner the duties of an only parent. In his youth he made a creditable appearance as a scholar, and acquired a high ardour for literature. This did not, as often happens, subside as soon as those more serious occupations to which, in the common calculations of mankind, literature is reckoned preparatory and subservient, were presented to his mind. His fortune being slender, he was destined to the profession of the law. But this pursuit, with all the prospects of honour and wealth which it presents to an aspiring mind, had not for him sufficient charms to eclipse the attractions of classical literature and philosophy. Nor was Mr Hume even content to cultivate the two pursuits in conjunction, the one as the means of his future livelihood, and the other as having a more immediate relation to man as a thinking being. The contrast of their intrinsic character had the effect of disgusting him with the study of law, which he wholly neglected in order to devote himself to literature. He therefore renounced entirely these professional pursuits. Not entertaining the hope, however, of supporting himself comfortably by literary occupations, he was prevailed on, at the age of twenty-three, to make a feeble attempt to enter on a mercantile employment in the city of Bristol. This he soon relinquished as totally unsuited to his turn of mind; and at last, combining a regard for his favourite studies with the dictates of prudence, he formed a plan for leading the life of a literary man. He resided for two years in France, first at Rheims, and afterwards at La Fleche in Anjou, where he practised a strict economy, and prosecuted with much industry his literary studies. In this retreat he probably had not access to extensive libraries, and depended chiefly on a small collection of his own, with such assistance as was furnished by the convents of the country. Here he was chiefly occupied in the composition of that ingenious, but singular and somewhat paradoxical work, his *Treatise on Human Nature*. He acknowledges that, in the midst of these studies, he was not certain of the utility of his labours, and was in some measure puzzled by the interminable problems which his own ingenuity had raised; yet he gave himself up to the bent of an inquisitive mind, regardless of conclusions, trusting that investigation, if free from bias, could not be too keen or persevering, and that all its apparent disadvantages must be accidental and temporary. He studied human nature in a point of view which was in a great measure his own, without consulting the prevailing taste, either in the choice of his subject, or in the style and manner in which he chose to handle it. He has been accused of a passion for singularity; but we find him in this instance regretting, that opinions which he found inevitable were so different from those which prevailed around him. He published his treatise in London in 1738, and then returned to his friends in Scotland. But all the visions of a sanguine author were now severely mortified. He had been prepared to encounter opposition and outcry. These he expected, and he seems to have pleased himself with contrasting his own unanswerable theorems with the shallow replies which would be zealously and from numerous quarters elicited. But his work excited no interest; it was neither known nor read, and, as he himself expresses it, "fell dead born from the press." He continued, however, to value the opinions which it contained; and endeavoured, by various persevering efforts, to conciliate to them the public attention. The admirers of his metaphysics reckon it the most profound of his works, and consider his subsequent writings on the same subject as losing in depth what they gained in popularity of manner.

His disappointment, though keenly felt, was surmounted by a cheerful and sanguine temper; and he prosecuted, with renewed industry, his literary labours in the country. In 1742, he published the first part of his *Essays*, which met with a reception sufficiently favourable to console him for his first disappointment. In 1745, he resided as a companion to the Marquis of Annandale in England for twelve months; and, from his appointments during that time, acquired a considerable accession to his small fortune. About this time the professorship of moral philosophy in the university of Edinburgh becoming vacant by the resignation of Dr (afterwards Sir John) Pringle, Mr Hume became a candidate for that situation; but the sceptical principles which he had advanced in his first work were too offensive to allow the magistrates, who were the patrons, or those learned persons whom they consulted, to receive him as a public instructor of youth, and that application was consequently ineffectual.

In 1746, he accompanied General St Clair, as his private secretary, in an expedition destined for Canada, which terminated in an incursion on the coast of France. In 1747, he attended the same gentleman in his military embassies to the courts of Vienna and Turin. From this cause his literary occupations were suspended for two years; but he enjoyed with much relish that polished society which he highly ornamented, and in which he was a general favourite. At this time he attempted to give a more popular form to his first speculations, in a work entitled *An Inquiry concerning the Human Understanding*; which, however, had little better success than the original *treatise*. A new edition of his *Essays* was also published, which met not with a much better reception. Mortified in some degree, but not discouraged, by these miscarriages, he continued his efforts to rouse the attention of the world to his favourite subjects. He had now returned to his brother's house in Scotland, where he composed his *Political Discourses*, and his *Inquiry concerning the Principles of Morals*. His opinions had gradually worked themselves into notice; an effect which the plausibility of his reasonings, the charms of his language, and the importance of the subjects, could not fail to produce. Being adverse to the prevailing philosophy, as well as bearing strongly on the religion of the age, and considered by many persons as alarming in their tendency, they could not, of course, be permitted to extend their influence, without having their validity subjected to the most rigid scrutiny. Mr Hume, either unalterably confident in the justness of his views, or considering them as less important than his fame, was principally disposed to look on the appearance of a succession of replies as flattering symptoms of his rising reputation, and derived from them encouragement to proceed in his career. In 1752, his *Political Discourses* were published. This was the first of his works which gained immediate attention, and general approbation. He also now published his *Inquiry concerning the Principles of Morals*, a work which met with little notice, though more highly valued by the author than any other. It appeared to correspond too much with the sceptical principles of his other writings on moral subjects, by referring all moral distinction to utility. It certainly, however, displayed much acuteness of research, and contributed to remove much of the rubbish by which questions of this nature had been encumbered. The dangerous character which Lord Kames, and some others of his opponents, attached to a theory which reduced all moral differences to utility, as leaving them to the arbitrary decisions and varying judgments of individuals, is more or less applicable to every theory on the subject. The agreement or disagreement of mankind on particular moral questions is rather matter of fact than of theory. The apprehensions of any dangerous tendency attached to the theory of Mr Hume, imply, in their most obvious sense, a contradiction in terms. Utility is, in itself, real and precise, however obscurely understood; and in its every essence excludes all idea of danger. We have, indeed, heard particular acts represented as inculcated by utility, while their danger was capable of being painted in the most convincing terms. These arguments only prove, that the character of utility may be rashly applied, while some circumstances essential to it are omitted. Utility, indeed, is not a simple original principle. It is a general feature applicable to a variety of phenomena, among which human actions are to be numbered; and even with those who grant that there are prior principles of our nature which serve to suggest moral distinctions, all such suggestions must be allowed to become the subjects of computation; and in all discussions of the propriety of particular actions, utility is the ultimate test to which we are referred, and is necessary to stamp them with the character of rectitude.

In the same year, he was made librarian to the Faculty of Advocates of Edinburgh, a situation which not only gave him command of the invaluable library belonging to that body, but forcibly directed his attention to the character of the works which it contained. It was now that he began to write his *History of England*, that highly pleasing performance, which, however censured in some of its parts and tendencies, is read with delight by all classes of persons, and does high credit to the country which gave birth to its author. The first volume that was published, commenced with the accession of the house of Stuart, and contained the reigns of James I. and Charles I. It appeared in 1754. The public, however, were not so easily won by the splendour of his narrative, and that air of easy philosophy which dictated the remarks of the historian, as to give any quarter to his obnoxious sentiments. He offended the Christian world, by treating religious systems too lightly, and even the advantages which this characteristic might at first seem to promise to the spirit of toleration were found to be coldly withheld. His displeasure is chiefly directed against the complaints, and even the non-conformity of the people; and he palliates in the conduct of princes all deviations from patriotism and law, as well as that offensive arrogance which set at nought the object of general satisfaction. He construes the slightest incongruity in the complaints of the nation, which was capable of being turned to ridicule, into a vindication of the most arbitrary and intolerant conduct on the part of the sovereign. The party questions relating to the rights which king or people respectively derived from precedent and law, were of much less moment than the spirit in which the contending parties maintained their point. Appeals to the original and universal rights of man are reckoned dangerous, as being subject to the widest differences of opinion, and therefore *precedents* in favour of liberty had been chiefly appealed to by the Whigs. Precedents, however, were to be found on both sides; and Mr Hume points out the shallowness of any pretence to make the ultimate decision of great and general questions in politics depend on them. It is with the degree of correctness and generosity of the spirit in which the king and the people approached to one another for the adjustment of their differences, that an unbiassed historian is chiefly concerned in measuring to each party his share of approbation and of censure. This was certainly so offensive and unconciliating on the part of the Stuarts, as to amount to a forfeiture of all submission, and even of all sympathy from the party which they laboured to crush. That the dissensions of the times rendered the duties of a sovereign arduous must be acknowledged, and strong measures might have been on some occasions necessary. But the measures of these princes had neither the merit of strength, nor the inoffensiveness of total inactivity. They were both irritating in their tendency, and destitute of efficiency. The exertion of a despotic authority, if evidently directed to ends substantially good, might have saved the country, and preserved the dynasty. But the Stuarts made their right of power a matter of ostentation rather than an instrument of good government, and thus insulted the nation instead of ruling it. There were errors on all sides. The people were often fanatical, and their complaints were sometimes inconsistent. All these facts should come alike under the scrutiny of the historian. But the plausible coolness of Hume degenerates into a cavalierly insensibility: his sarcasms are directed only against the great mass of the nation, while his sympathetic feeling and indulgence are reserved for kings and their ministers.

Dr Herring and Dr Stone, the one primate of England and the other of Ireland, were the only persons from whom the author heard favourable sentiments of his work. Both of these gentlemen wrote to him not to be discouraged. The impression made on his mind by the unfavourable reception of his work was however very deep. Although on looking to the periodical publications of that day, we find the due tribute repeatedly and even liberally given to his merits as a writer, he seems not to have been at all prepared to meet with any opposition or neglect. He shewed on this occasion the overweening importance which authors are disposed to attach to their own powers, and how little they calculate on the difficulty of making any impression in opposition to the general sentiments of the public. He confesses that his mortification would have now determined him to retire to a corner of France, to change his name, and never more revisit his native country, had not a war breaking out between the two nations prevented the execution of any such scheme.

He next published his *Natural History of Religion*, which was attacked with considerable acrimony by Dr Hurd, and, though otherwise not much attended to at the time, produced at a subsequent period no slight sensation in the religious world, as tending to reduce the general principles of religion to an uncertain and even a frivolous origin in the human mind.

A second volume of the History of England, which brought it down to the revolution, was published in 1756. This, containing fewer obnoxious sentiments, was better received than the first, and even served to impart to it a degree of adventitious character.

In 1759, he published his *History of the House of Tudor*. In this publication he displayed considerable address in supporting his Tory principles. While he details facts which demonstrate the duplicity of the character of Elizabeth, he gives her a character far higher than these facts can warrant. At the same time he describes her conduct, as well as that of her predecessors of the same family, as so offensively harsh, that the maxims of the Stuarts, reckoned by many tyrannical, must on the contrast appear mild and liberal. He neglects to give the due weight to the beneficial tendency and the magnanimous justice which marked some of her most arbitrary acts, and the activity which she displayed in managing the vital interests of the state. These characteristics were widely different from the vexatious and idle exaction of reluctant homage which the Stuarts delighted to make from their subjects. Habit had now rendered Mr Hume callous to the impressions of public opinion, which he affected to despise; yet he owed his equanimity in some measure to the increased forbearance of his opponents, and the tribute of admiration which some of his qualities as a writer extorted from all. In 1761, he published the two volumes which contain the earlier part of the English history. The copy money given to him by the booksellers much exceeded any thing of the kind formerly known in England, and his circumstances were in consequence rendered opulent.

At this time a storm of ecclesiastical censure was preparing by some members of the church of Scotland, directed against Mr Hume, and intended to include Lord Kames, and various other writers, who, though differing in their opinions, agreed in treating religious subjects with coolness, and subjecting them to metaphysical analysis. A motion was made in the *committee of overtures* of the General Assembly, in which Mr Hume was named as the most obnoxious author. It was proposed to call him before that court, to answer a list of accusations, on the tendency of the principles which he had published. This, however, was afterwards abandoned, as it was supposed that the influence of such discussions was limited to a narrow circle, and that there could be no propriety in extending them to the common mass of readers, who might, from the sympathy naturally felt for a man subjected to violent opposition, be led to an undue bias in favour of his opinions.

In 1763, he attended the Earl of Hertford on his embassy to Paris, where he was loaded with great civilities. He expresses himself highly pleased with the politeness and information which characterised the society of that metropolis.

In 1766 he returned to England, and then to Edinburgh. On this occasion he brought with him the celebrated Rousseau, who was exposed to some trouble in Switzerland and France, for the opinions which he had published on religious subjects, and had it in contemplation to take up his abode in a retired situation in England. Mr Hume, admiring his genius, and attached to him by fellow feeling as a free-thinker, exerted himself to provide for his comfort. But the morbid sensibility of Rousseau disappointed every scheme of kindness that could be adopted. He conceived himself to be neglected by the world, and was prone to suspect his best friends of intending to undermine his interests, and subject him to ridicule and scorn. Mr Hume soon perceived the troublesome temper of his friend; yet he treated him with great tenderness, making allowance for an excess of natural irritability, heightened by a severe bodily disorder under which he laboured. He even found that one of his complaints, that of extreme poverty, was an entirely false pretence, held out for exciting the interest of others. These frailties Mr Hume deplored, but did not cease to do what lay in his power to serve him. At last Rousseau suspected Mr Hume of being the author of a very improper sarcastic letter, which was circulated in the name of the King of Prussia as addressed to Rousseau, and was the work of Mr Horace Walpole. Suspicions of all kinds accumulated in his gloomy mind, till they burst forth in a storm of invective in the form of a long letter to Hume. To this Hume published a reply by the advice of the Parisian literati, though contrary to that of Mr Walpole, who thought Rousseau's letter a sufficient answer to itself, and the whole business unworthy of notice. Nothing could have rendered it necessary to answer an effusion so absurd, and so evidently the offspring of disease, except the celebrity of Rousseau, the interest which his admirers took in every thing he did and felt, and their disposition to vindicate the most far-fetched of his insinuations as the dictates of sentiment and sagacity, and to reiterate with zeal his reproachful complaints against other less favourite characters. This friendly connection was thus inevitably dissolved. Every part of it bore testimony to the humanity, tenderness, and sincere friendship of Mr Hume, who, far from neglecting to make due allowances, seems to have exceeded the ordinary limits of human patience.

In 1767, he was invited by Mr Conway to be under secretary of state; a situation which he accepted and held till 1769, when he returned to Edinburgh.

In 1775, his health began to decline. He was attacked with a disorder in his bowels, which gradually increased, and which he perceived at last, at the time that he drew up his short account of his life, to be mortal and incurable. But he continued his former occupations and amusements, and enjoyed unabated good spirits both in his private studies and in company. He lived in a house in James's court in Edinburgh, surrounded by the friends whom he most highly valued. The literary society of Edinburgh at this time contained a few men of the first genius and talent, along with many other persons who made the various objects of liberal study their principal delight. Dr Robertson, principal of the university, the historian, was one of the most eminent, and, notwithstanding the wide difference of opinion which existed between him and Hume on the most important subjects, yet as all hope of proselytism on either side was cut off, they avoided all disputes which tended to agitate the passions, and by mutual consent enjoyed the pleasure and improvement which in other respects they were fitted to impart to one another. The zeal of Dr Blair prevented him from being equally circumspect; and Hume found himself obliged to intimate to that worthy clergyman the necessity of abstaining from all topics which implied serious differences of sentiment, if they were ever to enjoy one another's society. This is decidedly though delicately expressed in the letter which he wrote to him, after the perusal of the work of Dr Campbell on Miracles, which Dr Blair had sent to him. Dr Joseph Black, the celebrated professor of chemistry, and Dr Adam Smith, were among the most intimate of his friends. The latter, however, was now engaged in the composition of that work which has associated his name in an indelible manner with the great interests of society, his *Inquiry into the Nature and Causes of the Wealth of Nations*, and lived in a state of retirement with his mother at Kirkcaldy, a town on the opposite shore of the Frith of Forth. This separation was vexatious to Hume, who often ineffectually urged his friend to take up his residence in Edinburgh. They had both written on the origin of moral ideas; they had embraced different opinions, and found it interesting to make the discussions implied in them part of the subject of their conversation. They were both ready to enter on any subject to which the ingenuity of either was directed, and a delightful diversity of topics was undoubtedly suggested by the fates, characters, and all the *memorabilia* of many literary friends, whom on former occasions, and in different parts of the country and of Europe, they had known. Lord Kames, Mr Smellie, Allan Ramsay the painter, (son of the Scottish poet,) were also among the number of the literati who, in the days of Hume, adorned the circle of this metropolis. The manners of literary men were particularly easy, and they had the character of great frankness and ready accessibility. No cause of political enmity operated as a source of division; differences of religious opinion were tempered in their expression by good manners; the facility of intercourse was not obstructed by affectation, or a harsh incommodious etiquette; literary controversies and private debates were managed without occasion of offence. If any excess existed, it seems to have been on the side of familiarity, which admitted of an indulgence in a coarse species of raillery. From this school issued the following curious sentiment, to be found in Lord Kames's *Art of Thinking*: "You are a fool, you dream, and such like, are expressions we may easily bear from friends. Among free spirits I love freedom. Let the words go the full length of the thought. In a manly society, familiarity is agreeable, because it has nothing effeminate or ceremonious." These manners may be consistent with correctness when of spontaneous origin; but when recommended and studied, they become flat and unmeaning. Familiarity degenerates into insipidity, and those who have indulged it begin to envy the ceremony which, though at first stiff and forbidding, preserves mutual respect, and obviates the cloying influence of extreme freedom. Men oscillate from one inconvenient bias to another, and those who can do it without going far into either extreme are the most happy. Such, in general, is the literary society of Edinburgh. Sober convivial clubs of men of taste and genius have at different times been formed, some of which have been supported with much greater steadiness than the precarious nature of such institutions renders generally practicable. They are soon broken up by the admittance of unaccommodating characters, and on the other hand, they are apt to lose the stamp of liberality when conducted on a principle of fastidious selection. It is therefore chiefly by a quick succession of them formed by the buoyant spirit of liberal sociality readily surmounting occasional causes of separation, that they prove agreeable and useful.

The philosophical opinions of Mr Hume subjected him to many controversial attacks. To these he never published any formal reply, but satisfied himself with making occasional private observations, and availing himself of public criticism for amending his works in subsequent editions.

In the manner in which he expressed himself towards those who wrote against him, he shewed himself extremely sensible to the pleasing influence of civility, and the galling effects of disrespect or rudeness. He was pleased with Dr Campbell's *Essay on Miracles*, and with an anonymous tract, entitled, *A Delineation of Morality*, written by Mr Balfour, an advocate and professor of moral philosophy. But such severities as those of Hurd, Warburton, and Beattie, teeming with petulance and abuse, produced in his mind the strongest feelings of alienation and contempt. His good humour probably too much depended on the cultivation of that radical hauteur which sometimes forms the man of fashion, and was too little cherished by that steady forbearance and that system of universal allowances which would have better suited the character of a philosopher.

The progress of his bodily disorder was rapid. In April 1776, he set out for London at the intreaty of his friends, who hoped that a long journey might improve his health. At Morpeth he met with Dr Adam Smith, and Mr Home, the author of the tragedy of Douglas. The latter remained with him in England, while Dr Smith returned to the north. Mr Hume finding himself seemingly improved when he arrived in London, went next to Bath to drink the waters, which contributed still farther to a temporary recovery. But his complaint relapsed with additional violence, and he returned to Edinburgh under a deliberate expectation of soon finishing his days. He employed himself in correcting his works, reading books of amusement, and conversing with his friends. He encouraged his friends to speak to him in the frankest manner as to a dying man. It is evident that he did not entertain a belief in any future state. Yet the constant expressions of a hope of this sort which a man is accustomed to hear in the course of early education, and in the common intercourse of life, render the mind familiar with an imagery founded on that hope to which the most sceptical occasionally recur for amusement, even while they reject a belief which appears to them incongruous. Some of them playfully indulge in supposing themselves to have been imbued with the belief of a mythology belonging to a different age or country, and thus balance the influence of present systems against that of others. Mr Hume had too much respect for society to indulge in any open scurrility directed exclusively against the religious sentiments of the age: but he playfully retailed the conversations which were likely to take place between himself and Charon, the ferryman of the river Styx, at the moment of his transit from the present to the unknown world. He did not affect any great wish to speak on the subject for the purpose of displaying his indifference or his courage, and only touched on it occasionally in reply to the enquiries of his friends. His strength very gradually declined. When no longer able to converse, he continued to read in a state of composure; and after four or five days passed under this degree of debility, he died on the 25th of August 1776.

In stature Mr Hume was above the ordinary size. His countenance was open and free, a just picture of his benevolent and cheerful temper. His features were large, and were exempt from that trifling smartness and habitual intensity of expression which characterise a bustling fashionable ambition. Lord Charlemont on this account considered them as blank and unmeaning, and wondered that the ladies at the court of Turin valued so much his company and conversation. His attractions seem to have consisted in the liberality of his mind exhibited in the jolly openness of his countenance. See Hardy's *Memoirs of Lord Charlemont*, and the critique on them given in the *Edinburgh Review*.

The manner in which he died has sometimes been made the theme of injudicious comment, for the purpose of elucidating the merits of particular views of philosophy or religion. The equanimity displayed in his last moments has been boastfully represented as a triumph to infidelity, and a proof that a philosopher may die in tranquillity. Such were the sentiments inculcated in a tract entitled, *An Apology for the Life and Writings of David Hume.* But the eagerness with which a single instance of this kind is grasped at might be plausibly construed into a presumption of the general fallacy of the remark. On the other hand, it is equally unfavourable to candour to embrace, with exclusive keenness, those anecdotes, whether well or i supported, which represent persons of these sentiments as doomed to the agonies of remorse in the hour of death. This spirit has given rise to some misrepresentations of fact, which fall under the character of pious frauds. We are told, that though a man may lead the life of a fool, by advocating the cause of Deism, yet a fool he cannot die; and then an anecdote is told of some noted infidel, which bears the marks of evident fabrication. That this direction of zeal is wholly superfluous and inefficient in the support of religion, we may be satisfied, when we reflect, that such anecdotes are only circulated concerning those who are infidels by profession. It is maintained that many who, from motives of policy, apparently acquiesce in the religion of the age, do not believe it in their hearts. Such persons might be supposed to labour under the double weight of infidelity and hypocrisy; yet we hear nothing of their death-bed agonies. Allowing, therefore, facts of that kind to which we have alluded to be as general as they have been sometimes represented, they must be otherwise accounted for than by being considered as the unmingled effects of the power of truth on the human conscience. They will be explained in a more satisfactory manner, if ascribed to the influence of that contrariety which an individual of solitary professions feels between himself and the rest of society, oppressing a mind bereft of its energy by the decay of nature. Weak man, even in his most vigorous moments, needs company to support him in the enjoyment of his opinions; and the influence of this principle enters much deeper into the private comfort of individuals than most men are willing to allow. We should always beware of resting questions of so grave moment on data thus precarious.

The character of David Hume as a man has been variously estimated. About his agreeable qualities there could be no difference of opinion; and those who abhorred his principles allowed that he possessed as much worth as was compatible with infidelity. The chief difference, therefore, depends on the amount of that degree of praise. One tells us that he was a pattern of good humour, benignity, and self-command;

and as near to perfection as the lot of humanity will admit. Such is the character assigned him by his friend Dr Smith. Another writer says, we may find fault with the measure of his faith, but we cannot deny him the credit of good works. To this Bishop Horne replies, that the promotion of religion is the best of works; and a conduct the reverse of this the worst and most infamous. As for religious principles, and every quality that is strictly implied in them, Mr Hume's character must be given up: and if such terms as virtue, morality, and goodness, are to be so restricted, he cannot be allowed the credit of them. But if we take such words in the sense in which they have been used by the world at large, and by men who scarcely entertain any religious knowledge or sentiment, we must acknowledge Mr Hume to have been honourably distinguished from the great mass of mankind, whether infidel or religious. Some have remarked, that, by his own confession, his ruling passion was the love of fame, and that this is at best a selfish principle. The validity of this reflection involves a question concerning the comparative propriety of preferring the ends of self-love or the good of others in adjusting the motives of human conduct. We seldom object to a man's character because he has a ruling passion, although it should not be the most dignified in its nature. With regard to selfish ends, even a man who enters on holy orders is allowed to be possessed of real worth, though his chief motive is the procuring of a living, provided he is attentive to his professional duties: and some of our gravest and best moralists represent the cultivation of a fund of internal happiness as the first duty of a man, and a far more copious source of benignant conduct than could be formed by cultivating social feelings as the first and leading object of attention, and making personal happiness a subordinate consideration. With the amplest allowance for differences of opinion, and taking benevolence in the most accommodating acceptation which licentiousness itself could desire, possessing also the fullest conviction of Mr Hume's personal sincerity, we cannot consider the general strain of his philosophical writings as indications of a pure benignity, even though we should proceed on the hypothesis of the truth of his speculative views. They had an evident tendency to make many persons unhappy: hard struggles are required from an admiring reader to surmount this tendency,—struggles for which the author furnishes but feeble assistance. Though he entertained no belief in the most consoling doctrines which had been cherished among mankind, benignity would not have led him to begin with overturning them, but rather with showing that happiness might be enjoyed independently of them, and thus he might have been considered as contributing to the creation of habits of feeling which were more to be relied on for their permanence, and as labouring to prepare the mind more completely for the comfortable exercise of a curiosity free from controul. Yet by persons whose reading on these subjects is extensive, the works of Mr Hume may be read with advantage. The German philosophers, whose conclusions are the most liberal and pious, look up to Hume as an author who materially contributed to guide intellectual research, though his system stood in need of some ulterior steps to bring us to the truth; and they speak with great contempt of the data on which the British writers endeavoured to subvert his doctrines. We find such observations as these emanating from the school of Kant, which, though chargeable with obscurity, is not destitute of acuteness.

The censure which we have expressed is most of all applicable to two tracts published after his death, one *On the Immortality of the Soul,* and the other *On Suicide.* The former is little more than a compression of doctrines which he had advanced, or to which he had at least pointed in his other works, but expressed in more dogmatic language. His tract *On Suicide* contains an argument which he had not formerly touched upon; and it must be admitted to have a most pernicious tendency. We read without unpleasant emotions the sentiments which the Romans entertained on this subject, because they cultivated a species of manliness, mistaken indeed, but plausible, and apparently consistent. Mr Hume, on the contrary, encourages that temper which leads to suicide, not by cultivating a heroic contempt of death, but by laying the mind open to the most wretched discontent. He maintains that those whose happiness is marred by the gloom of superstition have the most urgent motives to rid themselves of life, yet are cruelly prevented by the dread which their belief of future punishment inspires. This remark, inculcated with all the zeal of apparent sincerity, tends to generate the utmost degree of moral confusion; and the motive which could have prompted any writer to commit such a sentiment to paper cannot well be assigned, except by referring it to the perverseness which is so incident to the human mind. If the superstitious are deceived in the dread which they entertain of suicide, they must also be deceived in entertaining a belief in those gloomy opinions which render their lives miserable; and a philosopher wishing to emancipate them from their errors, can have no reason for recommending suicide, since he relieves them from the evils which generated a weariness of life. The only tendency that such a sentiment can have, is, by superadding a new doubt to their former perplexities, either to produce a still more wretched life, or give rise to an act of suicide committed in a tumult of horror, and degraded by cowardice. Whoever the person was that published this posthumous piece, he could not have any motive that could bear examination.

It is as a historian that Mr Hume is most generally popular. The beauty of his diction, and the interest which his elegant turn of thought imparts to the course of events described, render it on the whole the most pleasing book of English history in our language. Many who are sensible of the faults formerly mentioned, do not substitute any other for it in their recommendations to general readers. It might perhaps be rendered less exceptionable in its tendency, and more valuable for common use, if accompanied with *corrective* notes, and references in the most faulty places to other authors. It would require much delicacy, however, to do this without spoiling the effect, by a harsh interruption of the current of the narrative, and an interference with the general spirit of the historian. Fox's historical fragment published uniform with some popular edition of it, would greatly contribute to render it worthy of general perusal, by correcting the distrust produced by the peculiar colouring of the author.

See *Hume's Life, written by himself,* prefixed to his History; Smellie's *Lives;* Ritchie's *Life of Hume;* and a variety of anecdotes scattered in different biographical tracts, as Professor Stewart's *Lives of Dr Robertson and Dr Smith,* Lord Woodhouslee's *Life of Lord Kames,* and the Memoirs of Mr Gibbon in his *Posthumous Works.* (*H.D.*)

HUMIDITY. See HYGROMETRY.

HUNGARY.

History.

Ancient seat.

Conquests before Christ.

THE Huns, from whom the kingdom of Hungary derives its name, are the Hiong-nau of the Chinese, and were a nation of Tartars, who had their ancient, perhaps their original, seat in an extensive barren tract of country, immediately on the north side of the great wall of China. But the valour of the Huns extended their dominions; and their chiefs, who assumed the appellation of Tanjou, gradually became the sovereigns of a formidable empire. Towards the east, their victorious arms were stopped only by the ocean. On the west, near the head of the river Irtish, their enemies were numerous: in a single expedition, twenty-six nations or tribes are said to have been subdued. On the side of the north, they are said, but on dubious authority, to have extended their empire to the ocean; it is more probable that the Lake Baikal was the limit of their conquests in this direction. Towards the south, they were most desirous of extending their empire; and, in the third century before the Christian æra, a wall of 1500 miles in length was constructed, to defend the frontiers of China against the inroads of the Huns.

Wars with the Chinese.

Mode of life at this period.

Their cavalry frequently consisted of 200,000 or 300,000 men, who managed their bows and their horses with matchless dexterity; they supported the inclemency of the weather with hardy patience; and marched with incredible speed, being seldom checked by any obstacle. The Chinese were unable to oppose them, or to protect their empire, notwithstanding the defence of the great wall. A regular payment of money and silk was stipulated as the condition of a temporary and precarious peace; and by a more disgraceful and degrading condition, a supply of women was annually given to the Huns; and the Tanjou was united in marriage with the imperial family of China. In the verses of a Chinese princess, who laments that she had been condemned by her parents to a distant exile under a barbarian husband, some particulars of the mode of life of the Huns at this period are given: she complains that sour milk was her only drink, raw flesh her only food, and a tent her only palace.

Defeated by the Chinese before Christ 87.

Dissolution of their monarchy, A. D. 48.

In the long reign of Vouti, the fifth emperor of the powerful dynasty of the Han, which continued for the space of 54 years, from the year 141 to the year 87 before Christ, the Huns were frequently defeated by the Chinese. About the year 87, the camp of the Tanjou was surprised in the midst of sleep and intemperance, and though he cut his way through the ranks of his enemy, he left above 15,000 of his troops on the field of battle. But the power and empire of the Huns were not weakened so much by their defeats, as by the policy pursued by the Chinese emperors of detaching the tributary nations from their obedience; and these generally became their inveterate and formidable opponents. The Tanjou himself was at last obliged to renounce the character and privileges of an independent monarch, and to perform the duty of a respectful homage to the Emperor of China. The monarchy of the Huns after this gradually declined, till, about A. D. 48, it was broken by civil dissension into two hostile and separate kingdoms. One of the princes retired to the south with eight hords, which composed between 40,000 and 50,000 families: he fixed himself on the verge of the Chinese provinces, and attached himself to the service of that empire. The Huns of the north continued to languish about fifty years, till they were oppressed on every side by foreign and domestic enemies. The *Sienpi*, a tribe of oriental Tartars, retaliated upon them their former injuries; and, in the year A. D. 93, the power of the Tanjous, after a reign of 1300 years, was utterly destroyed. The emigrations of the Huns now began: above 100,000 persons, the poorest of the people, were contented to remain in their native country, to renounce their name, and mix with their conquerors. Fifty-eight hords, about 200,000 men, retired towards the south, and claimed and received the protection of the Chinese emperors. But the most warlike and powerful tribes of the Huns sought more distant countries, and moved westward in two great divisions. The first of these colonies established their dominion in the fruitful and extensive plains of Sogdiana, on the eastern side of the Caspian Sea. Here their manners were softened, and even their features were sensibly improved; and they obtained the appellation of *White* Huns, from the change of their complexions. The only vestige of their ancient barbarism was the custom which obliged all, or nearly all, the companions who had shared the liberality of a wealthy lord, to be buried alive in the same grave. Their vicinity to the kingdom of Persia involved them in frequent and bloody contests, in the course of which they gained a memorable victory, but, unlike their ancestors, they were moderate and mild in their use of it.

History.

Their emigrations, A. D. 93.

White Huns.

Huns of the north-west.

The second division of the Huns gradually advanced towards the north-west; and, by their intercourse with tribes more savage than themselves, their native fierceness was exasperated. As late as the 13th century, their transient residence on the eastern banks of the Volga was attested by the name of Great Hungary. In the winter they descended with their flocks and herds towards the mouth of that river.

Different tribes.

Manners and appearance.

It is impossible to give even an outline of the history of the Huns from this period till they became known to the Romans; but there is reason to believe that the same force which had driven them from their native seats, still continued to impel their march towards the frontiers of Europe. In their first irruption into the Roman empire, they are mentioned by ancient historians under a variety of appellations, all comprised under the general name of *Ugri* or *Hunni*. The more general distinction, however, was the Nephthalite or White Huns, who possessed a rich country on the north of Persia; and the Sarmatian or Scythian Huns. The latter are exhibited to us under the character of savages, without faith, laws, or any form of religion; living in the open air without houses or huts, which they denominated the sepulchres of the living; quite unacquainted with the use of fire, their only food being roots and raw meat, and their only clothing the skins of animals. They were also distinguished by their broad shoulders, flat noses, small black eyes deeply buried in the head, and the want of beards. This race, inured to all manner of hardships and deprivations, and having no fixed settlements, were delighted with the first accounts which they received of the rich and fertile kingdoms of the west. Crossing, therefore, the Volga under Balamir, one of their chiefs, they overwhelmed the Alans and Goths, who inhabited the ex-

Establish themselves in Dacia in 376.

Invade the empire, but are defeated.

tensive country between the Volga and the Danube; and, having either driven them out, or forced them to submission, established themselves in Dacia in A. D. 376. Theodosius I. dreading their presence in the frontiers of the empire, and wishing to attach them to his service, encouraged many of them, by large sums of money, to enter into the Roman armies. They continued for some time in their new possessions without molestation to the empire till A. D. 391, when they passed the Danube, and, being joined by the Goths, committed dreadful ravages in Mœsio and Thrace.—They were soon stopped, however, by the army of Stilicho, the imperial general, who overthrew them with great slaughter, and would have completely destroyed them, had not Theodosius agreed to terms of reconciliation.

Their cruelties.

Not discouraged by their late disasters, they broke unexpectedly into the eastern provinces, penetrated as far as Antioch, destroying all with fire and sword, and committing everywhere unheard of cruelties. St Jerome, speaking of this irruption, says, "All the East trembled when the dismal news were brought, that swarms of Huns, coming from the far distant Mœotis, and dwelling between the frozen Tanais and the country of the savage Massagetes, flew up and down, and filled all places with blood and slaughter.—The cruel enemy roved without controul, where they pleased, preventing by their speed the report of their coming. They had no regard either to religion or dignity; no age they spared, nor were they softened by the tears of the crying infant; but put those to death who had scarce begun to live, and who, not apprized of their danger, smiled, when in their enemies' hands, at those very weapons that were immediately to destroy them." After having overrun and plundered several provinces, they returned home loaded with spoil, and carrying with them an immense number of prisoners. From this time they made regular incursions into the empire, always extending their settlements; and in 432, we find them in possession of Panonia, on the south side of the Danube. Their arms, however, were sometimes also employed in defence of the empire. They joined the army of Ætius against the Burgundians and Goths; but no sooner was their pay as auxiliaries withdrawn than they renewed their hostility, and Theodosius II. was compelled to buy a peace from Rouas their king, with an yearly pension of 350 pounds weight of gold.

Join the Romans against the Burgundians and Goths.

Attila.

Rouas was succeeded by his nephew Attila, the fiercest and most magnanimous of their kings. The countless nations between the Danube and the Volga obeyed his summons, and he became the terror alternately of the Eastern and Western Empires. The court of Constantinople complied with his demands with servile submission; but the court of Ravenna prepared to repel his inroads by force; and at the memorable battle of Chalons, Attila for the first time sustained a complete defeat, and was compelled to recross the Rhine before Ætius the Roman general. For the exploits of Attila, and the progress which the Huns made under his dominion, see ATTILA.

The entrance of Attila into his capital.

Some idea, however, of the manners and civilization of the Huns, during the reign of Attila, may be formed from the account which Gibbon has given us of the entrance of that monarch into his capital, and of the royal feast. "The entrance of Attila into the royal village was marked by a very singular ceremony. A numerous troop of women came out to meet their hero and their king. They marched before him distributed into long and regular files: the intervals between the files were filled by white veils of thin linen, which the women on either side bore aloft in their hands, and which formed a canopy for a chorus of young virgins, who chanted hymns and songs in the Scythian language. The wife of his favourite Onegesius, with a train of female attendants, saluted Attila at the door of her own house, on his way to the palace; and offered, according to the custom of the country, her respectful homage, by entreating him to taste the wine and meat which she had prepared for his reception. As soon as the monarch had graciously accepted her hospitable gift, his domestics lifted a small silver table to a convenient height, as he sat on horseback; and Attila, when he had touched the goblet with his lips, again saluted the wife of Onegesius, and continued his march."——

Royal feast.

"The Romans both of the East and of the West, were twice invited to the banquets, where Attila feasted with the princes and nobles of Scythia. Maximin (the Roman ambassador) and his colleagues were stopped on the threshold, till they had made a devout libation to the health and prosperity of the king of the Huns; and were conducted, after this ceremony, to their respective seats in a spacious hall. The royal table and couch, covered with carpets and fine linen, was raised by several steps in the midst of the hall; and a son, an uncle, or perhaps a favourite king, were admitted to share the simple and homely repast of Attila. Two lines of small tables, each of which contained three or four guests, were ranged in order on either hand; the right was esteemed the most honourable, but the Romans ingenuously confess, that they were placed on the left; and that Beric, an unknown chieftain, most probably of the Gothic race, preceded the representatives of Theodosius and Valentinian. The barbarian monarch received from his cupbearer a goblet filled with wine, and courteously drank to the health of the most distinguished guest, who rose from his seat, and expressed in the same manner his loyal and respectful vows. This ceremony was successively performed for all, or at least for the illustrious persons of the assembly; and a considerable time must have been consumed, since it was thrice repeated as each course was set upon the table. But the wine still remained after the meat had been removed; and the Huns continued to indulge their intemperance long after the sober and decent ambassadors of the two empires had withdrawn themselves from the nocturnal banquet. Yet before they retired, they enjoyed a singular opportunity of observing the manners of the nation in their convivial amusements. Two Scythians stood before the couch of Attila, and recited the verses which they had composed to celebrate his valour and his victories. A profound silence prevailed in the hall; and the attention of the guests was captivated by the vocal harmony, which revived and perpetuated the memory of their own exploits: a martial ardour flashed from the eyes of the warriors, who were impatient for battle; and the tears of the old men expressed their generous despair, that they could no longer partake the danger and glory of the field. This entertainment, which might be considered as a school of military virtue, was succeeded by a farce, that debased the dignity of human nature. A Moorish and a Scythian buffoon successively excited the mirth of the rude spectators, by their deformed figure, ridiculous dress, antic gestures, absurd speeches, and the strange unintelligible confusion of the Latin, the Gothic, and the Hunnic languages; and the hall resounded with loud and licentious peals of laughter. In the midst of this intemperate riot, Attila alone, without a change of countenance, maintained his stedfast and inflexible gravity; which was never relaxed, except on the entrance of Irnac, the youngest of his sons: he embraced the boy with a smile of paternal tenderness, gently pinched him by the cheek, and betrayed a partial affection, which was justified by the assurance of his prophets, that Irnac would be the future support of his family and empire. Two days afterwards the ambassadors received a second invitation; and they had reason to praise the politeness, as well as the hospitality of Attila."

A. D. 453.

Weakened by civil dissension,

On the death of Attila, Ellac, by the will of his father, succeeded to an extensive empire, which, however, was soon embroiled in civil war by the ambition of his younger brothers. They insisted upon an equal division of their father's dominions, and immediately took up arms to support their demand. This afforded a favourable opportunity to the nations that had been subjected by Attila to throw off the yoke. Ardaric, king of the Gepidæ, accordingly declared that he would no longer obey the sons of Attila; and other nations led by his example, hastened to join his standard. Ellac, who possessed both intrepidity and experience in war, marched against him with all his forces. The two armies met on the banks of the Netad in Panonia, where the Huns were utterly routed; and king Ellac fell in the field, after having performed prodigies of valour worthy of the representative of the great Attila. They afterwards received repeated defeats, both from the Goths and Romans, and were compelled to confine themselves to their own settlements for nearly sixty years.

and are compelled to confine themselves to their own settlements.

Again break into the empire in 539.

In 539, however, the Cuturgurian and Uturgurian Huns united, broke into the empire, and laid waste Thrace, Greece, Illyrium, and all the provinces from the Ionian sea to the very suburbs of Constantinople. They then retired without molestation, with immense booty, and 120,000 captives. The Uturgurian Huns proceeded to their own country on the Euxine Sea; but the Cuturgurians received lands in Thrace, and an annual pension from the Emperor Justinian, upon condition of their serving when wanted in the Roman armies. Unable, however, to restrain them from committing continual depredations in the neighbouring provinces, Justinian had recourse to the Uturgurians; and by means of presents, and offers of pensions, embroiled the two nations in a bloody war, which lasted many years, and by which they were so weakened, that they were long prevented from offering farther molestation to the empire.

A. D. 776.

From this time, no credible historian makes particular mention of the Huns, till A. D. 776, when the remains of this nation, reinforced by the Avars, and other northern tribes equally barbarous with themselves, and with whom they are frequently confounded by historians, seem to have recovered their strength, and we find them masters of Dacia, Upper Mœsia, and the two Panonias. Two of their princes sent ambassadors to Charlemagne, desiring his friendship and alliance. Charles received them with extraordinary distinction, and readily agreed to their request; but a misunderstanding afterwards arising between him and them, he entered their territories with two numerous armies, ravaged the country with fire and sword, the Huns being unable to keep the field against so powerful an enemy. After a war of eight years continuance, he reduced them to complete subjection, and built strong fortifications along the Raab to repress their predatory irruptions into his territories.

Reduced to subjection by Charlemagne.

The Huns renew their ravages.

They remained within this boundary for more than a century, when Arnolph, emperor of Germany, invited them to his assistance against the king of Moravia. Equally ferocious with their ancestors, and glad of an opportunity to renew their devastations, they ravaged Bavaria, Suabia, and Franconia. Germany afterwards became a prey to their fury; and Louis IV. submitted to an annual pension to get rid of them. In the reign of Conrad I. who also became their tributary, they again devastated Germany, penetrated into Lorraine and Languedoc, plundering and massacring the inhabitants wherever they went.

A. D. 955.

but are driven with dreadful slaughter into their own country.

The Huns were at this time subject to petty chiefs, whose precarious authority rested on no solid foundation, and were respected only because the choice fell on the bravest. Fear naturally attached them to the man whose vengeance they dreaded, or to whom they looked for protection in the continual wars in which they were engaged. Their last irruption into Germany was severely chastised by the valour of Otho the Great, and the united power of the German princes, who compelled them, after a dreadful slaughter, to retire within the limits of Hungary, and to fortify with a ditch and rampart the most accessible passes into their country.

Their king Stephen establishes the Catholic religion in his dominions.

In process of time, and by their intercourse with other nations, civilization began insensibly to spread among them; and in 997, under their first king *Stephen*, they assumed a place among the nations of Europe. This monarch established the Catholic religion in his dominions, and received from the Pope the title of *Apostolic*, which the sovereigns of Hungary to this day retain. From him also they date the origin of many of those institutions and laws by which the state is still governed. On his death, the respect in which his memory was held by his subjects, led them to choose his son as his successor to the throne; and, without renouncing their right of election, to maintain the royal dignity in his family for more than three centuries.

Dynasty of Stephen.

Ladislaus.

A. D. 1161.

Geiza II.

Bela III.

A. D. 1196.

Andrew II.

A. D. 1222.

Bela IV.

There were twenty-four kings of the dynasty of Stephen, few of whom, however, deserve to be drawn from oblivion. The most remarkable were; *Ladislaus*, surnamed the Saint, on account of the purity of his life, who added Dalmatia and Croatia to his dominions, and flourished near the end of the eleventh century. *Geicza* or *Geiza* II. expelled the Saxons, Austrians, and Bavarians, from Poland and a part of Hungary, where they had committed great ravages. *Bela* III. after having freed his territories from the brigands which infested it, employed himself in the internal administration of his kingdom. He instituted many judiciary regulations, which still remain in force, and was the first who divided the kingdom into counties, appointing a governor to each. His son, *Andrew* II. was one of the most renowned sovereigns of his age. He joined the Crusade in the beginning of the thirteenth century, with a numerous army, and acquired great glory by his bravery and skill in war; and the nobles, as a reward for their services on this occasion, received from him very extensive privileges. In his reign, the regulations of his father were perfected and formed into a national code, called the *Golden Bull*, which every king at his accession was obliged to confirm by a solemn oath. The famous clause, however, which granted to every noble the right of *veto* in the election of their monarchs, had been so often the occasion of civil wars, that it was abolished in the reign of Leopold I. in 1687. The reign of *Bela* IV. is remarkable for the invasion of the Scythians, who, after having overrun Russia and Poland, penetrated as far as Pesth, spreading terror and rapine throughout the kingdom. Bela, surprised in his camp, was compelled to fly. The Scythians continued in possession of the

Stephen V. A. D. 1275.

Andrew IV.

country for nearly three years; but Bela, with the assistance of the Knights of Rhodes, dispersed the invaders, and regained this throne. His son Stephen V. was celebrated for his victories over the kings of Bohemia and Bulgaria. His daughter Mary espoused Charles, king of Sicily, from whom sprung the famous Charles Martel, the father of Charles of Anjou, who afterwards became king of Hungary. Andrew IV. the last, and perhaps one of the most illustrious of the dynasty of Stephen, received the surname of *Venetian*, from his conquests over the Venetians. He died without issue at Buda in 1301.

Competition for the crown of Hungary.

Charles of Anjou proclaimed in 1310,

and is succeeded by his son Louis.

Hungary then became a prey to all the calamities which anarchy brings along with it. Competitors for the crown appeared in the King of Bohemia and the Duke of Bavaria. The son of the former was elected by a party, and was kept upon the throne for six years, in opposition to the wishes of the nation, and amidst the greatest troubles. Being recalled to Bohemia by his father, the Duke of Bavaria was immediately crowned; but Ladislaus, waywode of the Jazyges, took him prisoner, and drove him from his throne and the kingdom. On the termination of these civil dissensions, Charles of Anjou was solemnly proclaimed king in 1310. Under his reign, Hungary, which had lately been regarded merely as a fief of the empire, became more powerful than the dominions even of the emperors. Dalmatia, Croatia, Servia, Transylvania, Bulgaria, Bosnia, Moldavia, and Walachia, received the laws of Charles. His marriage with the sister of Cassimir, king of Poland, who had no offspring, also secured a throne to his family. He died in 1339, beloved by his subjects and all his neighbours. The veneration which his memory inspired, and also the personal qualities of his son, fixed the choice of the nation on Louis. The reign of this prince was even more brilliant than that of his father. He pushed his conquests as far as Naples, to revenge the assassination of his brother Andrew, who had been strangled by his own wife Queen Jane; and appointed the waywode of Transylvania as governor of that kingdom, which however he afterwards restored. Part of Russia submitted to his dominion, and he drove the Tartars beyond the Euxine. He was acknowledged also as king of Jerusalem; but, while Hungary rose in power and estimation during his life, his death plunged her again into new calamities and dissensions.

A. D. 1382.

Mary proclaimed king.

Her subjects rebel, and offer the crown to the king of Naples, who is assassinated.

Horvat revenges his death.

Sigismund, the husband of Mary, ascends the throne.

Loses and recovers his crown.

Elected emperor in 1410, and is succeeded by Albert of Austria.

Louis leaving no male issue, the Hungarians, as by a general impulse of admiration and enthusiasm, called his daughter Mary to the throne, under the title of Maria Rex. She had been married to Sigismund of Bavaria, who was as yet under age, and in the mean time she shared the cares of government with her mother Elizabeth. The tyranny, however, of Nicolas Gara the Palatine, who in her name actually governed the kingdom, soon made her subjects regret their imprudent homage to the memory of Louis. They therefore offered the crown to Charles, king of Naples, the nephew of Louis, and the son of the unfortunate Andrew. But scarcely had he entered Hungary, than he was assassinated by the Palatine, with the direction and countenance of Mary and Elizabeth. John Horvat, bann of Croatia, in revenge for the murder of a prince to whose interests he was attached, slew the assassin, and, after having made Mary and her mother be dragged as common criminals by the hair, cast Elizabeth into the river Bozota. Mary was reserved for the infamous brutality of Horvat, and then shut up in prison. Horvat, however, dreading the rage of Sigismund, who was approaching with an army to reclaim his crown, set the Queen at liberty, after making her promise upon oath that she would forget her injuries. These injuries, however, were too cruel to be erased from her memory, and repelling the oath which fear alone had extorted from her, she visited them upon the fierce avenger of Charles in a manner still more cruel and barbarous. Sigismund was twenty years of age when he ascended the throne; but the whole of his reign was only a succession of wars, troubles, and calamities to Hungary. Mary dying without children in 1392, new dissensions arose; and the Turks taking advantage of these, seized upon Bulgaria. Sigismund was defeated, and put to flight at the battle of Nicopolis; when his subjects revolt against him, seize his person, and confine him in prison. The conspirators then offer the crown to Ladislaus, king of Naples. But Sigismund seemed to triumph over fortune and all his enemies. Escaping from prison, and collecting a considerable army, he obliges Ladislaus to desist from his pretensions. and recovers his kingdom. In 1410, he was elected emperor of Germany. At his death, Albert, archduke of Austria, who had espoused the only daughter of Sigismund by a second marriage, inherits all his possessions, and ascends the throne of Hungary in 1437. This event forms the earliest basis of the Austrian claim to the Hungarian monarchy.

Civil wars.

A. D. 1490.

The reign of Albert, however, was very short, and his death was succeeded by civil wars, which continued to desolate this kingdom for another century. Ladislaus, king of Poland, was invited to the throne; but soon after perished in the battle of Werna against the Turks. The famous John Hunniades was then appointed regent; and on the decease of another Ladislaus, the posthumous son of Albert, in 1457, Mathias Corvinus, the son of Hunniades, receives the crown from the states assembled in the field of Rakos, near Pesth. Mathias seized Vienna and the other Austrian states, which he retained till his death; and is regarded as the greatest prince that ever held the Hungarian sceptre. He was brave, prudent, and generous, the friend of letters and arts, and a man of letters himself. He founded the magnificent library of Buda, which he furnished with the best Greek and Latin authors, and many valuable manuscripts.

A. D. 1527.

The Turks invade Hungary.

Ferdinand of Austria crowned.

The Hungarians bear the Austrian yoke with much impatience.

The descendants of Albert again fill the throne; but upon the death of Louis II. the son of Ladislaus, who lost both the battle and his life in the plains of Mohats in 1527, the Hungarians were divided into two factions. John Zapolya, waywode of Transylvania, was proclaimed king by one party, while the nobles assembled at Presbourg offered the sceptre to Ferdinand of Austria, who had conducted some succours to the Hungarians against the Turks. Zampolya was unable to resist the forces of his rival; and after his defeat at Tokay, was compelled to evacuate the kingdom, when Ferdinand was crowned at Stuhl-weissenbourg. Some time after, the waywode returned with the Sultan Soliman, at the head of a formidable army, who pushed his conquests as far as Vienna; but on the death of Zampolya, his partisans, indignant at the conduct of the Turks, and preferring the dominion of Austria to that of the barbarian, immediately joined Ferdinand, who was crowned a second time. This monarch was afterwards called to the empire; but he retained the crown of Hungary till 1563, when he resigned it to his son Maximilian. The Hungarians, however, bore the Austrian yoke with much impatience, and every new election called forth their aversion to their masters, who regarded them as their lawful inheritance. But their efforts were fruitless, and those who ventured to support the rights of the nation,

History.

A. D. 1656.

The crown declared hereditary in the house of Austria, A. D. 1740.

were silenced by the stroke of the executioner. In vain did Tekely raise all the provinces to revenge these outrages; and, supported by the Turks, to whom the Hungarians in their despair had surrendered themselves, laid siege to Vienna. All Germany immediately armed against the common enemy the Turks, who were driven back into their own territories. Rakotzy, who after Tekely endeavoured to support these efforts of independence against tyranny, was equally unfortunate. The Archduke Joseph, son of Leopold I. was acknowledged king in 1687, and the crown was declared hereditary in the male descendants of the house of Austria. This line, however, failed at the death of Charles VI.; but the Hungarians, exhausted by continual wars, and fatigued by so many fruitless revolutions, had lost that ardent love of liberty for which they were so conspicuous, and which led them to brave so many dangers. They therefore submitted to the accession of Maria Theresa, the daughter of Charles, in 1741. She had gained and deserved their love and affection. Her husband, the emperor Francis, was associated with her in the government, and their descendants still hold the Hungarian sceptre. The preceding sketch of Hungarian history is all that our limits will allow.

History.

and the Hungarians submit on the accession of Maria Theresa in 1741.

STATISTICS OF HUNGARY.

Statistics.

Situation.

HUNGARY, properly so called, a kingdom in Europe, and under the dominion of Austria, lies in Latitude 44° 33′ 18″—49° 26′ 20″ North; and in Longitude 13° 45′ 2″—22° 46′ East of Paris. Nature herself points out the boundaries of this kingdom.

Boundaries.

The Carpathian or Krapak mountains separate it on the north and east from Moravia, Silesia, Galicia, Buckovina, and Transylvania; on the south, the Danube and the Drave divide it from Servia, Sclavonia, and Croatia; and on the west the Morau or Morava, with a range of mountains lying between the Drave and the Danube, form its boundary with the Archduchy of Austria.

Extent.

According to Captain Lipsky, it contains 4051 German square mile;* its greatest length from west to east being 136, and its greatest breadth from north to south 77 German miles.

Division.

The kingdom of Hungary is divided by modern geographers into four circles, comprehending forty-six counties, besides the districts of *Jazyg*, *Great Cumania*, *Little Cumania*; the sixteen cities of the *Zips*; the six cities of *Heidukes*, which enjoy peculiar privileges; and the two frontier regiments of the Bannat, and the battalion of *Tschaikistes*. The whole, according to the following Table, contained, in 1805, 42 royal free cities, 8 episcopal cities, 590 towns, 9214 villages, 2338 *prædien*,† and 22 cities of Zips and Heidukes.

Table of the counties and cities.

Statistics.

COUNTIES.	Royal Free Cities.	Episcopal Cities.	Cities of Zips and Heidukes.	Towns.	Villages.	Prædien.
I. The circle on this side of the Danube contains 13 counties:						
1 Presbourg, . . .	5			24	295	41
2 Neutra, ...	1	1		38	418	46
3 Trentschin, . . .	1			19	393	8
4 Thurotz, ...				6	96	9
5 Arw, ...				5	95	1
6 Liptau, ...				10	121	2
7 Sohl, ...	5			8	147	3
8 Barsch, ...	2			11	201	21
9 Hont, ...	3			9	171	30
10 Neograd, ...				10	245	142
11 Gran, ...	1			5	44	8
12 Pesth, ...	2	2		20	165	153
13 Baatch, ...	3			9	96	52
The district of Jazyg,				3	8	6
Do. of Little Cumania,				3	5	24
II. The circle on the other side of the Danube contains 11 counties:						
1 Wieselbourg, . .				13	37	7
2 Oedenbourg, . .	9			38	196	6
3 Eisenbourg, . . .	1			43	607	51
4 Raab, ...	1			2	80	35
5 Komorn, ...	1			5	85	69
6 Szalad, ...				25	584	101
7 Schumegh, . . .				22	292	256
8 Veszprim, ...		1		9	106	177
9 Stuhlweissenbourg,	1			12	65	115
10 Barany, ...		1		7	336	71
11 Toln, ...				17	89	85
III. The circle on this side of the Thiesse contains 10 counties:						
1 Abaujwar, . . .	1			11	230	41
2 Beregh, ...				6	261	7
3 Boschod, ...		1		11	167	68
4 Goemor, ...				13	257	74
5 Hewesch, ...				16	132	108
6 Scharosch, . . .	3			11	359	13
7 Zips, ...	2			12	177	6
Cities of the Zips, .			16			
8 Torn, ...				1	42	10
9 Unghwar, . . .				4	201	14
10 Zemplin, ...				24	426	34
IV. The circle on the other side of the Thiesse contains 12 counties:						
1 Arad, ...		1		18	171	24
2 Bekesch, ...		1		4	15	71
3 Bihar, ...	1			19	458	55
4 Tschanad, . . .				1	7	31
5 Tschongrad, . . .	1			3	6	52
6 Kraschow, . . .				8	221	
7 Marmarosch, . . .				5	141	1
8 Saboltsch, . . .				14	131	35
Cities of Heidukes,			6		4	4

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* In this Article, where English miles are not marked, German miles must be understood.

† By the laws of Hungary, the proprietors of the soil are obliged to let out to farm one half of their lands to their vassals; what they cultivate on their own account is called *Prædien*.

Statistics.

Counties.	Royal Free Cities.	Episcopal Cities.	Cities of Zips and Heidukes.	Towns.	Villages.	Praedien.
9 Szathmar, ...	3			19	244	16
10 Temesch, ...	1			6	178	3
11 Torontal, ...				7	115	48
12 Ugotsch, ...				5	63	9
The district of Great Cumania, ...				1	6	17
1st frontier regiment,					48	23
2d Do. do.					112	
The battalion of Tschaikistes, ...					14	
Total, 2 military communes, and . . .	42	8	22	590	9214	2338

General aspect.

The configuration of this country presents to us the most opposite regions and climates; rugged and enormous mountains, where reign sterility and eternal snows, and which cover almost one-third of the whole kingdom; extensive flats, irrigated by numerous rivers and lakes, where winter is scarcely known; plains of sand driven by the wind, which threaten the traveller with instant death; fertile and smiling vallies, producing every necessary, and many of the luxuries of life in the greatest abundance; numerous morasses, which cover the surrounding country with their noxious exhalations; and immense forests, where the foot of man has never penetrated.

On entering the Bannat of Temeschwar on the east, the country appears like Flanders, flat, and entirely destitute of wood, excepting in the vicinity of the villages. The soil is extremely fertile; and the prospect as we advance exhibits immense pastures covered with cows, sheep, and horses; or wide fields of corn without enclosures. Silk plantations, and orchards of peach, cherry, and plum-trees are every where common. Proceeding westward, the country towards Szegedin becomes sandy; and after crossing the Thiesse low swampy plains, full of stagnant pools, where nothing is heard but the croaking of toads, fill up the distance to Ketschkemet. From thence the country, though well cultivated in some places, is flat and sandy, resembling the *steppes* of Russia; and, on approaching the Danube, a chain of mountains appears, which rise with grandeur on the western side of the river. From Buda, towards Gran, the country is rich, populous, and highly cultivated. The hills are covered with vineyards to their very summits; and every where are seen delightful villages filled with healthy inhabitants. On the north of the Danube, the mountainous district towards Schemnitz is agreeably picturesque; and as we approach that town, the scenery becomes sublime. "The appearance of this beautiful country," says Mr Cripps, "although surrounded by mountains, reminded us of the county of Kent. The cottages are remarkable for their great cleanliness; and there are numerous villages. The district between *Zeilitz* and *Lewa* is the most beautiful imaginable, being full of rich meadows and fields of corn, every where thick set with noble oaks." Dr Clarke also remarks, that "the road, although constructed in the midst of mountains, is not inferior, either in breadth or excellence, to any of the roads about London; and the traveller, surrounded by the sublimest natural scenery, sees to his surprise the greatest artificial labours accomplished with neatness, ornament, and economy; beautiful roads through recesses, and over steeps, that would otherwise be impassible; churches crowning the most elevated summits; towns and villages; gardens and vineyards; all decorating without diminishing the wild grandeur of the Hungarian Alps." Indeed, the whole of this district, as far as Presbourg, is exceedingly rich and beautiful.

Statistics.

Mountains.

The most prominent feature of the Hungarian landscape are the mountains, the principal of which is the Carpathian chain, or mountains of Tatra, which run in a semicircular direction from west to east, about 500 English miles; and its summit, which consists of huge naked rocks completely destitute of vegetation, at its greatest height, in the county of Zips, is about 1350 toises above the level of the Black Sea. The mountains situated in the east and south-east, are separated from the northern chain by a plain, which extends from Hungary into the grand duchy of Transylvania. They take their rise in the latter province; and, following the direction of the Marosch as far as Arad, strike towards the south by the Bannat upon the confines of Transylvania and Walachia; the highest of these are Szemenik and Montye le mare, or, the high mountain. Those on the western part of the kingdom, run from the county of Eisenbourg in a crooked chain towards Stiria and Austria, as far as the Leitha; and some of them equal the Alps nearly in height. Besides these, there are other considerable mountains in the counties of Pesth, Gran, Veszprim, and Szalad, some of which are covered with impenetrable forests of oak.

Mineralogy.

The northern part of the Carpathians is composed chiefly of granite, and its summits are covered with limestone, or spread with a kind of brown freestone. Granite forms also an essential part of the mountains of Konigsberg, and of the rocks of Tatra, which are adjacent, and stretch into the southern part of the counties of Zips, Goemor, Sohl, Liptau, and into the western part of the counties of Arw, Thurotz, and Trentschin. It also abounds in the northern part of Zips, where the mountains of Fleischbank, Porte de Fer, Altendorf, and some others, are entirely composed of it. Near Altendorf it begins to disappear, and is replaced by a greyish free-stone, which covers almost three leagues of country, and forms the great mountain of Babagura. This stone extends along the extremity of the western frontiers of Tatra, Godivilk, and towards the south the county of Arw. From the eastern extremity, it extends still more along the frontiers of Hungary, and into the counties of Zips, Scharosch, Zemplin, and Unghwar. There another kind of stone presents itself; clay slate covered with brown freestone. It is likely that the clay-slate commences in the higher mountains of the north, as it begins to appear in the county of Goemor, near Rosenau, from whence it stretches into the southern part of the county of Zips, and into the northern part of the county of Abaujwar. The central mountains of the Carpathian chain and its promontories, produce limestone and porphyry. The other generations which are formed in the accessary mountains, are mica, clay-slate, trap, basalt, and breccia. There are also found volcanic stones, pumice stone, and different kinds of opals. The body of the Carpathians on the north-east, consist principally of clay-slate. The chain which stretches along the valleys of Marmarosch and the borders of the seven mountains, as far as the Theisse, and traverses the counties of Szathmar and Ugotsch, is composed chiefly of porphyry and grey free-stone. In the eastern mountains, and, in general, in those of the Bannat, there is a great deal of lime-stone; which prevails also in the interior mountains. The other stones that are found there are clay-slate, brown free-stone, and porphyry. The neighbouring mountains of Stiria and Austria contain lime-stone, free-stone and granite.

Grottos. The mountains of Hungary, especially the Carpathian chain, abound with grottos of various dimensions, the principal of which are *Mazarna* and *Dupna* in the county of Thurotz, *Drachenhole* in the county of Liptau, *Helgocz* in Zips, *Agtelek* in Goemor, and *Sziliacz* in Torn. Bones and skeletons, partly petrified, are found in these grottos, and the most beautiful stalactites of every size and form. Those of Drachenhole and Sziliacz are particularly curious, being filled during the summer with ice, which is formed in spring, and melts at the approach of winter. The grotto of *Veteranische Hole* is famous for the defence which General Veterani, with a few followers, maintained against the Turks, in 1694. It is situated on the left bank of the Danube, a little above the village of Ogradina. The rock of which it is formed is inaccessible on every side except at the entrance of the grotto, which is about four feet high and two broad, and secured by an iron gate. The interior is large enough to accommodate a thousand men; and, from the embrasures cut out in the rock, it has the complete command of the navigation of the Danube. Here also, in the last war of Austria against the Turks, the brave Major Stein, with a battalion of infantry, defied the whole power of the Turkish army, and after enduring for three weeks the most painful privations, made an honourable capitulation, and marched out at the head of his surviving followers with their arms and baggage.

Plains. The interior of Hungary consists of one almost continued flat, excepting a chain of mountains which, taking their rise near the Danube, run through Gran, Pesth, and the neighbouring counties, and divide the country into two immense plains, called the Upper Plain and the Lower Plain. The former is the smallest, and is of a circular form. It extends from the lake of Neusiedl for about twenty German miles, to the foot of the mountains on the north, and then stretches as far as the Drave, upon the confines of Croatia. The Lower Plain is of much greater extent, and comprehends all the eastern part of the kingdom, as far as Transylvania; and where it approaches the mountains, is finely diversified with hills and vallies. The level is evidently higher in the upper than in the lower plain, as the rivers in the former almost uniformly direct their course towards the Danube; and the lowest spot in the whole country is at its south-eastern extremity, near Orsova.

Rivers. The Carpathian chain gives rise to innumerable rivers, which flow in all directions, according to the declivity of the ground and the sinuosity of the vallies, but which eventually fall into the Thiesse or the Danube. The *Thiesse* has its source in the county of Marmarosch. Its course from its commencement is full and rapid while it continues among the hills; but when it reaches the plain its rapidity slackens, and, bending towards the west, receives innumerable tributary streams from the northern mountains. Taking a southerly direction, it is joined by the Marosch, near Szegedin, and, after a course of about 420 miles English, falls into the Danube not far from Belgrade. As the banks of this river are low, it often overflows them, and occasions extensive inundations, particularly in the neighbourhood of Tokay. Few rivers in Europe abound more with fish than the Thiesse; and it is a common saying in the country, that it contains two parts of water, and one of fishes. It is navigable as high as Szegedin. The *Waag* or *Woh* fertilizes the counties of Thurotz, Trentschin and Neutra. Circumscribed in its channel, it dashes its impetuous waters over frightful rocks, and forms during its course above a hundred whirlpools. It enters the plain at Sillein, and discharges itself into the left branch of the Danube, which forms the island of Schutt. Besides these, the other principal rivers which commence and finish their course within the boundaries of the kingdom are, the Gran, the Gollnitz, the Hernad, the Torisza, the Sajo, the Nera, the Temesch, and the Bega.

The rivers which have their sources in other countries, but which water, in some part of their course, the kingdom of Hungary, are the DANUBE, (of which a particular description will be found in vol. vii. p. 574.); the *Drave*, which rises in the Tyrol, and flows with such rapidity that its banks are neither so high nor so solid as to retain its waters. It is navigable during the whole of its course through Hungary, and falls into the Danube above Essek; the *Samosch*, the *Marosch*, and the *Korosch*, which take their rise in Transylvania, and fall into the Thiesse; the Morava, which gives its name to the province of Moravia, washes the western boundary of the kingdom; the Raab, which rises in Stiria; and the Leitha in Austria.

Lakes. The lakes and marshes of Hungary are both numerous and extensive. In the Upper Plain the most considerable are Lake *Balaton*. The Lake of *Neusiedl*, which the Hungarians call Tento, lies between the counties of Oedenbourg and Wieselbourg. Its western bank is formed by hills, which are covered with vineyards, woods, and cultivated fields, while the opposite shore is low and marshy, producing nothing but reeds. It is about thirteen miles English in length by four in breadth, but so full of shallows and sand banks, that its navigation is both difficult and dangerous. In the Lower Plain, the principal is the lake of *Palitsch*, in the county of Batsch. It is about eight miles (English) long, having a hard bottom covered with alkaline salt. Its water is used in the neighbouring baths, and is considered very salubrious in nervous disorders. The most remarkable of the Carpathian lakes is the *Grune-See*, which is formed by an enclosure of rocks, and is about 300 paces in circumference. It takes its name from the green colour of its waters, which is produced by the reflection of the surrounding pines. Its banks are covered with gravel and blocks of granite, and its water is pure and transparent, and excellent for drinking.

Marshes. Marshes of various extent pervade almost every quarter of the kingdom, and are in general formed by the inundations of the rivers. The most considerable are those of *Saretje*, *Mohatsch*, and *Etsed*. In the plain of Bannat, they cover more than a third of the county of Toronthal, almost the whole of Temeschwar, and the greatest part of the district of the frontier regiment of Bannat. The marsh of *Hansag*, which joins the lake of Neusiedl, is five miles long by three broad. The water appears only in the middle, the greatest part being covered with turf, and studded with trees. It produces plenty of hay; but it is dangerous to cross it, unless well acquainted with the particular direction of the paths.

Sandy plains. It would be proper to notice also the sandy plains, which overspread many parts of this country, the most extensive of which are *Ketschkemeten-Heide*, or the heath of Ketschkemet, lying between the Danube and the left bank of the Thiesse; *Debrecsin*, in the county of Bihar; and the *Ager Romanorum*, near Delliblat. Besides these, there are others in the counties of Tolna, Stuhlweissenbourg, Baranje, and particularly in Schumegh, which is one continued ocean of sand moving with the wind.

limate.

The morasses and swampy plains which abound in this country, are supposed to render the air damp and unwholesome, the cold of the night rivalling the heat of the day; but this evil is in some measure remedied by the wind from the Carpathian mountains; and the inhabitants in general are rather remarkable for health and vigour. In some of the counties on the north-west, the atmosphere is particularly pure and bracing; but in the Bannat, on the north-east part of the kingdom, it is quite the contrary. The transitions of temperature are extremely sudden. Agues and inflammatory fevers are very prevalent; and in Temeschwar, the capital, a healthy person is scarcely to be seen. Baron Born, when here, fancied himself in the realms of death, inhabited by carcases in fine tombs instead of men; and at a dinner, to which he was invited, all the guests had a fit of the fever,—some shivering, and others gnashing their teeth.

oil.

If we except the barren heaths and the mountainous districts in the north, the soil of Hungary is equal to that of any other country in Europe. It contains 5,897,218 acres of arable land, and produces the finest grain, without manure, and almost without cultivation; and were the exertions of the husbandman to keep pace with the abundance of his crops, the produce of the kingdom would be doubled. After a very superficial ploughing, the seed is thrown into the ground; a few branches of trees tied together serve the purpose of harrows; and without farther care the harvest is luxuriant. But much of the grain is lost, by the manner in which it is separated from the straw and stored. It is allowed to stand in the field after it is cut until the tithe is gathered, by which time it has begun to vegetate. They afterwards tread it out with horses and cattle in the open air, by which operation a third of it nearly is destroyed; and then, instead of receiving it into granaries, of which they have none in Lower Hungary, it is put into pits dug for the purpose, and there kept for future use. These pits are lined in the bottom and sides with straw and reeds, and contain from 100 to 200 bushels each. They are then covered in with straw and earth.

Agricul-ure.

This method of rural economy, however, applies only to the lower and central parts of Hungary, which are by far the most fertile. In the northern districts, and on the frontiers of Austria and Stiria, the soil requires all the industry of the inhabitants to make it produce even a tolerable crop; and were their exertions and method of culture (though still imperfect) transferred to the southern parts of the kingdom, Hungary would become the granary of Europe. An insuperable obstacle, however, to all improvement in this respect, lies in the tenure, by which the farmer holds his lands. The lands are parcelled out into farms, half farms, quarter farms, &c. A farm is measured by the seed it requires, being 48 bushels, and 12 *tagwerk* of meadow; if the soil is poor, the arable land is augmented in proportion. In Croatia they distinguish three kinds of land, good, middling, and bad. A farm of the first quality is 21,000 square toises; of the second 34,000; and of the third 40,000. The annual burdens attached to a farm in Hungary are, fifty-two days work with two horses, or four oxen, beginning at sun-rise, and finishing at sunset; a fourth part of them must be performed during the winter, and, in the time of harvest, the proprietor can demand two in the week: a ninth part of the crop, and also of the sheep, goats, lambs, and bee-hives; and if the number is under nine, 4 kreutzers for every lamb, 3 kreutzers for every goat, and 6 kreutzers for every hive: 2 hens, 2 capons, a dozen of eggs, and half a pint of melted butter: 30 farms together pay a calf or a florin, and 30 kreutzers in money: every married peasant to give eighteen days work, and pay a florin for the rent of his house, and all others to give twelve days work: every vassal to beat the bushes three times a year in the hunting season: four peasants, each possessing a farm, to unite in performing a job with four horses at the distance of two days journey, excepting the time of harvest or vintage: two florins for permission to distil *aquavitæ*, and to spin six pounds of lint. The proprietor furnishes his vassals with wood for fuel and building; and in return, they must cut a *cord* of wood in the forest, and transport it to the castle. The respective rights and obligations of the noble and his vassals are regulated by a statute, which is called *urbarium*, and which was provisionally confirmed by the diet in 1791. The peasant, however, holds his lands only from term to term, and must resign them when proper warning has been given by his lord.

Productions.

Notwithstanding these disadvantages, the soil is so productive, that the annual exportation of grain to Italy and Germany is very considerable. Wheat is the principal object of cultivation; and in the mountainous parts of the country, where the soil is lighter and the climate colder, rye, barley, and oats are produced of good quality, and in abundance. They have also plenty of maize, rice, peas, potatoes, turnips, melons, cucumbers, pumpkins, onions, and garlic. Lint and hemp are cultivated in many of the counties; also poppies, saffron, madder, and woad. Tobacco forms a considerable branch both of agriculture and commerce; and in 1779, when American tobacco was very scarce, the city of Trieste alone exported Hungarian tobacco to the amount of 100,759 pounds in powder, and 3,263,135 pounds in leaves or carrots. The best tobacco is produced at Tolna, Kospalogh, and Szegedin.

Vineyards.

The vineyards of Hungary are very extensive, and are general throughout the country, unless in seven of the northern counties, where the temperature is too cold. They occupy nearly 911,984 acres, and produce upon an average 18,239,680 *eimers* annually. The wine of Tokay is the most valuable, and is drunk by the rich in every country in Europe. The vines which furnish the real Tokay, grow on the mountain of *Hegy-Allya*, in the county of Zemplin; but as this mountain produces a very inconsiderable proportion of what passes under the name of Tokay, they sell for it the wines of Mada, Tallya, Zumbor, Szegu, Zsadany, Toltschwa, Benye, &c. which few but a Hungarian palate can distinguish. Next to the wines of Tokay, the most esteemed are those of Rust and Œdenbourg, which are cultivated with great care and intelligence. The others of consequence are the wines of Erlau, Buda, Neustadtel, Menesch, Scohmla, Resmil, and Ratschdorf.

Orchards.

Although the climate of Hungary be very favourable for the cultivation of all kinds of fruit, very little attention is paid to them in the Lower Plain. The orchards are confined chiefly to Œdenbourg, Presbourg, Neutra, and the neighbouring counties, where chesnuts, almonds, apricots, peaches, apples, and pears abound, and are of the first quality. Entire forests of plumtrees flourish in the counties of Trentschin, Neutra, and some others; and their fruit, both fresh and dried, is exported in great quantities to Austria and Prussia.

Woods. The meadows and pasture grounds of Hungary are very much neglected. They cover 1,483,003 acres, and yield about 17,085,935 quintals of hay. The northern and western districts of Hungary abound in immense forests of fir, pine, and oak, interspersed with yews, ash, hazel, and linden, which overspread nearly nine millions of acres. In the district of the frontier regiment of Walachia, the forests cover 465,362 acres, and afford employment and profit to many of the inhabitants. In 1802, there were drawn from these woods the following articles, which will give the reader some idea of their value and importance.

58,446	pieces for the construction of wheels.
1,414	cubic toises of ash.
108,732	staves for casks.
2,725	do. for scuttles.
2,560	do. of oak.
30,920	do. of beech.
344	cubic toises of oaken joists.
702,800	staves.
2,363	planks a foot square.
900	green poles.
11,013	planks for boat building.
5,293	laths.
1,704	planks for scaffolding.
40,624	do. of linden and maple.
1,099	do. of hazel.
196	posts of do.

The forests of Hungary produce an immense quantity of gall-nuts, which, from their exportation during ten years, (from 1777 to 1786,) yielded 516,679 florins of revenue. In the south, however, from Pesth to Debretzin on the one hand, and from the mines of Bannat in the county of Kraschow to Peterwardein on the other, a wood is scarcely to be seen. In this district the fuel, on account of the scarcity of timber, consists chiefly of reeds, and cow dung made into bricks with straw.

Animals. On the pastures of Hungary are reared a great number of cattle, which forms one of the principal sources of national opulence. The oxen are nearly equal to those in Kent, which are the finest in Europe. They are generally of a whitish colour, or light grey, and are valued for their great weight, and the fine flavour of their flesh. About the conclusion of the last century, there were reckoned in Hungary 797,540 fat oxen, 89,805 bulls, and 1,508,177 cows; and according to the commercial tables, during ten years of the same period, the exportation of oxen amounted to thirty millions of florins, when a pair of oxen sold only for 50 or 60 florins.

Horses. The horses are in general small, but are equal to any in Europe in elegance and swiftness. They have been, however, much neglected; and, notwithstanding the many attempts that have been made by the government for their improvement, they are still far removed from that state of perfection of which they are capable. The royal studs at *Mezoehegyes* in the county of Tschanad, and *Babolna* in the county of Komorn, were established by the Emperor Joseph II.; and from them 60 stallions are regularly distributed every year throughout the country, to produce a more noble breed. In 1795, the stud of Mezoehegyes consisted of 10,000 horses, of which 1000 were mares, and 60 stallions. It is under the direction of a major, 12 officers, 50 sub-officers, and 200 soldiers, besides grooms and labourers; and is obliged to furnish annually 1000 horses for the army. There are also several private studs, of which the most considerable are those of the lordship of Holitsch, established by Francis I., of Prince Esterhazy at Uzor, and of Count Palfy at Dertrekoe. The small size of the Hungarian horses may be attributed to their being too young when brought to the yoke, and to their scanty nourishment. They seldom give them hay, but drive them out at all seasons to pasture; and even when on a journey, they are sent into the fields, to find at the same time food and rest.

Sheep. The Hungarian sheep are very beautiful, especially those with forked horns, of which none are reared in any other country, except on Mount Ida, and in some of the islands in the Archipelago. Their wool, however, which is long and hairy, is used only in fabricating coarse stuffs, which are worn by the peasants. In 1773, the Austrian government attempted to improve the wool of the native sheep, by the introduction of Spanish rams; but it was long before this practice became general. At present, however, many of the nobles possess immense flocks of the improved breed, and draw from the sale of their wool a considerable revenue. Some of these flocks produce annually about 1500 quintals of wool, worth 274,000 florins. Flocks of every description pass the winter in the open fields. **Shepherds.** The shepherds, whom they call *juhasz*, are very little removed from savages. They burrow under ground with their dogs, and, except a boy or two who assist them and bring their food from the village, and the merchants, who in the beginning of summer come to make purchases, they seldom see a human face. Yet retired as they are from the world, they are fond of ornaments in their dress; and though their clothes are of the coarsest description, and besmeared with grease, they trim their hats with ribbands of various colours, and have their leathern girdles thick studded with bright metal buttons.

Hogs. As bacon is a favourite dish with the Hungarians, they rear an immense quantity of hogs; and the head of a family who had not a piece of fat pork on his table at Christmas, would be regarded as a very bad economist. The consumption of this animal in the country is so great, that they have none of their own to spare for exportation; but they carry on a very lucrative traffic, by buying them in Turkey, and selling them to their neighbours. According to the Commercial Tables, they annually purchased in Turkey to the amount of 531,973 florins, which they sold for 895,337 florins.

Among the animals of this country may also be mentioned a race of shepherds' dogs, of a white colour and noble size, and also a breed of immense mastiffs. Bees and silk-worms form considerable branches of industry in this country, and it abounds also in poultry and game. Fish are so abundant in Hungary, that they form an important branch of industry and commerce; and sturgeons, salmons, pikes, carps, perches, &c. are to be found in all the principal rivers. In 1803, they were exported to Austria to the amount of 98,230 florins.

Minerals. Hungary abounds in minerals of every description; gold, silver, copper, lead, iron, mercury, cobalt, antimony, salt, slate, &c. which, in their exploration and manufacture, afford employment to a great proportion of its inhabitants. Native gold is found in the beds of many of the rivers; and in the Koeroes, pieces of the size of a nut are picked up by the inhabitants of the Bannat, who upon an average gather to the amount of 900 ducats. In general, however, it is extracted from the auriferous sand, which is not only taken from the channels of the rivers, but also from their banks, and from pits in the adjacent ground. In these pits, which are generally about four feet deep, the first stratum consists of vegetable mould; the second of loam, and an alluvial deposit of pebbles; the third of the auriferous sand and pebbles; and the fourth of slate, clay, marle, and coal. The washing of the auriferous sand is practised by the gypsies, who, from long experience, are so expert that hardly a particle of gold escapes them. The operation is very simple, and is performed by means of a plank of lime-tree six feet in length, and about three in breadth, with grooves or furrows cut across. This plank is placed at an angle of about 45 degrees, and at the upper end is a trough where the auriferous sand is put. The sand is then washed down the sloping of the board by plenty of water, when the gold dust falls into the higher grooves, and is afterwards scraped or brushed off. Sometimes the plank is covered with woollen cloth, to which the gold adheres; or when they cannot obtain cloth, they substitute a fleece in its place. Many thousands of florins of gold are produced in this manner.

Mines.

The great emporium of the precious metals, however, are the mines, which surpass in richness those of any other country in Europe. The most valuable are those of Schemnitz in the county of Hont, and of Cremnitz in the county of Barsch. In these mines, the gold is always found united with silver; and they estimate the value of the ores, by calculating that one quintal (cwt.) of ore yields so many *lotos* of silver, and one mark of silver contains so many *deniers* of gold. At Schemnitz the metallic veins extend north and south, running parallel to each other; and their inclination or dipping from west to east is at an angle of about 60°. There are six principal veins, besides many smaller ramifications.

The first on the west is called *Theresa-schadt*, at an average about two fathoms wide. The matrix of the ore is principally *clay* and *red ferruginous jasper or sinople*, everywhere traversed by small veins and crystals *of quartz*; and the ore itself is for the most part *lead*. About 120 fathoms eastward is the *Hospital vein*, which is much broader, being 22 fathoms wide, although not pure throughout this width. It contains many foreign substances belonging to the mountain in which it lies. Both these veins lie near the surface; they are very rich, and were the earliest discovered. The third vein is called *Oberbiber-stohln*. It differs essentially in its nature from the others, the matrix of the ore being clay, but without any *sinople*; and containing a great deal of lime, and a small portion of quartz. The next is *Johan-schadt*, about a hundred fathoms from *Oberbiber-stohln*, and containing the same ores. They both lie about 1000 fathoms deep. The fifth is that of *Stephans-schadt*, which may be considered as an assemblage of several contiguous parallel veins, reaching to the breadth of eight fathoms. At present it is the most famous of all the mines of Schemnitz; and is wrought upon a more magnificent scale than any of the others; the galleries being better constructed, and the machinery of greater magnitude. The last is the *Green-stohln* vein, where the matrix of the ore is *schistus*, indurated clay, and *pyrites*. It is the last which has been discovered at Schemnitz, and is hardly known. The average value of the Schemnitz ores is thus rated: a quintal (cwt.) of the ore contains from five to ten *lotos* of silver; and one mark of the silver, from three to six *deniers* of gold. This, however, is liable to very considerable variation, for one quintal of the ore of the *Oberbiber-stohln* vein has been known to yield 2200 lotos of pure silver, after its separation from the gold.

At Cremnitz, the direction of the vein in the principal mine is north and south, inclined from the west towards the east, according to an angle which varies from 25° to 30° and 40°. The ore consists of *auriferous quartz*, speckled with minute glittering particles of auriferous pyrites, and penetrated either by a buff-coloured clay, or by an *argentiferous* sulphuret of *lead*, and the oxide of *iron*.

Manner of working the mines.

"The manner of working the mines is fourfold. *1st*, By a horizontal level, following the direction of the *vein*. *2dly*, By an inclined plane, ascending according to its inclination; forming always stages of wood, as galleries for the workmen. *3dly*, By an inclined plane descending in the contrary direction. *4thly*, By an excavation on either side of the vein, which is the most frequent at Schemnitz, owing to the great width of the veins." The apparent care, neatness, and advantage, with which the works are carried on; the spacious entrances into their mines; their dry, airy, and cleanly levels; and the great encouragement given to the study of mineralogy, and to all mining speculations, shew that the Germans surpass every other nation in skill and industry in the art of mining.

Dr Clarke, from whose excellent work we have extracted the preceding account of the Hungarian mines, has given us the following description of the process employed for the reduction of their ores.

Process for the reduction of the ores.

"*1st*, The first operation with the produce of the mine is of course that common to all mines, of *stamping* the *ore*. But the richer ores are not submitted to the stamping machines.* They are carefully broken with hammers into small pieces about the size of beans, which, being mixed with lead, a single operation of the furnace is sufficient for their reduction. With regard to the common ores, after being *stamped* and *washed*, they are brought in the form of a fine powder or sand to Cremnitz. Here they are exposed to what is called the *crude fusion*, being simply smelted into a compound regulus, which is called *lech*, consisting of all the following metals besides *sulphur*: *gold*, *silver*, *lead*, *copper*, *iron*, *arsenic*, *bismuth*, and *cobalt*. This is the first operation.

2d, The second operation relates to the treatment of the *lech*, or result of the first crude fusion. This is exposed to a furnace, the fire of which is regulated in the following manner: First, there is a layer of wood, then a layer of charcoal, and lastly a layer of the *lech*, broken into pieces. The fuel being ignited, the *lech* is here roasted for the evaporation of the sulphur.

3d, A third operation then follows: After the lech has been roasted, they add to it powder of the richer ores, and the whole is smelted in another furnace. This is called the *second fusion*, or the *fusion enriched*.

4th, The result or *regulus* obtained from the second fusion is then carried to another furnace. Here it is again smelted with the addition of the richest ores. This *third fusion* is called the *fusion upon lead*; because, when the furnace is tapped, and the metal begins to flow into a receiver made with charcoal and clay, they cast lead upon it: this, after smelting, combines with the gold and silver, and falls to the bottom of the vessel. During this operation, the lighter metals, such as copper, iron, cobalt, bismuth, and arsenic,

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* The rule is this: When a *quintal* of the *ore* does not contain two *lotos* of silver, it is sent to the stamping machines.

rise to the surface, and are raked off in the form of *scoriæ*, which they carry, as *lech*, to be fused again in the first operation. The lead thus combined with gold and silver, is collected into large crucibles, and carried to the *fourth fusion*, or fifth operation, for the separation of the lead.

5th, The furnace used for the separation of the lead is called a *purification furnace*. The shape of it resembles a hollow sphere, whereof the upper part is so contrived, that it may be taken off like a lid, being raised by large chains. Here the richest ores that can be procured are added to the compound of lead, silver, and gold; and the whole is fused, not with charcoal, but by means of a flame drawn over the superficies, uninterruptedly for twenty-four hours at least. During this process, the lead becomes calcined. A portion of it is absorbed by the bottom of the furnace, consisting of *wood-ashes* and *silica*; another portion escapes in a gaseous form; but the greater part is raked off as it rises to the surface, in the form of *galena*, by men employed with instruments for that purpose. During all this operation, the gold and silver concentrate more and more, until at the last they are found pure and combined together in a cake of metal, at the bottom of the purification furnace. Then follows the *sixth* and the most beautiful of all the operations,—that of separating the gold from the silver.

6th, The *cake*, or combined regulus of gold and silver, obtained from the purification furnace, is separated into thin pieces in this manner: It is melted, and, in a state of fusion, cast into cold water. By this means it is obtained with a very extended superficies, and easily divided into a number of thin scales. These are put into immense glass retorts, of a spherical form, nearly filled with *nitric acid*. Here the silver dissolves, a gentle heat being communicated to the retorts to accelerate the solution. It has been usual to exclude foreigners from the great *laboratory*, where this takes place; but as we had witnessed every operation, we were also permitted to view the interior of this chamber. The sight was beautiful. It was a spacious and lofty hall, filled with enormous globes of glass ranged in even rows, whence the *nitrous gas* was escaping in red fumes to the roof; the solution of silver being visible in all of them by the effervescence it caused; the gold falling at the same time, in the form of a black powder, to the bottom of every retort. After the solution of the silver is completely effected, the *acid* containing the silver, by augmenting the heat, is made to pass into another retort, and the gold is left behind in the former vessel. Afterwards increasing the heat to a great degree on the side of the silver, the whole of the acid is driven off, and the silver remains beautifully crystallized within the retort. All the glass globes containing the crystallized silver are then cast into a common furnace, where the glass, by its levity remaining on the surface of the metal, is removed in the form of scoriæ. This is the last operation. The gold is smelted into ingots of 12,000 florins each."

Essaying laboratory.

"In the essaying laboratory, instead of the long process we have described for extracting the precious metals from their ores, two simple and easy experiments are sufficient. The first is a trial of the pulverized ore by *cupellation*. About a tea-spoonful of the pulverized ore, first weighed, is put into a small *cupel* made of calcined bones: this being exposed to the heat of a powerful furnace, the lead, semimetals, &c. are either absorbed by the cupel, or they are sublimed. Nothing remains afterwards in the cupel but a small bead of combined gold and silver; and by the proportion of its weight to the original weight of the ore, the value of the latter is determined. The gold is then separated from the silver by the solution of the latter in nitric acid; and the difference of the weight of the gold from the whole weight of the two metals combined, determines the quantity of silver dissolved by the acid." "A hundred pounds weight of their richest ores contained from four to five *marks of silver*, and each mark of the silver about 15 *deniers* of gold."

The mines are wrought partly at the expence of the crown, and partly at the expence of individuals, who pay a duty called *urbur*, and are besides obliged to deliver the metal at a fixed price to the royal treasury.

Produce of the mines.

The number of miners employed by the crown at these mines amounts to 9,500, of whom 8000 are at Schemnitz; and the expence to government of working is estimated at 50,000 florins a month, and the clear profits during the same period 12,000 florins, about £1333, calculating the pound sterling equal to nine florins. The workmen are paid, when the ore is *rich*, according to the quantity and quality of the ore raised, but when it is *poor*, they receive wages. The Schemnitz ores, in the space of thirty-three years, (from 1740 to 1773) produced seventy millions of florins in gold and silver; and those of Cremnitz thirty millions during the same period. The greatest produce, however, was derived from them in 1780, when they yielded 2,429 marks of gold, and 92,267 marks of silver, making 3,043,000 florins. In common years, according to the calculations of Born and Ferber, these mines, including the copper mine of *Neusohl*, where one quintal of copper produces twelve ounces of silver, yield from 58,000 to 59,000 marks of silver, and from 1,200 to 1,300 marks of gold.

The silver mines in Upper Hungary at Nagy-Banya, Felsoe-Banya, and Lapos-Banya, in the county of Szathmar; at Metzenself in the county of Bihar, with the copper mines of Retz-Banya and Schmoelnitz, according to Mr Ferber, give an annual produce of from 12,000 to 15,000 marks of silver, and from 300 to 400 marks of gold. The copper and lead mines in the Bannat at Oravitza, Saszka, Dognaszka, and Moldava, yield annually about 11,041 marks of silver, and 20½ marks of gold.

Copper mines.

The copper mines of Hungary produce annually from 30,000 to 40,000 quintals. The richest are situated at Schmoelnitz in the county of Zips, and in the Bannat.

Lead mines.

The lead mines in 1786 were wrought to the extent of from 14,000 to 15,000 quintals, but this produce is now considerably diminished.

Iron mines.

The iron mines in this country are almost inexhaustible. The best is drawn from a mountain called Hradek, near Esetnek; but as this metal is not subject to any duty or tithe, the annual produce of these mines have not been ascertained. In the county of Goemor, including the district of Kleinhont, there are eight great furnaces, a floating furnace, eighty-seven small ones, and forty-nine forges, which furnish annually 94,200 quintals of iron, worth 1,304,240 florins. But notwithstanding the great quantity of iron which this country produces and exports, they are obliged to be indebted to Austria for most of their tools and vessels made of this metal.

Metals.

Manganese is found near Felsoe-Banya, and in some of the iron mines; *Titanium*, in the county of Goemor near Roeze; and *tellurium*, which was discovered by Dr Kietaibel in a mineral of Deutsch-Pilsen in the county of Hont. Many valuable and beautiful minerals are found in the Hungarian mines. Among them may be mentioned, *amethysts* invested by efflorescent *manganese-spar*, in a minute crystallization upon the surface of the amethystine crystals; rich *sulphurets of silver*, called by the Germans *Weisgulden Erz*, or "white money ore," which is so malleable, that medals have been struck from the unwrought ore; *sulphurets of silver*, both massive and crystallized; *red antimonial*, or *ruby silver* crystallized; *dodecahedral* and *primary* crystallizations of *quartz*; phosphates and carbonates of *lead* crystallized; red sulphurets of *arsenic* crystallized; diaphanous crystals of the sulphuret of *zinc*, and of the sulphate of *barytes*; *pearl spar* in spheroidal tubercles, upon silver ore; native gold crystallized, &c.

Precious stones.

Of the precious stones of Hungary, the vallies of Konigsberg afford emeralds and rubies, and its mountain contains topazes, hyacinths, and chrysalites; granates are very common, and rock crystals of various forms; small crystals, remarkable for their brilliancy, are found in the county of Marmarosch, and receive the name of *Hungarian diamonds*. There are also amethysts of various colours, opals, jaspers, and agates.

Salt mines.

The salt mines of Hungary are very productive, particularly those in the counties of Scharosch and Marmarosch. In the former county, near the village of Sovar, great quantities of rock salt were extracted during the 16th century; but towards the end of the 17th century, the quarries were inundated by salt springs, which contain a remarkable quantity of muriate of soda. Since that time other inundations have taken place; but without neglecting the extracting of rock salt, establishments have been formed for obtaining common salt. These mines produce 27 per cent. All the salt pits and mines are under the direction of the crown, and produce annually about a million and a half of quintals. The price is fixed by the government, and cannot be augmented but by the king, with the consent of the diet. As the profits arising from the sale of this commodity form a part of the regal duties, it is not allowed to any individual to appropriate to his own use any saline earths or springs which he may have discovered, even on his own property.

Quarries.

Hungary abounds in quarries of limestone, and marbles of various colours. Alabaster and chalk are also common.

Manufactures.

Manufactures and the arts are still in their infancy in Hungary, and do not nearly supply the consumption of its inhabitants. Linen and woollen cloths are made throughout the country; but there is only one cotton manufactory, which is established at Sassin, in the county of Neutra. In 1800 it employed 20,000 individuals in different parts of the country, and circulated every year nearly half a million of florins. There was formerly another cotton factory at Lisza, which consumed annually about 150 quintals of cotton, and yielded a gain of 18,000 florins; but the proprietor several years ago removed it to Baad in Austria. According to M. Schwartner, this manufacture in 1796 kept 1,700 looms in employment, which produced 25,000 pieces of cotton cloth. Those in the northern districts, though still very imperfect, are the most flourishing, and have made considerable progress within the last twenty years. The other branches of industry that are deserving of notice, are the manufacture of oils, paper, potashes, spirits, liqueurs, tobacco, wood, hats, soap, leather, alum, earthen-ware, glass, copper, and iron.

The Germans were the first who introduced the arts into this kingdom in the 12th century; and from that time the principal artisans have been of that nation. A true Hungarian would consider himself degraded by being employed in any other labours than those of agriculture or arms. This repugnance is very general; and though their national *costume* has always been a hussar dress covered with lace and fringe, yet it is only within these fifty years that the capital possessed a single lace-maker.

Commerce.

Considering the extent of this kingdom, its commerce may be divided into two branches; the trade carried on between its different districts, and its trade with foreign countries, or its *internal* and *external* commerce. The inhabitants of the north, who, with their utmost industry, are unable to raise sufficient corn for their own consumption, exchange their iron, salt, cloths, and other manufactures, for a portion of the luxuriant harvests of the south; and this traffic is greatly facilitated by the establishment of fairs, of which there are 1610. The itinerant merchants, however, who frequent these fairs, and travel through the country, though they are serviceable in supplying the inhabitants with many articles which they could not otherwise easily obtain, are supposed to have done considerable injury to trade in general, and also to the revenue of the state. The merchants stationary in the towns presented a memorial to the diet on this subject in 1802, complaining that their itinerant brethren possessed neither knowledge nor character proper for merchants; that they defrauded the revenue, by smuggling articles of import; that they imposed upon the inhabitants, with damaged goods and exorbitant prices; and thus destroyed that confidence which the public ought to have in the merchant. Notwithstanding this remonstrance, however, the fairs are still continued.

The external commerce of Hungary was so very inconsiderable as late as 1779, that it yielded only 27,347 florins; but by the exertions and speculations of a few spirited individuals, who employed every possible mean for establishing foreign relations, it was brought, in the beginning of the present century, to 3,031,553 florins. Many difficulties, however, must be overcome before Hungary can be formed into a commercial country. Its geographical situation is very unfavourable to commercial operations, being sixty-eight leagues from the maritime coasts of Austria; and consequently the expence of transportation precludes it from competing in foreign markets with those countries which are more favourably situated.

Exports.

Its productions, in spite of these obstacles, are carried into Austria, Italy, Switzerland, Germany, Prussia, Russia, and other northern states. These consist chiefly in grain, tobacco, wine, gall-nuts, cattle, wool, skins, tallow, honey, wax, buckthorn, antimony, and potashes. Grain is exported into the frontier states of Austria, and by the Adriatic. In 1803, Vienna alone received from this country 543,088 Presbourg measures of wheat and rye, 316,163 of barley, and 591,839 of oats. Hungary supplies Austria and the German states with tobacco, and exports wine into all the northern kingdoms and states of Europe. Vienna alone consumes annually from 30,000 to 35,000 *eimers*.

Imports.

The imports of Hungary are derived chiefly from Austria, the government having prohibited the admission of goods through any other channel. Turkey, however, is excepted, as a prohibitory system with respect to this country could not be carried into effect without great difficulty and expence. The great magazine for Turkish produce, which passes into Hungary by land, is at Schuppanek. A considerable quantity enters also by the Danube at Panczova, Kubin, and Homolitz. The imports from Turkey by the city of Schuppanek during the years 1803 and 1804 amounted to 2,652,473 livres: viz.

	Livres.		*Livres.*
Wool	1,232,505	Suet	238,176
Cotton	194,877	Bacon	1,652
Red thread	61,743	Hams	550
Rice	32,064	Candles	116
Honey	156,378	Sturgeon's spawn	9,829
Wax	8,996	Grease	6,527
Leather	356,619	Cabbage	35,530
Hare skins	5,839	Onions	19,928
Goat do.	2,721	Garlic	365
Sheep do.	1,469	Pot-herbs	5,686
Stag do.	106	Melons	2,114
Chamois do.	11	Plums	659
Badger do.	8	Lint	490
Buck do.	38	Tobacco	155
Wolf do.	33	Buck-thorn berries	952
Bear do.	9	Gall-nuts	240
Fox-tails	371	Olives	288
Horned cattle	2,384	Olive-oil	54
Calves	129	Frankincense	48
Horses	609	Raisins	304
Sheep	3,150	Buck-horns	19
Goats	1,839	Figs	142
Hogs	6,589	Lime	23,349
Fish	214,584	Soap	1,268
Tortoises	2,239	Reed-mats	627
Salt meat	6,053	Boots	312
Beef tallow	4,419	Cordage	5,750

The imports which enter by the Danube are of the same description as those in the preceding Table; but their amount is comparatively inconsiderable. Of colonial produce Hungary consumes annually about 8,000 quintals of coffee, and 10,000 quintals of sugar. Upon the whole, notwithstanding its commercial difficulties and obstructions, the exports of Hungary are to its imports, in the proportion of more than four to three. According to the calculations of Schwartner, during ten years (from 1777 to 1786) its exports were valued at 148,229,177 florins, and its imports at 106,721,371 florins.

Coins.

The money, weights and measures of this country correspond nearly with those of Austria. In money, the common reckoning is in *florins* and *kreutzers*,—60 kreutzers being equivalent to one florin. The copper coins are; the *polturak*, equal to a kreutzer and a half; the *groszel*, value of half a polturak; and the *ungrisch*, of which five are equivalent to three kreutzers. The ideal or fictitious money of Hungary, consists of

the *bauer-gulden* = 49½ kreutzers
the *kurze-gulden* = 50 do.
the *vonas-gulden* = 51 do. and
the *ort* = 12 do.

Measures.

The measure prescribed for corn throughout the kingdom is the Presbourg bushel. In the county of Zips this measure is called a *kubel*, and is divided into two *koretzs*; but in other places the kubel is divided into four koretzs or *veka*. The *eimer* is the general measure for wine, but it varies in its contents in different parts of the country. At Oedenbourg it contains 84 *halben* or pints, and at Buda only 60. The great eimer of Debretzin is 100 pints, and the small one 50. In consequence of this discrepancy of measures, the merchants presented a remonstrance to the committee of commerce appointed by the diet. On this subject they remarked, that such a variety of measures were hurtful to commerce, and destroyed their credit among foreigners; that an *antal* of Tokay wine, which ought to hold an eimer and a half, in general contained scarcely an eimer; and that a *piece* of wine, which ought to contain 64 halben, has seldom more than 58.

The *foot* of Vienna is the standard square measure for surveying. According to a regulation called *urbarium*, the *joch* or acre is fixed at 1600 square toises; but in some of the counties where this regulation has not been introduced, this measure varies greatly; as at Oedenbourg, for instance, the acre measures only 900 square toises.

Weights.

The weights are in general the same as at Vienna, (except the *stein* used in Upper Hungary, which weighs 20 pounds) viz.

1 quintal (cwt.) = 100 pounds.
1 pound = 2 marks
1 mark = 16 loths
1 loth = 4 *quintales* or drams.
1 *quintale* = 4 deniers.

Roads.

The greatest obstructions to the commerce of this country arise from the difficulty and expence of conveyance. Except in the districts on the north and west, there are few made roads in Hungary, and these are kept in very bad repair. The bridges in general are wretched, and almost all built of wood, which the rising of the rivers often carries away and destroys. Some of the flying bridges, however, used in this country, are very magnificent, and are adorned with considerable elegance. That over the Danube at Gran consists of a large platform constructed across two barges, and held by other boats at anchor. It is provided with several small houses, a large bell and cupola, images, &c. and is capable of conveying, at the same time, a great number of carriages, passengers, and cattle. From Pesth, the centre of Hungarian commerce, the road to Vienna passes through Komorn, Raab, and Wieselbourg; to Gallicia, by Erlau, Kaschau, and Eperies; to Transylvania, by Debretzin, and also by Ketschkemet, Szegedin, Temeschwar, and Lugosch; to Walachia, by Temeschwar, Karansebes, and Schuppenek; to Semlin and Belgrade, by Theresienstadt and Neusatz; to Croatia, by Stuhlweissenbourg, Veszprim, and Kanischæ; and to Stiria and Treiste, by Veszprim, Somogy, and Pettau.

Bridges.

The transportation of goods by water, though more expeditious, suffers many interruptions, from the shallows and rapids in the rivers. The Danube itself is far from being free of these inconveniences; but boats with from 6000 to 8000 quintals of grain can pass as high as Komorn. The formation of canals, however, which has of late become an object of improvement, promises to facilitate greatly the internal commerce of this country. Those that are finished are the canal of Baatsch, the Bega canal, and the Tranzisci canal. The Bega canal commences near Facsed in the county of Krascho, and after forming a communication between the rivers Bega and Temesch, traverses all the Bannat, and falls into the Theisse. The Tranzisci canal was first opened only in 1802. It receives the waters of the Danube at Monoflor-Segh, and discharges itself into the Theisse at Foldwar; and in its whole extent requires only four sluices. In 1804, there passed through this canal 634 boats, many of which carried from 4000 to 5000 quintals; and their cargoes, which we here present to the reader, will enable him to form some idea of the internal commerce of this country.

Canals.

Statistics.

Salt	52,443	quintals
Wine	32,950¾	eimers
Wheat	607,874¾	bushels
Barley	7,540	do.
Millet	14,476	do.
Maise	4,407¼	do.
Oats	97,166¼	do.
Fruit	1,250	quintals
Copper and Silver	2,400	do.
Timber	24,654	do.
Fire-wood	850	do.
Oak-plank	529	do.
Pales	3,639	do.
Empty casks	2,376	do.
Furniture	1,105	do.
Hay	150	do.
Marble	936	do.
Free-stone	300	do.
Tobacco	271	do.
Planks	1,444	do.
Mill-stones	402	do.
Wheel-barrows	199	do.
Pitch	115	do.
Earthen-ware	6,189	do.
Hoops	100	do.
Lime	1,450	do.

Population.

The population of Hungary is much less in proportion to its extent, than that of the neighbouring countries of Austria, Moravia, or Bohemia; and this may easily be accounted for from the immense plains of sand, and the great numbers of morasses and heaths, which render a great portion of the lower plain entirely uninhabitable. According to M. Demian, the number of inhabitants amounts to 6,620,687, making 1634 to every square mile. These consist of a variety of nations, Hungarians, Slavons, Walachians, Germans, &c.

Different nations.

Huns.

The Hungarians or Huns, who settled here near the end of the ninth century, and gave their name to the country, have established themselves in the best and most fruitful part of the kingdom. They inhabit almost all the lower plain, beginning at Marmarosch, and the western part of Hungary, and form the population of 3,668 towns and villages. The true Hungarians are of a free and independent character, and affect to despise the Germans. They prefer the trade of arms, or the labours of agriculture, to every other employment. The dress, called *Hessian* in England, consisting of pantaloons and military half-boots, with spurs fastened to the heels, is so universal, that it is worn both by boys and men; and the Hussar uniform, which is peculiar to this nation, and consists of a tight vest, mantle, and furred cap, with the whiskers, give them a graceful and military appearance.

Slavons.

The Slavons are more numerous, and are daily increasing. They are divided into several branches: Slowacs, Russniacs, Croats, Vandals, and Servians or Rasciens. The *Slowacs* inhabit chiefly the counties on the north and north-west, particularly those of Presbourg, Neutra, Trentchin, Thurots, &c. and occupy 3,768 towns and villages. Of all the inhabitants of Hungary, this people are the most fruitful; for wherever they have established themselves among Hungarians or Germans, these have ceased to prosper, and their families have become extinct in a few generations. The *Russniacs* have settled in the counties of Marmarosch, Beregh, &c. bordering on eastern Gallicia. According to the *conscription tables* of 1787, they amounted to nearly half a million of souls, and peopled 702 towns and villages. The *Croats* dwell principally on the banks of the lake Neusiedl, and the counties of Wieselbourg and Oedenbourg; and the Vandals on the mountainous parts of Eisenbourg. The *Rasciens* or Servians came as colonists to Hungary during the reign of the emperor Sigismund. They occupy a great part of the military frontiers, and also many places in the interior, and have had considerable privileges granted to them by the kings of Hungary.

Statistics.

Walachians.

The *Walachians*, who are supposed to be the descendants of the ancient Roman colonies, dwell chiefly in the Bannat on the confines of Walachia, and in the counties of Arad, Bihar, and Szathmar, in 1,024 towns and villages. Those of the Bannat bear a very bad character. They are noisy and quarrelsome, and fond of gambling. They commit many disorders and crimes, which have been attributed to the influence of their priests, who are called *Popes*; and it has been calculated, that in twenty executions for capital offences, there is always one pope.

Germans.

The *German* population is scattered almost equally over all the kingdom, but it predominates in 921 villages and towns in the counties of Zips, Eodenbourg, and Wieselbourg, and in some of the royal free cities. They are almost all Suabians, and their reception as colonists into Hungary is of a late date, chiefly between the years 1765 and 1787. In the last of these years alone more than thirty villages were built for them. In general the establishment of new colonies in Hungary have cost the government more than six millions of florins. The population of the royal free cities varies from 30,000 to 1,100 inhabitants. Presbourg, Pesth, and Debretsin, are the most populous; but Rust, on the lake of Neusiedl, in 1794, contained only 1,105 inhabitants. Of the towns, the principal are, Ketschkemet, containing, in 1803, 24,000; Nagy-Koros, 12,000; Szarwasch, 9,000; Saxbereny, 12,000; and Bekesch, 11,000 inhabitants. The villages are very unequally peopled. In the lower plain, some are found with six, ten, and sometimes twelve thousand souls; but in the mountainous districts they seldom exceed 700.

Gypsies.

Besides these principal nations, there are also *Macedonians* or Modern Greeks, who have no settled habitations, but travel over the country, engaged entirely in commerce; *Jews*, who are chiefly itinerant merchants; *Armenians*, who are employed in agriculture; and *Bohemians* or gypsies. This vagabond race are very numerous in Hungary; and, in spite of all the attempts of the Emperor Joseph II. to reform and civilise them, they still maintain their ancient customs and habits. Those of the Bannat get their livelihood as itinerant blacksmiths or musicians. During summer they go almost naked, and are then employed in washing gold from the sand of the rivers; and in winter they cut spoons, ladles, troughs, and other implements of wood. They form the orchestra at all weddings and merry meetings; and many of the richest nobles invite them to their castles, to amuse their guests with their music and national songs. Schwartner, in his Statistics of Hungary, attempts to account for this variety of population: "From the earliest history, Hungary has been the native abode of the Sarmatians or Slavonic tribes. Since the fourth century, it has been the hospitable region where reposed the innumerable hordes which overturned the Roman Empire,—the asylum of many Tartar nations that were driven from their own homes, —the passage of those fanatic bands of crusaders, whom the knavery and avarice of monks sent to perish in Palestine, that they might take possession of their wealth in Europe,—as the frontier of Christendom, the theatre of European valour and Turkish ferocity,—and for a long time the cherished homes of the gypsies, the *El-Dorado* of the Germans, especially of the laborious Saxons, and numerous Suabians."

Classification of the inhabitants.

The inhabitants of Hungary may be classed under three heads, viz. the nobility, the citizens, and the peasants. The nobility are very numerous, and are calculated at 325,894 individuals, making nearly one for every twenty-one inhabitants and a half. These consist of the barons of the kingdom, or officers of state, and the order of *Magnats* (*liberi barones*). Of the latter there were, according to the Political Almanack of 1805, 95 families of counts, 79 of barons, and 297 of noble strangers, who had obtained letters of naturalization since the commencement of the Austrian sovereignty. There are only three families whose heads enjoy the title of *prince*: Esterhazy, Bathyany, and Grassalkovics. The first is supposed to be the richest subject in Europe. Among the nobility, also, are included all gentlemen who possess landed property, as the individual doing so is *ipso facto* ennobled. The title of citizen or burgher belongs only to the inhabitants of the royal free cities, who have particular privileges; and their number, including the inhabitants of the six free cities of Croatia and Sclavonia, amounts to nearly 366,000. The peasants are the inhabitants of the country, who belong neither to the noblesse, the clergy, nor the military, but who live entirely by husbandry, the cultivation of the vine, or the rearing of cattle. Of these they reckon 509,825. With them may also be classed 788,993 other individuals, whom they call *haüsler*, who have no lands to cultivate, but who live by their own labour.

Government.

The government of Hungary is a limited monarchy, where the king enjoys great authority and influence; but where the nobility also have extensive rights and numerous privileges. The order of succession is established in the descendants of either sex of the House of Hapsburg, who at their coronation must take an oath in the presence of the diet, to preserve and maintain inviolate the liberties, privileges, rights, laws, and usages of the kingdom at present existing, or which may hereafter be decreed during their reign; never to carry the Hungarian diadem out of the kingdom, but to entrust to two lay guardians elected by the diet for the purpose; to unite to the crown of Hungary all the countries which it formerly possessed should they be reconquered; to restore to the estates of the realm the right of electing a king after the extinction of the line of the descendants of Charles VI., Joseph I., and Leopold I.; and that each of their successors shall be bound to sanction this conservative act at the diet of his coronation within six months after his accession.

Prerogatives of the king.

The prerogatives of the monarch consist in his exercising the executive power in its full extent; but the legislative power he holds only in conjunction with the diet, whose decrees alone have the force of laws; the nomination to all bishoprics and abbeys, and ecclesiastical dignities, as also to all civil and military appointments, (the Palatine, and the two keepers of the crown excepted, who are chosen by the diet from a list of candidates presented by the king); the power of creating nobles, of making peace and war, and of calling out the personal levy; the right to the revenues of all vacant benefices, as also to the properties of all deceased nobles who have died without heirs, or who have been convicted of treason or rebellion; the immediate superintendance and direction of all establishments of public instruction, whether religious or temporal, whether Catholic or Protestant; and the right of convoking the diet, of pointing out the matters that are to be there discussed, and of proroguing or dismissing it.

Privileges of the nobility.

The privileges of the nobility, by an act of the diet in 1741, were formed into a fundamental law of the kingdom, and consist in the right of assisting at the deliberations of the legal assemblies of the county, wherein they dwell or possess property, whatever be the subject under consideration; the inviolability of their persons from arrest, unless in the cases of felony, high-way robbery, and some other crimes; the sole right of possessing lands with the seignorial power over their vassals; and the exemption from all contributions and imposts.

Royal privileges.

The royal free cities enjoy the same rights as the nobles without exception, and are subject to the same laws and usages. They are considered as domains of the crown, which can neither be alienated nor mortgaged. They constitute the fourth order of the diet, and are represented by two members each; and the citizens elect their own burgomasters, judges, and magistrates. Besides the royal free cities, there are others which possess particular privileges; the most considerable of which are the sixteen cities of Zips, which were mortgaged to Poland by King Sigismund, but restored to Hungary in 1772. Their jurisdiction, civil and military, is independent of the county; and they enjoy the right of appeal from their own tribunals to the supreme courts of the kingdom. Their population is 45,000. The six cities of Heidukes, in the county of Saboltsch, which possess nearly the same privileges, and send two deputies to the diet. They contain about 27,500 inhabitants; and the districts of Jazyg, of Great and Little Cumania, which form a population of 112,723 souls. They are under the immediate jurisdiction of the palatine, and form, like the royal free cities, a domain of the crown. They pay neither duty nor tithe, and send two representatives to the diet. All these, however, are subject, like the other cities, to the general contributions.

Peasants.

The peasants, since 1791, by an act of the diet, are no longer attached to the soil, but are at liberty to leave their habitations at the proper term, and seek another lord. Formerly it was not permitted for plebeians to plead in law against a noble; but the free cities pleaded for their individual burghers, and one noble defended the rights of his vassals against another. By the diet of 1802, however, it was decreed, that, for the future, citizens and peasants should be permitted, in certain cases, to prosecute for themselves. Plebeians, also, as such, may fill the highest situations in the church; and it is not unfrequent, that, on account of their learning and good conduct, they obtain letters of nobility. When once ennobled, the career of honours is open to them, and they may then aspire to the first offices of the kingdom.

Officers of state.

The principal officers of state are the *palatine*, who, besides other duties, presides at the assembly of the diet, is viceroy in the absence of the king, and generalissimo of the Hungarian troops; the grand judge of the kingdom; the *bann* of Croatia, Dalmatia, and Sclavonia; and the grand treasurer.

Diet of the state.

The *Diet* of the states is composed of four orders, viz. the prelates; the lay-barons and the magnats; the representatives of the counties, each county sending two members; and the representatives of free cities. They are invited to the diet, in the name of the king, by letters of convocation dispatched by the chancery;

and these letters often contain a statement of the different points that are to be there discussed, that the counties and free cities may give proper instructions and powers to their deputies. According to the constitution, no one but a noble, that is, one who possesses landed property, can sit and deliberate in the diet. When assembled, all the members are considered as upon an equality; neither baron nor bishop having any privileges more than a simple gentleman. They meet in separate chambers: the chamber of *magnats*, where the palatine presides, and which is composed of the prelates, the barons of the kingdom, the governors of counties, and all the counts and barons who may be members of the diet; the other deputies, who are the most numerous body, constitute the chamber of *states*, where the grand judge presides. When a motion has passed both chambers, the king has the power of confirming or rejecting it, his approbation being necessary to give it the force of a law.

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The internal police of the kingdom is administered by the supreme aulic chancery, the council of government, and other subordinate courts. The first sits at Vienna, and is composed of an aulic chancellor, vice-chancellor, and ten aulic counsellors, all chosen by the king. Of the counsellors, two are bishops, two magnats, and six nobles. It is the organ by which the king exercises his royal authority, and directs the political affairs of the interior. It expedites all letters-patent, granting favours and privileges, and also all diplomas, nominating to vacant bishoprics, ecclesiastical benefices, and other offices. The *council of government* sits at Buda, and consists of the palatine, who is president, and 24 counsellors. It has the superintendance of all inferior courts, and of all matters regarding general police and public safety, and the inspection of churches, universities, &c.; it encourages agriculture, industry, and commerce; and decides in all matters of litigation respecting the services of peasants towards their lords, &c.

ubordinate ourts.

The subordinate courts are those of the counties and free cities. Each county has its governor and two vice-governors, a procurator and vice-procurator-fiscal, a receiver-general and assistant, a notary, &c. The governors are appointed by the king, except in the cases of the palatine, the primate, the princes Esterhazy and Bathyany, the counts Kobari, Illeshazy, Palfy, Nadasdy, Schonborn, Csaky, Erdody, and baron Revay, who are hereditary governors of counties; the other magistrates are appointed by the county, and are renewed every three years. The governor convokes the county whenever he thinks it necessary, and all the nobility within its bounds have a right to deliberate and vote. The subjects which are there discussed, regard the police and agriculture of the county; the election of their deputies and magistrates; the levying of contributions and imposts; and the publication of the decrees of the diet, and of the council of government. The magistracy of a free city consists of a judge, a burgomaster, a counsel, a notary, &c. to whom are entrusted the administration of justice and police within the royalty.

Tribunals f justice.

The tribunals of justice, which possess general jurisdiction throughout the kingdom, are the septemviral table, and the royal table. The *septemviral table* consisted formerly only of seven members, but it is now augmented to twenty-two, of whom the palatine is president. It is only a court of cassation, and receives processes by appeal from the royal table and inferior tribunals. The *royal table*, where the grand judge presides, is composed of seventeen members, nine of whom must be present, in order to constitute its decisions valid. It pronounces on all disputes respecting property, the maiming or murdering of nobles, and crimes of high treason. It is also a court of appeal, and holds four sessions during the year.

Special judicatories.

The inferior and special judicatories are the four tribunals of the circles, which decide only in civil cases, having no criminal jurisdiction; the county tribunals, which have also four sessions, and take cognizance of all matters civil and criminal, except in cases of high treason; the district tribunals; the city tribunals; and the tribunals of individual nobles. Croatia has also a court of appeal called *tabula banalis*, which sits at Agram, and of which the ban of Croatia and Sclavonia is president. It has the same jurisdiction within these provinces as the royal table at Pesth, with this difference, that an appeal may be carried from the *tabula banalis* to the royal table.

Jurisprudence.

The bases of Hungarian jurisprudence are the *corpus juris Hungarici; decretum tripartitum Verboeczianum*, and *decisiones curiales*. The *corpus juris Hung.* is a collection of all the decrees passed by the diet from the commencement of the monarchy, and was first formed in 1584. Since that time it has received so many additions, that it is increased one half; but, latterly, these laws have been so ill digested, and so intermixed with other matters, that the confusion which is thus occasioned renders the study of them both difficult and laborious. The *decretum tripartitum Verboeczianum*, is a collection of customs introduced into the administration of justice, which, by long usage, have received the force of laws. This collection was made by Verboecz, the grand judge in the reign of Ladislaus II.; and though it has been rejected as a national code by several diets, yet, through the course of time, it has acquired such reputation, that it is actually acknowledged throughout the kingdom as forming a legitimate part of Hungarian law. The *decisiones curiales* are the decisions of the judges of the royal table on certain questions to which no existing law could be directly applied. They were collected by order of Maria Theresa in 1769; and, after having been revised by the septemviral and royal tables, were published under the title of *planum curiale*.

Revenue.

The revenue of Hungary arises from three sources; the royal domains, the regal duties, and the contributions or imposts. The *royal domains* consist of the *kron-güter*, or such property as is attached to the crown, and is unalienable; and the *kammer-güter*, that which belongs to the king personally, and which he can dispose of at his pleasure. The annual value of both amounts to 6,000,000 of florins. The *regal duties* comprehend the management of the salt, which is supposed to yield nearly 6,800,000 florins; the mines, which, after deducting all expences, produce 1,097,000 florins; the duties upon exports and imports, valued at 1,300,000 florins; the quit-rents of the royal free cities, and of the sixteen cities of the Zips, amounting to 34,000 florins; the royal exchequer, which brings 94,000 florins; the toleration tax paid by the Jews, producing 100,000 florins; the tax of 5 per cent. upon all employments, to which is attached a retiring pension, yielding 37,000 florins; the ecclesiastical subsidy, which, in 1781, was 71,000 florins. To these may be added the post-office, the tolls upon the bridges, the tax of 10 per cent. which all must pay who carry their fortune out of the country; the lottery; and the banks, of which there are two, one at Presbourg, and the other at Buda. The contributions or imposts are levied upon the counties and cities.

The total amount is fixed by the diet, and is divided into *porten* or portions, each of which is valued at 688 florins, 50 kreutzers. Every county and city is then burdened with so many *porten* according to its population and resources, which they collect from the citizens and peasants. The sources of this branch of the revenue arises from the poll-tax; tax upon cattle, &c.; the land-tax paid by the farmer; and a tax upon trades, &c. The total amount of the contributions in 1802 was 6210$\frac{2}{3}$ *porten*, making 4,277,827 florins, 12$\frac{2}{3}$ kreutzers; to which may be added 113,615 florins, 58$\frac{2}{3}$ kreutzers for Croatia. The total revenue of Hungary cannot be well ascertained, as the different items given above are not for the same year, and authors are also much divided in opinion respecting it. Schloezer makes it 13,500,000 florins; Busching, 18,000,000; De Lucca, 15,000,000; Schwartner, 11,750,000; and Demian, who is the latest author, fixes it at between 15 and 16 millions of florins. After deducting the public expenditure, the surplus, according to Schwartner, amounts to 1,002,296 florins.

Finance.

The management of the finances is entrusted to the royal chamber of Buda, which is independent of all other authority within the kingdom, and corresponds with the royal treasury at Vienna. It administers all the royal revenues, except the contributions, which are lodged in the government chest, and the mines and mint, which are entrusted to a particular council.

Army.

Since 1802, the Hungarian army, exclusive of the frontier regiments, is formed of twelve regiments of infantry and ten regiments of cavalry, making an armed force of 64,000 men. The military cordon, which extends along the frontiers from the Adriatic to the county of Marmarosch, is formed of seventeen regiments of armed peasants, each regiment having its particular district; viz. eight in Croatia, three in Sclavonia, two in the Bannat, and four in Transylvania. Each regiment has two battalions, and in time of war a battalion of reserve; the whole, exclusive of the reserve, amounting to 49,402 men. There is also a regiment of hussars, whose complement, in time of peace, is 1364 men and 1212 horses. The Hungarian army is maintained by an annual contribution, fixed by the diet in 1715, which is levied upon the citizens and peasants, and amounts to nearly three millions of florins. The country is also obliged to furnish bread and forage necessary for the troops at a fixed price, whatever be the price of these necessaries in the public markets; and the loss which is thus sustained by the counties, is computed at about a million of florins. The extraordinary contributions, however, which were required during the late wars with France, were paid almost entirely by the nobility.

Levies.

In addition to the permanent army establishment, the diet, in urgent cases, grants a levy at the request of the king. During the middle ages, every Hungarian noble, by a law of the kingdom, was obliged to arm himself and his vassals in defence of the country when threatened by an enemy; and in cases of imminent danger, the whole nation took up arms. The levy now, however, is confined to a certain additional force, furnished and paid by the counties and cities. The first levy of this description was raised in 1741, for the war of the succession; and in the first coalitions against France, regular levies were decreed by the diet; but they were always too late of being brought into the field, to be of any service to the common cause. The levy of 1797, 40,000 strong, was scarcely assembled before the peace of Campo Formio was concluded; that of 1800 was stopped in their march by the peace of Luneville; and that of 1805 was withdrawn on account of the peace of Presbourg.

Religion.

Roman Catholic church.

All religious sects enjoy full toleration and security in this kingdom, as well as in other parts of the Austrian dominions. The Roman Catholic is the established religion, and is under the jurisdiction of three archbishops, Gran, Kolotcha, and Erlau; 14 diocesan bishops, and 16 titular bishops; 16 metropolitan chapters, and two others of collegiate churches; 178 beneficed canons, and 79 honorary canons; 1 archabbot, and 146 abbots; 19 grand provosts, and 89 provosts. The revenues of the bishops and chapters are very considerable; and, according to Schwartner, that of the former, in his time, amounted to 864,776 florins, and of the latter to 530,668; but, according to Demian, they may now be valued, when taken together, at above two millions of florins. The inferior clergy are composed of pastors and monks. Of the former, there are 4189, including 2298 rectors, 402 chaplains, and 1489 curates; and of the latter are 3059, including 2236 priests, 214 novices, and 609 lay brethren. The Emperor Joseph II. increased the number of the pastors, so that every *commune*, containing a certain number of parishioners, should have one; and fixed their allowance at 300 florins for each rector, and 240 for each chaplain or curate. According to Grellmann, the Roman Catholic pastors, comprehending those of Croatia and Sclavonia, receive 1,379,500 florins. But, while the Emperor Joseph augmented the number of pastors, he at the same time suppressed 134 monasteries, containing 1209 priests and 275 lay brethren. There are still 136 remaining, of different orders: the *Piaristes*, who have two residences and 23 colleges; the *Benedictines*, four abbeys and three residences; the *Premontres*, five abbeys; the *Citeaux*, two abbeys and three monasteries; the fathers of *Charity*, ten monasteries; the *Cordeliers*, 61; the *Minimes*, eleven; the *Capuchins*, seven; the *Dominicans*, four; the *Carmes*, one; the *Servites*, three; and the *Augustines*, one. The support of these religious beggars, since they were precluded from seeking alms, costs the chest of religion 75,000 florins a year. There are also ten convents, containing 274 nuns and 116 lay-sisters; six of the order of *Sta. Ursula*, two of *Sta. Elizabeth*, one of *Notre Dame*, and one for English ladies at Buda. Six convents had been suppressed by the Emperor Joseph, containing 152 nuns and 39 lay-sisters. In 1802 there were 500 monks and nuns of the suppressed convents still living, who received pensions from the chest of religion; the priests and nuns from 300 to 200 florins, and the lay-brethren and sisters 150 florins. The number of Roman Catholics in the kingdom is calculated at about 4,000,000.

Greek Catholic church.

The Greek Catholic church, whose members amount to nearly 500,000, is under the direction of two bishops, who are suffragans to the Roman Catholic archbishop of Gran; two chapters composed of two grand provosts; eleven beneficed canons and six titular canons, and 820 pastors. The revenue of the two bishops is 28,000 florins, that of the chapters 9150, and that of the pastors 78,000 florins. Belonging to this church, are eight monasteries of the order of *St Basil*, containing 68 monks, 21 novices, and 17 lay brethren.

Greek Schismatic church.

The Greek Schismatic Church has five bishops, all suffragans of the metropolitan archbishop of Carlowitz in Sclavonia, whose dioceses contain 1120 parishes. There are ten monasteries of this religion, having a revenue of about 17,000 florins, and are inhabited by 82 monks. This sect amounts to 1,877,587 souls.

Lutheran church.

The Protestant Evangelical, or Lutheran Church,

Statistics. consisting of 700,000 souls, has 445 places of worship, and 478 ministers, who are chosen and supported entirely by their congregations.

Reformed church. The Reformed Evangelical Church is under a similar constitution, and includes 1324 churches, 1361 ministers, and 1,300,000 members.

Jews. There are 75,128 Jews, who have 42 synagogues and 56 rabbis. This sect is excluded from all the cities which are near the mines; and some other cities consider the prohibiting of Jews to settle within their walls among the number of their privileges. **Anabaptists.** The Anabaptists are inconsiderable in number, and are to be found only in a few cities.

Public instruction. **General schools.** The establishments for public instruction in Hungary may be distinguished into General and Particular. Of the former, there is an elementary school, with two masters, established in every Catholic commune, where are taught reading, writing, arithmetic, and religion. In addition to these, there are also 73 principal schools, to which are attached 234 teachers; 9 normal schools, with 51 masters; 43 gymnasia, with 88 professors; and 5 arch-gymnasia, with 26 professors. In all these establishments, education is gratuitous, and costs the state about 90,000 florins. For the higher sciences, there are four academies, at Presbourg, Kaschau, Grosswardein, and Raab; a lyceum at Erlau; two schools of philosophy at Stein-am-Anger and Szegedin; and a university at Pesth. Besides a school in each of their parishes, the Lutherans have several other establishments for the education of their youth. In all of them, however, the sciences are very imperfectly taught, and the masters very poorly paid. The Reformed, in addition to their parish-schools, have two colleges at Debretzin and Saros-Patak, which are intended chiefly for the education of their ministers. The Greek Schismatics have very few schools, except in the military frontiers of the Bannat, where there are 130, with 3615 scholars; and those of this persuasion who wish to study the higher branches of science attend the Catholic or Protestant academies.

Special schools. The Special Schools consist of the practical schools for rural economy in all its branches, of which there are four, at Szarwasch, Kesthely, St Mikloseh, and Hradek; a school for the deaf and dumb at Waitzen, and the royal school of mines at Schemnitz. To the school of mines at Schemnitz, are attached two professors, one for metallurgy and chemistry, and the other for mathematics and other subjects connected with the mines. It is of great repute on the continent, and is generally attended by 90 students of different nations.

Literature. Notwithstanding the number of public establishments for education in this country, the state of the sciences and literature is still very low. The Latin language is in general use among the inhabitants, and indeed there are few parts of the country where it is not understood even by the lower orders. At Schemnitz, "the most prevailing tongue is the Sclavonian; next to this the Hungarian; then the German, and lastly the Latin." "Some conjecture," says Dr Clarke, "respecting the state of literature in any nation may perhaps be formed by examining the booksellers shops belonging to its capital; and with this view we eagerly inspected those of Presbourg, but no prospect could be more barren: there was not a single volume worth a moment's notice either upon sale in the town, or mentioned in any of their catalogues." The public library at Pesth, however, contains all the best editions of the classics, and some manuscripts, but these are of little value. The Hungarian language cannot boast of one work of merit; and even its Latin writers are very little known. The most voluminous and celebrated authors of this nation are Pray and Windisch. The researches of the former, who wrote in Latin, were confined chiefly to the history of his country; and those of Windisch, in German, to its geography.

See Gibbon's *Roman Empire*, 4to, vol. ii. p. 577. vol. iii. p. 362, and vol. v. p. 143, 548. *Anc. Un. Hist.* vol. xix. p. 204. *Mod. Un. Hist.* vol. xxxii. p. 99. Demian *Tableau Geographique et Politique des Royaumes de Hongrie*, &c. translated from the German. Clarke's *Travels*, vol. iv. pp. 627—700. Pray's *Historia regum Hungariæ*, &c. Windisch's *Political, Geographical, and Historical Description of the Kingdom of Hungary*, in German; also his *Geography of Hungary*. Schwartner's *Statistics of the Kingdom of Hungary*. Sacy's *History of Hungary*. Townson's *Travels in Hungary*. Born's *Travels in Hungary*, &c. (*p*)

HUNGER. See Abstinence and Fasting.

HUNS. See Hungary.

HUNTER, William, M. D. celebrated as a physician and author, and as the collector of the Hunterian museum now in Glasgow, was born on the 23d of May 1718, at Long Calderwood, his father's estate, in the parish of Kilbride. At the age of 15 he was sent to the university of Glasgow, where he passed five winters, being destined by his father for the church. This pursuit, however, did not accord with some modes of thinking which he had adopted; and an acquaintance which he formed with Dr Cullen, then a practitioner at Hamilton, inspired him with a taste for the medical profession, to which accordingly he attached himself. He resided three years with Dr Cullen as his pupil; after which it was agreed that he should study in Edinburgh and London, and afterwards return to Hamilton, to settle in partnership with Dr Cullen. In pursuance of this plan, he studied in Edinburgh in the winter of 1740 and 1741; and in the summer of 1741 he went to London, where he lived in the house of Dr Smellie; and prospects gradually opened on him, which induced him to remain in the metropolis. He brought with him a letter of recommendation to Dr Douglas from Mr Foulis of Glasgow, (the well-known printer of excellent editions of several of the classics,) who had formed a connection with that physician, by procuring for him various editions of Horace, of which the enthusiastic admiration of Dr Douglas made him anxious to possess himself of every existing edition. Dr Douglas, entertaining a favourable opinion of Mr Hunter's talents, proposed to engage him as his assistant in performing dissections for a splendid work on the bones, which he was then preparing for publication. Mr Hunter, obtaining his father's consent, accepted of this offer. His father died soon after, and in a few months, he also lost his patron Dr Douglas, who died, leaving a widow and two children. Mr Hunter continued to reside in the family, superintending the education of the children, and prosecuting his own studies. In 1743, he communicated to the Royal Society his observations on the structure of the cartilages of the joints, in which he shewed that, contrary to the ideas previously entertained, they were formed of short perpendicular fibres, like the enamel of the teeth. Meeting with applause in his anatomical pursuits, he wished to lecture on anatomy; and an opportunity was soon afforded him by Mr Sharpe, who had for some years lectured to a society of naval surgeons, and declined this task in favour of Mr Hunter. In commencing his first course, he felt great solicitude; but he soon met with applause which encouraged him. He had little difficulty to encounter compared to one who commences such an undertaking, without previous introduction to public notice. His eminent talents were in the first instance exercised in a field in which they were sure to be recognised. He therefore proceeded, not merely with confidence, but with enthusiastic zeal, in the pursuits in which he so much delighted. The profits of the first winter put him in possession of a larger sum than he had ever before possessed, 70 guineas; but as his generosity led him to supply the wants of different friends, his fund was completely exhausted before next winter, and he was even obliged to delay his lectures for a fortnight for want of money to pay for advertising. This incident, together with the ultimate inutility of some of his generous acts to those who were the objects of them, impressed on him a lesson of prudence, which preserved him ever after from similar inconveniences, and laid in part the foundation of that fortune which he expended in a public-spirited manner.

In 1747, he became a member of the college of surgeons; and in the spring of the following year he made a tour with the son of Dr Douglas through Holland to Paris. The beautiful anatomical preparations of Albinus which he saw in Holland inspired him with admiration, and an ambition to emulate their excellence. He returned to resume his lectures; and in the mean time he practised both surgery and midwifery. But he soon gave up the former of these branches, and attached himself to midwifery, in which his late preceptor Dr Douglas had been eminent. He was elected, in 1748, surgeon accoucheur to the Middlesex hospital, and the following year to the British lying-in hospital. These appointments, together with his agreeable person and address, in which he furnished a favourable contrast to Dr Smellie, who at that time enjoyed a high reputation, promoted greatly the extension of his practice, which was rendered still greater by the death of Sir Richard Manningham, and the retirement of Dr Sandys.

In 1750, he obtained the degree of M. D. from the university of Glasgow. At this time, he quitted the family of Mrs Douglas, and took a house for himself in Jermyn Street. In the summer of 1751, he paid a visit to his mother and other relations in Scotland, where he had an opportunity of exchanging congratulations with Dr Cullen, who was now, like himself, rising into eminence, and was established as a physician and professor in Glasgow.

In 1755, he was made physician to the British lying-in hospital on the resignation of Dr Layard, was admitted licentiate of the college of physicians, and soon after became a member of the medical society of London. He published, in the *Observations and Inquiries* of this body, a history of an aneurism of the aorta.

Dr Hunter turned his extensive practice to very eminent account, by adding to the pathological and medical knowledge of the age. He had the merit of first explaining the nature of the disease called *retroversio uteri*, and distinguishing it from other diseases with which it had been confounded; he explained the texture of the cellular membrane, and the pathology of anasarca and emphysema; he also threw much light on the subjects of ovarian dropsy, diseases of the heart and stomach, and hernia. For his papers on these and many other subjects, we refer to his *Medical Commentaries.*

In 1762, he was consulted during the pregnancy of the queen, and in two years after was appointed physician-extraordinary to her Majesty. In 1767, he became a fellow of the Royal Society, and enriched their Transactions with his learned observations on the bones of animals found on the banks of the river Ohio, and on the rock of Gibraltar.

He, after this, became engaged in some personal disputes with the present Dr Monro, senior, of Edinburgh, on their contending claims to priority in anatomical discoveries. This contest became keen, and was enlivened with wit and pleasantry; but probably more was lost by the irritation which it created, than was in any respect gained by either party. A man, in defending his own claims, is tempted to expose every defect which tends to shake the general credit due to his adversary, and the feelings which are most profitable and becoming for men of liberal pursuits are extinguished. Those are happiest who feel no temptation to enter on such controversies, or who, if accidentally betrayed into them, soon perceive their pernicious tendency, and in good time relinquish them. The subjects of dispute were indebted to both of these celebrated anatomists, but they both had been anticipated in some of their boasted discoveries by Haller, in others by Nougues. The principal of them were the origin and uses of the lymphatics; the possibility of injecting the epididymis, and the excretory ducts of the lacrymal gland.

In 1768, Dr Hunter was elected a member of the Society of Arts, and was appointed anatomical professor to the Royal Academy of Arts. By now applying his anatomical knowledge to the elucidation of painting and statuary, he displayed in a new field the versatility and extent of his genius. In 1781, he was unanimously elected to succeed Dr John Fothergill as president of the London Medical Society. In the same year, the Royal Medical Society of Paris elected him one of their foreign associates; and, in 1782, he received a similar mark of honour from the Royal Academy of Sciences of Paris.

Dr Hunter's most distinguished publication was his *Anatomy of the Gravid Uterus,* which he began in 1751; but, from his great ambition to give it in the most complete state, he delayed to publish it till 1775.

In consequence of a memoir read by Mr John Hunter in 1780 to the Royal Society on the functions of the placenta, Dr Hunter was led into another keen dispute with this eminent man and near relation, in which he claimed, with considerable warmth, the share of merit which belonged to himself in the discovery. He seems to have perceived that he carried these disputes too far. They promoted an irritability of temper, which must have created to him much uneasiness; and it was remarked by those who occasionally conversed with him on professional subjects, that sometimes, when an organ or function was barely mentioned which had been the subject of a dispute, he broke out into a torrent of abuse of the knavery of his adversary. In the supplement to the first part of his *Commentaries,* he excuses his polemical appearances by representing *enthusiasm* as necessary to promote the sciences, and observing, that no man had ever been a great anatomist who had not been engaged in some violent dispute.

Dr Hunter was long employed in collecting and arranging materials for a history of morbid concretions formed in the human body. This design, however, was left imperfect, along with others contained in different manuscripts.

The magnificent museum, which we have already mentioned, is a monument which will perpetuate the name of Dr Hunter. The systematic manner in which he planned and conducted that undertaking was characteristic of a strict philosophic prudence. He did not follow the occupation of a collector under the influence of a passion the effects of which might afterwards interfere with his private happiness. He first laid aside a sum which he reckoned an adequate provision for himself whenever he should be obliged to retire from practice, and resolved to dedicate the remainder of his fortune to some plan of public utility. In 1765, he projected an anatomical school on a grand scale, proposing to expend £7000 on the building, and to endow a professorship of anatomy. He did not however receive the encouragement from government which he expected; and, though afterwards the Earl of Sherburne entered so much into the scheme as to offer 1000 guineas to encourage the execution of it by means of subscription, the doctor's delicacy would not allow him to accede to this plan, and he chose to execute it at his own expence: for which purpose he purchased a house in Great Windmill Street, to which he removed in 1770, in which he had an amphitheatre and apartments for dissection, besides a magnificent room for a museum. Previously to this time he had confined his collection to human, comparative and morbid anatomy; but he now extended his views to the formation of a general museum, including fossils, antique medals, and rare books in the Greek and Latin languages. In an account of a part of this collection published by his friend Mr Combe, the expence of it was estimated at £20,000. In 1761, he added to it the collection of Dr Fothergill, consisting of shells, corals, and other curious objects in natural history, which were purchased for £1200.

About the year 1773 he had experienced so much injury to his health from gout, that he thought of giving up practice, and returning to Scotland; but prudential considerations, and his attachment to his favourite pursuits, determined him to remain in London. The returns of his disease became more frequent; and at last, on Saturday the 15th of March 1783, after having experienced a return of wandering gout, he complained of great head ach and nausea, and was confined for a few days to bed. He then thought himself so well that he gave his introductory lecture to an intended course of surgery; but, towards the conclusion of the lecture, he fainted away, and was carried to bed. This happened on a Thursday. On the Saturday morning he told his friends, that he had a paralytic stroke in the night, though no symptom of it then appeared about him. He suffered little or no pain; and at one time, turning to his friend Mr Combe, he said, "If I had strength enough to hold a pen, I would write how easy and pleasant a thing it is to die." His death happened in ten days after his last lecture, viz. on the 30th of March 1783. His figure was small and slender, but symmetrical and becoming. He was an agreeable, lively companion. The chief blemish in his character was an irritability on some subjects which gave his manner an air of imperiousness. He will long be held in high estimation as a man who, when the limited extent of his means is considered, contributed in a singular degree to the promotion of science. His nephew, the present celebrated Dr Baillie, was left the use of his museum for life, to be succeeded by Mr Cruickshanks, Dr Hunter's assistant, who was to enjoy it for thirty years, and then it was to become the perpetual property of the university of Glasgow. The right of reversion of Mr Cruickshanks was extinguished by the death of this gentleman; after which Dr Baillie generously gave up his claim, and the museum was removed to Glasgow, where magnificent apartments have been built for it, and the annual interest of £8000, left by Dr Hunter, is appropriated to the preservation and augmentation of it. It has already been enriched with many additional articles; and, on the whole, adds a new lustre to that seminary, and tends to promote the resort to it which it has so long and so deservedly attracted. (*H. D.*)

HUNTER, John, an eminent surgeon and author, and brother to the subject of the preceding article, was born at Long Calderwood on the 14th of July 1728. He was about ten years old when he lost his father; and, being the youngest child, was so much indulged by his mother, that, though sent to the grammar-school in Glasgow, he made no proficiency in his studies, and at last leaving them, lived for some time idle in the country. Tiring of this mode of life, he wrote to his brother Dr Hunter in London, proposing to become his assistant in his dissections; or, if that would not suit him, to go into the army. The doctor gave him a kind invitation to London, and he went up to him in September 1748. The doctor found, on a very short trial, that he promised to become an expert dissector; and, entertaining great hopes of him, gave him every encouragement to persevere in professional pursuits. The following summer he attended Chelsea hospital, where he learned the first rudiments of practical surgery. By the succeeding winter he had made such proficiency, that his brother left in a great measure to him the superintendence of his public dissecting room. In the following summer he renewed his attendance at Chelsea hospital, and the summer after that he attended at St Bartholomew's. In 1753, he entered as a gentleman commoner at St Mary's Hall, Oxford. In 1756, he was appointed house surgeon to St George's hospital, where he had attended as a pupil the two preceding summers. In 1755, he was admitted to a partnership in his brother's lectures. His uncommon dexterity in making anatomical preparations, and some distinguished discoveries which he made in anatomical science, gradually raised him to great celebrity. He traced the ramifications of the olfactory nerves on the Schneiderian membrane; he demonstrated the mode of termination of the arteries of the uterus in the placenta; and he was the first who discovered the lymphatic vessels of birds. By directing his labours extensively to comparative anatomy, he laid the foundation of his splendid anatomical museum. These labours were not conducted with the design of exhibiting preparations of the entire bodies of different animals, but for the more useful purpose of illustrating, in a regular series, the varieties of organization subservient to each function in the different classes of animals. He applied to the keeper of the Tower, and other persons who kept wild beasts, to procure the bodies of those that died; and he had generally in his possession living animals of different species, for the purpose of observing their manners and instincts. Two anecdotes are related by his brother-in-law Sir Everard Home, that are very characteristic of his enthusiasm in this amusement. Two leopards which he kept broke loose on one occasion from their den, and the howling of his dogs in the same yard alarmed the whole neighbourhood. Mr Hunter ran into the yard, and found one leopard scrambling over the wall, while the other was surrounded by the dogs. He without reflection seized both of the leopards, and led them back into their den; but immediately after, when he thought of the risk which he had run, as an unlucky irritation on their part might have terminated in his immediate destruction, he was so much agitated that he almost fainted away. On another occasion while he was struggling with a young bull, a species of amusement in which he had delighted, the animal got him down on the ground, and would have proceeded to the utmost extremities, if a person luckily coming to the spot had not rescued him.

In 1767, he was made fellow of the Royal Society, and formed a party of friends, who met at a coffee-house to discuss points of science after the meetings of the Society, which he soon found to increase, and to consist of some of the most eminent men of the age. It contained Sir Joseph Banks, Dr Solander, Sir Charles Blagden, Sir Harry Englefield, Mr Watt of Birmingham, and several others. An accident which he suffered, the rupture of the tendo achillis of one leg in dancing, led him to study particularly the surgical pathology of that part, which he illustrated by experiments on animals. In 1768, Mr Hunter went to the house which had been occupied by his brother in Jermyn-street, as the latter moved to his house in Windmill-street, which he had just completed, and adapted on an extensive scale to his learned pursuits. Mr Hunter was thus placed in a favourable situation for private practice, and he now became a member of the College of Surgeons. In May 1771, he published his celebrated work on the natural history of the teeth. In the following July he married Miss Home, of whom the present Sir Everard Home was a younger brother. The latter was then at Westminster school, and was brought up by Mr Hunter to the profession of surgery. It is to this gentleman that we are indebted for the interesting life of Mr Hunter, prefixed to a posthumous edition of his book on Inflammation. Mr Hunter's progress in acquiring practice was at first slow, as he was not possessed of those winning manners, and did not study those superficial arts by which many rise in this respect to distinction. But the weight of his character for genius and professional industry at last brought him into the highest repute. His income was greatly augmented; but it was chiefly expended on his museum, to which he also regularly devoted his mornings from sun-rise to the hour of breakfast. He continually laboured to turn his physiological discoveries and observations to account in improving the art of surgery. To enumerate his improvements would far exceed our limits, and they are only to be learned by perusing his valuable works. He always delighted in making acute discoveries, and striking out new views. It is in explaining the phenomena of inflammation in its various forms, and the principles on which the healing process under various circumstances is conducted, that Mr Hunter's genius is most usefully displayed. Some of his opinions cannot be easily admitted as well-founded; such as his doctrine of the life of the blood, and of the identity of syphilis and gonorrhœa. In the winter of 1773, he began to give lectures on surgery, in which he delivered a full account of his practical improvements, as well as his pathological views. His first two courses were given gratis. He continued to improve comparative anatomy by the dissection of various animals, some of which were rare and curious, such as the torpedo and the gymnotus electricus, the electrical organs of which he described. He repeatedly dissected the elephant; he discovered those receptacles in the bodies of birds, to which the air passes through the lungs, which threw a new light on the function of respiration as performed by that class of animals. He engaged an artist to live with him, for the purpose of making drawings of such parts as did not admit of being preserved. In 1776, he was appointed surgeon extraordinary to his Majesty. In the autumn of that year however, he was taken dangerously ill, and began to reflect seriously on his situation and that of his family. As he had expended his fortune in his museum, he was desirous of making it appear to advantage, that it might bring its value after his death. Accordingly, as soon as his health permitted he arranged it, and made out a systematic catalogue of its contents. He aferwards regained sufficient health to prosecute his physiological and surgical investigations; and numerous ingenious papers written by him after this period, appeared in the Transactions of the Royal Society. In 1783, he had the honour of being admitted into the Royal Society of Medicine, and the Royal Academy of Surgery of Paris. The lease of his house in Jermyn-street having at this time expired, he purchased one of a large house in Leicester Square, on which he was tempted to expend above £3000, which sum was in a great measure lost to his family by the shortness of the lease. Here he had ample accommodation for his museum. The eclat which this great object gave to him, however, was very great; and the services of his friends and the public were always readily furnished, when they could contribute to adorn it with new articles in comparative anatomy. In 1786, he published his work *On the Venereal*, and his *Observations on certain parts of the Animal Economy*, consisting of a collection of papers which had appeared in the Philosophical Transactions. About this time his health began to decline, and he was obliged to resign much of his laborious duty to his brother-in-law Mr Home; but we find him still active in adding to the stock of professional information. He wrote some physiological papers, for which he obtained the Copleian medal. In 1792, he gave up his course of lectures entirely to Mr Home. But he continued to receive splendid marks of public respect; he was appointed inspector-general of hospitals, and surgeon-general to the army; he was made a member of the College of Surgeons of Dublin, and one of the vice-presidents of the Veterinary College then first established in London. He continued to write various papers which appeared in the Transactions of the Society for promoting medical and chirurgical knowledge.

His health during the last twenty years of his life was greatly impaired. The symptoms of his disease, which was *angina pectoris*, are minutely described by Sir Everard Home in the account of his life. The first attack was brought on by mental irritation, and, though he was liable afterwards to slight affections from causes of different kinds, every severe attack arose from some mental cause. Unfortunately his mind was easily provoked by trifles, while matters of real importance produced no effect. He died suddenly under an accidental irritation at St George's hospital, while he laudably attempted to controul it till he obtained information of the circumstances by which it was occasioned. This event took place on the 16th of October 1793, in the 65th year of his age.

He was a man of uncommon originality of thought, which he displayed under considerable deficiencies of general erudition. In this respect he was a contrast to his brother, who united genius with erudition in an eminent degree. This circumstance seems, however, to have had the effect of concentrating his attention more completely in his favourite objects of pursuit, and to have given a character of more obvious originality to all his writings. Though ambitious of a high name in his own line of investigation, he was not envious of the well merited honours of others. But he was liable to strong indignation at the presumption of ignorant mediocrity or indolence. He was prone to undervalue too much those professional men who were his inferiors in merit, and who, while they paid no homage to his doctrines, made feeble attempts to shine by their own light. He was frank in his manners and conversation, a decided enemy to all deceit and intrigue, but on the whole too apt to speak harshly of his cotemporaries.

The museum which he left, was purchased by the

British government, was by them committed to the charge of the college of the college of surgeons, and is now contained in a splendid hall fitted up for the purpose, where a professorship of comparative anatomy is attached to it; and it is open to the inspection of the public on certain days of the week for the greater part of the year. This museum affords a brilliant proof of the comprehensive views and persevering assiduity of the collector. It presents a very extensive collection of anatomical facts, arranged in such a manner, as to illustrate, in a beautiful series, the various functions as performed in the gradations of organised nature from vegetables to animals, and from the lowest tribes of animals to the beautiful complication exhibited in the fabric of the human body. It is divided into four parts, corresponding to a fourfold division of the functions. 1. The parts adapted to motion; 2. The parts essential to the internal economy of the different tribes; 3. The parts which connect living beings with surrounding objects; and 4. The parts subservient to the propagation of the species. We understand that the arrangement has undergone some modifications since the appointment of Mr Lawrence, the present professor of comparative anatomy. In this museum, the eye surveys as in one vast landscape all that is interesting in the sublime science of physiology. It furnishes even to the most ignorant a pleasing and rapid view of the subject, which could not be obtained from books without much study. To those who are already well informed, a visit to this museum affords an opportunity of giving form and body to their knowledge, and adds a permanence to their impressions which they could not have otherwise obtained. It is indeed now imitated on a smaller scale, by the laudable industry of many other professional men; but it is still an object of the highest interest, both for its own merits, and when considered as one of the earliest of those vast efforts, which have been made to give an intellectual celebrity to the whole seminaries of our native country. (*H. D.*)

HUNTING, or the pursuit of wild animals, in its most comprehensive signification, includes those of every denomination, and all the different means by which their capture is accomplished; but in its more restricted sense, it chiefly denotes the pursuit of terrestrial and amphibious quadrupeds.

Mankind, in establishing themselves in uncultivated regions, find it alike essential to destroy those creatures, whose ferocity may endanger their life, or to seek subsistence from the flesh, and clothing from the skin of others, from which no danger is to be dreaded. Originally a measure of necessity, hunting becomes an enterprise, wherein all the strength and activity of the human frame is called forth; or it is converted into an amusement, in which equal skill and ingenuity must be exercised, to combat the power and instinct of animals. Savage nations, during their repose from war, are principally occupied in the chace; and there are some, to whose country nature has been so sparing of vegetation, that without the resources obtained by hunting, a famine would infallibly ensue. Hunting has enabled us to bring the most useful animals into a state of domestication. While employed to subdue the horse, the ox, and the elephant in their native climates, it is elsewhere followed to procure those precious furs, which pay the tribute of entire countries, and are so highly valued, as to be the emblem of royalty itself. Hence have resulted various expedients and stratagems to ensure the capture of wild animals. But it is to his faithful ally the dog, that man is chiefly indebted for their possession. This invaluable creature is trained not only to rouse the game in the forests, to pursue it on the plain, and after a successful chace, instead of devouring its prey, to watch until the approach of its master, or to lay it uninjured at his feet. What substitute could the huntsman find for his dog? Deprived of its aid, those excursions which enable him to return laden with spoils, would terminate in fatigue and disappointment.

Modes of hunting.

Hunting is prosecuted after a great variety of fashions, according to the nature of the country and the description of the game. 1. Wild animals are hunted by means of others specially trained for that purpose. 2. They are caught by various stratagems; as by nets and pitfalls, or in traps formed either for the purpose of destroying them, or of taking them alive. 3. They are shot by fire-arms or arrows, or destroyed by the same weapons set in their paths. 4. They are taken by intoxicating substances, which they are induced to swallow, or killed by poisons. These are the principal methods employed throughout the world in destroying wild animals.

Animals naturally hunt each other.

Man is engaged in incessant warfare against the rest of the animated creation: the numbers sacrificed by him exceed all credibility; for scarcely has he come into the world, and gained the use of his members, when he begins to think of destruction. But animals have opponents equally formidable among each other, and frightful havoc is committed among the weaker by the stronger and more carnivorous tribes. Endowed with natural antipathies, they hunt each other down for the purpose of extirpation, not for the sake of prey. The ancients have told us of an invincible antipathy entertained by the ichneumon against the crocodile; and although this singular property has not been witnessed by the moderns, it indubitably exists in respect to snakes. The rhinoceros, a herbivorous animal, is said constantly to seek the elephant, when the most furious combats ensue between them; and it is affirmed to delight in the destruction of all other animals. Dogs incessantly endeavour to destroy cats, on which they are not known to feed; and horned cattle will frequently make an attack, and gore the object to death, from rage and antipathy combined. But it is less for the indulgence of such antipathies, than to satisfy the cravings of nature, that animals hunt each other in their wild state, and have thus taught men to avail themselves of their properties. Yet, as they carefully shun our presence on those occasions, we are acquainted only with some of the methods which they pursue. Animals of the canine species seem to hunt in troops; those of the feline race are in general solitary. The nature of the wild dog, which we can so materially improve by education, is little known; but it appears to hunt in packs of eight, ten, or twelve, in India and Persia; and in this way it does not dread to attack the most ferocious of beasts of prey, the tiger. In Africa, it has been observed, that wild dogs hunt with much sagacity, always acting in concert, while each in particular does its best to overtake or meet the game, until at length it becomes their joint victim. Not content, however, with merely satisfying their hunger, they are said to wound and destroy every thing that comes in their way, and prove the greatest enemies of the herds which are kept among the colonists or natives of Southern Africa. The wolf, the fox, and jackal, all hunt in troops, though each may be seen alone in quest of prey. But many animals are by nature solitary in their pursuits, and seem jealous of the presence of each other. The lion never hunts in company, and is said to chace its prey at full speed by the eye, from its sense of smelling being obtuse. It makes a spring when within reach of the object; but, if foiled by distance, skulks away, as if ashamed of the disappointment. The tiger, a cruel and terrible destroyer, is generally single in its immediate attack; and instead of trusting to speed, like the lion, it lies in wait in some thicket, whence, with an astonishing leap, it pounces on its victim in an instant. Immediate death follows a blow from its tremendous paw, and the prey is then dragged off to be devoured at leisure. Nothing can restrain the ferocity of the tiger; not even fire, the dread of all wild animals. It is the terror of the forest; it attacks man as readily as beasts, and even pursues boats while navigating rivers. As the fatal blow is always inflicted by the paw of this animal, in like manner others evince the same uniformity in the mode of hunting and killing their prey. The wolf bites it in the throat; the jackal invariably seizes a cow by the udder; and the crocodile, fixing its teeth in the nostrils, draws its prey into the water to be drowned.

Animals employed to hunt.

Man, in every country, has availed himself of the instincts evinced by certain animals in hunting their prey, to aid him in the chace. Dogs of many different kinds are trained to it, and in every possible fashion; either running down the game by speed, conquering it by absolute strength, or dislodging it from its haunts, or merely pointing out its position. In the East, a species of panther, there named *cheeta*, but more commonly the hunting tiger, is taught to pursue the antelope; but if caught young, and brought up among mankind, so much of its activity and fierceness are lost, that it proves unserviceable. Therefore the cheeta is always taken old in pits, and soon becomes familiar with its keeper. The cheeta is carried hoodwinked on a cart to the vicinity of the game; and being then unhooded, steals from bush to bush, until approaching within 70 yards of it. Rushing forwards with surprising swiftness, by a dexterous use of its paw it throws the animal down, and seizes it firmly by the throat, until it feels that respiration has ceased. Sometimes the cheeta cannot be induced to run; but if it is forward to the chace, it seldom continues longer than for 300 or 400 yards, within which space the antelope is either caught or escapes. If disappointed in its original spring should it get near enough, or be foiled in the course, it lies down, testifying much disappointment; and in its resentment will sometimes, though rarely, turn on its keeper. On the day of hunting, the cheeta is kept without food, at other times it is allowed 4 lb. of flesh daily. The lion is said to be taught by the Africans to hunt for them, as is also reported to have been practised by the ancient Romans. In this country, we teach the ferret to hunt after rabbits; and, considering that many animals are susceptible of this education, it is not unlikely that more would be trained to hunt, were not their use superseded by the universal employment of the dog. There is hardly a situation in which the dog is not serviceable. There is scarcely an animal which it will not venture to attack, when encouraged by the voice and presence of its master; and it equally promotes the capture of the terrestrial and the feathered tribes.

Companies of huntsmen.

The most general mode of pursuing game is by a small and select company of huntsmen, and then, perhaps, the greatest success attends their exertions; but in some countries, vast multitudes assemble, surrounding a great extent of territory, and driving numbers of wild animals into a narrow space, where their destruction is accomplished at will. Some of the sovereigns of China have carried an army of people into Tartary, and occupied themselves several months uninterruptedly in the chace, while the monarch himself, unable to use fire arms, dexterously shot the animals with arrows. The modern princes of Hindostan were wont to advance with 400 or 500 elephants, besides horses, and all the necessary equipment of several hundred dogs, nets, and weapons, to the country where the game was sought. Even in Scotland, we read of hunting matches conducted on a great scale, where 12,000 men were present, and when "thirty score of wild beasts" were killed. But the real hunting for profit and utility, in which many thousands engage for subsistence, is conducted by small parties, or by individuals only. It appears that in Britain it was very common for ladies anciently to participate in the pleasures of the chace.

Hunting the lion.

The lion is a large and powerful animal, less ferocious, and not equally dreaded as the tiger, perhaps from an imaginary attribute of generosity, and from the belief that it never wantonly kills its prey. Nevertheless, the lion is also a terrible enemy, and its roar inspires all other animals with fear. Shaw, the eastern traveller, affirms, that the wild boar is principally its prey; but sometimes after so courageous a defence, that victory has inclined to neither, or both have been found lying dead together, and torn in pieces. We have said that the lion never hunts in company, and on this head M. Golberry relates, that a lion and a lioness having discovered a wild boar on the skirts of a forest, the latter sprung forward to the attack. Having furiously seized the boar by the throat, she lashed its sides with her tail, while the lion sat a tranquil spectator of the combat, which lasted five minutes, seemingly indifferent to the struggles of both. At length the boar, yielding to the force of its opponent, fell with horrible cries; and, only when dead, the lion leisurely advanced to participate in the repast of his mate. It is supposed that the lion will not attack women, but the number of victims evince the fallacy of this hypothesis. However, it is confidently affirmed, that no person is in danger who has courage to look the lion stedfastly in the face. An African colonist of the Cape of Good Hope having unexpectedly met a lion, levelled his gun, but the ball fell short as the piece hung fire; and, apprehensive of the consequences, he immediately fled. The lion closely pursued him, when the colonist, leaping on a small heap of stones, resolved to defend his life with the butt end of his gun, being precluded from loading it again, as he had unfortunately dropped his powder flask in his flight. At this moment the lion made a sudden stand also; and then lay down, at the distance of a few paces, quite unconcerned. Meantime the colonist durst not move; but the lion, after remaining before him completely half an hour, slowly retired. The fleetness of this animal enables it to keep up with a horse galloping, and its strength is such that it can drag away a heifer with perfect facility. In general, it is said to lie in ambush, whence it springs upon its prey; but should the object be missed, no second attempt is made; the lion returns silently to the spot, to practise more address on the next occasion. Probably animals are more usually preferred, but there are instances of a single lion attacking a whole caravan. The lion is hunted by horsemen on the plains, and large dogs, but not of any particular species, are used to dislodge him from his haunts. At the first sight of the huntsmen, he always endeavours to escape by speed; but if they and the dogs get near, he either shakes his head with a terrible roar and slackens his pace, or quietly sits down to wait their attack. The dogs immediately rush on; and he has time only to destroy two or three, each with a blow of his paw, until they tear him in pieces. Twelve or sixteen are, in this manner, a sufficient match. Huntsmen going on the enterprize keep together in pairs. If they have not the requisite number of dogs, one, when within reach of the lion, leaps off his horse, and aims at the animal's heart; but he must instantly remount, in order to fly from its rage if wounded. Should he miss, the same is done by his companion, who must also give full reins to his horse; and then the third of the party follows. This mode of hunting is represented as quite free from danger, there being no example of its being attended with fatal consequences. In the northern parts of Africa, where lions are not so numerous, the whole surrounding district is raised when one is discovered to infest it. A circle of three, four, or five miles in compass is formed, according as circumstances require, and dogs of large size are employed to rouse the game. Horses are here trained for the purpose, and the party proceeds always narrowing the circle until the lion appears. But this is a moment of danger, as he will readily spring on the person nearest to him. The expert huntsman, however, is generally prepared to terminate his career by a musket-ball. The lion is likewise killed by spring guns set in the path by which it returns to commit its ravages; or the Moors and Arabs dig a pit, which, being slightly covered with reeds and branches, the animal falls in, and is taken.

Tiger hunting. One of the noblest sports of the East is the hunting of the tiger; and indeed, considering the size, the strength, and the ferocity of the game, no inconsiderable gratification must arise from the conquest. The tiger is sometimes so large as to measure 13 feet from the nose to the tip of the tail. It is active, bold, and cunning; it is one of the most destructive beasts of prey: flocks and herds are its usual pursuit, but it is the mortal enemy of man; and, having once tasted his blood, it is said to reject ever after the blood of other animals. The immense and extensive thickets of Asiatic countries are so many retreats where it can lurk in concealment, and spring forth upon its victim, which it does with a horrible growl; or if the prey is in motion, where this cannot be accomplished, the tiger creeps along parallel to it and unperceived, until it gains the favourable position for its spring. A deadly blow from the paw precedes the seizure of its victim, and the prey is then dragged away. An instance occurred of a Sepoy on a march acquainting his comrades that he observed a tiger, "which had set him," as it is called, stealing along through a jungle. Divesting himself of all incumbrances, he drew a broad sword, and intrepidly watching the moment of the spring, with dexterity as singular as his courage, immediately disabled his assailant. Sometimes a tiger takes possession of a pass, whence it has, for a length of time, carried off a man daily. This animal is hunted in various fashions, but chiefly by a numerous party of sportsmen, and elephants trained for the chace: those males having long tusks are preferred, but few females are fit to be employed in it. Indeed the elephant and the dog are the only auxiliaries of man on this occasion. Horses become fractious and ungovernable; camels offer an insecure position to their riders, independent of their natural dread of the game; and even the elephant can with difficulty be urged onward with due preparation. When the retreat of a tiger is discovered, which is generally in a jungle near the carcase of a mangled animal, a line of elephants is formed, and every exertion made for its dislodgment. The jungle, however, may contain more than one; and as the tiger becomes lethargic when satiated, and does not remove far from the spot of its depredations, the jungle is entered with much precaution. Here the search is made with the largest and best trained elephants; and it is they that first disclose the presence of the tiger by a peculiar kind of snorting and trumpeting, and likewise an uncommon agitation. The tiger is prone to spring on an approaching object; but if skulking off, the whole covert becomes impregnated with its smell, and the elephants, uncertain of its distance, and always dreading an attack, frequently become perfectly ungovernable, nor can some be restrained from flight. A certain emanation from the body of the lion and the tiger, even when unseen, has a powerful effect on other animals; and men themselves have experienced a kind of shuddering sensation solely from that cause. The huntsmen who, mounted on their elephants, are not above ten yards asunder, immediately on discovering the tiger, fire from a piece of large calibre; but should the shot not prove instantly fatal, the tiger springs up with a furious roar, and endeavours to attack its enemy. Particular danger may thence ensue, and both skill and dexterity are required in the hunter expeditiously repeating his discharge for his own preservation. The elephant may then be brought forward to crush the fallen animal, and gore it with its tusks; which, although quite dead, it often testifies a repugnance to do. Horses shew the most decided antipathy, and dogs take a tour around the carcase. Sometimes the tiger will spring upon the elephant, and put the hunter in the most perilous situation. Notwithstanding its intimate resemblance to the cat in every thing, the tiger takes the water without hesitation, and it has been known to force its way into a boat in spite of all opposition. It does not appear that hunting this ferocious creature solely with dogs is ever attempted: indeed it could not be accomplished without great loss to the huntsman. It is taken in nets, however; but the sport is dangerous, for the game is apt to recoil on its pursuers; and besides, the nets are not always of sufficient strength, nor is the tiger so perfectly enveloped and secured, as to be deprived of the power of doing mischief. Tigers are caught, but very rarely, in traps and pits, the former constructed like a large cage, and baited with a live dog or goat, which is confined in an interior division. They are likewise shot by a single sportsman, who, having discovered a carcase half devoured, promptly constructs a platform of bamboos 15 or 20 feet high, and there awaits the depredator's return. The natives of the hills of Bengal set poisoned arrows in their path to be discharged from a bow of extraordinary strength, sometimes so great, that the weapon penetrates to the heart. It is difficult, however, to give it the proper direction from the step of the tiger, which effects the discharge. Even though the arrow does not touch a vital part, the poison speedily begins to operate, and never fails to destroy the animal within an hour. The same apparatus is used with an arrow free of poison. By means of the vigorous warfare carried on against tigers, many places of India, formerly almost uninhabitable, are completely cleared of them. In other parts they are still common, and the appearance of one inspires the whole neighbourhood with alarm.

Leopard. The panther, leopard, ounce, and lynx, all of the feline tribes, are closely allied in habits and disposition to the lion and tiger. But none readily attack man. Their depredations, nevertheless, are not confined to smaller animals, as some of them are endowed with considerable strength. The leopard is particularly expert in climbing trees, whence it drops or springs on its prey. It greedily devours dogs; but seldom prowling about by day, it chiefly commits nocturnal ravages. All animals of prey, of every tribe, are for the most part occupied in seeking their sustenance at dawn and twilight. Leopards are roused by dogs, and shot with fire-arms or arrows. The natives of the East also capture them in deep pits, which are baited with the carcases of beasts.

Hyæna.

Animals of the canine species are endowed by nature with the most remarkable sagacity. Almost all, with suitable treatment, may be rendered tractable, while those of the feline tribes seem absolutely indocile and void of attachment. The hyæna is one of the fiercest of the canine kind; its strength enables it to resist the lion, and encourages it to attack the panther. It overpowers the bear, and readily assails mankind. Acting as a decoy, it is said to imitate the cries of other animals, or, by a frightful howl, to scare a whole herd, that it may then seize some one of the stragglers. It is a solitary animal, inhabiting the clefts of rocks and caverns in mountains, whence it issues forth on its prey at night. Hyænas are hunted by dogs, and traps are set for them, but few are taken. One of the most remarkable methods of capturing these animals is practised by the gypsies of Aleppo; who, according to M. Olivier, enter with torches in the day-time into the grottos known as the haunt of hyænas, and, on perceiving one, make a great outcry, or boldly approach, speaking aloud, in order to intimidate the animal. The hyæna, which is terrible by night, does no injury by day; and the effect of the light and clamour are such, that it retires farther and farther to the extremity of the cavern, where no sooner do the gypsies reach it, than it is bound, muzzled, and led out. When taken after other methods by the Arabs, they carefully bury the head, lest the brain should be employed against them in sorcery and enchantment

Wolf-hunting.

Hunting the wolf, an animal the type of destruction, and the enemy of the shepherd, has been every where and in every age an ardent pursuit. But its sagacity is so great, that while others run headlong into danger, it carefully avoids the snare. When roused by hunger, the ferocity of the wolf is great. It attacks man, and runs down creatures far larger than itself. It boldly leaps inclosures, and steals into cottages to carry away children, which are always seized by the throat. A wolf suddenly appeared in a district of France, which it ravaged a whole year about 1765, proving so crafty, that an association of 68 parishes provided a band of 40,000 men for its destruction. At length 40 huntsmen and their dogs accomplished its destruction. Hunting the wolf was anxiously enjoined by the laws of this country, particularly in Scotland, formerly a wild and mountainous country, whence it could not be easily extirpated. King Edgar is said to have effected the utter destruction of wolves in England, by commuting the tribute of money into an annual tribute of the heads or skins of these animals. They still subsisted in Ireland in the reign of Elizabeth, and were not extirpated from Scotland until the year 1670. The means which have been devised of destroying this redoubtable enemy are not few; but owing to the habits and sagacity of the animal, they are of very uncertain success. Its haunts are exceedingly diversified: It sometimes seeks the recesses of the woods, sometimes the bottom of the cavern; it hunts by day and also by night, first assuming one path for its exit, and then another for its return. In certain seasons of the year it has no fixed abode. In Tartary, and other parts of the East, the wolf is hunted by eagles trained specially for the purpose. In Europe, the strongest greyhounds and other dogs are employed, and the chace is prosecuted either on foot or on horseback. Much difficulty, however, is experienced in running down the wolf; nay it frequently proves impracticable, for the full grown animal is infinitely stronger than any dog. An old wolf is able to run 20 miles easily, which added to the nature of the ground to which it resorts, often renders the pursuit abortive. The wolf besides, has recourse to many stratagems for deceiving both the dogs and the huntsman. When one is known to infest a district, the first attempt is to dislodge it from the covert, and to bring it to an open chace. But hunting the whelps is more interesting sport, because they have fewer means of defence, nor are they so capable of foiling the hunter as the old and experienced animals. Independent of the constant use of fire arms, it becomes necessary to recur to various stratagems, as nets, traps, and pitfalls. If an animal of large size, as a horse or an ox, is discovered to have become the prey of a wolf, to which it will return for the purpose of satisfying its appetite, the huntsman drags the carcase above a mile from the spot, always proceeding against the wind. Then leaving it in a place exposed to view, as the wolf will follow, he takes his station in concealment by moonlight, in a spot whence he may pierce the animal with a ball. It is said that the wolf never passes through by a door where it can leap a wall; whence the position of traps is regulated, so as to deceive its watchfulness. Sometimes the traps are constructed with springs and iron teeth; sometimes with a wicket, which yields to gentle pressure, but refuses an exit to the captive. Some years ago, during a terrible famine in India, where the miserable sufferers were devoured half alive by wolves, these creatures, emboldened by the want of resistance, continued their ravages after its cessation. They openly attacked men and women, and children at the breast seemed to be their favourite prey. An ingenious and simple apparatus was devised for their destruction. Two bamboos eight or nine feet high, were erected at the opposite sides of an old well, and their tops being brought together, a basket, containing a kid, was suspended from the junction. A pot of water with a hole in the bottom, loosely stopped by a rag, was hung over the animal, which was kept bleating and in constant agitation by the dripping upon it. Brushwood and thorns disguised the edge of the well, and the wolves in stretching over or leaping up to reach the bait, readily tumbled in. On another occasion, they were successfully smoked out of burrows in the earth, which they had chose for a retreat, or were killed in attempting to escape suffocation. In digging up the burrows, an incredible quantity of trinkets, not less than ten pounds weight, was found belonging to children they had carried away and devoured. The affliction of the unfortunate parents at recognising the different ornaments that had decorated their offspring, presented a most impressive scene. At present packs of wolves are said to infest a district of France, where the inability of the inhabitants to resist them, has led to extraordinary instances of their attacks in open day, and on every opportunity.

Hunting the jackal.

Similar address, though demonstrated in a less conspicuous manner, is displayed by the jackal and the fox, both of the canine species. The former is hunted by greyhounds, which it will so harass by its extreme cunning in incessantly crossing the haunts of its fellows, that it can seldom be taken in this manner. Likewise the dogs, while in full pursuit, are sometimes attacked with great fury by another troop of jackals attempting to rescue the fugitive, and beaten off with severe injuries. The jackal itself hunts in packs of 30 or 40 together.

Fox-hunting.

As fox-hunting is so common a sport in Great Britain, and of so much consequence to other nations which traffic in the fur of animals, we shall lay before our readers a pretty full account of it. Though the total number of foxes in this island may not exceed a few hundreds, yet in the north of Europe and America, and in the north-eastern parts of Asia, they are more numerous. There they are frequently to be found in vast multitudes, and of various species, called the black, blue, grey, and arctic fox, some of them changing their colour according to the season of the year. Two islands, St George and St Paul, were discovered in 1786 in the Northern Pacific Ocean; the first does not exceed 30 miles in length, nor the second 19; yet in the course of only two years, 8000 blue foxes were taken upon them. But to enable the huntsman to conduct the chace successfully, he must always render himself intimately acquainted with the nature of the game: it is by this means that he can ascertain its haunts, defeat its stratagems, and avail himself of those particular circumstances which will lead to its capture. The instincts and propensities of the fox are exhibited in the most decided manner; though they receive strong modifications from the circumstances under which the animal is placed. In populous and civilized countries, it is shy and watchful; in those seldom trodden by the foot of man, it exhibits no apprehensions at his presence, and may easily be led to destruction. In one country it will devour nothing except what has been killed by itself; in another, where scarcity usually prevails, every kind of animal food is acceptable. It is highly carnivorous in many places; yet in some it fattens on grapes, and is noxious to vineyards. The craftiness of the fox is proverbial. Without the strength of the wolf, it possesses equal sagacity, which is similarly exercised in destroying creatures weaker and more timid than itself. In addition to the smaller quadrupeds, its ravages are considerable among birds which nestle on the ground, and also among poultry of the domesticated kinds. The day is the period of repose; while the dawn and twilight are industriously employed in quest of prey. The fox is a bold and a cunning animal, adventurously approaching the object it has singled out, and waiting a favourable opportunity of accomplishing its ends; but, not content with satisfying the cravings of hunger, it often destroys many more victims than it can devour; which are either left behind, or carried away and stuffed into a hole, or buried in the ground, to provide for future necessity. It is said to feign sleep, in order to betray its prey into security; and a tame fox has been known to spurt its food around it, for the purpose of attracting poultry within the length of its chain. Foxes burrow in the earth, or inhabit the clefts and cavities of rocks, and also dwell in thick coverts, or among furze. As swallows testify their antipathy to the hawk, the common enemy of their tribe, so does the clamour of crows and magpies disclose the retreat of the fox, when unseen by his enemies; and during pursuit, the latter will scream from tree to tree, according to the course which the animal takes. By the northern nations, where the preservation of the fur is an object, the fox is captured in traps, by bows set in its path, discharging arrows against it, and it is also destroyed by poisons. Sometimes a net is used. The natives observe, as a remarkable circumstance, that the more valuable foxes are the most cunning: and Krascheninikow mentions, that the Cossacks of Kamtschatka tried unsuccessfully during two years to catch a black fox frequenting the Great River. But it is likely that this arises from such animals becoming more sagacious in endeavouring to avoid danger, than those which have none to apprehend. In Britain and some other countries, foxes are hunted almost exclusively by packs of hounds trained to the sport; and the chief source of entertainment arises from the nature of the animal itself. A rank odour, peculiar to its species, of which it can never be divested, constantly escapes from its body, and is distinguishable by the hounds from that which emanates from other animals, whereby they are enabled to follow the same course without once obtaining a view of the game. The manner in which this effluvia is conveyed, is a point of exceedingly difficult explanation; but, like all odorous emanations, it is of very unequal intensity at different times. Our ancestors were certainly acquainted with the properties of hounds, as "sharp-scented dogs fit for hunting wild beasts," are mentioned at a very early period of English history; and the aborigines of every nation are addicted to the chace. But we are unacquainted with the particular species which were employed. Much attention is requisite both for the breeding and training of hounds; and no where has the art been more studied than in Great Britain. When the dogs are bred and trained, then the selection is to be made. Hounds are prized for colour, figure, voice, and especially for staunchness, without which the rest of their qualities are of little avail. In respect to the first, there can be no absolute rule; and the huntsman who has had a few excellent hounds of a certain colour, will be prejudiced in its favour; but we must admit, that the properties depending on colour are very uncertain, particularly when we reflect that a total change takes place in several animals according to the alternation of the seasons, and that it is again restored without having occasioned any extraordinary effects. Naturalists have not yet determined the inseparable concomitants of colour. Hounds of a uniform colour seem to rank highest in the estimation of sportsmen; next, those spotted with red, and white hounds with black ears and a black spot at the root of the tail. Those spotted with dun are conceived to be defective in courage, and therefore bear an inferior value. Properties which would require the most undoubted confirmation by repeated trials, are ascribed to some external characters. Thus it is said that the black tanned, the uniform white, the true Talbots, are the best for string or line; that the grizzled, if the hair is shaggy, are the best runners, and that a couple of these should always belong to a pack. Those uniformly dun are thought fit for all kinds of the chace; their sagacity is great; they are more sensible of their master's voice or his horn, and less liable to be influenced by the unsteadiness of other hounds. The figure of the hound is probably more essential than his colour, being more decisive of pure descent. A small head, very pendulous ears, a thin neck, broad back, deep chest, straight legs, and round feet, not too large, are esteemed prominent characteristics. Defective proportions indicate

Fox-hunting.

Hounds.

that little can be expected from exertion. Hounds of middle size are the strongest, and most capable of protracted fatigue: and here it is necessary to regulate the equality of the pack. There should be complete uniformity in speed; for, though the fleetest hound is commonly esteemed the best, yet he may do much injury among his companions in the chace. Speed and vigour are indispensible qualities, and these are likely to be promoted by having hounds of the same family. Both are conspicuous in those of English breed. A hound has been known to run seven miles in four minutes; and a fox chace is said, on one occasion, to have been continued for about 120 miles, calculating, as nearly as possible, from the places where the hounds were seen. The ardour of the hounds is so great, that they sometimes actually die in the course of pursuit. A prejudice formerly prevailed in France against British hounds, which probably arose from their having degenerated on being transported from their native climate. Most animals degenerate under great transitions, whereas, were they carried to moderate distances, they might easily be habituated to the change of climate and of circumstances. The breed of all the useful animals ought to be anxiously studied, because real quality can be obtained in no other way than by selection from the offspring of parents who are themselves of the genuine stock. On both sides those alone should be chosen which demonstrate the properties of the fox hound in a superior manner: age must be avoided; and, as both sexes reach maturity nearly about the same period, there ought not to be a great disparity between them. General rules nevertheless admit of many exceptions, as the origin and properties of animals are but little known. The breeder will often be disappointed of his expectations, and he will sometimes have to admire the offspring of parents from whose union nothing was expected. In both cases, good qualities and defects may lurk in concealment during one generation, and be unfolded in the next. Some persons who have paid strict attention to this subject, maintain, that, in the course of numerous experiments, they succeeded in obtaining excellent hounds. The whelps must be kept very clean, both before and after leaving the mother. When they cease to obtain subsistence from her, it is recommended that they should be fed with wheat bread, to improve their strength; but, in France, it is said that bread made of barley-meal is universally admitted to be better feeding, and is given at the rate of two pounds and a half cr three quarters daily, in two portions. The whelps should be well aired, and have sufficient exercise, until they attain their full strength, or arrive at an age a little beyond it, when their active powers are to be called forth. It is supposed that dogs continue to grow during eleven months. Something probably depends on climate; for a much longer time frequently elapses before some of them have acquired all their vigour. Numerous specific rules are given regarding the entrance or initiation of hounds to the chace, on which head there are hunters who advance extraordinary, and apparently inconsistent, opinions; such as, that the first object of pursuit ought to be different from that for which the dog is ultimately destined. But it has been judiciously remarked, that "*nature* will instruct hounds how to hunt; *art* only is necessary to prevent them from hunting what they ought not to hunt." Instinct is incessantly operating; and if it is to be modified, we must always keep in remembrance, that early habits have a great preponderance; and that animals will probably be most eager in the pursuit of that game which they have been taught to hunt originally. One of the primary qualities of a dog is, to addict itself exclusively to the specific object of pursuit, and to abstain from every other; whence it would appear as inconsistent to enter pointers with larks, as fox hounds with rabbits. If hounds are accustomed, at an early age, to woods, or hills and vallies, it is likely that they may not be equally successful when there is a complete transposition of circumstances, whence a considerable variety of surface seems beneficial in exercising those which are young. These necessary preliminaries having been attended to, hounds are to be assorted in packs, the extent of which is quite arbitrary. Experienced hunters affirm, that 25 couple are sufficient at any time to be taken into the field; and this is the ordinary number. Forty couple will admit of hunting three times a-week; but if packs are very numerous, each hound will have too little occupation in the chace: hence it is essential that the qualities of hounds should be frequently brought into action, in order that they may be preserved by practice. Although instinctive habits may be permanent, yet artificial acquirements are soon forgotten. A pack of good hounds is a valuable property, and has been sold in England for a thousand guineas. With respect to the actual practice of fox-hunting, it is a subject susceptible of so much detail, that we must chiefly refer those who are desirous of becoming masters of it, either to certain districts of England and Ireland, where gentlemen of fortune follow it as a kind of profession, in preference to the more useful pursuits of agriculture, and more delicate and refined amusements, or to the modern authors Beckford and Daniel, who treat copiously of the subject. They have not only exhausted the observations of their predecessors, but have embellished their writings with new and entertaining illustrations. As the fox leaves his burrow in quest of prey before the day breaks, all the earths are to be stopped at a very early hour in the morning; and the huntsmen having met at the appointed covert, it is to be carefully drawn for the game. A bad or windy day is always to be avoided, as the scent is so much affected and so precarious, that the hounds may be disappointed, which is injurious to their nature. It is not necessary that the fox should ever be seen by the dogs; when once roused, they pursue him by the scent alone, continuing the chace through many miles. But this animal neither possesses much speed, nor apparently entertains great dread of the hounds. His principal object is gaining the earth; and he trusts by wiles and stratagems to deceive his pursuers. If he is foiled, many turnings, doublings, and crossings, are resorted to: when fatigued, he will either lie down in a field, should one be in his way, or run amidst a flock of sheep, or a herd of cattle. In the course of the chace, sometimes the scent becomes quite imperceptible, especially when confounded with the emanations of other animals, as in the latter case, when the hounds are said to be *checked* or *at fault;* and the recovery of it becomes most interesting to hunters. Silence is then to be observed, as the dogs will be industrious enough themselves in endeavouring to regain the scent. If they are successful, which does not invariably happen, they rapidly renew the pursuit, and gaining distance as the strength of the fox declines, they at length come up, and tear him to pieces. "Then," say sportsmen, "they should be allowed to eat him ravenously." It frequently occurs, that amidst a number of earths all are not stopped, and the fox having taken shelter, is dug out or dislodged by terriers; sometimes the hounds pursue him thither, and are themselves suffocated within. It is difficult to kill the female while breeding, from her never wandering far from the burrow, and retreating into it on the slightest alarm. A modern author remarks, that "the whole art of fox-hunting is to keep hounds well in blood; therefore every advantage of the fox is taken. Sport is but a secondary consideration with the true fox hunter; his first motive is the killing of the fox, by which he makes his hounds. Present success is almost a sure forerunner of future sport; and he is better pleased with an indifferent chace, with death at the close of it, than with the best chace possible, if it terminates with the loss of the fox." This kind of amusement has been practised a considerable time in Great Britain. That King James I. had its commendation in view, when treating of the education of a prince, we shall not affirm; but he says, "I cannot omit here the hunting with running hounds, which is the most honourable and noblest sort thereof; for it is a thievish form of hunting to shoot with guns and bows; and greyhound hunting is not so martial a game." Fox-hunting is certainly no inconsiderable enterprise, when we hear of horses running themselves blind, or dying of fatigue under the lash of their riders; of dogs perishing during the chace, and of men breaking their limbs, or dislocating their necks. But whether it is an amusement either humane, or attended with any utility, might admit of some discussion.

Wild cattle.

Wild cattle are numerous on the southern continent of America, and herd together in great flocks; and the same may be said of horses. Both are hunted by the Indians in two different ways. A lash or belt is made of skin or leather, about fifty feet in length and two inches broad, with a running noose at one end. The huntsman holds the noose in his right hand, and being well mounted, on approaching within a few yards of the wild animal, throws the noose over its head though running at full speed, whereby it is easily taken. By the second method, an iron ball, of about two pounds weight, is fastened to each end of a leather strap about twelve feet long, and the huntsman, when within the necessary distance, having swung one of the balls several times around his head to give it an impetus, throws it at the animal's legs, also parting with the other whereby they are entangled. Hunting the buffalo, which is a powerful, fierce, and intractable animal, is attended with greater danger; for it readily attacks its pursuers, who must trust to the swiftness of their horses for escape. It entertains the utmost antipathy to every thing coloured red; and it is said that if a piece of red cloth is thrown in its way, it will be so much occupied in venting its rage upon it, that the huntsman has sufficient opportunity to advance or to retire.

Buffaloe.

Stag-hunting.

A valuable animal, the deer, has been liberally dispersed by nature throughout the world, especially in the colder regions. In Siberia, vast herds of reindeer shift their abode at certain seasons, leaving the woods to seek for better pasture, and swim across wide rivers, always having a leader at their head. Then they become an easy prey; but if the leader suspects danger and returns, he is invariably followed by the rest, and the sportsman is disappointed of his game. The elk or moose deer north of Hudson's Bay, is hunted in a singular manner; for there the Indians themselves absolutely run it down. This is attempted only when the earth is covered by snow, and especially when the surface is encrusted over; then it sinks with the weight of the animal, while the snow shoes of the huntsman bear him up. A good runner will generally tire a moose in less than a day, and very often in six or eight hours; though it sometimes happens, that the hunters continue the pursuit two days before they can come up with and kill the game. They are very lightly clothed on such occasions, and carry only a bow with two or three arrows, and a small bag with implements for striking fire. Dogs are trained for this sport by the southern Indians, which renders it easier and more expeditious; and they are likewise used in Europe and other countries inhabited by the deer. In Britain, stag hunting is followed with hounds, and the strength and swiftness of the animal renders this description of the chace particularly interesting. Its agility surmounts every obstacle; the plains vanish under its feet; rivers are no barrier; and it seeks for shelter alike in the woods and the mountains. Thence the pursuit is generally long and difficult, and the stag can be wearied down only by the strongest and most steady hounds. When the stag despairs of escaping, it sometimes stands at bay; and, presenting its antlers to the pursuers, seems resolved to sell its life as dearly as possible. The huntsman, however, is always the victor, and his precautions most commonly secure him from injury. But a more treacherous method is generally followed in stalking or approaching in disguise to shoot this fine animal, at least in those parts of the north and western parts of Scotland where it still runs wild. In the northern climates deer are shot with arrows, by means of a spring bow set in their path.

Antelope.

The antelope is a gregarious animal, very shy, and of great speed. Besides the use of the cheeta, it is hunted by numbers of men forming a circle, which, gradually closing, brings it within reach of the sportsman; or it is pursued by dogs, while hawks, trained for the purpose, being let fly, retard its swiftness by striking it on the head, and fluttering before its eyes.

Bears.

There are various species of bears, which are hunted after different fashions both in the warmer and colder climates. The white bear, an enormous animal of the polar regions, is never seen but on ice and snow. Winterers on Nova Zembla remark, that it retreats from their abode as the sun sinks below the horizon in November, and returns with his appearance in January; meanwhile, they are visited by the arctic fox, which retires as the bear approaches. White bears attack man, and swim around ships as if to get on board. They are hunted by the northern savages, on the ice and snow, with pikes, swords, bows, and arrows; but the bear makes a vigorous defence, turning on its assailants, whose victory is sometimes dearly purchased. However, a single man has been known to engage intrepidly in combat with a very fierce bear, without any other weapon than a knife, and to destroy his antagonist. The black bear never attacks man unless when provoked; it then rises upright, and, clasping him in its fore paws, endeavours to crush him to death. Before any encounter, it is said to make its young ascend trees. This animal can be dislodged with difficulty from its retreats by dogs; but when once roused, it is pursued, and shot. It is likewise taken by a great number of stratagems, of which we have already given an account under the article Bear, Vol. III. page 365. Hunting the badger, which pertains to the same genus, is followed in another shape. It burrows in the earth, and is also difficult to dislodge. When driven out by terriers, it fights boldly, inflicting severe lacerations on its pursuers. However, it is generally overpowered. Though covered with a strong hide and long hair, which render it tenacious of life, a

Badger.

slight blow on the nose occasions inevitable death. The badger is caught alive in sacks covering the mouth of its burrow, into which it is driven by the terriers.

Hare-hunting.

After speaking of all these powerful, ferocious, and crafty animals, it is painful to treat of the hunting of the timid hare—a weak, harmless, and defenceless creature, which the very sight of man renders breathless with alarm. Yet, in Britain, whole troops of men, horses, and dogs, collect to enjoy the gratification of running it down; a feat which is accomplished either by grey-hounds surpassing its utmost speed, or by slow hounds wearing it out with fatigue. But these are not the only means devised for its destruction, as numberless traps and snares besides fire-arms are always ready to bereave it of life. The hare is the ordinary prey of other animals: yet it feeds on none; its subsistence is derived exclusively from vegetable productions, and in few instances does it appear in sufficient numbers to occasion injury. Many fables are interwoven with the history of this animal, and the prejudices of mankind have determined its presence to be ominous on certain times and occasions. In general the hare shuns the haunts of men: it is abroad chiefly at dawn and twilight, and during the night troops of this animal meet to sport in the fields. Its vigilance is incessant: the eyes, which are not closed while it sleeps, are so constructed, that it can see farther around in the same position than other animals: its ears are adapted for the reception of the faintest sounds, and its foot is particularly fashioned for protection against different substances that cover the ground. As if aware that safety is to be found in concealment, it remains closely squatted in its form, even though its enemies be near; but when once roused, no bounds are set to its flight. Unlike the fox, which is regardless of distance, the hare feels confidence only when beyond the voice of its pursuers; but it is nevertheless full of stratagems. In the first outset a circular figure is described; all the subsequent course will approximate to the original line: but doubles are repeated after doubles, and the point of departure will frequently be approached during the chace.

Coursing.

Hares are hunted either by harriers, a species of slow hound, or by greyhounds, the latter sport being technically designed *coursing*. Under a few modifications, nearly the same rules and principles are applicable here as before, regarding the choice, breeding, treatment, and entrance of hounds; but it is invariably to be observed, that the best harriers are those that never pursue any other game than hares. There is a very diminutive species called beagles, which are in much request for this kind of sport, and some of them are so small, that ten or eleven couple are said to have been carried to the field in a pair of large panniers slung across a horse. Twenty couple of harriers are esteemed a sufficient number in any pack. The hare, though swift, and endowed with considerable strength, is weaker than the fox, and the chace is rarely of equal duration; yet there is an instance of a hare, after having been chaced sixteen miles, taking to the sea, and swimming nearly a quarter of a mile before it was caught, and also of one running above twenty miles in about two hours. The chace is followed by the scent, which is lost and recovered as in fox-hunting; and this peculiar emanation is thought to depend on the motion of the animal, because it is seldom perceptible while the hare remains quiet in its form. When it is first started, strict silence should be preserved by the hunters, as the hare is so timid, it is very readily headed back; whereby the

hounds pushing forward lose the scent. Coursing is more generally practised in different countries, from requiring less of the apparatus of hunting, and because every master is in this case his own huntsman. Whether the shaggy or the smooth greyhound should be preferred, is not decided; but a greater portion of strength is usually ascribed to the former. Contrary to the nature of harriers, greyhounds hunt entirely by the view, and while the others remain intent on recovering the scent, they very soon become bewildered on losing sight of the game. They should attain their full vigour before they are initiated into the chace, and in the meantime they should have abundance of air and exercise; but sportsmen are commonly too impatient to wait for the proper period. The qualities of the greyhound are often to be discovered almost entirely from their figure; and some have instinctively the property of carrying the game to the hunter's feet. Coursing can be traced to a very early period: it is said, however, that the Britons anciently abstained from eating the flesh of hares. Grants of land were obtained from several of the earlier sovereigns, for an annual tribute in horses, hawks, or hounds; and as greyhounds were used in stag-hunting, it is not to be supposed that they would be omitted. In the reign of King John, two charters were granted in 1203 and 1210, in consideration of which a certain number of greyhounds should be delivered, in addition to other obligations. Coursing is a favourite amusement in many countries besides Britain; and a good greyhound is so highly prized by some tribes in the eastern parts of Persia, that, according to a recent traveller, Lieut. Pottinger, the natives sometimes pay £50 for one of acknowledged quality; a very high sum considering their narrow finances. But sportsmen go farther still among ourselves, as, under the article Dog, it will be seen that £152 has been paid for a greyhound. The greyhounds of Cyprus interrupt the chace by the huntsman merely throwing a pole before them, which indicates singular docility. It is said that a huntsman should acquire so much knowledge of the stratagems of the hare, as to be able to defeat the whole in two or three seasons; and he will also find his greyhounds improve by experience. The speed of the hare is great, and so are the speed and strength of the greyhound. Two are reported to have coursed a hare seven miles, though they were then so completely exhausted, that medical aid could scarcely preserve them; and there are examples of their dying in the very act of seizing the game. Whether the hare can see distinctly during the rapidity of its flight, or how its vision is then directed, is doubtful. It runs against obstacles with great violence; and we are told of a terrier eagerly coming up to join the chace, having been met by the hare, when the latter was killed on the spot by the concussion, and its skull broken to pieces. When hard pressed, the hare will run to earth like a fox or a rabbit: it often takes the water; seeks shelter in a house; or even leaps on the breast of a spectator. Thus do we behold the effect of terror and the love of self-preservation conquer its almost invincible timidity. But the devoted victim seldom escapes its merciless pursuers. Compared with that description of the chace, where the power, the ferocity, and the craftiness of animals, are to be combated by the strength and ingenuity of man, it may be questioned whether hare-hunting should be ranked among the more elevated kinds of sport.

We shall now say a few words of hunting animals

Hunting animals for their fur.

which are sought only for the value of their furs, without any regard to the species to which they belong. These are more particularly of the weasel tribe, the *Mustela* of naturalists. The fur of some of these, as the ermine sable and sea otter, are of the finest quality, and always bear a very high price. A large portion of the revenue derived by Russia from her Siberian possession consists in the skin of the sable only. But hunting it is a more tedious occupation than the capture of any of the animals hitherto named, as it occupies the hunters a whole year at a time. Companies of from 6 to 40 men agree to hunt together, and they ascend the river Witim and two subsidiary streams, dragging boats capable of containing 3 or 4 people, and their provisions along with them, as far as the Lake Oronne. There they erect huts, and constitute a leader, to whom the whole promise implicit obedience. The party subdivides to hunt in different districts, and in this second excursion small huts banked up with snow are built, while all are occupied in constructing traps. As the sable is a carnivorous animal, they are suitably baited and set; and being so devised that the slightest touch ensures its capture, they are seldom long empty: but should the huntsman be unsuccessful in this manner, he is conducted by the tract of the sable in the snow to its burrow, from which being dislodged by a piece of smoking wood, it falls into a net spread for it, and there the huntsman kills it with his dog. Smoke is never used where there is only one hole to the burrow, as the sable would rather perish than come forth. Sometimes it runs up a tree, which case is then cut down, the huntsman again spreading his toils in the direction in which it is to fall; or he employs blunt arrows to shoot the sable, whereby its skin is preserved from injury. Hunting being closed as the ice begins to melt, the whole produce is collected, the skins properly prepared, and when the rivers are open, carried down in the boats. Many superstitious ceremonies are practised by the hunters: they never articulate while skinning the sable; nor must any thing hang on the stakes around them. The carcase is laid on dry sticks, which are set on fire, and afterwards carried round it, previous to its being buried in the earth or snow. A portion of the spoils called God's sables is always devoted as an offering to some church, in honour of which each leader also builds his hut.

Sable.

Sea otter.

However arduous and tedious a task it may be to hunt the sable, the pursuit of the sea otter, combined with that of several other animals, exceeds it infinitely in duration. Parties of huntsmen, consisting of from only a few to many hundreds together, engage in it, and ten years sometimes elapse before their return home. Far from being a pursuit of sport or pleasure, it is an occupation of dire necessity: the hunters are sparingly subsisted, they are scantily clothed, and, exposed to all the inclemency of a rigorous climate, they lead the most miserable lives. Such is particularly the case with the Russians in Siberia, and the natives of the continent, or the islanders under their controul. The sea otter is of an amphibious nature. It inhabits the shores of the Northern Pacific Ocean, and is found, though not in plenty, as far as Japan, or even the Yellow Sea. It is exceedingly pacific, and seeks safety only in flight; but it is unceasingly persecuted, and destroyed for the sake of the beautiful jet black fur that covers it. The hunters having obtained a vessel, to which the Russian government appoints a steersman, they sail from Okhotsk, or the harbours of Kamtschatka, with a small cargo of what will prove most acceptable to the savages of the distant islands which they mean to visit. Taking possession of some of these, they either compel the natives to depart alone in quest of game, (and in this way a fleet of canoes, carrying 300 Aleutans, went out some years ago, which was never after heard of,) or they are themselves of the party. Hunting the sea otter is in other respects attended both with danger and difficulty. Two very small canoes, each containing two expert hunters, are prepared with bows and arrows, and a small harpoon, to which last is attached a line a few fathoms in length. Though the animal is hunted also on ice, it is more commonly captured by pursuit in the water, continued during several hours. From the necessity of respiration, it can dive but for a few minutes; the principal skill to be displayed is in the canoes taking the same direction which it does in its course. They separate, therefore, as the sea otter goes down, in order to inflict a mortal wound either with the arrows or harpoon at the moment it rises. If hunted on a larger scale, the mode adopted renders the animal so sure a prey, that scarcely one in a hundred can escape. A number of hunters being engaged, when one observes a sea otter he endeavours to pierce it, and at all events rows to the spot where it plunges. Here he stations his canoe, and raises his oar as a signal, on which the rest of the hunters form a surrounding circle. The moment of reappearance, he discharges his arrows, or throws another harpoon, and hastening to the place where the otter dives, makes a signal by again raising his oar. A second circle is then formed, and the chace protracted, until the animal is exhausted. The first plunge exceeds a quarter of an hour, the next is of shorter duration, and thus the intervals diminish until the animal can plunge no more. When the female sea otter is overtaken with its young, parental affection is manifested in the most interesting manner: it supersedes all sense of danger. Taking the cub in her paws, she dives to save it; but obliged to rise for breath, she is exposed to the hunter's weapons. Should it be taken first, she becomes regardless of her own safety, and, approaching the boat, falls an easy sacrifice. But both parents sometimes defend their young furiously, tearing out with their teeth the arrows that have pierced them, and even attacking the canoes. Incessant pursuit of this animal has almost totally extirpated it from places where it was common formerly.

It would require a long enumeration to specify all the different modes of hunting, and the various stratagems employed for the capture of wild animals. Some are exceedingly ingenious, and others require continual alteration, according as the game becomes more wary of the designs of its pursuers. The skill of the huntsman, which an ordinary spectator is ready to undervalue, is the result of long continued experience only: the footstep, the track, the pasture of the animal, and other indications, are all studied, to discover its age, its sex, and its haunts; and it cannot be denied, that much of the naturalist's knowledge is deduced from the information of huntsmen alone. The whole geographical discoveries of the Russians in the north-east of Siberia originated exclusively with their hunters, to whom also they were indebted for the discovery of the Kurile and Aleutan islands, the promontory of Alaksa, and the island Kadiak. Hunting, when directed to the more important game, is an interesting, manly, and athletic exercise. Yet, if prosecuted for no other object than to deprive an innocent animal of life, or merely for the pleasure of witnessing its speed, and beholding the vigour of its defence for self-preservation, it is a cruel and hateful pastime. Men familiarised with the torture of animals, whose flesh is needlessly torn from their bones, will soon behold with indifference the pain of their fellow creatures. See *Chasse au fusil.* Williamson's *Field Sports of the East.* Daniel's *Rural Sports.* Beckford *On Fox and Hare Hunting. Sportsman's Dictionary. La Chasse Encyclop. Method.* Krascheninikow's *History of Kamtschatka.* Meare's *Voyage.* Lisianky's *Voyage.* Krusenstern's *Voyage.* Hearne's *Journey.* Cartwright's *Journal.* See Beaver, Bear, and Elephant, for an account of the method of hunting these animals. (*c*)

HUNTINGDON, is a town of England, and the principal town in Huntingdonshire. It is situated on a gently rising ground on the northern side of the river Ouse. It consists principally of one street, stretching in a north-west direction from the Ouse to nearly a mile from it, with several lanes branching off at right angles. The houses, which are built of brick, are genteel and commodious, and the streets are well paved and lighted. The town is nearly connected, by a causeway and three bridges, with the village of Godmanchester.

The principal public buildings and establishments are St Mary's church, All Saints church, and the town-hall. St Mary's, which is the corporation church, was rebuilt between the years 1600 and 1620. It has an elegant embattled tower at the west end, with nave, chancel, and aisles. All Saints church stands on the north of the market-place, and appears to have been built in the time of Henry VII. It is an embattled edifice, with nave, chancel, and aisles, and a small tower at the north-west angle. The town-hall, which stands on the south side of the market-place, is a good modern brick building, with a piazza at the front and sides, and butchers' shambles behind. In the lower part of the building are the civil and criminal courts, where the assizes are held. Above is a spacious assembly-room, adorned with the portraits of George II. and III. and their respective Queens, and of Lord Sandwich, who died in April 1792. The Free Grammar School is well endowed, and well conducted. There is also a green-coat school, called Walden's Charity, where 24 poor boys are clothed and educated. The county gaol, which stands at one end of the town, has recently been repaired and rendered more commodious. There are two places of worship here belonging to the dissenters, one for the Quakers, and the other for the sect patronised by the Countess of Huntingdon.

As Huntingdon is situated on the great north road, it has several good inns. The brewing trade is carried on here, though less extensively than formerly. It has also a small vinegar manufactory. Coals, wood, &c. are brought to the town by barges, which come up the river from Lynn in Norfolk, and return with the corn of the surrounding country.

This borough returns two members to Parliament, the right of election being vested in about 200 of the freemen and inhabitants. It is governed by a mayor, 12 aldermen, and a number of burgesses. The following is the population of the borough of Huntingdon in 1811:

Number of houses	450
Number of families	522
Families employed in trade and manufactures	291
Males	1085
Females	1312
Total population	2397

See the *Beauties of England and Wales,* vol. vii. p. 345.

HUNTINGDON. See Pennsylvania.

Situation, boundaries and extent.

HUNTINGDONSHIRE, an inland county of England, is almost inclosed by Cambridgeshire and Northamptonshire; by the former it is bounded on the north-east, and part of the south; by the latter, on the north and west. Bedfordshire bounds it also partly on the south-west. Its limits are nearly artificial. The river Nen, and the canals which join it to the Ouse, form its limits on the north and north-east, on the Northamptonshire and Cambridgeshire borders. The Ouse, at its entrance, separates for a short space from Bedfordshire, and at its exit from Cambridgeshire. The figure of this county is so irregular as scarcely to afford a proper measurement; but reckoning from its furthest projection, it does not exceed 24 miles each way, and in general is of much less extent. In fact, it is the smallest county in England except Rutland, and is very nearly the size of Middlesex; Huntingdon containing, according to the best accounts, about 210,000 acres; Rutland, 110,000; and Middlesex about 200,000 acres. The whole upland part in ancient times was a forest, and particularly adapted to the chace, whence the name of the county took its rise. It was disafforested by Henry II., III., and Edward I., the last of whom left no more of it a forest than what covers his own ground.

Divisions.

It is divided into four hundreds, namely, Normancross towards the north; Toseland towards the south; Hurstingstone towards the east; and Leightonstone towards the west. It contains one county-town, Huntingdon; six market towns, of which the principal are Kimbolton, St Neots, St Ives, and Godmanchester. The number of parishes is 104. It is in the province of Canterbury, and diocese of Lincoln. The ecclesiastical government is managed by the archdeacon of Huntingdon, and it is divided into five deaneries. It is in the Norfolk circuit, and returns four members to Parliament, viz. two for the county, and two for Huntingdon. This county and Cambridgeshire are joined together under one civil administration, there being but one high-sheriff for both; who is alternately chosen one year out of Cambridgeshire, the second year out of the isle of Ely, and the third year out of this county. It is one of the seven counties, Bedford, Huntingdon, Bucks, Berks, Hertford, Essex, and Suffolk, that are contiguous without a city.

Surface.

The fenny part of it lies in the Bedford level on the north-east, and joining the fens of Ely. There are besides three distinct varieties of surface in this county. The borders of the Ouse, flowing across the south-east part, consist of a tract of most beautiful and fertile meadows, of which Portsholme Mead, near Huntingdon, is particularly celebrated. The middle and western parts are finely varied in their surface, fruitful in corn, and sprinkled with woods. The upland parts still bear the appearance of ancient forest lands.

Soils.

The soils are various. In the upland parts, they are chiefly a strong deep clay, more or less intermingled with loam, or a deep gravelly soil, with loam. Of what are called the deep stapled lands, by far the greatest part are still in an open-field state. Indeed, there is a larger proportion of this most unproductive land in Huntingdonshire than perhaps in any other county of England; upwards of one-third of the high lands being still uninclosed. The more anciently inclosed parts are, generally speaking, in the possession of a few proprietors; but in the new inclosures, and in the open fields, property is divided among a much greater number of persons. The woodlands are but of inconsiderable extent, and the county is thin of timber. This is attributed to the very great demand for it in the fens, underwood being sold at a higher price than in most other counties. The meadow lands consist of about 1200 or 1400 acres, bordering on the rivers Nen and Ouse, but chiefly on the latter. They are extremely productive, but the produce is frequently damaged or carried away by the floods.

Fens. The fens consist of about 44,000 acres, besides nearly 5000 acres of what are provincially called skirty lands. The fens of Huntingdonshire constitute nearly a seventh part of what is called Bedford Level. About 8000 or 10,000 acres of them are productive; but the expence of preserving them from inundation amounts to almost one-third of the rents, in consequence of the drainage having been undertaken on an erroneous and imperfect plan. It is effected by engines, which throw the water out of the lands into the rivers, without having a proper out-fall near the sea. In consequence of this, the embankments are frequently broken through by the immense pressure of the weight which they contain. The mode of management of the fen lands has been much improved of late years, and the fen-men are very expert at the plough; no such thing as a driver being known, though they frequently plough with three horses abreast. The *skirty* lands, in general, afford luxuriant grazing.

Climate. The climate is rather mild, and by no means so unhealthy as might be anticipated from the fenny nature of a large portion of the county. The most unhealthy parts are the low moorish tracts near Huntingdon, Godmanchester, Ramsey, and Yaxley; for in the other parts about Kimbolton, and indeed through the whole of the hundred of Leightonstone, the air is remarkably good.

Rivers. The principal rivers connected with Huntingdonshire are the Ouse and the Nen. The Ouse, which is generally called the Lesser Ouse, to distinguish it from a river of the same name in Yorkshire, enters this county from Bedfordshire between St Neots and Little Paxton, and, in its course southwards to Huntingdon, is increased by a number of small streams from the north-west. After passing that town, it flows eastward, and passing the west end of St Ives, becomes, near Holywell, the boundary between this county and Cambridgeshire, till it enters the great level of the fens near Erith. It is navigable along its whole line across this county. The Nen rises in Northamptonshire, and reaches Huntingdonshire near Elton, where it becomes the boundary between the two counties. It afterwards flows to Peterborough, below which it sinks into the fens. Some smaller streams water the north-east side of the county, together with several large meres or pools of water. **Whittlesea Mere.** Of these, Whittlesea Mere is by far the largest. In the time of Camden, it was six miles long and three broad; but its limits are now much contracted, so that the water is said at present to cover only an area of 1570 acres. It affords excellent sailing and fishing; and is, in the summer season, much frequented by parties of pleasure. Anciently, there was a navigation from Peterborough by the river to this Mere, and from thence to Ramsey.

Agriculture. Though this county has long been celebrated for its wealthy farmers, particularly in the vicinity of Godmanchester, yet its agriculture presents very little that is interesting or important. In Camden's time, Godmanchester was reckoned the largest village in England; and at that period, no place employed so many ploughs; and, according to that author, no people had so much advanced in agriculture, either by their purse or their genius. When James I. came through it on his journey from Scotland to take possession of the throne of England, the inhabitants met him with 70 new ploughs, drawn by as many teams of horses; for they hold their lands by this tenure, that whenever the sovereign took this place in their progress, the farmers should make the most pompous appearance with ploughs and horses, adorned like triumphal cars with rustic trophies. King James was so pleased with the sight, that he granted them a charter constituting Godmanchester a borough, at the same time condescending to partake of a collation prepared under a bush, still known by the name of the King's Bush, and the Beggar's Bush. But Huntingdonshire is no longer remarkable for the excellence of its agriculture; nor, indeed, could improvement in this most useful art be excited in a county where so large a proportion of the land is still in the barbarous state of open field. **Mustard.** Besides the common produce of wheat, barley, oats, hemp, and rape in the fens, turnips on the drier soils, and a few hops, this county grows a considerable quantity of mustard: it is cultivated on various soils, chiefly rich loam, good old pasture land, rich clay, and the best fen soils. The ground is ploughed only once for it: it is sown any time between Candlemas and Lady Day. There are two kinds, the black and white; the former is most esteemed. The weeding is performed by sheep, which will not eat the mustard. The produce is from 28 to 44 bushels per acre.

Sheep and cattle. The breed of sheep upon the enclosed lands is of a mixed description, nearly approaching to the Leicestershire and Lincolnshire kinds, with which the native breeds have been much crossed. Those bred on the open fields and commons are much inferior. The cattle are for the most part the refuse of the Lancashire, Leicestershire, and Derbyshire breeds: oxen are purchased for grazing generally without any attention to the breed, and are never used in husbandry. From the open state of the county, dairy farming is not much followed; and the cows are used for suckling calves in the southern parts, to supply the London market. **Stilton cheese.** The rich and celebrated cheese, called Stilton cheese, takes its name from a village in Huntingdonshire; but it is made in the vicinity of Melton Mowbray in Leicestershire; and it is generally supposed never to have been made at Stilton, but always to have been sent there for sale: of this, however, there seems some doubt. Mr Nicholls, in his History and Antiquities of the County of Leicester, says that it began to be made in the parish of Little Dalby, in that county, about the year 1730; but, on the other hand, there is the evidence of a very old inhabitant of Stilton, who died there about the year 1777, aged 80 years, that, when he was a boy, the cream used to be collected in the neighbouring villages for the purpose of making Stilton cheese: this of course fixes the making of this famous cheese at Stilton long before, according to Mr Nicholls' evidence, it was made in Leicestershire. **Horses.** In the fens of Huntingdonshire, mares are used for all the purposes of agriculture; and every farmer breeds from them as many foals as he can, selling the colts off at two years old, and as many of the fillies as can be spared, with proper attention to the team. **Roads.** The high roads in this county, in general, are tolerably good; the cross roads are but indifferent, and in the winter season many of them are nearly impassable.

Manufactures. No manufactures of note are carried on in Huntingdonshire except wool, stapling, and spinning yarn: the latter is the chief business of the women and children in the winter season; in the summer they find more profitable employment in the fields. There is a small manufacture of lace at Kimbolton; and at St Neots, there is a very large paper mill worked by patent machinery. At Standground, there are two manufactures for sacking. The markets and fairs of St Ives for live cattle are some of the greatest in England.

Poor's rates.

In the year 1803, the poor's rates amounted to £30,952: in the year ending the 25th of March 1815, it amounted to £40,625.

Antiquities.

There are few remarkable antiquities in this county. Dornford in the north-west part of it, formerly called Deorm-ceaster and Caer Dorm, is probably the *Durobrivæ*, a passage of the Nen mentioned in the Itinerary of Antoninus. A little above Stilton, a Roman pathway, leading from Dornford to Huntingdon, appears with a very high bank, which, in an old Saxon charter, is called Erming-street. From Ramsey, which stands on an isle of the same name, formed by the fens, there runs a causeway, called Kings-delf, for ten miles, to Peterborough. It appears upon record in King Edgar's time. At Ramsey, was formerly a very rich abbey, built in the midst of a bog. There is little left of it, beside a part of the old gate-house, and a statue of its founder Alwyn, who was called alderman of all England, and cousin to King Edgar. The keys and ragged staff in his hand, denote his offices. This is reckoned one of the most ancient pieces of English sculpture extant.

History.

This county, under the Saxon heptarchy, formed part of the kingdom of Mercia, or the middle Angles. Mr Speed mentions an observation of Sir Robert Cotton, that the families of this county were so worn out even in his time, (about the beginning of the 17th century,) that, though it was formerly very rich in gentry, yet few surnames of any note were then remaining that could be traced higher than Henry VIII. Mr Camden remarks, that in the civil wars, there were more actions in this than in much larger counties, because it was the native county of Oliver Cromwell.

Population.

According to the returns made in the year 1800, the population of this county was 37,568. In the year 1811, the returns afford the following results.

Houses inhabited	7,566
Families occupying them	8,808
Houses building	23
—— uninhabited	153
Families employed in agriculture	5,361
———— in trade and manufactures	2,205
——— not comprised in these classes	1,242
Males	20,402
Females	21,806
Total	42,208
Square statute miles	370
Rental of land	£202,076
Amount of tithe	£10,166
Annual value of square mile	£574
Persons in a square mile	114
Agricultural population	61
Net product per family	£40

(W. S.)

HUNTLY is a small town of Scotland, in the county of Aberdeen. It is pleasantly situated on a point of land at the confluence of the rivers Bogie and Deveron. It consists of two principal streets, crossing each other at right angles, and forming a spacious market-place at their junction. The town contains some good houses, and has of late years increased considerably. In 1792, it contained 52 flax-dressers, the annual value of whose manufactures was £16,224; and 209 weavers, who produced yearly 73,150 yards of cloth. Huntly Lodge, the seat of the Marquis of Huntly, stands near the town, on the banks of the Deveron; and near the bridge over the same river are the remains of Huntly Castle.

The town and parish contained, in 1811,

Inhabited houses	608
Number of families	720
Ditto employed in agriculture	190
Ditto employed in trade and manufactures	510
Males	1186
Females	1578
Total population	2764

HURON, LAKE. See CANADA, vol. v. p. 329, col. 2.

HURRICANES. See METEOROLOGY.

HUSBANDRY. See AGRICULTURE.

HUSS, JOHN, the celebrated reformer and founder of the sect called Hussites, was born at Hussinez, a village in Bohemia, about the year 1376, and received his education at the university of Prague, where he took his degrees of M. A. and B. D. and at length became minister of a church in that city. In the year 1400, he was chosen confessor to the queen Sophia; and at this early period, he already began to distinguish himself by his freedom and zeal in reprehending the corrupt morals of the laity, as well as the vices of the clergy. The monks, under the protection of some of the nobles, complained of him to the king Winceslaus; but this prince, who was no friend to the clergy, declined to interfere.

About this period, in consequence of the marriage of Ann of Bohemia with Richard II. of England, a communication and intercourse were opened between these two countries; and several young Bohemians repaired to England, where they became acquainted with the writings of Wickliffe. Among these was Jerome of Prague, who had formerly been a pupil of Huss, and after spending some time at the university of Oxford, returned to his native country, bringing along with him several of the works of the English reformer. Huss perused these writings, and having found that many of the opinions which they contained coincided with those which he himself had been led to entertain, he continued to preach openly and zealously against the errors and corruptions of the reigning church. His eloquence was powerfully directed against the sale of indulgences; he inveighed against this system of Papal extortion with uncommon warmth; and his arguments received countenance both from the monarch and the people. By this conduct, however, he rendered himself greatly obnoxious to Subinco, the archbishop of Prague, a violent, bigotted, and illiterate prelate, who from thenceforth became his irreconcileable enemy. Being aware that Huss was secretly attached to the doctrines of Wickliffe, he obtained a decree of the university, in which the opinions of the English reformer were condemned as heretical, and those who should in future attempt to disseminate these opinions were threatened with the punishment of burning. Huss perceived at once that this decree was levelled at his person, rather than the opinions of Wickliffe; but he relied upon the protection of the queen, and the acknowledged purity of his life and conversation.

Meanwhile, two young Englishmen, and zealous disciples of Wickliffe, having arrived at Prague, contributed to strengthen his attachment to the doctrines of that reformer; and Wickliffe's treatise *De realibus Uni-*

versalibus having fallen into his hands, he relished it so much, that he adopted the opinions of the author, and became a decided *realist*. The whole university was at this time divided into two parties, the German and the Bohemian, or the *nominalists* and *realists*, whose contests were carried on with great animosity, and not without bloodshed. The German, or foreign party, possessed most influence in the university, as the original constitution allowed them three votes in all elections and deliberations; while the native Bohemians had only one. This constitution conferred upon the former a superiority, which the latter could not contemplate without jealousy, especially as the Germans conducted themselves with great arrogance towards the natives. Huss took upon himself to contest the right of the Germans to this superiority, and demonstrated, that although, by the original constitution of the university, the German masters had been allowed three votes, while the Bohemians had only one, as the latter were then inconsiderable in point of number; yet that, by a later act of Charles IV. it was expressly declared, that in all matters they should be governed by the constitution of the university of Paris, according to which foreigners had but one vote, and the natives three. Through his great influence at court, Huss actually succeeded in carrying this measure, the consequence of which was, that almost all the Germans withdrew from Prague, and repaired to Leipsic, where a new university was soon after founded.

No sooner did the Bohemians find themselves in full possession of the university, than they proceeded to elect Huss for their rector. He now exerted his eloquence more powerfully than ever in declaiming against the scandalous corruption of morals among the clergy; and, among other doctrines, he strongly recommended a diminution of the superfluous revenues of the church, as the best means of producing a moral reformation. He even ventured to attack the supreme power of the pope, in whom he would acknowledge no superiority over other bishops.

As soon as the conduct of Huss was represented to Pope Alexander V. he gave the Archbishop Subinco a commission to take measures for repressing these dangerous doctrines. The archbishop accordingly not only prohibited all preaching in chapels, but ordered all the writings of Wickliffe, which he could collect, to be publicly burnt. Huss, however, entirely disregarded the prohibition, and continued to preach, as zealously as ever, in favour of the condemned doctrines. At length, in the year 1410, he was summoned to appear before the papal tribunal by John XXIII.; but Huss, under the protection of the king and queen, several powerful nobles, and the university, declined appearing in person, but sent three deputies to excuse his absence, and to answer all that should be alleged against him. In the mean time an event occured, which made the breach between Huss and the court of Rome utterly irreparable. In the autumn of 1411, Pope John caused a general indulgence to be proclaimed for all those who should assist him in his crusade against the excommunicated king, Ladislaus of Naples; and for this purpose he sent his commissaries to Prague. Huss, who had formerly opposed the sale of indulgences, now raised his voice boldly against this papal traffic; while his friend Jerome of Prague even went so far as to burn the papal bull in the market-place under the gallows. This was sufficient to call forth the vengeance of the Roman pontiff. Huss was now excommunicated for his contumacy in declining to appear personally at the papal tribunal; and the town of Prague was laid under an interdict. The number of his friends and adherents would probably have enabled Huss to set at nought this sentence; but, in order to remove every pretext for tumult and disorder, he resolved to withdraw from Prague, and accordingly retired to his birthplace, Hussinez. Here, and at Cracowitz, to which place he soon after repaired, Huss continued to disseminate his doctrines by preaching, and composed several treatises, with a view to expose the most objectionable tenets of the Romish church.

Matters were in this situation, when the Emperor Sigismund agreed with Pope John to assemble a general council at Constance. To this general council Huss was summoned, in order to defend himself publicly against the accusation of heresy. His friends having procured for him a safe-conduct from the emperor, and being likewise provided with attestations of his orthodoxy and innocence from the university and the papal inquisitor at Prague, he set out upon his journey to Constance, where he arrived shortly before the opening of the council. The pope treated him with kindness, assured him of his protection, and even removed the sentence of excommunication. But shortly afterwards, some of his most violent persecutors having arrived at Constance, they used their utmost influence to procure his condemnation; and Huss himself having had the imprudence to promulgate the doctrines of Wickliffe at Constance, he was summoned before the pope and the cardinals, and, notwithstanding the emperor's safe-conduct, thrown into prison.

Upon receiving intelligence of these proceedings, the emperor, who had not yet arrived, sent an order to his ambassador to insist with the pope and the cardinals upon the liberation of John Huss, and to threaten, if they refused to comply, that the prison would be opened by force. The pope and the cardinals, however, disregarded the command of the king, and caused the prisoner to be more strictly confined. When Sigismund arrived at Constance, he allowed himself to be persuaded by the theologians and canonists, that he was not bound to keep faith with a notorious heretic; and he issued a declaration that the council should have free power in all matters of faith, and should be allowed to proceed as judges against all those who were accused of heresy. Some of the most considerable among the Bohemian nobles, indignant at the perfidious conduct of the emperor, repeatedly requested, in pretty bold language, that John Huss, who had received a safe-conduct from the monarch himself, and otherwise would certainly not have repaired to Constance, should be set at liberty, and publicly heard in his defence before the whole council. But Sigismund excused himself in evasive terms, and thereby drew upon himself the mortal hatred of the Bohemians, which, in the sequel, proved highly dangerous to his power.

After Huss had remained more than six months in prison, he was, for the first time, allowed a public hearing, in a general congregation, in which, however, the proceedings were so irregular and tumultuous, that he found it impossible to speak. In the following audience, three points of accusation were read; to which Huss answered in a manner so satisfactory, that no charge of heresy could be fixed upon him, and every impartial judge must have acquitted him. In the third diet, thirty-nine articles were read to him, which had been drawn up by his enemies, and were alleged to have been extracted from his writings. Huss acknowledged such of these as contained opinions which he had really held; but with regard to the greater number, he utterly denied them, declaring that they were either garbled and distorted, or altogether forged by his enemies. Some of the prelates, and even the emperor himself, now urged him to retract and abjure the whole of these articles; but Huss required that he should first be convicted of error; for so long as this was not done, it was impossible for him to retract any of his opinions. And to this determination he adhered, with immoveable firmness, as often as the council endeavoured to induce him to retract, and even threatened to bring him to the stake.

At length, in the 15th session, which Sigismund attended in person, the final sentence was pronounced, that the writings of Huss should be publicly burnt; and that he himself, as a manifest heretic, who openly taught, and refused to retract, doctrines which had long been condemned as dangerous to the Catholic faith, should be deprived of his ecclesiastical dignity, and delivered over, for punishment, to the temporal arm. Huss, who was obliged to listen on his knees while this sentence was publicly read, repeatedly attempted to complain, and to vindicate himself in regard to several offences which were falsely laid to his charge; but he was always interrupted, and compelled to keep silence. The unfortunate victim was now forced to submit to the punishment of degradation, which was performed with several absurd ceremonies by seven bishops commissioned for that purpose. He was then delivered over, by the emperor, to the elector palatine, who was commanded to execute upon him the usual punishment of heretics.

Immediately after the termination of the session, Huss was conducted under a strong escort to the square in front of the episcopal palace, where he was compelled to witness the public burning of his writings; and from thence to the place of execution before the city gate. While he was preparing for the stake, several fruitless attempts were made to extort from him a recantation; but his fortitude remained unshaken to the last. When he was fastened to the stake, and fire was laid to the faggots around him, he continued his devotional exercises until the vital spark became extinct within him. His ashes were gathered up and thrown into the Rhine.

Such was the fate of John Huss, who fell a victim to the most abominable persecution. His talents and acquirements, although not of the first order, were highly respectable; and his moral character was universally acknowledged to be irreproachable. In his manners he was gentle and condescending. Strict in his principles, and virtuous in his conduct, he looked more to the practice than to the opinions of others. His piety was calm, rational, and manly; and his zeal in the cause of Christianity was untainted with fanaticism. The events of his life sufficiently prove, that his fortitude was not to be shaken by any human power.

It is difficult to conceive how such a character as that of Huss should have been exposed to such unrelenting animosity and furious persecution. His creed, it is true, did not exactly square with the tenets of the established orthodox faith; yet several of his persecutors had publicly maintained almost all the offensive doctrines which he was charged with disseminating. It seems most probable, according to the opinion of some authors, that the violent animosity excited against him is to be ascribed chiefly to the zeal with which he declaimed against the dissolute morals of the ecclesiastics, the usurpations of the Roman court, and the temporalities of the clergy. These principles were naturally considered as dangerous to the power and influence of the priesthood; and his brethren, who dreaded the effects of his eloquence and example, were glad to have recourse to an accusation of heresy, as the best and least unpopular means of destroying the enemy of their corruptions, and of crushing those principles which appeared subversive of their privileges and pretensions.

Jerome of Prague, the friend and pupil of Huss, underwent the same fate with his companion. He, indeed, was at first terrified into a temporary submission; but he afterwards resumed his fortitude; and, at length, on the 30th of May, 1416, sealed by martyrdom his belief in the principles he professed.

The memory of John Huss was long cherished by his countrymen, the Bohemians; the sixth of July was for many years held sacred, as the anniversary of his martyrdom, and medals were struck in honour of the martyr. The Bohemian and Moravian nobles addressed a spirited protest to the council of Constance, in answer to the intimation of his sentence and execution; and the zeal of his indignant disciples afterwards broke out into an open war against the emperor, which was conducted, on both sides, with a savage spirit of barbarity, and gave rise to acts of atrocity at which humanity shudders. These troubles were at length fortunately terminated by the interference of the council of Basil in the year 1433. See Zitte *Lebens beschreibung des Mag. Johan. Huss*, Prague, 1789; Æn. Sylvii *Hist. Bohem.* in Freheri *Script. rer. Bohem.*; Wil. Seyfried *De Johannis Hussi martyris vita, fatis et scriptis*, Jena, 1743; Pelzel's *Geschichte der Böhmen*, Prague, 1782; Mosheim's *Ecclesiast. Hist.* vol. iii.; Gilpin's Lives, *Life of John Huss*; and the *Gen. Biog. Dict.* (z)

HUSUM is a sea-port town of Denmark, situated on the west coast of the duchy of Sleswick, about two miles from the small river Ow, and about four from Sleswick. It was formerly celebrated for the great quantities of malt which it exported. At one time 40 large vessels belonged to this town, and the oyster trade was almost confined to its inhabitants.

HUTCHESON, Francis, an ingenious philosopher and elegant writer, was the son of a dissenting minister in the north of Ireland, and was born on the 8th of August 1694. From his childhood he discovered a superior capacity, and an ardent thirst after knowledge; and having received the usual elementary instruction at a grammar-school, he was sent to an academy to begin his course of philosophy. In the year 1710, he was entered a student in the university of Glasgow; where he renewed his application to the study of the Latin and Greek languages, and explored every province of literature; but devoted himself chiefly to divinity, which he proposed to make the peculiar study and profession of his life.

After spending six years at Glasgow, he returned to his native country; and having entered into the ministry, he was just about to be settled in a small congregation of Dissenters in the north of Ireland, when some gentlemen about Dublin, who were acquainted with his great talents and virtues, invited him to undertake the charge of a private academy in that city. With this invitation he complied; and he had resided but a short time in Dublin, when his talents and accomplishments attracted general notice, and procured him the acquaintance of persons of all ranks, who had any taste for literature. Lord Molesworth is said to have taken great delight in his conversation, and to have assisted him with his criticisms and observations upon his *Enquiry into the Ideas of Beauty and Virtue,* before it was committed to the press. He experienced the same favour from Dr Synge, Bishop of Elphin, with whom he cultivated an intimate friendship. The first edition of the work to which we have just alluded, was published anonymously; but its great merit did not allow the author to remain long concealed. Lord Granville, who was then lord-lieutenant of Ireland, sent his private secretary to enquire at the booksellers for the author; and when he could not learn his name, he left a letter to be conveyed to him, in consequence of which he soon became acquainted with his excellency, and was ever after treated by him with distinguished marks of familiarity and esteem.

From this period, his acquaintance began to be still more courted by men of distinction, either for station or literature, in Ireland. The celebrated Archbishop King held him in great esteem; and the friendship of that prelate was highly useful in screening him from two attempts which were made to prosecute him, for venturing to take upon himself the education of youth, without having subscribed the ecclesiastical canons, and obtained a regular license from the bishop. He also enjoyed a large share of the esteem of the Primate Boulter; who, through his influence, made a donation to the university of Glasgow of a yearly fund for an exhibitioner to be bred to any of the learned professions.

In the year 1728, Mr Hutcheson published his *Treatise on the Passions;* and about the same time he wrote some philosophical papers, inserted in the collection called *Hibernicus's Letters,* in which he accounted for laughter in a manner different from the theory of Hobbes, and more honourable to human nature. Some letters having appeared in the "*London Journal,* 1728," subscribed Philaretus, containing objections to some parts of the doctrine contained in the *Enquiry,* he was induced to give answers to them in those public papers. Both the letters and answers were afterwards published in a separate pamphlet.

After he had conducted his private academy at Dublin for several years with great reputation and success, he was invited to Scotland in 1729, to fill the chair of moral philosophy in the university of Glasgow. In this situation he spent the remainder of his life, in a manner highly honourable to himself, and useful to the university of which he was a member. About this time, the degree of Doctor of Laws was conferred upon him. A firm constitution, and a pretty uniform state of good health, with the exception of some slight attacks of the gout, seemed to promise his friends a long enjoyment of his valuable life; which, however, was terminated by a sudden attack, in the year 1747, when he had only attained the age of 53.

He was married, soon after his settlement in Dublin, to Mrs Mary Wilson, the daughter of a gentleman in the county of Longford; by whom he left one son, Francis Hutcheson, M. D. who published from the original MS. of his father, *A System of Moral Philosophy,* Glasgow, 1755, 2 vols. 4to.

Dr Hutcheson was a man of considerable learning, and various acquirements. He was not only acquainted with those subjects most intimately connected with his profession, but was also well versed in mathematics and natural philosophy. His works have been frequently reprinted, and have been universally admired, both for the sentiments and language, even by those who have not assented to the author's principles. He belonged to that class of philosophers, who deduce all our notions of right or wrong from a moral sense or faculty implanted in our constitution, which leads us to perform good actions ourselves, and to approve of them when performed by others, independently of any reasoning with regard to their utility or fitness. He was a decided antagonist of the doctrines of Hobbes; entertaining high notions of the dignity of human nature, and being persuaded that, even in this corrupt state, it is capable of great improvement, by proper instruction and assiduous culture. See Dr Leichman's *Account of the Life, Writings, and Character of Dr Hutcheson,* prefixed to the *System of Moral Philosophy;* and the *Gen. Biog. Dict.* (z)

HUTTON, James, M. D. well known as the author of an ingenious Theory of the Earth, was the son of a respectable merchant in Edinburgh, and was born on the 3d of June 1726. He received at the high school and the university the rudiments of a liberal education, during which his curiosity was powerfully excited by various facts in chemistry which came under his knowledge, and he acquired a taste for chemical pursuits which distinguished him through life. His friends, however, placed him as an apprentice with Mr Chalmers, Writer to the Signet. But this gentleman soon perceiving that he disliked his employment, and occupied much of his time with chemical experiments, liberally released him from his engagements, and advised him to turn his attention to more congenial pursuits. He now entered on a course of medical studies, which he prosecuted first in Edinburgh, from the year 1744 to 1747. He next studied at Paris; and in 1749, he took the degree of M. D. at Leyden. Having thus completed his education, however, he perceived serious difficulties opposed to his views of success in obtaining practice. He also apprehended that the labours of a professional life might interfere with the gratification of his taste for chemistry; and in 1750, he resolved to apply himself to agriculture. For the purpose of learning that art, he went to Norfolk, where he resided two years in the house of an intelligent farmer. During this residence, he made pedestrian excursions to different parts of England for his improvement in agricultural knowledge; in the course of which he contracted an attachment to mineralogy and the kindred speculations of geology.

In 1754, he extended his agricultural knowledge, by making a tour in Holland and Flanders. During all these peregrinations, he made a collection of facts which were afterwards made to contribute to his theory of the earth. He returned to Scotland, and reduced his agricultural knowledge to practice, by improving his patrimonial property in Berwickshire. In this occupation he was engaged for 14 years. He had the honour of being among the first who introduced good husbandry into our country, where it has since been so successfully cultivated. In 1768 he let his farm, which he had now brought to a high state of improvement. He had been for several years concerned in a manufactory of sal ammoniac, conducted in Edinburgh under the name of Mr James Davie, who was one of his early and constant friends; and in 1765, a regular partnership had been formed, after which the work was conducted in the name of both. When he gave up his farm, he took up his residence in Edinburgh, and devoted his attention to the pursuits of science, in which he was assisted and animated by his learned friends, whose company he enjoyed in this metropolis. In the course of his chemical pursuits, he discovered that soda was contained in zeolite; the first time an alkali had been found in a stony mineral. He continued to make tours to various parts of the island, in prosecution of his geological inquiries, which assumed greater and greater consistency. In 1777, Dr Hutton published a pamphlet entitled, *Considerations on the Nature, Qualities, and Distinctions of Coal and Culm*, with a view to throw light on a disputed point, whether the small coal of Scotland was liable to the duty on English coal, or to that on English culm. On this subject he displayed great accuracy of observation; and his discussion led to a satisfactory decision of the question. From the time of fixing his residence in Edinburgh, Dr Hutton had been a member of the Philosophical Society, known by the three volumes of literary and physical essays which it published. In that Society he read several papers, none of which have been published, with the exception of one which appeared in the second volume of the Transactions of the Royal Society of Edinburgh, "On certain natural appearances of the ground on the hill of Arthur's Seat." The institution of the Royal Society, which happened in 1783, called forth from Dr Hutton the first sketch of his Theory of the Earth, which he had matured in his own mind, but communicated only to his friends Dr Black and Mr Clerk of Eldin, both of whom approved of it. For an account of this theory, see the article MINERALOGY. The distinguishing feature of it was, the universal agency of heat in consolidating the rocky strata, after the materials of which they were formed had been collected by the subsiding of loose earthy materials at the bottom of the sea. This heat he conceived to be seated in the central parts of the earth. To the expansive power of this agent, acting on water or other bodies, he ascribed the elevation of the strata from the bottom of the sea to the higher situations which they have since occupied. He thus accounted for the present appearances. He supposes the earth to have undergone many revolutions at very distant intervals of time, and to be subjected to a law which produces a general and sudden convulsion as a stage in certain cycles of changes, which at all other times are slowly yet incessantly advancing. This theory has been defended by the author and his followers with much learning and ingenuity; and in a particular manner by his zealous and enlightened admirer Professor Playfair. It has however met with a formidable competitor in that of Werner; the leading feature of which is, to account for consolidation by crystallization from a state of aqueous solution, rejecting the hypothesis of a central heat, whether as concerned in the fusion of the rocks, or in the elevation of the strata. It supposes the materials of the strata to have subsided at their present elevation; and its chief embarrassment consists in the difficulty of accounting for the retiring of the waters. The illustration of these opposite general views includes a vast variety of discussion on the constitution of the rocky strata. The controversy has eminently promoted the investigation of the mineral kingdom. A great part of the world content themselves with a smile bordering on contempt, when they casually listen to these speculations; and a superficial observer is generally struck with the character of extravagance which appears so prominent in the hypotheses assumed. No hypothesis, however, within the limits of possibility is too extravagant for the subject. The disposition of the strata is itself an extravagant fact, if we may be allowed to apply this epithet to any thing in nature. It points to causes so different in their general character from any that we see in actual operation, that no hypothesis is to be rejected for its strangeness; and hypotheses of this kind are unavoidable to those who attempt to explain the phenomena before them. A wish of this sort cannot be reasonably condemned. There can scarcely be a more sublime speculation in physics, than to attempt the resolution of problems which nature suggests on so magnificent a scale. We may indeed sometimes wonder to see a particular theory so tenaciously adhered to; and it may be regarded as a curious fact, that in the present age the one or the other of the theories now mentioned should be adopted by all geologists. It might be supposed, that the subject would afford several others equally plausible; but it is probably not so much a satisfaction with their own theory as a simple preference of it to its opponent, that is indulged in by the greater part of geologists. The unexplained phenomena of magnetism, particularly the fluctuating variations of the needle, and the supposition of interchanges of materials among the different planets, (countenanced in some measure by the well authenticated instances of stones which have fallen from the atmosphere,) will perhaps at some future period lead to a modification of our geological theories, or to the formation of others.

A paper of Dr Hutton "On the Theory of Rain," was published in the first volume of the Edinburgh Transactions. It forms the only scientific explanation of the phenomena that we have. The discovery of it evinced profound genius and accurate information, and it will probably always be retained by meteorologists. Two portions of air of different temperatures, both saturated with humidity when mixed, and thus reduced to a medium temperature, have not the power of retaining the same quantity in a state of vapour. The reason of this is, that the quantities of humidity retained in this state proceed in a geometrical ratio, while those of temperature increase arithmetically. A larger quantity of water is retained by that heat which had kept the one portion of air above the resulting medium, than when the same heat is employed in raising to that medium the temperature of the coldest portion. The consequence of this is, that a part of the water is precipitated. This theory was opposed by Monsieur de Luc, who maintained, that the heat was communicated from one part of the atmosphere to another without the actual intermixture of different portions of air. Dr Hutton made several other acute improvements in meteorology, which were afterwards published in his "Physical Dissertations," in which his theory of rain was again given. It was by the theory of the earth, however, that the greatest portion of his interest was absorbed. The journeys which he made to Glen Tilt, to Galloway, the isle of Arran and St Abb's Head, supplied him with facts which afforded him exquisite delight, especially those which elucidated his peculiar views of the nature of granite, and the circumstances under which it assumed its present situation in relation to the other rocks. He supposed it to have been forced up in a state of igneous fusion by the expansive power of the central heat, and injected in that state into the rents produced in the superincumbent strata, which had previously formed the exterior crust of the globe. It was the continuation of the granite upward into these rents or veins that so much delighted Dr Hutton. This is a fact which still furnishes one of the strong points of the Huttonian theory.

This philosopher also turned his attention to another subject suggested by his chemical pursuits, viz. the general nature of matter. His doctrines on this subject, are given in his "Dissertations on different subjects in

Natural Philosophy." They bore some resemblance to those of Boscovich, though somewhat different, and seem to have been with Dr Hutton altogether original. After this he published a more voluminous work, entitled "An Investigation of the Principles of Knowledge and the Progress of Reason from Sense to Science and Philosophy," in three 4to volumes. His leading idea was, that matter is an assemblage of powers; that our ideas of external substances have no resemblance to the causes which produce them; and consequently that the world as conceived by us, is entirely the creation of the mind itself acted on by unknown external causes.

In 1793, Dr Hutton was seized with a severe and dangerous illness from a retention of urine. When he recovered from its severest symptoms, he continued his literary occupations. It was then that he prepared the work last mentioned for publication. He was also now called on to defend his doctrine on the theory of the earth from the arguments of Mr Kirwan, published in the Transactions of the Irish Academy, especially as these were accompanied by some misrepresentations which it was incumbent on him to expose, and some charges of an odious tendency which it was necessary to repel. It was only now that he began to publish his theory of the earth in a separate state, as it had hitherto been but partially unfolded in a variety of papers. He published two octavo volumes in 1795, and a third was left behind in manuscript.

After this he published his "Elements of Agriculture," and eminently contributed by this publication, as he had done by his former example, to give an impulse to the progress of that important art.

After this he suffered under a renewed and very severe attack of his complaint; and in 1796 and 1797, his strength was greatly reduced, and his constitution broken. Still, however, he employed himself in reading and writing. Saussure's travels among the Alps, which at this time were newly published, furnished him with high entertainment, congenial with the favourite scientific amusements of his life. On Saturday the 26th of March 1797 he suffered much pain, but continued to make some efforts in study. In the evening of that day, his complaint increased in a most rapid manner, and carried him off before time was allowed for his medical attendant to arrive.

He was undoubtedly a man powerfully qualified to advance science. It is reckoned by some persons a reflection on the memory of any philosopher, to have been the author of a theory of the earth. But we have already observed, that such persons are not aware of the engaging nature of such speculations to a philosophical and attentive mind, to which it is a natural object of ambition to throw a consistent light on the stupendous and mysterious appearances exhibited in the mineral kingdom. Some who have studied this subject profoundly, and have embraced conclusions very different from those of Hutton, have betrayed too great proneness to throw reflections on the degree of soundness attached to this author's general philosophical discernment. They show themselves little sensible of the uncertain nature of all such speculations, and thus furnish greater evidence of their own deficiencies than of those of their opponents. The theory of the earth should be acknowledged to be as yet an enigmatic department of science; and the various attempts which have been made to solve its difficulties, both those of old and those of recent date should be allowed their respective share of plausibility, while the defects of each should be equally kept in view. It is a mistaken idea to suppose, that enthusiasm in favour of one system is in any degree necessary to keep up the spirit of science. Such an enthusiasm partakes of intemperance; the activity to which it gives birth is of a spurious complection, and is not of that kind which promises greatest durability. Dr Hutton's private character was highly amiable. His manners were simple, but his conversation was animated. A combination of sincerity and ardour gave a charm to his company in the eyes of all his learned friends, though he was not formed on such a model as to fit him for gay or general society, which he did not relish or in any degree cultivate. His expressions in explaining his views of points of science were remarkably clear and forcible, and would not have led his friends to expect so much obscurity as is found in some of his writings. For an interesting view of his character and pursuits, we refer to the account of him published in the 5th volume of the *Transactions of the Royal Society of Edinburgh*, from the pen of his friend Professor Playfair. From that source the present short abstract has been chiefly taken. (*H. D.*)

HUYGENS, Christian, a celebrated mathematician and natural philosopher, was born at the Hague on the 14th April 1629. He was the son of Constantine Huygens, Lord of Zelem and Zuylichem, who had acted as secretary and counsellor to three successive princes of the house of Orange. Constantine Huygens was not only a poet but a good mathematician, and took particular pleasure in the instruction of his son, who, at the early age of thirteen, exhibited an ardent passion for mathematical learning, and was constantly occupied in examining all the machines and pieces of mechanism that accident threw in his way. In the sixteenth year of his age he went to the university of Leyden, to study law, under Professor Vinnius; but he still pursued his mathematical studies, in which he was assisted by the learned Professor Schooten, the commentator of Descartes. After remaining a year at Leyden, he prosecuted his studies at the university of Breda, which had been newly established, and placed under the direction of his father. In the year 1649, he travelled into Holstein and Denmark, in the suite of Henry, Count of Nassau; but, on account of the short stay which that prince was to make in Denmark, he was prevented from visiting Descartes in Sweden, an object which he was very anxious to accomplish.

In the year 1651, he began his career as an author, by publishing a refutation of the famous work of Gregory St Vincent, entitled *Opus Geometricum quadraturæ circuli et sectionum Coni.* Huygens' reply, which is considered as a model of distinctness and precision, was entitled *Exetasis quadraturæ circuli P. Greg. à sancto Vincentio,* 4to. He published, in the same year, his *Theoremata de circuli et hyperbolæ Quadratura*; and in 1654 appeared his ingenious work, entitled *De circuli magnitudine inventa nova, accedunt problematum quorundam illustrium constructiones.* In 1656, he travelled into France, and took out his degree of Doctor of Laws at the university of Angers. The new subject of the calculation of probabilities, which had been successfully begun by Pascal and Fermat, and which has recently been so much advanced by La Place, now occupied the attention of Huygens, who developed the principles of the science in his treatise *De Ratiociniis in Ludo Aleæ*, which appeared in 1657. In the same year he printed his *Brevis institutio de Usu Horologiorum ad inveniendas Longitudines*, in which he described the model of a newly invented pendulum. In 1659, Huygens published his *Systema Saturnium, sive de* *causis mirandorum Saturni phenomenon, et comite ejus Planeta novo,* which contains the various important discoveries relative to the planet Saturn, of which we have already given a full account. See ASTRONOMY, vol. ii. p. 598, 647, 648.

In the year 1660, Huygens travelled into France; and in the following year he came to England, where he made known his method of grinding the lenses of telescopes. In the year 1663, he paid a second visit to this country, and was one of the hundred individuals who were declared members of the Royal Society, at a meeting of the council held on the 20th May 1663. At this time the Royal Society had requested its members to apply themselves to the consideration of the laws of motion, and Huygens resolved several of the cases which were proposed to him. On the 15th November 1668, Dr Wallis communicated to the Society his principle of the collision of bodies. Doctor, afterwards Sir Christopher, Wren made a similar communication on the 17th of December; and on the 5th January 1669, Huygens wrote a letter to Mr Oldenburgh, containing his first four rules, with their demonstration, concerning the motion of bodies after impact. The method of Wallis was the most direct, but related only to bodies absolutely hard. Wren's method was founded on the same principle, but related only to elastic bodies; and the method of Huygens was the very same as that of Wren.

Huygens had now acquired such a reputation, that, in the year 1663, he was invited by Colbert to settle in France. He accepted of the honourable and advantageous conditions which were offered to him, and took up his residence in Paris in 1666, when he was admitted into the Academy of Sciences. In 1668, he published, in the *Journal des Sçavans,* and also in the Memoirs of the Academy, a paper entitled *Examen du livre intitulé Vera Circuli et Hyperboles quadratura a Jacobo Gregorio,* which led to the dispute of which we have already given some account in our life of GREGORY. In the year 1673, he published his great work, entitled *Horologium oscillatorium; sive de motu pendulorum ad horologia aptato demonstrationes geometricæ,* in which he published his great discovery of applying pendulums to clocks, and rendering all their vibrations isochronous, by causing them to vibrate between cycloidal cheeks. This discovery was made about the year 1656; and about the middle of 1657, he presented to the States of Holland a clock constructed on this new principle. In our article HOROLOGY,* we have given a description and a drawing of this machine. The contrivance of cycloidal cheeks, however, though exceedingly beautiful in theory, was found in practice to be of no advantage.

About this time our author invented the spiral spring for regulating the balances of watches, without knowing what had been done by Dr Hooke; and he applied to the French government for the exclusive privilege of employing it. The Abbé Hautefeuille had, however, conceived the first idea of this invention, and communicated to the Academy of Sciences, in 1674, the secret of regulating the balances of watches "by a small straight spring made of steel." He therefore disputed Huygens' right to the exclusive privilege, and the affair was accommodated in consequence of Huygens renouncing his claim. The observations of Montucla on this subject are certainly unjust towards the Abbé Hautefeuille, when he characterises his invention as rude and clumsy, and claims all the merit for Huygens. The idea of regulating the balance by a spring was certainly the principal part of the invention, which is unquestionably due to the Abbé Hautefeuille; while Huygens is entitled to the credit of having perfected the invention by giving a spiral form to the spring.

Huygens would probably have continued in France during the remainder of his life, had it not been for the revocation of the edict of Nantz. He resolved to remain no longer in a country where his religion was proscribed, and its professors persecuted; and, anticipating the fatal edict, he returned to his native country in 1681.

After his return to Holland, he continued to prosecute his favourite studies with his usual zeal. In 1684, he published his *Astroscopia Compendiaria tubi Optici molimine liberata,* in which he gives an account of a method of using telescopes of great focal length, without the incumbrance of a tube. He published also in 1690, at Leyden, his *Traité de la Lumiere,* and his *Tractatus de Gravitate.* The first of these works contains his Theory of Light, which he supposes to be propagated like sound, by the undulation of an elastic medium,† and the beautiful law by which he represented all the phenomena of double refraction as exhibited in Iceland spar. The remainder of our author's life was occupied in composing a work on the plurality of worlds, entitled Κοσμοθεωρος, *sive de terris celestibus, eorumque ornatu conjecturæ.* While this work was in the printer's hands, Huygens was seized with an illness, which proved fatal on the 5th of June 1695.

All his papers were bequeathed by his will to the Library of Leyden, with a request that Burcher de Volder and Fullenius, two excellent mathematicians, should print such of them as seemed of most importance. In the year 1700, this posthumous volume was published. The *Cosmotheorios* had appeared in 1698, and was speedily translated into French, English, German, and Dutch. In 1703, there appeared another posthumous volume, entitled CHRISTIANI HUGENII *Dioptrica, Descriptio Automati planetarii; de parheliis, Opuscula Posthuma.* This work contains Huygens' interesting dissertation on coronæ, and mock suns, of which we have given a short account in our article HALO, vol. x. p. 615, and which was reprinted by Dr Smith in his *Complete System of Optics.* A complete edition of the works of Huygens was published, in four volumes, by M. S'Gravesende. The two first appeared at Leyden in 1724, in 4to, entitled *Opera Varia,* and the two last at Amsterdam in 1728, entitled *Opera Reliqua.* He published also several papers in the early volumes of the *Philosophical Transactions,* and in the *Memoirs of the Academy of Sciences.* In the *Machines Approuvées par l'Academie,* tom. i. p. 71 and 72, he has published two papers, one of which is entitled *Machine pour Mesurer la force mouvante de l'air;* and the other, *Maniere d'empecher les vaisseaux de se briser lorsqu'il echouent.* He also published a letter on a new microscope, in the *Collections Academiques,* tom. i. p. 281; and another on the Toricellian experiment, in the second volume of the same work.

Christian Huygens was unquestionably one of the most eminent mathematicians and natural philosophers of the age in which he lived. His application of the pendulum to regulate the motion of clocks; his beauti-

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* See HOROLOGY, p. 317. and Plate CCC. Fig. 4.

† This doctrine has found an able supporter in Dr Thomas Young; but recent discoveries respecting the polarisation of light, seem to give a new degree of probability to the doctrine of the emanation of material particles.

Huygens' Temperament.

ful investigation of the isochronism produced by making pendulums swing between cycloidal cheeks; his discovery of the ring and satellites of Saturn; his application of the spiral spring to regulate the balances of watches, (in which however he was anticipated by Dr Hooke;) his discovery of the law of collision, which he shares with Dr Wallis and Sir Christopher Wren; his theory of the centre of oscillation; his investigations respecting central forces; and the beautiful law, by which he has represented the phenomena of double refraction, exhibit the depth and variety of his attainments, and entitle him to a very high rank among those illustrious men who have done honour to their species. In our articles ASTRONOMY, HALO, HOROLOGY, MECHANICS, and OPTICS, the reader will find an ample account of his various labours.

HUYGEN's TEMPERAMENT of the musical scale. In 1682, M. Christian Huygens published his *Cyclus Harmonicus*, or commensurate system, of 31 equal divisions in the octave; of which his mean tone is 5, and major limma 3, of these divisions. The temperaments calculated by Mr Farey's 12th scholium, in the *Philosophical Magazine*, vol. xxxvi. p. 52. are as follows, viz. $V-2.651765\Sigma$, $III+0.400802\Sigma$, and $VI-3.05256\Sigma$. In p. 224. of the second edition of Dr Smith's *Harmonics*, he gives the monochord lengths of strings for each of the notes of this system; and at p. 207. he mentions a method by which the beats of its concords may nearly be obtained: but this being neither sufficiently easy of application, or exact enough, we have calculated them anew, as follows, viz.

1.	2.			3.	4.	5.	6.	7.	8.	9.
C	612.000000	12	53	480.0000						
B	552.741175	11	49	448.8585	9.2608	51.7853	5.3810	4.0233	1.6234	7.7449
♭B	513.303530	10	44	429.2280	65.6060	.9712	5.1456	3.8480	77.4450	7.4058
A	454.044705	9	40	401.3504	8.2824	.9076	4.8118	3.5984	1.4532	6.9254
♯G	394.785880	8	36	375.3394	7.7449	43.3030	4.4996	♯22.0202	1.3582	49.0570
G	355.348235	7	31	358.9213	7.4058	.8117	4.3028	3.2173	1.2984	6.1927
♯F	296.089410	6	27	335.6379	6.9254	38.7225	5.3810	3.0089	1.2142	43.8681
F	256.651765	5	22	320.9590	49.0570	.7266	4.0233	2.8770	57.9100	5.5384
E	197.392940	4	18	300.1357	6.1927	.6791	4.3028	2.6905	1.0856	5.1787
♭E	157.955295	3	13	287.0096	43.8681	.6492	♭22.0202	2.5728	51.7853	4.9520
D	98.696470	2	9	268.3889	5.5384	.6071	3.2173	2.4059	.9712	4.6304
♯C	39.437645	1	5	250.9762	5.1787	28.9550	3.0089	2.2498	.9076	32.8030
C	0	0	0	240.0000	4.9520	.5428	2.8770	2.1514	43.3030	4.1412
Notes	Σ Value of the Notes.	+f	+m	Vibrations in 1″ of time.	*Sharp of* 3ds on	*Sharp of* IIIds on	*Sharp of* 4ths on	*Flat of* Vths on	*Flat of* 6ths on	*Flat of* VIths on
					Beats in 1 Second of Time.					

In column 2. the values of the notes are given, as they arise in calculating by the series of tempered fifths, as above, its wolf fifth ♯G ♭E being $V+17.161553\Sigma$. Col. 3. is, as usual, adapted to the octave above the tenor cliff C. All the beatings in columns 5. to 9. are *sharp or flat*, as marked at the bottom of each column, except the 4th and Vth wolves, which are contrary to all the others of these concords.

Mr Ambrose Warren, in a thin quarto work, called *The Tonometer*, published in 1725, gave the lengths of strings for this system, without any intimation of its having been before published by M. Huygens. (ε)

HYÆNA. See HUNTING, vol. xi. p. 370. and our article MAMMALIA.

HYBERNATION OF ANIMALS.

Hybernation of Animals.

THE changes which take place in the condition of PLANTS at the approach of winter are familiar to all of us. In the course of a few weeks in autumn, the fields exchange their dress of summer green for the harvest yellow, while the forests acquiring an orange hue, speedily become leafless. While these alterations are taking place, the vital principle retires to the roots, or is in part condensed in the buds. In this state of preparation, the various tribes of perennial plants await the approach of winter—a state which is termed their *hybernation*. As this department of vegetable physiology has been already illustrated in the article BOTANY, and may be found fully explained in the elementary works on that science, we refrain from farther discussion on the subject.

In the *Animal Kingdom*, changes equally remarkable precede the rigours of winter. The swallow forsakes the windows of the altar, the landrail retires from the fields, and the cuckoo deserts the hedges. The nightingale ceases to pour forth her evening song, and in the grove all the warblers are silent. The lost or broken feathers of birds are renewed, to complete their covering, and to enable them, if necessary, to retire to warmer regions. Quadrupeds, and other animals, obtain an additional supply of clothing, collect a stock of provisions, or peacefully fall into a temporary lethargy. In these various conditions, animals prepare to pass the winter, or are said to *hybernate*.

This subject is still involved in much obscurity. It does not immediately interest us, as being but remotely connected with the ordinary concerns of life. Hence we possess few well established facts, and even those which have been ascertained, are still widely scattered in various publications; as naturalists in general are more anxious to establish the nomenclature of animals, than to investigate their habits and instincts.

Naturalists are in the practice of restricting the term *hybernation*, to that condition of animals during the winter season more familiarly expressed by the term *torpidity*. We are not aware of any reason to induce us thus to limit the original meaning of the word; and therefore in this article, we use it as expressing the various conditions in which animals are found during the winter season, and the circumstances by which these conditions are distinguished.

The subject naturally divides itself into four branches, corresponding with the different states of hybernation which animals exhibit. The first includes those animals which obtain a change of dress;—the second, those which provide for themselves a store of food;—the third, those which migrate;—and the fourth, those that become torpid.

CHAP. I.

Hybernating Animals which obtain a Supply of Clothing.

"Ante omnia (says Pliny when comparing the condition of man with that of the inferior animals) unum animantium cunctorum alienis velat opibus: cæteris varia tegumenta tribuit, testas, cortices, coria, spinas, villos, setas, pilos, plumam, pennas, squamas, vellera. Truncos etiam arboresque cortice, interdum gemino, a frigoribus et calore tuata est. Hominem tantum nudum, et in nuda humo, natali die abjicit ad vagitus statim et ploratum, nullumque tot animalium aliud ad lacrymas, et has protinus vitæ principio." But this condition of man is most agreeable to his nature, as he can provide for himself a suitable covering, and accommodate his dress to all climates, seasons, and occupations.

As the inferior animals do not possess such powers of contrivance, we find that nature has furnished them with clothing suited to their situations and habits. Hence those animals, whose appointed residence is in the warm regions of the earth, are in possession of the thinnest coverings; while those which are destined to dwell in the arctic regions, are enveloped in fur. Thus in the climate of Spain and Syria, the dog and the sheep have fine tufty and silky hair; while in the Siberian dog and Iceland ram, the hair is long and rigid. In still warmer regions than those which we have mentioned, the fur becomes so very thin, that the animals may be considered as naked. This is strikingly illustrated in the dogs of Guinea, and in the African and Indian sheep.

The clothing of animals living in cold countries, is essentially different from that of the animals of warm regions in another respect. If we examine the fur of the swine of warm countries, it consists entirely of bristles or hair of the same form and consistency; but those which live in colder districts possess not only common bristles or strong hair, but a fine frizzled wool next the skin, over which the long hairs project. This statement may easily be verified, by a comparison of the fur of the swine of the south of England with that which is found on those of the Scottish Highland breed. The same observation may be made on the sheep of warm and cold countries. The fleece of those of England consists entirely of wool; while those of Zetland, Iceland, and other northern regions, besides the wool contains a number of long hairs, which at first sight give to the fleece while on the back of the animal, the appearance of great coarseness. The living races of rhinoceros and elephant of southern regions, have scarcely any fur on their bodies; while those which have formerly resided in the middle and northern parts of Europe, now only found in a fossil state, have been covered with long hair, and a thick coating of short frizzled wool.

Climate in this case exercises a powerful influence over the secretions of these animals, in the increase or diminution of their clothing. Were such changes not to take place, the inhabitants of cold countries would perish by the inclemency of the weather, while those of warmer regions would be exhausted by a profuse perspiration.

The effects which climate is here represented as producing on the clothing of animals, are also observable as the annual result of the season of the year in all the temperate and cold regions of the earth. There is always an increase in the quantity of covering during the winter season, and not unfrequently a change in its colour. Let us now attend to each of these changes.

Increase in the quantity of clothing.

Increase in the quantity of clothing.—If we attend to the condition of the clothing of our domestic animals previous to winter, we shall witness the changes which take place. The fur is not merely renewed, but it is increased in quantity and length. This is very plainly exhibited in those quadrupeds which are kept out of doors, and exposed to the vicissitudes of the weather. But even with those animals kept in houses during the winter, the length and thickness of the fur vary according to the warmth of their habitations; and as the temperature of these habitations depends in part on the elevation, so we find the cattle living on farms near the level of the sea, covered with a shorter and thinner fur than those which inhabit districts of a higher level. Hence if we look at the horses, for example, of the farmers in a market day in winter, we might determine the relative temperature of their respective farms, from the relative quantity of clothing provided by nature for the animals which live on them.

In quadrupeds.

This winter covering, if continued during the summer, would prove inconveniently warm. It is, therefore, thrown off by degrees as the summer advances; so that the animals which were shaggy during the cold months become sleek in the hot season.

This process of *casting the hair* takes place at different seasons, according to the constitution of the animal with respect to heat. The mole has, in general, finished this operation before the end of May. The fleece of the sheep, when suffered to fall, is seldom cast before the end of June. In the northern islands of Scotland, where the *shears* are never used, the inhabitants watch the time when the fleece is ready to fall, and pull it off with their fingers. The long hairs, which likewise form a part of the covering, remain for several weeks, as they are not ripe for casting at the same time with the fine wool. This operation of pulling off the wool, provincially called *rooing*, is represented by some writers, more humane than well-informed, as a painful process to the animal. That it is not even disagreeable, is evident from the quiet manner in which the sheep lie during the pulling, and from the ease with which the fleece separates from the skin.

Sheep.

We are in general inattentive with respect to the annual changes in the clothing of our domestic animals; but when in search of those beasts which yield us our most valuable *furs*, we are compelled to watch these

Animals which obtain a supply of Clothing.

operations of the seasons. During the summer months the fur is thin and short, and is scarcely ever an object of pursuit; while during the winter, it possesses in perfection all its valuable qualities. When the beginning of winter is remarkable for its mildness, the fur is longer in *ripening*, as the animal stands in no need of the additional quantity for a covering; but as soon as the rigours of the season commence, the fleece speedily increases in the quantity and length of hair. This increase is sometimes very rapid in the hare and the rabbit, whose skins are seldom ripe in the fur until there is a fall of snow, or a few days of frosty weather; the growth of the hair in such instances being dependant on the temperature of the atmosphere.

In birds.

The *moulting* of birds is another preparation for winter, which is analogous to the casting of the hair in quadrupeds. During summer, the feathers of birds are exposed to many accidents. Some of them are torn off during their amorous quarrels; others are broken or damaged; while in many species they are pulled from their bodies to line their nests. Previous to winter, however, and immediately after the process of incubation and rearing of the young is finished, the old feathers are pushed off by the new ones, and in this manner the whole plumage of the bird is renewed. During this process of moulting, the bird seems much enfeebled, and, if previously in a weak state, is in danger of dying during the process. In consequence of this complete renewal of the feathers, the winter covering is rendered perfect, and the birds prepared for withstanding all the rigours of the season.

Change in the colour of the clothing.

CHANGE IN THE COLOUR OF THE CLOTHING.—The difference in point of colour between the summer and winter dress of animals is very conspicuously displayed both among the quadrupeds and birds. We are not aware that it has been observed among the cold-blooded animals.

In quadrupeds.

Among quadrupeds, the Alpine hare (*Lepus variabilis*) is a very remarkable example. It is found, in this country, on the high mountains of the Grampian range. Its summer dress is of a tawny grey colour; but, about the month of September, its fur gradually changes to a snowy whiteness. It continues in this state during the winter, and resumes its plainer covering again in the month of April or May, according to the season. The *ermine* is another of our native quadrupeds which exhibits in its dress similar changes of colour according to the season. It frequents the outskirts of woods and thickets. During the summer months its hair is of a pale reddish brown colour; in harvest it becomes clouded with pale yellow; and in the month of November, with us, it is of a snow white colour. Its winter dress furnishes the valuable fur called ermine. Early in spring, the white becomes freckled with brown, and in the month of May it completely resumes its summer garb.

In birds.

Among the feathered tribes such instances of change of colour in the plumage during winter are numerous. They greatly perplex the ornithologist, and have been the means of introducing into the system several spurious species. The white grous or ptarmigan (*Tetrao lagopus*) may be produced as a familiar example of this kind of hybernation. This bird, like the Alpine hare, inhabits the higher Grampians, and is never found at a great distance from the limits of the snow. In summer its plumage is of an ash colour, mottled with small dusky spots and bars. At the approach of winter the dark colours disappear, and its feathers are then found to be pure white. In remarkably mild winters the change is sometimes incomplete, a few dusky spots of the summer dress remaining. In spring its winter garb becomes again mottled; and the bird loses much of its beauty. Even the young birds in their first dress resemble their parents in their mottled plumage, and like them become white at the approach of winter.

Ptarmigan.

Animals which change the colour of their Clothing.

Guillemots.

Among the aquatic birds similar changes in the colour of the plumage have been observed. The black guillemot (*Uria grylle*), so common on our coasts, is of a sooty black colour during the summer, with a white patch on the wings. During winter, however, the black colour disappears, and its plumage is then clouded with ash-coloured spots on a white ground. In the winter dress it has been described by some as a distinct species, under the name of the *spotted guillemot*. In the more northern regions, as in Greenland, for example, this bird, in winter, becomes of a pure white colour. This is a decided proof of the influence of temperature in producing this change of colour. There is a fine example of this bird in its white winter dress in the collection of the Dublin Society, where we saw it a few months ago. It was brought from Greenland by that intelligent and enterprising naturalist Sir Charles Giesecké.

Little auk.

These changes of colour, which we have already mentioned, extend throughout the whole plumage of the bird; but in other instances, the change extends to only a small part of the plumage. Thus the little auk (*Alca alle*) during summer has its cheeks and throat of a black colour, but in winter these parts become dirty white. In this its winter garb, it is often shot on our coasts. Its summer dress induced Pennant to consider it as a variety, and as such to figure it. The black headed gull (*Larus ridibundus*), has a black head during summer, as its trivial English name intimates. During the winter, however, the black colour on the head disappears; and when in this dress, it has been regarded by many as a distinct species, under the name of the *red-legged gull*.

Black-headed gull.

In many other birds there is a remarkable difference in point of colour between the summer and the winter plumage, although not so striking as those which we have noticed. The colours of the summer feathers are rich and vivid; those of the winter obscure and dull. This is well illustrated in the Dunlin (*Tringa alpina*), whose summer plumage has much black and rufous colour, but whose winter plumage is dull and cinereous. In its winter dress it has been described as a distinct species, under the trivial name of *T. cinclus*, or Purre. Similar instances might be produced in the case of the Wagtails, Linnets, and Plovers, and a great many other birds.

Dunlin.

Mode of the change of colour.

From the preceding statements we are naturally led to inquire, in what manner these changes in the colour of the dress are produced? It has been supposed by some, that those quadrupeds which, like the alpine hare and ermine, become white in winter, cast their hair twice in the course of the year; at harvest when they part with their summer dress, and in spring when they throw off their winter fur. This opinion does not appear to be supported by any direct observations, nor is it countenanced by any analogical reasonings. If we attend to the mode in which the hair on the human head becomes grey as we advance in years, it will not be difficult to perceive, that the change is not produced by the growth of new hair of a white colour, but by a change in the colour of the old hair. Hence there will be found some hairs pale towards the middle, and white towards the extremity, while the base is of a dark colour. Now, in ordinary cases, the hair of the human head, Animals which change the colour of their Clothing.

unlike that of the inferior animals, is always dark at the base, and still continues so during the change to grey; hence we are disposed to conclude from analogy, that the change of colour, in those animals which become white in winter, is effected, not by a renewal of the hair, but by a change in the colour of the secretions of the rete mucosum, by which the hair is nourished, or perhaps by that secretion of the colouring matter being diminished, or totally suspended.

As analogy is a dangerous instrument of investigation in those departments of knowledge which ultimately rest on experiment or observation, so we are not disposed to lay much stress on the preceding argument which it has furnished. The appearances exhibited by a specimen of the ermine now before us are more satisfactory and convincing. It was shot on the 9th May (1814), in a garb intermediate between its winter and summer dress. In the belly, and all the under parts, the white colour had nearly disappeared, in exchange for the primrose yellow, the ordinary tinge of these parts in summer. The upper parts had not fully acquired their ordinary summer colour, which is a deep yellowish brown. There were still several white spots, and not a few with a tinge of yellow. Upon examining those white and yellow spots, not a trace of interspersed new short brown hair could be discerned. This would certainly not have been the case if the change of colour is effected by a change of fur. Besides, while some parts of the fur on the back had acquired their proper colour, even in those parts numerous hairs could be observed of a wax yellow, and in all the intermediate stages from yellowish brown, through yellow, to white.

These observations leave little room to doubt, that the change of colour takes place in the old hair, and that the change from white to brown passes through yellow. If this conclusion is not admitted, then we must suppose that this animal casts its hair at least seven times in the year. In spring, it must produce primrose yellow hair; then hair of a wax yellow; and, lastly, of a yellowish brown. The same process must be gone through in autumn, only reversed, and with the addition of a suit of white. The absurdity of this supposition is too apparent to be farther exposed.

With respect to the opinion which we have advanced, it seems to be attended with few difficulties. We urge not in support of it, the accounts which have been published of the human hair changing its colour in the course of a single night; but we think the particular observations on the ermine warrant us in believing that the change of colour in the alpine hair is effected by a similar process. But how is the change accomplished in birds?

The young ptarmigans are mottled in their first plumage similar to their parents. They become white in winter, and again mottled in spring. These young birds, provided the change of colour is effected by moulting, must produce three different coverings of feathers in the course of ten months. This is a waste of vital energy, which we do not suppose any bird in its wild state capable of sustaining; as moulting is the most debilitating process which they undergo. In other birds of full age, two moultings must be necessary. In these changes, the range of colour is from blackish grey through grey to white, an arrangement so nearly resembling that which prevails in the ermine, that we are disposed to consider the change of colour to take place in the old feathers, and not by the growth of new plumage; this change of colour being independent of the ordinary annual moultings of the birds.

Animals which change the colour of their Clothing.

Independent of the support from analogy which the ermine furnishes, we may observe that the colours of other parts of a bird vary according to the season. This is frequently observable in the feet, legs, and bill. Now, since a change takes place in the colouring secretions of these organs, what prevents us from supposing that similar changes take place in the feathers? But even in the case of birds, we have before us an example as convincing as the ermine already mentioned. It is a specimen of the little auk, (*Alca alle*,) which was shot in Zetland in the end of February 1810. The chin is still in its winter dress of white, but the feathers on the lower part of the throat have assumed a dusky hue. Both the shafts and webs have become of a blackish grey colour at the base and in the centre, while the extremities of both still continue white. The change from black to white is here effected by passing through grey. If we suppose that in this bird the changes of the colour of the plumage are accomplished by moulting, or a change of feathers, we must admit the existence of three such moultings in the course of the year—one by which the white winter dress is produced, another for the dusky spring dress, and a third for the black garb of summer. It is surely unnecessary to point out any other examples in support of our opinion on this subject. We have followed nature, and our conclusions appear to be justified by the appearances which we have described.

Causes of the change of colour.

Having endeavoured to ascertain the manner in which this change of colour takes place, we are now ready to investigate the causes by which it is produced. As this change of colour in winter is peculiar to the animals which inhabit cold countries, we may safely conclude, that temperature exercises over it a powerful influence. This supposition is countenanced by the slowness of the process of change of colour in a mild autumn, and its imperfect accomplishment during a mild winter. Besides, in some animals, such as the black guillemot, the change is never complete in the more temperate regions, but becomes more perfect as we proceed northwards, until at Greenland the bird is of a pure white. If this change of colour proceeds from a renewal of feathers, here at least the colour of the feathers must be considered influenced by the temperature, and consequently a corresponding influence must be exercised on the secreting organs.

The distribution of colour in the animal kingdom in general seems to follow the same law; the deep and bright colours prevailing in the warm regions, while the tints of the colder regions are pale and dull. Are we to conclude, that cold diminishes the action of the vessels which furnish the colouring matter, and, when intense, entirely suspends their functions? or are we to consider light as in part concerned in producing the effect? In general, the fur of quadrupeds, and the feathers of birds, are darkest where exposed to the light, and are pale coloured towards the base; but in the instances before us, this difference disappears, and a complete uniformity in all the parts of the covering prevails. Besides, the change does not take place on all parts of the body at the same time, but appears in spots, or on single hairs or feathers. Light therefore has little influence.

There is another agent besides cold apparently concerned in the change in the colour of the feathers of birds. In all birds the feathers become more vivid in spring, and certain spots appear which are not observable at other seasons. This brightness of plumage and these spots continue only during the season of love;

Animals which lay up Provisions.

and hence, instead of supposing them the production of new moultings, we consider them as resulting from the action of the generative impulse on the colouring secretions.

In attempting to account for these phenomena of nature, it has generally been supposed, that these periodical changes of colour take place, to enable the animals more readily to escape from their prey during the winter season. Thus Montagu, in reference to this subject, has the following reflections: "Here we perceive the ptarmigan invariably effect this curious, and, we may add, most providential change; for if the young of those birds at first assumed their snowy winter plumage, while yet the surface of the ground was not consonant with their colour, few would escape the piercing eye of the falcon or the eagle, in the lofty and exposed situations they are found to inhabit." To suppose that in winter the ptarmigan is rendered white, to cause it to resemble the snow and deceive birds of prey, and that the alpine hare undergoes similar changes for the same purpose, would be to yield our assent to public opinion. But all our conclusions concerning final causes ought to be the result of very extended observations; and if our observations on this subject are extended, some difficulties will present themselves. If this white colour yields protection to the ptarmigan and alpine hare, it must enable the ermine, an animal well qualified to provide for its wants at all times, by its determined boldness, extreme agility, and exquisite smell, to prey with greater certainty upon its defenceless neighbours. What protection, we would ask, is afforded to the black guillemot, during the winter, by its mottled plumage, or to the little auk by its white chin, since the whiter they become, so much the more unlike the dark colour of the water? Protection from foes, therefore, cannot be considered as the object of nature in these curious changes, especially as the change of colour, always from dark to white, does not differ, however different the habits and even stations of the animals may be.

Perhaps the laws of chemistry may furnish us with a more consistent and plausible explanation. If the radiating power of bodies with regard to heat be inversely as their reflecting power, a conclusion very generally admitted, then the white winter dress of these animals must be better calculated for retaining the heat generated in their bodies by the vital principle, than any other coloured dress which would possess greater radiating power, and, consequently, would more readily contribute to the reduction of their temperature. It is probable, therefore, that these changes in the quantity and colour of the clothing of animals are designed by nature to regulate their temperature in the different seasons of the year.

CHAP. II.

Hybernating Animals which lay up a Stock of Provisions.

The kind of hybernation of which we treated in the last Chapter, is of more frequent occurrence than that which we are now to consider. In common with those animals, they obtain an addition to their clothing, while they differ from them in being provident of futurity. They collect with care the superabundant productions of autumn, and dispose of them in such a manner, as to furnish a supply of food when the fruits and flowers are destroyed by the frost. Such may with propriety be termed *storing animals*, as they all possess the industry so beautifully expressed by Virgil.

> *Venturæque hiemis memores æstate laborem*
> *Experiuntur, et in medium quæsita reponunt.*

This class of hybernating animals contains but few species. These are all phytivorous, and, without exception, belong to the natural tribe of Glires or Gnawers. All the animals of this tribe do not possess this *storing* inclination, although it is certainly observable in many of them.

Beaver.

Of all those animals, whose industry in collecting, and wisdom in preserving a winter store, have attracted the notice of mankind, the beaver stands pre-eminently conspicuous. But, as the habits of that singular animal have been detailed under the article Beaver, we forbear in this place to reconsider the subject. And, as we rather wish to confine our remarks to British animals, wherever the subject will permit, we select as an example of this kind of hybernation, the common squirrel, (*Sciurus vulgaris*). This active little animal prepares its winter habitation among the large branches of an old tree. After making choice of the place where the timber is beginning to decay, and where a hollow may be easily formed, it scoops out with its teeth a suitable magazine. Into this store-house, acorns, nuts, and other fruits are industriously conveyed, and carefully concealed. This granary is held sacred until the inclemency of the weather has limited the range of its excursions, and consequently diminished its opportunities of obtaining food. It then begins to enjoy the fruits of its industry, and to live contentedly in its elevated dwelling. All the species of mice seem to possess the inclination to lay up provisions; even the house mouse and the rat; but the field mouse is the most remarkable instance. Says the pious and intelligent Derham, "I have in autumn, not without pleasure, observed, not only the great sagacity and diligence of swine, in hunting out the stores of the field mice, but the wonderful precautions also of those little animals, in hiding their food before hand against winter. In the time of acorns falling, I have, by means of the hogs, discovered that the mice had, all over the neighbouring fields, treasured up single acorns in little holes they had scratched, and in which they had carefully covered up the acorn. These the hogs would, day after day, hunt out by their smell."

Squirrel.

Mice.

Among birds, reptiles, and fishes, no examples are known of this kind of hybernation. The bee, among insects, is an interesting example, but requiring no explanation. No instances occur among the animals which compose the inferior classes.

Since all these storing animals are destined to live on the productions of the vegetable kingdom, we witness the wise provisions of nature in assigning to them such propensities. By this faculty, existence is comfortably maintained, under circumstances which would prove fatal without it. The seeds of many plants are translated by them from the places of their growth, and more extensively disseminated. But how are we to account for the conduct of those animals, in thus providing for a futurity, who have never suffered from former inexperience, as must be the case with young animals—that in autumn, when the bounties of nature are scattered so profusely, they should subject themselves to much labour, in heaping up a treasure for supplying the deficiences of a winter, of whose accompanying privations they are ignorant. Part of this industry may, in those animals which are gregarious, be the result of education; but in other instances, we must confess our inability to offer any explanation.

> Such baffled searches mock man's prying pride,
> The God of Nature is your secret guide.

CHAP. III.

Hybernating Animals which Migrate.

This subject has long occupied the attention of naturalists; and several important observations have been published by different authors. It is chiefly, however, as it regards birds, that the subject is deserving of particular consideration. We are acquainted with but few circumstances connected with the migration of quadrupeds. Limited in their powers of locomotion, their range of travelling is confined, so that other means are provided for their safety and sustenance during winter. The cheiroptera are well fitted for migrating; and accordingly we find that some species are known to do so. In Italy, the common bat (*Vespertilio murinus*) abounds; but it migrates southwards at the approach of winter, and is not found in any of the caves in a torpid state. The *V. noctula*, however, arrives annually to winter, although it retires to spend the summer in more northern regions. Dr Barton informs us that some species of dipus migrate from the northern to the southern parts of America during winter. Many of the ruminating animals shift their habitations according to the changes of the year. Thus, the stag and the roebuck leave the alpine regions at the approach of winter, and seek protection in the more sheltered plains. More extensive migrations are performed by the palmated quadrupeds, particularly the *seals*. These shift their stations to reach safe breeding places, in whatever country they live in. But the common seal (*Phoca vitulina*) often performs regular migrations in quest of food. In the Statistical Account of the parish of North Knapdale, we are told that the lake called Lochow, about twenty miles in length, and three miles in breadth, "abounds with plenty of the finest salmon; and, what is uncommon, the *seal* comes up from the ocean, through a very rapid river, in quest of this fish, and retires to the sea at the approach of winter." Another species, the *P. Groenlandica*, seems to seek more temperate regions during the winter. Seals of this kind, says Horrebow in his History of Iceland, "arrive annually in the month of December, especially about the northern parts of the country, and generally stay till May, at which time, those that escape the Icelanders depart." A few curious facts regarding the migrations of the Cetacea may be found under the article Greenland. Several kinds of small whales visit the coasts of Scotland, chiefly during the autumnal months; but we are ignorant of the places from whence they come, and unacquainted with the laws of their migration.

Migrating quadrupeds.

Migration of Birds.

Migrating birds.

The migrations of the feathered race, as connected with their hybernation, have been the subject of popular observation since the days of the prophet Jeremiah. "Yea, the stork in the heaven knoweth her appointed times; and the turtle, and the crane, and the swallow, observe the time of their coming." (ch. viii. v. 7.) Many important facts have been ascertained, and a few general conclusions have been established. But the subject is still far from being exhausted; nay, without fear of contradiction, we may venture to assert, that it is but very imperfectly understood by naturalists in general. Popular errors have gained admittance as scientific documents, and the well authenticated facts have been suffered to remain, in their original detached form, destitute of connection and arrangement.

It is not our intention to enter into any minuteness of detail regarding the migrations of the different species of birds. This has already been done under the article Birds, where the reader will find a statement of several facts connected with the migration of our native species. And he may also consult at his leisure, the ornithological productions of Pennant, White, and Montagu. Our observations in this place, will be of a general nature, and will have for their object to ascertain the laws of migration, and the circumstances under which it takes place.

Migrating birds may be divided into two classes, from the different seasons of the year in which they arrive or depart. To the first class will belong those birds which arrive in this country in the spring, and depart in autumn, and are termed *Summer Birds of Passage*. The second will include those which arrive in autumn, and depart in spring, and are called *Winter Birds of Passage*.

Summer birds of passage.

The Summer Birds of passage are not confined to any particular order or tribe; nor are they distinguished by similarity of habits. Some of them belong to the division of *Water Fowls*, as the terns and gulls; while others are *Land Birds*, as the swallow and rail. They differ also remarkably with regard to their food. Thus, the hobby is carnivorous; the gulls and terns, piscivorous; the swallow, insectivorous; and the turtle dove and the quail, granivorous.

In many particulars these summer birds of passage exhibit very remarkable differences. They, however, present one point of resemblance. All of them, during their residence in this country, perform the important offices of pairing, incubation, and the rearing of their young, and hence may with propriety be termed the natives of the country. We hail their arrival as the harbingers of spring, and feel the blank which they leave on their departure, alhough it is in some measure supplied by another colony of the feathered race, who come to spend with us the dreary months of winter.

Winter birds of passage.

The Winter Birds of Passage have more points of resemblance among themselves than those of the former division. They chiefly belong to the tribe of water-fowls. None of them are insectivorous, and very few are granivorous. They chiefly frequent the creeks and sheltered bays of the sea, and the inland lakes, or they obtain their food in marshy grounds, or at the margins of springs. When the rigours of the season are over, and when other birds which are stationary are preparing for incubation, these take their departure, to be again succeeded by our summer visitants.

We have stated generally, that our summer and winter birds of passage visit us at stated seasons of the year; that the summer visitants arrive in spring and depart in autumn; and the winter visitants arrive in autumn and depart in spring. But the different species do not all observe the same periods of arrival and departure. Thus, among the summer birds of passage, the wheat-ear always precedes the swallow, while the swallow arrives before the martin, and the martin before the landrail or corncrake. Among the winter birds of passage, similar differences in the time of arrival are observable. Thus the woodcock precedes the fieldfare, and the fieldfare the redwing. The time of departure has not been observed with so much attention, as the subjects have then lost their novelty, so that we do not so readily perceive their absence. It is probable, however, that in their departure, as well as their arrival, each species has its particular period.

The periods of arrival and departure, even in the same species, do not always take place at exactly the same day, or even month of the year. In different years these vary from one to four weeks, and evidently depend on very obvious circumstances. The meanest rustic, in regard to the summer birds of passage, is aware, that cold weather prevents the arrival of these messengers of spring; and that the early arrival of our winter birds of passage indicates a proportionally early winter. The same circumstances which retard our summer visitants also check the progress of vegetation. Hence, in all probability, we might be able to prognosticate the arrival of these birds, by attending to the time of the leafing or flowering of particular trees or plants. As the state of vegetation depends on the temperature of the season, and the life of insects on the state of vegetation, we may safely conclude, that the movements of the phytivorous and insectivorous birds must be dependant on these circumstances.

Linnæus bestowed some attention on these connected circumstances, in his Calendar of Flora for Sweden; and Stillingfleet in that of England. Linnæus observed, that the swallow returned to Sweden when the bird-cherry came into leaf, and when the wood-anemone flowered. He also found the arrival of the nightingale accompanied with the leafing of the elm. Stillingfleet says, that the swallow returns to Norfolk with the leafing of the hazel, and the nightingale with the leafing of the sycamore. It has also been observed, that the cuckoo sings when the marsh-marigold blows. It would tend greatly to increase our knowledge of this subject, were observations of this sort multiplied. We earnestly recommend the subject to the attention of the practical naturalist.

Having thus offered a few observations on the periods of arrival and departure of migrating birds, let us now enquire after *the places from whence they come, and to which they return.* In doing this, it will be proper to bestow some attention on those birds whose migrations are only partial, and which merely shift from one part of the island to another. The movements of these birds, though confined within narrow bounds, are probably regulated by the same laws which with other species produce more extensive migrations.

In the inland districts of Scotland, the lapwing makes its appearance about the end of February or the beginning of March, and, after performing the purposes of incubation, hastens to the sea-shore, there to spend the winter, picking up the small crustacea from among the rejectamenta of the sea. These birds seldom however remain all winter on the Scottish shores, though they are always to be found at that season on the southern English shores. In that part of the island they do not perform such extensive migrations, but may with propriety be considered as resident birds. The curlew arrives at the inland districts along with the lapwing, and they depart in company about the beginning of August. The curlew, however, remains on the Scottish shores during the winter. The oystercatcher, though it breeds in Scotland, retires to the English shores during the winter, and joins those which have remained there during the breeding season. The black-headed gull breeds both in England and Scotland; but it retires from the last mentioned country, while it continues resident in the former.

From the examples quoted, it appears that some birds, which are stationary in one district, are migratory in another. But that which chiefly merits our consideration is the circumstance of those birds, whose annual migrations are confined to our own shores, forsaking the high grounds when the purposes of incubation have been accomplished, and seeking for protection at a lower level, and in a warmer situation. When these migrations become more extensive, they forsake the bleak moors and shores of Scotland for the warmer and more genial climate of England. Hence it happens, that some of our Scottish summer visitants come from England, while some of the English winter visitants come from Scotland: the summer birds of passage coming from the south, and the winter passengers from the north. Do those birds, whose migrations are more extensive, obey the same laws?

Winter resort of our summer birds.

As the summer birds of passage are more interesting to us, since they perform the great work of incubation in our country, than the winter birds of passage, which are the harbingers of storms and cold, and only wait the return of spring to take their leave of us, we will endeavour to find out the winter residence of the former, before we attempt to discover the summer haunts of the latter. Natural history, it is true, is still in too imperfect a state, to enable us to point out with certainty the retreats of those birds which visit us during summer. But enough appears to be known to enable us to ascertain the laws by which these migrations are regulated in a number of birds, and as the points of resemblance in the movements of the whole are numerous, we can reason from analogy on safer grounds with regard to the remainder.

Swallows.

The swallow, about whose migrations so many idle stories have been propagated and believed, departs from Scotland about the end of September, and from England about the middle of October. In the latter month M. Adanson observed them on the shores of Africa after their migrations from Europe. He informs us, however, that they do not build their nests in that country, but only come to spend the winter. The nightingale departs from England about the beginning of October, and from the other parts of Europe about the same period. During the winter season it is found in abundance in Lower Egypt among the thickest coverts in different parts of the Delta. The birds do not breed in that country, and to the inhabitants are merely winter birds of passage. They arrive in autumn and depart in spring, and at the time of migration are plentiful in the islands of the Archipelago. The quail is another of our summer guests, which has been traced to Africa. A few indeed brave the winters of England, and in Portugal they appear to be stationary. But in general they leave this country in autumn, and return in spring. They migrate about the same time from the eastern parts of the continent of Europe, and visit and revisit in their migrations the shores of the Mediterranean, Sicily, and the islands of the Archipelago. When speaking of this subject, the intelligent Willoughby adds, that "when he sailed from Rhodes to Alexandria in Egypt, many quails from the north towards the south were taken in our ship; whence I am verily persuaded that they shift places: for formerly also, when I sailed out of the isle of Zant to Morea, or Negropont, in the spring time, I had observed quails flying the contrary way, from south to north, that they might abide there all summer. At which time also there were a great many taken in our ship." *Ornith.* p. 170.

Animals which Migrate.

Auks.

While these birds perform those extensive migrations which we have here mentioned, others are contented with shorter journies. Thus the razor-billed auk (*Alca torda*) and the puffin (*Alca arctica*) frequent the coast of Andalusia during the winter season, and return to us in the spring.

These facts, and many others of a similar nature, which might have been stated, enable us to draw the conclusion, that our summer birds of passage come to us from southern countries, and after all the purposes of incubation are accomplished, return again to milder regions. A few of our summer visitants may winter in Spain or Portugal; but it appears that in general they migrate to Africa, that unknown country, possessing every variety of surface, and consequently great diversity of climate. It is true that we are unacquainted with the winter retreats of many of our summer birds of passage, particularly of many small birds; but as these arrive and depart under similar circumstances with those whose migrations are ascertained, and as the operations which they perform during their residence with us are also similar, we have a right to conclude, that they are subject to the same laws, and execute the same movements. What gives weight to this opinion, is the absence of all proof of a summer bird of passage retiring to the north during the winter season.

In proof of the accuracy of the preceding conclusion, we may observe, that it is a fact generally acknowledged, that the summer birds of passage visit the southern parts of the country a few days, or even weeks, before they make their appearance in the northern districts. Thus the common swallow (*Hirundo rustica*) appears in Sussex about the beginning of the third week of April; while in the neighbourhood of Edinburgh it is seldom seen before the first of May. The cuckoo appears in the same district about the last week of April; in Edinburgh seldom before the second week of May. The reverse of this holds true with these summer visitants at their departure. Thus dotterels (*Charadrius morinellus*) forsake the Grampians about the beginning of August, and Scotland by the end of that month; while they return to England in September, and remain there even until November. A difference of nearly a month takes place between the departure of the goatsucker (*Caprimulgus Europæus*) from Scotland and from the south of England.

Summer resort of our winter birds.

Having thus ascertained the winter haunts of our summer birds of passage, let us now endeavour to find out the summer retreat of our winter visitants. The conclusions which we have already established dispose us to look for these birds in countries situated to the northward. And as we are much better acquainted with the ornithology of those countries than of Africa, it will be in our power to prosecute our researches with greater certainty of success.

Snow bunting.

The snow bunting, (*Emberiza nivalis*), which is among the smallest of our winter guests, retires to the hoary mountains of Spitzbergen, Greenland, and Lapland, and there performs the purposes of incubation, making its nest in the fissures of the rocks. In these countries it is therefore a summer visitant, as it retires southwards in autumn, to spend the winter in more temperate regions. To the sea coasts of the same regions the little auk (*Alca alle*), and the black-billed auk (*Alca pica*), repair for similar purposes as the snowflake. The *woodcock* winters with us, but retires in the spring to Sweden, Norway, and Lapland. Eckmark says of this bird, as a Swedish summer bird of passage, "Pullis in sylvis nostris exclusis, mare transmigrans, in Angliam avolat; ut ex Austria in Italiam. Vere autem novo, dum blatire incipit Tetrao tetrix, illinc descedunt, matrimonio junctæ ad nos revertentes." The fieldfare and the redwing resemble the woodcock in their migrations, depart at the same season, and retire for similar purposes to the same countries.

Woodcock.

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These instances may suffice to support the conclusion, that all our winter birds of passage come from northern countries, and that the winter visitants of the south of Europe become the summer visitants of its northern regions. This is evidently an arrangement depending on the same law by which the African winter birds of passage are summer birds of passage in Europe.

In support of this conclusion it may be mentioned, that, in their progress southward, the winter birds of passage appear first in the northern and eastern parts of the island, and gradually proceed to the southward and westward. Thus the snow-bunting arrives in the Orkney islands about the end of August, and often proves destructive to the corn fields. It then passes into the mainland of Scotland, and is seldom seen in the Lothians, even in the high grounds, before November. In like manner, the woodcock, which crosses the German Ocean, is first observed on the eastern side of the island, and then by degrees disperses towards the west.

Mode of migration.

Having now ascertained the period and the direction of these migrations, let us next attend to the act of migration itself, and the circumstances attending the flight.

Migrating birds, before they take their departure, in general collect together in flocks. This is very obviously the case with the swallow, and is even still better known with woodcocks. These last arrive in this country in great flocks about the same time; and should adverse winds occur at the period of their departure, they accumulate in such numbers on the eastern shores, as to furnish the fowler with excellent sport. Geese too, during their migratory flights, always keep in company; and the picture which the poet draws of the movements of the crane is equally just when applied to them, only we do not vouch for the truth of their geometrical precision, and their knowledge of the power of the wedge.

> ————————In figure wedge their way,
> Intelligent of seasons; and set forth
> Their airy caravan, high over seas
> Flying, and over lands: so steers the prudent crane
> Her annual voyage, borne on winds: the air
> Floats as they pass, fann'd with unnumbered plumes.
> MILTON.

But there are many migrating birds which have never been observed to congregate previous to their departure. Thus the cuckoo, seldom seen in company with his mate even during the breeding season, is to all appearance equally solitary at the period of migration. These birds are supposed by naturalists to go off in succession.

It is certainly a very curious, and perhaps unexpected occurrence, that the males of many species of migrating birds appear to perform their migrations a few days before the females. This is remarkably the case with the nightingale. The bird catchers in the neighbourhood of London obtain only males on the first arrival of this bird. The females do not make their appearance for a week or ten days after. Similar observations have been made with respect to the wheatear (*Motacilla œnanthe*).

Those birds which feed during the night may be expected to perform their migrations during the same interval, it being the season of their activity; while those birds which feed during the day, may be expected to migrate with the help of light. The migrations of the woodcock and quail confirm this conjecture. The woodcocks arrive in this country during the night, and hence they are sometimes found in the morning after their arrival, in a neighbouring ditch, in too weak a state to enable them to proceed. Poachers are aware that they migrate during the night, and sometimes kindle fires on the coast, to which the woodcocks, attracted by the light, bend their course, and in this manner great numbers are annually destroyed. Quails, on the other hand, perform their migrations during the day, so that the sportsman in the islands of the Mediterranean can use his dog and gun.

It has often excited surprise in the minds of some, how migrating birds could support themselves so long on wing, so as to accomplish their journies, and at the same time live without food during their voyage. These circumstances have induced many to deny the existence of migration, and has excited others to form the most extravagant theories on the subject, to account for the preservation of these birds during the winter months. But the difficulties which have been stated, are only in appearance, and vanish altogether if we attend to the rapidity of the flight of birds.

Rapidity of flight.

The rapidity with which a hawk and many other birds occasionally fly, is probably not less than at the rate of one hundred and fifty miles in an hour. Major Cartwright, on the coast of Labradore, found, by repeated observations, that the flight of an eider duck (*Anas mollissima*) was at the rate of ninety miles an hour. Besides, it is generally known, that a falcon which belonged to Henry the Fourth of France escaped from Fontainbleau, and in twenty-four hours afterwards was found at Malta, a distance computed to be no less than thirteen hundred and fifty miles; a velocity nearly equal to fifty-seven miles an hour, supposing the falcon to have been on wing the whole time. But as such birds never fly by night, and allowing the day to be at the longest, his flight was perhaps equal to seventy-five miles an hour. It is probable, however, says Montagu, that he neither had so many hours of light in the twenty-four, to perform his journey, nor that he was retaken the moment of his arrival. But if we even restrict the migratory flight of birds to the rate of fifty miles an hour, how easily can they perform their most extensive migrations! And we know, in the case of woodcocks, and perhaps all other migrating birds, that they in general take advantage of a fair wind with which to perform their flights. This breeze perhaps aids them at the rate of thirty or forty miles an hour; nay, with three times greater rapidity, even in a moderate breeze, if we are to give credit to the statement of aërial navigators, who seem to consider the rate of the motion of winds as in general stated too low.

It has been already observed, that many species do not perform their migrations at once, but reach the end of their journey by short and easy stages. There is little exertion required from such; while those who execute their movements at one flight, (if there be any that do so,) may in a very short time, perhaps a day, by the help of a favourable breeze, reach the utmost limits of their journey. Many birds, we know, can subsist a long time without food; but there appears to be no necessity for supposing any such abstinence, since, as Catesby remarked, every day affords an increase of warmth and a supply of food. Hence we need not perplex ourselves in accounting for the continuance of their flight, or their sustenance in the course of it. Such journies would be long indeed for any quadruped, while they are soon performed by the feathered tribes.

It is often stated as a matter of surprise, how these birds know the precise time of the year at which to execute their movements, or the direction in which to migrate:—

> Who calls the council, states the certain day,
> Who forms the phalanx, and who points the way?

But this is merely expressing a surprise, that a kind and watchful Providence should bestow on the feathered creation powers and instincts suited to their wants, and calculated to supply them. How, we ask, does the curlew, when perched upon a neighbouring muir during the flowing of the tide, know to return at the first of the ebb, to pick up the accidental bounty of the waves? How are the sea fowl, in hazy weather, guided to the sea-girt isles they inhabit, with food to their young, which they have procured at the distance of many miles? "The inhabitants of St Kilda," says Martin, "take their measures from the flight of these fowls, when the heavens are not clear, as from a sure compass; experience shewing, that every tribe of fowls bend their course to their respective quarters, though out of sight of the isle. This appeared clearly in our gradual advances; and their motion being compared, did exactly quadrate with our compass."

In the course of these annual migrations, birds are sometimes overtaken by storms of contrary wind, and carried far from their usual course. In such cases, they stray to unknown countries, or sometimes are found at sea in a very exhausted state, clinging to the rigging of ships. Such accidents, however, seldom happen, as these birds, year after year, arrive in the same country, and even return to the same spot. The summer birds of passage return not, it is true, in such numbers as when they left us; but, amidst all the dangers of their voyage, the race is preserved.

Proximate causes of migration.

Having established the principal facts regarding the periods of migration, and the circumstances by which it is accompanied, it now remains for us to ascertain those proximate causes to which these movements are to be referred. Powerful indeed must be the causes which prompt those animals to forsake the woods in which they were reared, or the rocks on which they were hatched, and undertake a perilous journey to distant countries. They must be intimately connected with the first laws of life, otherwise the movements to which they give birth would not be so constant and uniform. The procuring of a supply of food, a suitable temperature, or a safe breeding place, are probably all the proximate causes which have any concern in such migrations.

Food.

If we attend to the *food* of many of our summer visitants, we may easily perceive, that it can only be procured during those months in which they remain with us. Subsisting chiefly on insects, they are compelled to shift their quarters, and retire to warmer dis-

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tricts at the end of our summer, in order to procure support. Montagu, when speaking of the cuckoo, makes the following pertinent observations. "Few birds but the titmice will devour the larvæ of the cabbage butterflies; and none that we have noticed make a repast on the hairy species of caterpillars but the cuckoo, who is a general devourer of all kinds of *Lepidopterous larvæ,* more especially the rough sort. It is therefore probable, that the early remigration of this bird is the defect of this favourite food, the greater part having by that time enclosed themselves, preparatory to a change. Of the many cuckoos we have dissected in the months of May and June, the stomach has always been found to contain more or less of the hairs of caterpillars, and sometimes quite full of them."

If insects are thus the favourite food of many of our summer birds of passage, it must frequently happen that their food will be scarce, even after their arrival in this country, owing to the variableness of our climate, and the dependence of the movements of insects on the temperature of the weather. Hence it happens, that some birds disappear again, retiring to other districts where insects are to be obtained. Montagu mentions a curious fact of this kind with regard to the chimney swallow. "It makes its first appearance with us in April, sometimes as early as the first week, if the weather is mild; and it sometimes happens, that after their arrival a long easterly wind prevails, which so benumbs the insect tribe that thousands die for want of food. We recollect, as late as the ninth of May, the swallows on a sudden disappeared from all the neighbouring villages around. The thermometer was at 42°, and we were at a loss to conceive what was become of these birds, which a day or two before were seen in abundance. But by chance we discovered hundreds collected together in a valley close to the sea side, at a large pool which was well sheltered. Here they seem to have found some species of fly, though scarce sufficient to support them; for many were so exhausted, that after a short time on wing they were obliged to pitch on the sandy shore." In the case of the waders, which obtain their food in the neighbourhood of springs and marshes, they are compelled to leave the regions of the north, where, during winter, these are all frozen, and the extent of their migration southwards depends on the severity of the weather.

A supply of food is certainly one of the proximate causes of migration, since we can support many of our summer visitants during the winter, as the nightingale for example, by giving them a regular supply of food. But powerful as this principle may appear, it is certainly not the only one in operation; as we observe one or two species of a genus migrating, while the others are stationary; and this taking place among granivorous as well as insectivorous birds. Equally powerful as the desire to obtain food, seems to be the love of a suitable *temperature.*

Temperature.

If we attend to the motions of the snow bunting, which is a granivorous bird, we find, that on its first arrival in this country it is only to be met with on the high grounds. As the temperature sinks at the approach of winter, it descends to a lower level, while it occupies the higher grounds in more southern districts. Its migrations to the south, therefore, depend entirely on the state of the winter. It has been attempted to preserve these birds during the summer season in this country, but, although liberally supplied with food, they have not survived. The experiment has succeeded, however, in America, with General Davies, who informs us, (*Linn. Trans.* vol. iv. p. 157.) that the snow bird of that country always expires in a few days, (after being caught, although it feeds perfectly well,) if exposed to the heat of a room with a fire or stove; but being nourished with snow, and kept in a cold room or passage, will live to the middle of summer: a temperature much lower than our summer heat proving destructive to these birds. The swallow, on the other hand, seems to delight in the temperature of our summer, and at that heat to be able to perform the higher operations of nature. When attempted to be kept during our winter, besides a regular supply of food, care must be taken to prevent it from being benumbed with cold. It is probably owing to some constitutional difference with respect to cold, that the female chaffinches in Sweden are migratory during winter, while the males are stationary. Eckmark, when speaking of the migrations of this bird, informs us, "*Mares* inter primas sunt aviculas, quæ sonum suum hieme usitatum in cantum vertunt jucundissimum: vere primo, sub initium *mensis regelationis,* arboribus ad pagos insidentes garruli, *fœminis* adhuc *absentibus,* ver indicant adstans. Redeuntibus denique turmis maximis, quæ cœlum fere abscondunt, *fœminis,* omnes conjuges requirunt, quibus conjuncti sylvas petunt, ibi ut nidulos construant et multiplicentur. Initio *mensis defoliationis* mares suos, apud nos remanentes, *fœminæ* deserunt mutabiles, solæ regiones petentes peregrinas." The same cause, namely temperature, renders some birds migratory in one country, while they are stationary in another. No separation of this kind takes place between the sexes of the chaffinch in this country. The linnet, which is a summer bird of passage in Greenland, is always stationary with us.

Breeding.

But, independent of these two causes, we presume, that the desire of obtaining a *safe breeding place* is likewise intimately connected with the movements of many species. "Of the vast variety of water fowl," says Pennant, "that frequent Great Britain, it is amazing to reflect how few are known to breed here: the cause that principally urges them to leave this country, seems to be not merely the want of food, but the desire of a secure retreat. Our country is too populous for birds so shy and timid as the bulk of these are. When great part of our island was a mere waste, a tract of woods and fens, doubtless many species of birds (which at this time migrate) remained in security throughout the year. *Egrets,* a species of heron, now scarce known in this island, were in former times in prodigious plenty and the *Crane,* that has totally forsaken this country, bred familiarly in our marshes, their place of incubation, as well as of all other *cloven-footed water-fowl* (the heron excepted) being on the ground, and exposed to every one. As rural economy increased in this country, these animals were more and more disturbed; at length, by a series of alarms, they were necessitated to seek, during the summer, some lonely safe habitation. On the contrary, those that build or lay in the most inaccessible rocks that impend over the British seas, breed there still in vast numbers, having little to fear from the approach of mankind; the only disturbance they meet with, in general, being from the desperate attempts of some few to get their eggs." It happens, in consequence of this desire of safety during incubation, that the same species may be stationary at one place, while it is migratory at another. Thus, in the Western Islands, the common plover is stationary, while on the Grampians it is migratory. Herons may be met with along all the British shores during

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the winter season, while they are found congregated to breed in but few places. The turnstone is migratory in England, but stationary in the northern islands of Scotland. The same remark is applicable to the hooded crow, a few of which pass from us during the winter months into England, but return during the breeding season.

None of these causes, taken singly, may be able to account for the migrations of the feathered race; but, when viewed in connection, they seem to include all those proximate causes which operate in the production of these curious, and to us in some respects useful voyages. These migrations extend our knowledge of birds, by making us acquainted with the productions of the shores of Greenland, the mountains of Norway, and the marshes of Lapland. They also contribute to enliven the scenes of winter, and occasionally add to the delicacies of our table; while, in their movements, we discern the marks of benevolence in preserving their existence, increasing their happiness, and extending their usefulness.

We cannot dismiss this subject of migration without recommending it to the attentive consideration of our readers. To those who pass their time in the sweets of retirement in the country, it will prove a never-failing source of amusement; and to a reflecting mind, will yield no small portion of delight. The field of observation is extensive, the subject curious. "Quis non cum admiratione videat ordinem et polititiam peregrinantium avium, in itinere, turmatim volantium, per longos terrarum et maris tractus absque acu marina.—Quis eas certum iter in aëris mutabili regione docuit? Quis preteritæ signa, et futuræ viæ indicia? Quis eas ducet, nutrit, et vitæ necessaria ministrat? Quis insulas et hospitia illa, in quibus victum reperiat, indicavit, modumque ejusmodi loca in peregrinationibus suis inveniendi? Hæc sane superant hominum captum et industriam, qui non nisi longis experientiis, multis itinerariis, chartis geographicis—et acus magneticæ beneficio—ejusmodi marium et terrarum tractus conficere tentant, et audent."

Migration of lower animals.

As we descend in the scale of being, the instances of actual migration diminish in number. The locomotive powers of these animals, are too limited to enable them to undertake extensive journies, and when necessary to be protected from the cold of winter, nature employs, with respect to them, a more simple process, by subjecting them to a temporary lethargy. This is the case with reptiles, which present no instances of migration.

Fishes.

The migrations of fishes have long been the subject of keen discussion among naturalists. An agreement of opinion, however, has not been produced, although many observations have been published on the subject. Many of these observations, we fear, are the result of prejudiced inquiry, and ought therefore to be received with caution.

The movements of fishes are not performed with the same regularity and precision as the migrations of the feathered tribes. Shoals of haddocks, for example, frequent for several years a particular part of the coast, and, without any apparent cause, take their departure, accompanied with all those animals which feed on them. The movements of those fish which approach our shores, for the purpose of depositing their spawn, are more regularly performed. But these migrations can scarcely be considered as instances of hybernation. They have but little relation to the seasons of the year, as the fry of these fish may be found in almost every season in our rivers, and, as their movements are known to depend on their condition with respect to fecundation. In our article Ichthyology, a particular account will be given of the migratory movements of the different species of British fishes.

Animals which become Torpid.

Among the Mollusca, Cirrhipedes, and Annelides, no examples of a migrating hybernation have occurred. In the class Crustacea, there is one very curious instance of migration, which the reader will find given in detail under the species *Ocypode uca*, in Vol. VII. page 391.

CHAP. IV.

Hybernating Animals which become Torpid.

Torpidity

This is one of the most curious subjects in zoology, and has long occupied the attention of the natural historian and the physiologist. All animals we know require stated intervals of repose to recruit exhausted nature, and prepare for farther exertion,—a condition which we term sleep. But there are a few animals, which, besides this daily repose, require annually some months of continued inactivity, to enable them to undergo the common fatigues of life during the remaining part of the year. These animals exhibit, therefore, two kinds of sleep—that which they enjoy daily during the season of their activity, and that which they experience during their brumal retirement. This last kind of sleep is generally termed *torpidity*, and is also known by the term *hybernation*.

in quadrupeds.

As the phenomena which torpid animals exhibit are somewhat different according to the classes to which they belong, it will be more convenient for us to treat of the animals of each class separately, beginning with Quadrupeds.

The quadrupeds which are known to become torpid belong exclusively to the digitated order. Some species are found among the *primates*, as the different kinds of bats; among the *feræ* we find the hedgehog and the tanric; while among the *glires* the torpid species are numerous, and their habits have been studied with the greatest attention, as the marmot, the hamster, and the dormouse.

The *food* of these animals is very different, according to the orders or genera to which they belong. The bats support themselves by catching insects, and those chiefly of the lepidopterous kinds; the hedgehog lives on worms and snails; while others, as the marmot and hamster, feed on roots, seeds, and herbs.

It is usually supposed that torpid animals are confined to the cold regions of the earth. That they abound in such regions, must be admitted; but their range of latitude is not so limited as to prevent their occurrence even in warm countries. Thus the *Dipus sagitta*, which is found from the 53d degree of north latitude to the tropics, is equally torpid during the winter months in Egypt as in Siberia. In the former country it is more easily revived by a very slight increase of temperature, its lethargy not being so profound. The tanric (*Tanric caudatus*), which is an inhabitant of India and Madagascar, becomes torpid even in those countries, and continues so during nearly six months of the year.

The precise period of the year in which these animals retire to their winter quarters and become torpid, has not been ascertained with any degree of precision. The jumping mouse of Canada (*Gerbillus Canadensis*) is said to retire to its torpid state in September, and is again restored to activity in the month of May. The tor-

Animals which become Torpid.

pid animals of this country usually retire in October, and reappear in April. It appears probable, however, that the different species do not all retire at the same time, but, like the migrating birds, perform their movements at separate periods. It is also probable that the time of retirement of each species varies according to the mildness or severity of the season. In general, however, they retire from active life when their food has become difficult to obtain, when the insects have fled to their hiding places, and the cold has frozen in the ground the roots and the seeds on which they subsist. At the period of their reviviscence, the insects are again sporting in the air, and the powers of vegetable life are exerted in the various processes of germination and vegetation. In short, during the *dead season* of vegetable life, these animals pass their time in this lethargic state. We see the coincidence, but we cannot well account for the connection.

Previous to their entrance into this state of lethargy, these animals select a proper place, in general assume a particular position, and even in some cases provide a small stock of food.

All these torpid animals retire to a *place of safety*, where, at a distance from their enemies, and protected as much as possible from the vicissitudes of temperature, they may sleep out, undisturbed, the destined period of their slumbers. The bat retires to the roof of gloomy caves, or to the old chimnies of uninhabited castles. The hedge-hog wraps itself up in those leaves of which it composes its nest, and remains at the bottom of the hedge, or under the covert of the furze, which screened it, during summer, from the scorching sun or the passing storm. The marmot and the hamster retire to their subterranean retreats, and when they feel the first approach of the torpid state, shut the passages to their habitations in such a manner, that it is more easy to dig up the earth any where else, than in such parts which they have thus fortified. The jumping mouse of Canada seems to prepare itself for its winter torpidity in a very curious manner, as we are informed by Major-General Davies, in the *Linnean Transactions*, vol. iv. p. 156, on the authority of a labourer. A specimen which was found in digging the foundation for a summer-house in a gentleman's garden about two miles from Quebec, in the latter end of May 1787, was "enclosed in a ball of clay, about the size of a cricket ball, nearly an inch in thickness, perfectly smooth within, and about twenty inches under ground. The man who first discovered it, not knowing what it was, struck the ball with his spade, by which means it was broken to pieces, or the ball also would have been presented to me."

Much stress has been laid upon the *position* which these animals assume, previous to their becoming torpid, on the supposition that it contributes materially to produce the lethargy. In describing this position, Dr Reeves (in his Essay on the Torpidity of Animals) observes, "that this tribe of quadrupeds have the habit of rolling themselves into the form of a ball during ordinary sleep; and they invariably assume the same attitude when in the torpid state, so as to expose the least possible surface to the action of cold: the limbs are all folded into the hollow made by the bending of the body; the clavicles and the sternum are pressed against the fore part of the neck, so as to interrupt the flow of blood which supplies the head, and to compress the trachea: the abdominal viscera and the hinder limbs are pushed against the diaphragm, so as to interrupt its motions, and to impede the flow of blood, through the large vessels which penetrate it, and the longitudinal extension of the cavity of the thorax is entirely obstructed. Thus a confined circulation is carried on through the heart, probably adapted to the last weak actions of life, and to its gradual recommencement." Professor Mangili of Pavia, (*Annales du Museum*, tom. ix.) with greater simplicity of language, says, that the marmot rolls itself up like a ball, having the nose applied contrary to the anus, with the teeth and eyes closed. He also informs us, that the hedgehog, when in a torpid state, in general reposes on the right side. The bat, however, during the period of its slumbers, prefers a very different posture. It suspends itself from the ceiling of the cave to which it retires, by means of its claws, and in this attitude outlives the winter. This is the natural position of the bat when at rest, or in its ordinary sleep. In short, little more can be said of the positions of all these torpid animals, than the correspondence with those which they assume during the periods of their ordinary repose.

Animals which become Torpid.

It is also observable, that those animals which are of solitary habits during the summer season, as the hedgehog and dormouse, are also solitary during the period of their winter torpidity; while the congregating social animals, as the marmot, the hamster, and the bat, spend the period of their torpidity, as well as the ordinary terms of repose, collected together in families or groups.

Many of those animals, particularly such as belong to the great natural family of *gnawers*, make provision in their retreats, during the harvest months. The marmot, it is true, lays up no stock of food; but the hamsters fill their storehouse with all kinds of grain, on which they are supposed to feed, until the cold becomes sufficiently intense to induce torpidity. The *Cricetus glis*, or migratory hamster of Pallas, also lays up a stock of provision. And it is probable that this animal partakes of its stock of provisions, not only previous to torpidity, but also during the short intervals of reviviscence, which it enjoys during the season of lethargy. The same remark is equally applicable to the dormouse.

Changes which torpid animals undergo.

Having thus made choice of situations where they are protected from sudden alternations of temperature, and assumed a position similar to that of their ordinary repose, they fall into that state of insensibility to external objects which we are now to examine more minutely. In this torpid state they suffer a diminution of temperature; their respiration and circulation become languid; their irritability decreases in energy; and they suffer a loss of weight. Let us now attend to each of these changes separately.

Diminished temperature.

1. *Diminished temperature.* When we take in our hand any of these hybernating torpid animals, which we are now considering, they feel cold to the touch, at the same time that they are stiff, so that we are apt to conclude, without farther examination, that they are dead. This reduction of temperature is not the same in all torpid quadrupeds. It varies according to the species. Hunter, in his "Observations on certain parts of the Animal Economy," informs us, on the authority of Jenner, that the temperature of a hedgehog at the diaphragm was 97° of Fahrenheit, in summer, when the thermometer in the shade stood at 78°. Professor Mangili states the ordinary heat of the hedgehog a little lower, at 27° of Reumur, or about 93° of Fahrenheit. In winter, according to Jenner, the temperature of the air being 44°, and the animal torpid, the heat in the pelvis was 45°, and at the diaphragm 48½°. When the temperature of the

atmosphere was at 26°, the heat of the animal in the cavity of the abdomen, where an incision was made, was reduced so low as 30°. The same animal, when exposed to the cold atmosphere of 26° for two days, had its heat at the rectum elevated to 93°, the wound in the abdomen being so much diminished in size as not to admit the thermometer. At this time, however, it was lively and active, and the bed in which it lay felt warm. As this animal allowed its heat to descend to 30°, when in its natural state of torpidity, and when there was no necessity for action, the increased temperature cannot be attributed to the cold, but to the wound, which called forth the powers of the animal to repair an injury, which reparation could not be effected at a temperature below the standard heat of the animal. The sources of error in making experiments where the living principle is concerned are so numerous, that attention ought to be bestowed on every circumstance likely to influence the result.

The zisel, (*Arctomys citillus*), according to Pallas, usually possesses a summer temperature of 103° Fahr. but during winter, and when torpid, the mercury rises only to 80° or 84°. The temperature of the dormouse (*Myoxus muscardinus*) during summer, and in its active and healthy state, is 101°. When rolled up and torpid during winter, the thermometer indicates 43°, 39°, and even 35°, on the external parts of the body. When introduced into the stomach, the temperature was found to be 67°, and sometimes 73°. Mangili found this animal torpid even when the temperature of the air was 66°. Hence he considers it as the most lethargic of animals.

The marmot (*Arctomys marmota*) possesses a summer temperature of 101° or 102°, which is gradually reduced in the torpid season to 43°, and even lower.

Bats have a temperature in summer nearly equal to that of marmots. They are soon affected by the changes of the atmosphere, and they cease to respire in a medium of 43°. In the month of July, the thermometer standing at 80°, the internal temperature of a bat was 101°, which is just the degree of heat in a group of them collected together in summer, and may therefore be considered as the natural standard. Mr Cornish applied a thermometer to a torpid bat, and found that it indicated 36°. When awakened so much that it could fly a little, he again applied the thermometer, and it then indicated 38°. Spallanzani found a bat, after being exposed an hour to a temperature of 48°, to indicate 47°, the bulb of the thermometer being placed in the chest; exposed to a temperature of below the freezing point, the heat of the animal became the same as the surrounding medium, yet it always remains internally higher than the low temperature produced artificially, though the skin indicates the same.

The wood-mouse (*Mus sylvaticus*) became torpid, according to Spallanzani, when the thermometer in its cage stood at 33°. The temperature of the belly externally was 45°, but its internal temperature is not much diminished even by a degree of cold sufficient to render it very torpid.

In these experiments we observe, that the temperature of these hybernating quadrupeds is greatly reduced below the summer standard, or the ordinary temperature of the animal in health and activity. Still, however, they continue to maintain a superiority in point of temperature above the surrounding medium, in whatever circumstances they are placed. Even in this torpid state, the energies of life, though feeble, are still sufficient to the production of a certain quantity of heat.

Diminished respiration.

2. *Diminished Respiration.* In this, as in all the other departments of this curious subject, accurate and varied experiments are still wanting. The following are the principal facts which we have collected on the subject.

The hedgehog, according to Professor Mangili, who has bestowed more attention on this part of the subject than any of his predecessors, respires only from five to seven times in a minute during ordinary repose. When it becomes torpid, the process of respiration is periodically suspended and renewed. Thus a hedgehog, obtained after it had revived naturally from its winter lethargy in April, was placed in a chamber whose temperature was about 54°. It refused vegetable food, and became torpid, and continued in that state to the tenth of May. At first, after every fifteen minutes of absolute repose, it gave from thirty to thirty-five consecutive signs of languid respiration. In the beginning of May, when the thermometer was about 62°, it gave from seven to ten consecutive respirations, after an interval of ten minutes of absolute repose. Upon lowering the temperature, the intervals of repose became greater, while the number of respirations increased to eighteen or twenty.

Marmots, according to the same author, when in health and active, perform about five hundred respirations in an hour, but when in a torpid state, the number is reduced to fourteen, and these at intervals of four minutes, or four minutes and a half, of absolute repose.

Bats, when kept in a chamber from 45° to 50°, were observed at the end of every two, three, or four minutes of absolute repose, to give four signs of respiration. Spallanzani, not aware of these periodical intervals of repose, could not discover any signs of respiration. Indeed, when their temperature is reduced to about 47°, this function does not appear to be exercised.

The dormouse, when in a torpid state on the 27th December, exhibited a languid respiration of one hundred and forty times in forty-two minutes. On the tenth of January, the thermometer being at 43°, it respired at intervals in the following manner, according to Mangili.

Intervals of repose.	Number of consecutive respirations.
5 minutes	16
4	30
3	29
2	29
12	5
9	10
10	6
13	18
12	23
12	8

In some instances, the intervals of repose or suspended respiration lasted sixteen minutes.

Mangili also found the fat dormouse (*Myoxus glis*) when in a torpid state on the 27th December, and when the thermometer indicated 40°, to respire at intervals. After every four minutes of repose, it respired from twenty-two to twenty-four times every minute and a half. The thermometer being raised one degree of Reaumur, the intervals became only three minutes. The temperature being reduced to 37°, the intervals of repose became four minutes, and the consecutive respirations twenty to twenty-six. The cold increasing, Animals which become Torpid.

it awoke and ate a little, and then became torpid again. On the 10th of February the intervals of repose were eighteen or twenty minutes, and then thirteen to fifteen respirations. On the 21st February, the thermometer being 48°, the intervals of repose were from twenty-eight to thirty, and the consecutive respirations from five to seven.

From the observations already made on this important subject, it appears, that respiration is not only diminished, but even in some cases totally suspended. During the severe winter of 1795, Spallanzani exposed dormice to a temperature below the freezing point, and enclosed them in vessels filled with carbonic acid and azotic gas over mercury three hours and a half without being hurt, and the sides of the vessels were not marked by any vapour. Hence we may conclude, that they did not breathe, nor give out any carbonic acid.

Mangili placed a marmot under a bell glass, immersed in lime water, at nine o'clock in the evening. At nine next morning the water had only risen in the glass three lines. Part of the oxygen was abstracted, and a portion of carbonic acid was formed, as a thin pellicle appeared on the surface of the lime water, which effervesced with nitric acid. Spallanzani placed torpid marmots in vessels filled with carbonic acid and hydrogen, and confined them there for four hours, without doing them the least injury, the temperature of the atmosphere being several degrees below the freezing point. But he found, that if these animals were awakened by any means, or if the temperature was not low enough to produce complete torpor, they very soon perished in the same noxious gases. A bird and rat, introduced into a reservoir containing carbonic acid gas, did not live a minute; whereas a torpid marmot remained in it an hour, without betraying the least desire to move, and recovered perfectly on being placed in a warmer medium.

In the exhausted receiver of an air pump, a torpid bat lived seven minutes, in which another bat died at the end of three minutes. Torpid bats, when confined in a vessel containing atmospheric air, consumed six hundredths of the oxygen, and produced five hundred parts of carbonic acid. Viewing this in connection with his other experiments, this philosopher concluded, that the consumption of the oxygen, and the evolution of the carbonic acid, proceeded from the skin.

The respiration of torpid quadrupeds is thus greatly diminished, and even in some cases suspended; and in general, instead of being performed with regularity as in ordinary sleep, the respirations take place at intervals more or less remote, according to the condition of the lethargy.

Diminished circulation.

3. *Diminished Circulation.* From the experiments already detailed with regard to the reduction of the temperature and the respiration of torpid quadrupeds, we are prepared to expect a corresponding diminution of action in the heart and arteries.

In the hamster, (*Cricetus vulgaris,*) the circulation of the blood during its torpid state is so slow, according to Buffon, that the pulsations of the heart do not exceed fifteen in a minute. In its active and healthy state they amount to one hundred and fifty in the same space.

We are informed by Barrington in his Miscellanies, that Mr Cornish applied a thermometer to the body of a torpid bat, and found that it indicated 36°. At this temperature the heart gave sixty pulsations in a minute. When awakened so much as to be able to fly a little, he again applied the thermometer, which now indicated 38°, and the heart beat one hundred times in a minute. As the torpor becomes profound, the action of the heart is so feeble, that only fourteen beats have been distinctly counted, and those at unequal intervals.

Animals which become Torpid.

Dormice, when awake and jumping about, breathe so rapidly, that it is almost impossible to count their pulse; but as soon as they begin to grow torpid, eighty-eight pulsations may be counted in a minute, thirty-one when they are half torpid, and only twenty, nineteen, and even sixteen, when their torpor is not so great as to render the action of the heart imperceptible.

Spallanzani and others are of opinion, that the circulation of the blood is entirely stopped in the remote branches of the arteries and veins, and only proceeds in the trunks of the larger vessels, and near the heart. But it is probable, that however languid the circulation may be, it is still carried on, as the blood continues fluid. He found, that if the blood of marmots be subjected, out of the body, to a temperature even higher than that to which it is exposed in the lungs of these animals, it is instantly frozen; but it is never congealed in their dormant state.

Diminished irritability.

4. *Diminished Irritability.* The irritability of torpid animals, or their susceptibility of being excited to action, is extremely feeble, and in many cases is nearly suspended. Destined to remain for a stated period in this lethargic state, a continuance of their power of irritability would be accompanied with the most pernicious consequences; as thereby they would be often raised prematurely into action under a temperature which they could not support, and at a time when a seasonable supply of food could not be obtained. In their torpid state, therefore, they are not readily acted upon by those stimuli, which easily excite them to action during the period of their activity. Parts of their limbs may be cut off without the animal shewing any signs of feeling. Little action is excited even when their vital parts are laid open. When the hamster is dissected in this torpid state, the intestines discover not the smallest sign of irritability upon the application of alcohol or sulphuric acid. During the operation, the animal sometimes opens its mouth, as if it wanted to respire, but the lethargy is too powerful to admit of its reviviscence.

Marmots are not roused from their torpid state by the electric spark, strong enough to give a smart sensation to the hand, and a shock from a Leyden phial only excited them for a short time. They are insensible to pricking their feet and nose, and remain motionless and apparently dead. Bats are also equally insensible to the application of stimuli.

The most curious experiments on this subject are those of Mangili. Having killed a marmot in a torpid state, he found the stomach empty and collapsed, the intestines likewise empty, but there was a little matter in the cœcum and rectum. The blood flowed quickly from the heart, and in two hours yielded a great quantity of serum. The veins in the brain were very full of blood. The heart continued to beat during three hours after. The head and neck having been separated from the trunk, and placed in spirits of wine, gave signs of motion even after half an hour had elapsed. Some portions of the voluntary muscles gave symptoms of irritability with galvanism four hours after death. In a marmot killed in full health, the heart had ceased to beat at the end of fifty minutes. The flesh lost all signs of irritability in two hours; the intercostal and abdominal muscles retaining it longer than those of any other part of the body.

5. *Diminished Action of the Digestive Organs.* The

Diminished digestion.

digestive faculty in torpid animals is exceedingly feeble, and in general ceases altogether. The situation, and still more the lethargic state of the system, render this process unnecessary. The intestines are in general empty, and in a collapsed state, and the secretions so small, that a supply of nourishment from the stomach is not requisite. Mr Jenner found a hedgehog, when the heat of the stomach was at 30°, to have no desire for food, nor power of digesting it. But when the temperature was increased to 93° by inflammation in the abdomen, the animal seized a toad which was in the room, and, upon being offered some bread and milk, immediately began to eat. The heat excited the action of the various functions of the animal, and the parts unable to carry on these actions, without nourishment, urged the stomach to digest.

While many torpid quadrupeds retire to holes in the earth unprovided with food, and in all probability need no sustenance during their lethargic state, there are others, as we have already mentioned, which provide a small stock of provisions. These, we are inclined to believe, eat a little during those temporary fits of reviviscence to which they are subject. This is in part confirmed by the experiments of Mangili, both on the common dormouse and the *Myoxus glis*. Whenever these awoke from their torpid slumbers, they always ate a little. Indeed he is of opinion, that fasting long, produces a reviviscence, and that, upon the cravings of appetite being satisfied, they again become torpid.

Diminished weight.

6. *Diminished Weight*. All the experiments hitherto made on this subject indicate a loss of weight sustained by these animals from the time they enter their torpid state until the period of their reviviscence. Mangili obtained two marmots from the Alps on the first of December 1813. The largest weighed twenty-five Milanese ounces, the smallest only $22\frac{1}{12}$th ounces. On the third of January the largest had lost $\frac{11}{12}$ths of an ounce, and the smallest $\frac{11}{12}$ and a half. On the fifth of February the largest was now only $22\frac{11}{12}$th ounces, the smallest twenty-one ounces. He adds, that they lose weight in proportion to the number of times in which they revive during the term of their lethargy.

Dr Monro kept a hedgehog from the month of November (1764) to the month of March (1765), which lost in the interval a considerable portion of its weight. On the 25th of December it weighed thirteen ounces and three drams, on the 6th of February eleven ounces and seven drams, and on the 8th of March eleven ounces and three drams. He observed a small quantity of feculent matter and urine among the hay, although it neither ate nor drank during that period. In this experiment there was a daily loss of thirteen grains. According to Mr Cornish, both bats and dormice lose from five to seven grains in weight during a fortnight's hybernation.

Dr Reeves endeavours to account for the lean state of the marmot when found in the spring, as occasioned by another cause than the slow but uniform exertions of the vital principle. "I have (he says) been repeatedly assured by men who hunt for these animals in winter, that they are always found fat in their holes on the mountains of Switzerland, and it is only when they come out of their hiding places before provisions are ready for them, or if a sharp frost should occur after some warm weather, that they become emaciated and weak. This testimony may be received as explaining the emaciated appearance of some marmots, but does not in the smallest degree invalidate the general conclusion, that all torpid animals sustain a loss of weight during the continuance of their lethargy.

From the experiments which we have already quoted, it must appear obvious, that respiration is in general carried on, although sometimes in a very feeble manner. Carbon, consequently, must be evolved. Accordingly we find carbonic acid produced in those vessels in which these torpid animals have been confined; and hence must conclude, that a loss of weight has taken place.

Such being the preparatory and accompanying phenomena of this torpid state, let us now endeavour to discover the cause of these singular appearances.

Causes of torpidity.

In a subject of this kind, so intimately connected with the pursuits of the naturalist and the physiologist, it was to be expected that numerous hypotheses would be proposed, to explain such interesting phenomena. Unfortunately, indeed, many hypotheses have been proposed, while few, from a connected view of the subject, have ventured to theorise. Perhaps we are not prepared to draw a sufficient number of general conclusions, from the scanty facts which we possess, in order to build any theory. But the following observations may be considered as embracing the principal opinions which have been formed on the subject, and announcing the more obvious causes in operation.

In an investigation of this sort, it was natural to attempt to trace this singularity of habit in torpid animals to some peculiar conformation in the structure of the organs. Accordingly we find many anatomists assigning a peculiarity of organization as a reason why these animals become torpid, or at least pointing out a structure in torpid animals different from that which is observable in animals that are not subject to this brumal lethargy.

Pallas observed the thymus gland unusually large in torpid quadrupeds, and also perceived two glandular bodies under the throat and upper part of the thorax, which appear particularly florid and vascular during their torpidity.

Mangili is of opinion, that the veins are larger in size, in proportion to the arteries in those animals which become torpid, than in others. He supposes, that, in consequence of this arrangement, there is only as much blood transmitted to the brain during summer as is necessary to excite that organ to action. In winter, when the circulation is slow, the small quantity of blood transmitted to the brain is inadequate to produce the effect. This circumstance, acting along with a reduced temperature and an empty stomach, he considers as the cause of torpidity. By analogy he infers, that the same cause operates in producing torpidity with all the other hybernating animals of the other classes.

Mr Carlisle, in his Croonian Lecture on Muscular Motion, asserts, that "animals of the class mammalia, which hybernate and become torpid in the winter, have at all times a power of subsisting under a confined respiration, which would destroy other animals not having this peculiar habit. In all the hybernating mammalia there is a peculiar structure of the heart and its principal veins: the superior cava divides into two trunks, the left passing over the left auricle of the heart into the inferior part of the right auricle near to the entrance of the vena cava inferior. The veins usually called azygos accumulate into two trunks, which open into the branch of the vena cava superior, on its own side of the thorax. The intercostal arteries and veins in these animals are unusually large." *Phil. Trans.* 1805.

We cannot refrain from observing, that these general views do not appear to be the result of a patient investigation of a number of different kinds of torpid animals, but a premature attempt to theorise from a few insulated particulars. Passing, therefore, from these attempts of the anatomist to illustrate the phenomena in question, let us attend to those other causes which are concerned in the production of torpidity.

Effects of cold.

From the consideration, that this state of torpidity commences with the cold of winter, and terminates with the heat of spring, naturalists in general have been disposed to consider a *reduced temperature* as one of the principal causes of this lethargy. Nor are circumstances wanting to give ample support to the conclusion.

When the temperature of the atmosphere is reduced, as we have already seen, below 50°, and towards the freezing point, these animals occupy their torpid position, and by degrees, relapse into their winter slumbers. When in this situation, an increase of temperature, the action of the sun, or a fire, rouse them to their former activity. This experiment may be repeated several times, and with the same result, and demonstrates the great share which a diminished temperature has in the production of torpidity. If marmots are frequently disturbed in this manner during their lethargy, they die violently agitated, and a hemorrhage takes place from the mouth and nostrils.

The circumstance of torpid animals being chiefly found in the colder regions, is another proof that a diminished temperature promotes torpidity. And, in confirmation of this, Dr Barton informs us that, in the United States of America, many species of animals which become torpid in Pennsylvania, and other more northern parts of the country, do not become torpid in the Carolinas, and other southern parts of the continent.

But while a certain degree of cold is productive of this lethargy, a greater reduction of temperature produces reviviscence as speedily as an increase of heat. Mangili placed a torpid marmot which had been kept in a temperature of 45°, in a jar surrounded with ice and muriate of lime, so that the thermometer sunk to 16°. In about half an hour a quickened respiration indicated returning animation. In sixteen hours it was completely revived. It was trembling with cold, and made many efforts to escape. He also placed a torpid bat under a bell glass, where the temperature was 29°, and where it had free air. Respiration soon became painful, and it attempted to escape. It then folded its wings, and its head shook with convulsive tremblings. In an hour no other motions were perceptible than those of respiration, which increased in strength and frequency until the fifth hour. From this period, the signs of respiration became less distinct; and, by the sixth hour, the animal was found dead. He also exposed a torpid dormouse (from a temperature of 41°) to a cold of 27° produced by a freezing mixture. Respiration increased from ten to thirty-two times in a minute, and without any intervals of repose. There were no symptoms of uneasiness, and the respirations seemed like those in natural sleep. As the temperature rose, respiration became slower. He then placed it in the sun, when it awoke. Two hours afterwards, having exposed it to the wind, respiration became frequent and painful; it turned its back to the current without, however, becoming torpid.

That cold is calculated to produce effects similar to torpidity on man himself, is generally known. When persons in health are immersed in salt water at the temperature of 40°, the thermometer under the tongue sinks from seven to nine degrees below the standard heat. In a little, however, it recovers its ordinary elevation, and becomes stationary. Exposure to cold has also the effect of diminishing the force of the pulse very much—of producing great exhaustion, and an accumulation of blood in the extreme vessels.

But the effects of a reduced temperature on the human system are still better illustrated in the tendency to sleep, produced by a cold atmosphere in certain situations. Those who have ascended to the summits of high mountains, have, by the exposure to cold, felt an almost irresistible propensity to lie down and sleep. Dr Solander, while exploring Terra del Fuego, though perfectly aware of the inevitable destruction attending the giving way to this inclination; nay, though he had even cautioned his companions against indulging it, could not himself overcome the desire. When this feeling is gratified, sleep succeeds, the body becomes benumbed, and death speedily arrives. How long this sleep might continue without ending in death, were the body defended from the increasing cold and the action of the air, will probably never be determined by satisfactory experiments. Partial torpor has often been experienced in the hands and feet, which is easily removed by a gradual increase of temperature. We may add, that in the case of persons exposed to great cold in elevated situations on mountains or in balloons, there are other causes in operation which may have a tendency to produce sleep. The previous exertions have reduced the body to a very exhausted state —the pressure of the atmosphere on the body is greatly diminished, and the air inhaled by the lungs is rarefied.

When these torpid animals, kept in a confined state, are regularly supplied with food, and kept in a uniform temperature, it has been observed that they do not fall into their wonted lethargy, but continue lively and active during the winter season. This experiment has often been repeated with the marmot and other animals. But when in this state they are peculiarly sensible to cold. Dr Reeves, in some experiments which he performed, says, "When I was in Switzerland I procured two young marmots in September 1805, and kept them with the view of determining the question whether their torpidity could be prevented by an abundant supply of food and moderate heat. I carried them with me to Vienna, and kept them the whole of the winter 1805-6. The months of October and November were very mild. My marmots ate every day turnips, cabbages, and brown bread, and were very active and lively: they were kept in a box filled with hay in a cellar, and afterwards in a room without a fire, and did not shew any symptoms of growing torpid. December the 18th, the weather was cold, and the wind very sharp; Fahrenheit's thermometer stood at 18° and 20°. Two hedgehogs died which were kept in the same room with the marmots; and a hamster died also in a room where a fire was constantly kept, though these animals had plenty of hay and food. The marmots became more torpid than I ever saw them before; yet they continued to come out of their nest, and endeavoured to escape: the food given them in the evening was always consumed by the next morning. In January the weather was unusually mild and warm; my marmots ate voraciously, and were jumping about in the morning; but at four o'clock in the afternoon I examined them several times, and found them not completely rolled up, half torpid, and quite cold to the touch. They continued in this state of semi-torpor for several weeks longer, never becoming so torpid as to live many days without eating, and never so active as to resist the benumbing effects of the cold weather." Spallanzani performed similar experiments with the same result on the dormouse. He found, that although cold to the touch during the day, and completely torpid, that it awoke at night and ate a little, and fell asleep again in the morning. He shews also that dormice kept in a situation more resembling their wild state became torpid in the month of November, and remained till the middle of March without eating the food which was placed near them.

Confined atmosphere.

With some animals, at least, a *confined atmosphere* appears to be indispensibly necessary to the production of torpidity. This is very strikingly illustrated in the case of the hamster. This animal does not become torpid though exposed to a cold sufficient to freeze water, unless excluded from the action of the air. Even when shut up in a cage filled with earth and straw, and exposed to cold, he still continues awake; but when the cage is sunk four or five feet under ground, and free access to the external air prevented, in eight or ten days he becomes as torpid as if he had been in his own burrow. If the cage be brought above ground, in two or three hours he recovers, and will resume his torpid state when again sunk under ground. This experiment may be repeated several times, at proper intervals, either in the day time or during the night, the light having no apparent influence. A confined atmosphere, such as the hamster requires, does not appear necessary to the torpidity of the hedgehog, the dormouse, or the bat. But exposure to the open air, seems to be equally hostile to the lethargic state, in many animals. Mangili always found that marmots awoke when taken from their nest, and exposed to the free action of the air. A current of air he found always to have the effect of producing reviviscence, both with dormice and bats. From these circumstances, we perceive the utility of the precautions of these animals in retiring to places where the air is still, and where they may enjoy a confined atmosphere.

Influence of constitution.

Torpidity appears also in some cases to depend on the state of the *constitution*. Thus, in the same chambers, one marmot shall continue awake and active while the others are in a profound lethargy. A hedgehog, during the winter season, becomes torpid upon the application of cold; but, during the summer season, or after the period of reviviscence, it resists the sedative effects of that agent. Mangili took a hedgehog, on the 21st June, and placed it in a temperature of 8° of Reaumur. It first rolled itself up; afterwards lifted its head and tried to escape. Its respiration became frequent and painful. At the end of the first hour, respiration had become feeble; at the end of an hour and a half, it had ceased to respire; and twenty minutes after, it was frozen to the heart. When examined in this condition, the flesh was found white, the veins of the neck were much swollen, and a small quantity of extravasated blood was observed in the brain and the lungs. It appears probable, that, during torpidity, the constitution experiences a change something similar to ordinary sleep, by which its exhausted energies are recruited, and it becomes better able to resist the effects of those ordinary agents with which it has to contend.

There are some circumstances in the history of these torpid animals which seem to indicate, that they possess the power of becoming torpid at pleasure, even in the absence of those disposing circumstances which we have enumerated. Spallanzani has seen bats in a torpid state even during summer, and supposes, that as these animals appear to possess some voluntary power over respiration, this torpidity may be some instinctive propensity to preserve life. Mangili, in spring, when the *Cricetus glis* was awake, and when the temperature of the air was between 60° and 68°, placed it in a vase along with nuts and other food. The animal attempted to escape, and refused to eat. It then became torpid. In this state the number of its respirations diminished. Instead of rolling itself up as usual before becoming torpid, it lay all the while upon its back, and remained in that state until the 17th of July.

Influence of fat.

By some it has been supposed, that the *fat* accumulated in torpid animals during the winter is another of those causes which produce this lethargy. The circumstance is certainly very common, but no direct experiments have hitherto been performed to warrant the conclusion. Spallanzani has indeed asserted, that among the dormice which he caught for his experiments, some were very fat, while others were lean, and yet they were equally susceptible of torpidity from the action of cold. All this may be the case; but there is certainly reason to believe, that these animals stand in need of some previous store of nourishment to enable them to support that gradual waste which takes place during the period of their slumbers.

Reviviscence of torpid animals.

Before concluding our account of torpid quadrupeds, it may be proper to add a few observations on their *reviviscence*. When the hamster passes from his torpid state, he exhibits several curious appearances. He first loses the rigidity of his members, and then makes profound respirations, but at long intervals. His legs begin to move; he opens his mouth, and utters rattling and disagreeable sounds. After continuing this operation for some time, he opens his eyes, and endeavours to raise himself on his legs. All these movements are still unsteady, and reeling like those of a man in a state of intoxication; but he repeats his efforts till he acquires the use of his limbs. He remains fixed in that attitude for some time, as if to reconnoitre and rest himself after his fatigues. His passage from a torpid to an active state is more or less quick according to the temperature. It is probable that this change is produced imperceptibly when the animal remains in his hole, and that he feels none of those inconveniences which attend a forced and sudden reviviscence.

It is evident, from the situations which some torpid animals occupy, that they must experience, in the course of their lethargy, considerable changes of temperature. It would form a very curious subject of inquiry, to ascertain the superior and inferior limits of this torpid state with respect to temperature. The *Cricetus glis* has been observed dormant from 34° to 48°; the dormouse from 27° to 66°; the marmot from 40° to 51°; and the hedgehog from 26° to 56°.

It is certainly very difficult to account for the torpidity of those animals, which, like the marmot and hamster, congregate and burrow in the earth. Previous to their becoming torpid, a considerable degree of heat must be generated, from their numbers, in their hole; and besides, they are lodged so deep in the earth, as to be beyond the reach of the changes of the temperature of the atmosphere. Their burrow, during the winter season, must preserve a degree of heat approaching to the mean annual temperature of the climate. If this is the case, how is reviviscence produced in the spring? It cannot be owing to any change of temperature, for their situation prevents them from experiencing such vicissitudes. Is it not owing to a change which takes place in their constitution? and, is not awakening from torpidity, similar to awakening from sleep?

A similar remark may be made with regard to bats in their winter quarters. The caves to which they resort, approach at all times the mean annual temperature. A few individuals, not sufficiently cautious in choosing proper retreats, are sometimes prematurely called into action, at a season when there is no food, so that they fall a prey to owls, and the cold of the evening. But what indications of returning spring have those who are attached to the roofs of the deeper caves? Surely no increase of temperature? Perhaps an internal change is the cause which again excites to action.

There is another very curious circumstance attending the reviviscence of quadrupeds from their torpid state, which deserves to be mentioned. As soon as they have recovered from their slumbers, they prepare for the great business of propagation. This is a proof, that torpidity, instead of exhausting the energies of nature, increases their vigour. It also indicates a peculiarity of constitution, to the preservation and health of which, a brumal lethargy is indispensibly requisite.

Torpidity of birds.

It appears to be the general practice of modern naturalists, to treat with ridicule those accounts which have been left us of Birds having been found in a torpid state during winter. These accounts, it is true, have in many instances been accompanied with the most absurd stories, and have compelled us to pity the credulity of our ancestors, and withhold our assent to the truth of many of their statements. But are there no authenticated instances of torpidity among birds?

In treating of the torpidity of quadrupeds, we were unable to detect the cause of torpidity, as existing in any circumstances connected with structure or with circulation, respiration, or animal temperature; nor in the places which they frequent, nor the food by which they are supported. Hence we cannot expect much help from a knowledge of the anatomy, physiology, or even habits of birds, in the resolution of the present question. It has indeed been said, that as birds can readily transport themselves from one country to another, and in this manner shun the extremes of temperature, and reach a supply of food, the power of becoming torpid would be useless if bestowed on them, although highly beneficial to quadrupeds, that are impatient of cold, and cannot migrate to places where there is a supply of food. This mode of reasoning, however, is faulty, since we employ our pretended knowledge of final causes, to ascertain the limits of the operations of nature, and cannot be tolerated in a science depending entirely on fact and observations. Besides, there are many animals, as we have seen in the class *Mammalia*, which become torpid, and a similar state obtains among the reptiles. As birds, in the scale of being, hold a middle rank between these two classes, being superior to the reptiles, and inferior to the mammalia, we have some reason to expect instances of torpidity to occur among the feathered tribes.

These remarks have for their object, to prepare the mind for discussing the merits of the question, by the removal of presumptions and prejudices, as we fear preconceived opinions have already exercised too much influence.

In treating of the migrations of the swallow, we endeavoured to point out their winter residence, and even traced them into Africa. We are not however prepared to assert, that in every season all these birds leave this country. If they remain, in what condition are they found?

Submersion of Swallows.

Many naturalists, such as Klein, Linnæus, and others, have believed in the submersion of swallows during winter in lakes and rivers. They have supposed, that they descend to the bottom, and continue there until the following spring. Many of the proofs produced in support of this opinion may be found by consulting the article Birds, vol. iii. p. 514. On this subject we willingly quote the judicious note in the introduction to Bewick's *Land Birds.* "There are various instances on record, which bear the strongest marks of veracity, of swallows having been taken out of water, and of their having been so far recovered by warmth as to exhibit evident signs of life, so as even to fly about for a short space of time. But, whilst we admit the fact, we are not inclined to allow the conclusion generally drawn from it, viz. that swallows, at the time of their disappearance, frequently immerse themselves in seas, lakes, and rivers, and, at the proper season, emerge and reassume the ordinary functions of life and animation; for it should be observed, that in those instances which have been the best authenticated, it appears, that the swallows so taken up were generally found entangled amongst reeds and rushes, by the sides, or in the shallowest parts of the lakes or rivers where they happened to be discovered, and that having been brought to life so far as to fly about, they all of them died in a few hours after. From the facts thus stated we would infer, that at the time of the disappearance of swallows, the reedy grounds by the sides of rivers and standing waters are generally dry, and that these birds, especially the later hatchings, which frequent such places for the sake of food, retire to them at the proper season, and lodge themselves among the roots, or in the thickest parts of the rank grass which grows there; that during their state of torpidity they are liable to be covered with water from the rains which follow, and are sometimes washed into the deeper parts of the lake or river, where they have accidentally been taken up; and that probably the transient signs of life which they have discovered on such occasions, have given rise to a variety of vague and improbable accounts of their immersion."—We may add, that whoever denies that swallows have been found in such situations, let his reasonings be what they may, tramples under his feet the laws of evidence, and cherishes a scepticism as unphilosophical as the most unthinking credulity.

But, independent of these instances of submersion, as it is termed, which we regard as purely accidental, there have been many instances of actual torpidity observed. Swallows, if we may credit the testimony of many who have been eye-witnesses of the fact, are often found during the winter season in a torpid state in their old nests, and in the crevices of old buildings. The belief of this kind of torpidity is very common in many parts of Scotland, and can scarcely be supposed to have originated from any other cause than the occurrence of the fact.

But besides the occurrence of the torpidity of the swallow, Bewick relates an instance of the same condition being observed in the cuckoo. "A few years ago a young cuckoo was found in the thickest part of a close whin-bush. When taken up, it presently discovered signs of life, but was quite destitute of feathers. Being kept warm, and carefully fed, it grew and recovered its coat of feathers. In the spring following it made its escape, and in flying across the river Tyne it gave its usual call."—*Brit. Birds*, 1. Introd. xvii.

There is a still more decided example of torpidity in birds recorded by Mr Neill, in his *Tour through Orkney and Shetland*, as having been observed in the case of the land-rail, or corncrake as it is called in Scotland. " I made," says he, " frequent inquiry, whether corncrakes had been seen to migrate from Orkney, but could not learn that such a circumstance had been observed. It is the opinion of the inhabitants, indeed, that they are not able to undertake a flight across the sea. Mr Yorston, the farmer at Aikerness, further related a curious fact, rather leading to the conclusion that they do not migrate. In the course of demolishing a *hill-dyke*, (*i. e.* a mud wall,) at Aikerness, about midwinter, a *corncrake* was found in the midst of the wall. It was apparently lifeless; but, being fresh to the feel and smell, Mr Yorston thought of placing it in a warm situation, to see if it would revive. In a short time it began to move, and in a few hours it was able to walk about. It lived for two days in the kitchen, but would not eat any kind of food. It then died, and became putrid.—I do not assert that this solitary instance ought to be regarded in any other light than as an exception to the general rule of migration, till further observation have determined the point."

These are the only instances with which we are acquainted of actual torpidity having occurred among the feathered tribes. They seem calculated to remove all doubt as to the fact, while they point out to us the numerous resources of nature in extreme cases to preserve existence. Thus when birds from disease or weakness, or youth, are incapable of performing the ordinary migrations of their tribes, they become dormant during the winter months, until the heat of spring restores to them a supply of food and an agreeable temperature.

Hitherto we have been considering the torpidity which warm-blooded animals experience. Several cold blooded animals observe a similar mode of hybernation.

Torpidity of Reptiles.

The period of the year at which REPTILES prepare for this state of lethargy varies in the different species. In general, when the temperature of the air sinks below the 50th degree of Fahrenheit, these animals begin their winter slumbers. They adopt similar precautions as the mammalia, in selecting proper places of retreat, to protect them from their enemies, and preserve them from sudden alternations of temperature. Those which inhabit the waters sink into the soft mud, while those which live on the land enter the holes and crevices of rocks, or other places where the heat is but little affected by changes in the temperature of the atmosphere. Thus provided, they obey the impulse, and become torpid.

As the temperature of these animals depends on the surrounding medium, they do not exhibit any peculiarities with respect to it. When the air is under 50°, these animals become torpid, and suffer their temperature to sink as low as the freezing point. When reduced below this, either by natural or artificial means, the vital principle is in danger of being extinguished. In this torpid state, they respire very slowly, as the circulation of the blood can be carried on independent of the action of the lungs. Even in a tortoise kept awake during the winter by a genial temperature, the frequency of respiration was observed to be diminished.

The circulation of the blood is diminished, in proportion to the degree of cold to which these torpid reptiles are exposed. Spallanzani counted from eleven to twelve pulsations in a minute in the heart of a snake at the temperature of 48°, whose pulse in general in warm weather gives about thirty beats in the same period. Dr Reeves made some very interesting experiments on the circulation of the toad and frog. " I observed," he says, " that the number of pulsations in toads and frogs was thirty in a minute, whilst they were left to themselves in the atmosphere of which the temperature was 53°; when placed in a medium cooled to 40°, the number of pulsations was reduced to twelve, within the same period of time; and when exposed to a freezing mixture at 26°, the action of the heart ceased altogether."

The powers of digestion are equally feeble during torpidity as those of respiration or circulation. Mr John Hunter conveyed pieces of worms and meat down the throats of lizards when they were going to their winter quarters, and, keeping them afterwards in a cool place, on opening them at different periods, he always found the substances, he had introduced, entire, and without any alteration; sometimes they were in the stomach, at other times they had passed into the intestines, and some of the lizards that were allowed to live, voided them toward the spring entire, and with very little alteration in their structure.

The immediate cause of torpidity in reptiles has been ascertained with more precision, than in the animals belonging to the higher classes with warm blood. This condition with them, does not depend on the state of the heart, the lungs, or the brain; for these different organs have been removed by Spallanzani, and still the animals became torpid, and recovered according to circumstances. Even after the blood had been withdrawn from frogs and salamanders, they exhibited the same symptoms of torpidity as if the body had been entire, and all the organs capable of action.

Cold, with these animals, is evidently the chief cause of their torpidity, acting on a frame extremely sensible to its impressions. During the continuance of a high temperature, these animals remain active and lively; but when the temperature is reduced towards 40°, they become torpid, and in this condition, if placed in a situation when the temperature continues low, will remain torpid for an unknown period of time. Spallanzani kept frogs, salamanders, and snakes, in a torpid state in an ice-house, where they remained three years and a half, and readily revived when again exposed to the influence of a warm atmosphere. These experiments give countenance to those reports in daily circulation of toads being found enclosed in stones. These animals may have entered a deep crevice of the rock, and during their torpidity, been covered with sand, which has afterwards concreted around them. Thus removed from the influence of the heat of spring or summer, and in a place where the temperature continued below the point at which they revive, it is impossible to fix limits to the period during which they may remain in this dormant state.

Since reptiles are easily acted upon by a cold atmosphere, we find but few of those animals distributed in the cold countries of the globe; while in those countries whose temperature is always high, these animals are found of vast size, and of many different kinds, and in great numbers.

Mollusca.

The torpidity of the *Mollusca* has not been studied with care. Those which are naked and reside on the land, retire to holes in the earth, under the roots of trees, or among moss, and there screen themselves from sudden changes of temperature. The different kinds of land Testacea, such as those belonging to the genera Helix, Bulimus, and Pupa, not only retire to

Mollusca.

crevices of rocks and other hiding places, but they form an operculum or lid for the mouth of the shell, by which they adhere to the rock, and at the same time close up even all access to the air. If they be brought into a warm temperature, and a little moisture be added, they speedily revive. In the case of the *Helix nemoralis*, the operculum falls off when the animal revives, and a new one is formed when it returns again to its slumbers. The first formed opercula contain a considerable portion of carbonat of lime, which is found in smaller quantity in the later formed ones. If the animal has revived frequently during the winter, the last formed opercula consist entirely of animal matter, and are very thin. The winter lid of the *Helix pomatia* resembles a piece of card.

All the land testacea appear to have the power of becoming torpid at pleasure, and independent of any alterations of temperature. Thus, even in midsummer, if we place in a box, specimens of the *Helix hortensis, nemoralis* or *arbustorum*, without food, in a day or two they form for themselves a thin operculum, attach themselves to the side of the box, and remain in this dormant state. They may be kept in this state for several years. No ordinary change of temperature produces any effect upon them, but they speedily revive if plunged in water. Even in their natural haunts, they are often found in this state during the summer season, when there is a continued drought. With the first shower, however, they recover, and move about, and at this time the conchologist ought to be on the alert.

The Spiders pass the winter season in a dormant state, enclosed in their own webs, and placed in some concealed corner. Like the torpid mammalia, they speedily revive when exposed to intense cold, and strive to obtain a more sheltered spot.

Insecta.

Many Insects which are destined to survive the winter months, become regularly torpid by a cold exceeding 40°. The common honey bee, in a small hive, when reduced to this temperature, loses all power of motion, but may be easily revived by an increase of temperature. When the hive is large, there is always as much heat generated, as to protect them against this lethargic disposition. The house fly may always be found in the winter season torpid, in some retired corner; but exposure for a few minutes to the influence of a fire recalls it to activity. Even some of the lepidopterous insects, which have been hatched too late in the season to enable them to perform the business of procreation, possess the faculty of becoming torpid during the winter, and thus have their life prolonged beyond the ordinary period. These insects can all be preserved from becoming torpid by being placed in an agreeable temperature, as the following experiments of Mr Gough's (Nicholson's *Journal*, vol. xix.) abundantly testify. In speaking of the Hearth Cricket, (*Gryllus domesticus*,) he says, "Those who have attended to the manners of this familiar insect will know that it passes the hottest part of the summer in sunny situations, concealed in the crevices of walls and heaps of rubbish. It quits its summer abode about the end of August, and fixes its residence by the fireside of the kitchen or cottage; where it multiplies its species, and is as merry at Christmas as other insects are in the dog-days." Thus do the comforts of a warm hearth afford the cricket a safe refuge, not from death, but from temporary torpidity; which it can support for a long time, when deprived by accident of artificial warmth. "I came to the knowledge of this fact," he says, "by planting a colony of these insects in a kitchen, where a constant fire is kept through the summer, but which is discontinued from November to June, with the exception of a day, once in six or eight weeks. The crickets were brought from a distance, and let go in this room in the beginning of September 1806: here they increased considerably in the course of two months, but were not heard or seen after the fire was removed. Their disappearance led me to conclude that the cold had killed them: but in this I was mistaken; for, a brisk fire being kept up for a whole day in the winter, the warmth of it invited my colony from their hiding place, but not before the evening, after which they continued to skip about and chirp the greater part of the following day, when they again disappeared; being compelled by the returning cold to take refuge in their former retreats. They left the chimney corner on the 28th of May 1807, after a fit of very hot weather, and revisited their winter residence on the 31st of August. Here they spent the summer merely, and lie torpid at present (Jan. 1808) in the crevices of the chimney, with the exception of those days on which they are recalled to a temporary existence by the comforts of a fire."

Intestina.

Nothing is known with regard to the hybernation of the Intestina. Those which inhabit the bodies of torpid quadrupeds, in all probability, like them, experience a winter lethargy. If they remain active, they must possess the faculty of resisting great alterations of temperature. Among the *infusory animals*, numerous instances of suspended animation have been observed, continued not for a few months, but during the period of twenty-seven years. But such instances of lethargy do not belong to our present subject. Besides, they have been fully discussed under the article Animalcula, in Vol. II. Part I. of this work.

Quiescence of animals.

There is another kind of hybernation, in some respects resembling torpidity, which deserves to be taken notice of in this place, and which merits the appellation of Quiescence. The animals which observe this condition, remain during the winter months in an inactive state, requiring but little food, without however experiencing the change to torpidity.

Of these quiescent animals, the common bear (*Ursus arctos*) is the most remarkable example. Loaded with fat, he retires in the month of November to his den, which he has rendered comfortable by a lining of soft moss, and seldom reappears until the month of March following. During this period he sleeps much, and when awake almost constantly licks with his tongue the soles of his feet, particularly those of the fore paws, which are without hair, and full of small glands. From this source it is supposed that he draws his nourishment during the period of his retirement.

This quiescence appears to differ in its kind from torpidity. This animal is always in season before he retires to his winter quarters, and the female brings forth her young, before the active period of the spring returns, and before she comes forth from her hiding place.

The common badger is supposed to pass the winter in the same manner as the bear, with which, in structure and habit, he is so nearly related. It is also probable, that many species of the genus Arvicola become quiescent, particularly the *amphibia* or common water rat, which always leaves its ordinary haunts during the winter.

It is in this state of hybernation that many of our river fishes subsist at the season of the year when a supply of food cannot be obtained. A similar condition prevails among the fresh water mollusca, and also among many species of Annelides. But we must observe, that accurate observations on this branch of the subject are still wanting.

In concluding the subject of torpidity, it may be proper to mention a few of those questions to which it has given rise, without, however, going into detail. It has been asked, Is torpidity a condition natural to those animals, or is it a habit produced by external circumstances? Mr Gough indeed considers "the torpidity of these animals in a wild state, to be nothing but a custom, imposed by necessity, on a constitution which nature has intended to retain life during the cold season of winter, with but little food, and an imperfect degree of respiration, as well as a languid, or perhaps a partial action of the sanguiferous system." Since these animals, when in a natural or perfectly wild state, invariably become torpid, we must regard such a condition, not as the effect of "custom imposed by necessity," but as the effect of a law of their constitution, enabling them to accommodate themselves to circumstances natural to their condition.

Some have supposed that these torpid animals were at first natives of warmer regions, and have acquired the habit of torpidity, in consequence of having removed to colder countries. Before attempting to account for the occurrence of torpidity in such circumstances, a proof of the assertion regarding the origin of these torpid animals ought to be given. Besides, we know but little of the effects exerted by climate on this tendency to become torpid; neither do we know whether our torpid animals would remain all the year active and lively if removed to a warmer country, nor whether the animals of warmer countries would become torpid if brought to us. The fact, that torpid animals are chiefly found in cold countries, is a proof of the great influence exerted by climate on the habits of animals; but it is also probable, that this influence will be chiefly felt, where the constitution has been previously arranged, to accommodate itself to the vicissitudes of cold regions.

In all these different kinds of hybernation, we meet with difficulties in investigating the laws of animal life. We cannot account for the phenomena which present themselves, or ascertain the relation of these to external objects. But it is both easy and delightful to trace the benevolent intentions of nature in providing for the wants of her creatures, in accommodating their feelings and propensities to the circumstances in which they are placed, in removing them from situations of danger, and in continuing to them life, and health, and enjoyment. (J. F.)

HYDATIDES. See MEDICINE.

Boundaries. HYDERABAD, is a province of the Deccan, in India. It is situated between the 16th and 19th degrees of north latitude, and bounded on the north by the Godavery, on the south by the river Krishna, on the east by the province of Gundwana, and on the west by Beeder and Aurungabad. History. It formed a considerable portion of the ancient kingdom of Telingana, which, in its independent state as a distinct Hindoo sovereignty, comprehended the principal part of the tract between the rivers Godavery and Krishna, and of which the capital city was Warangol. It was reduced at an early period of the Mahommedan invasion, and afterwards formed part of the great Bhamenee Empire of the Deccan. On the dissolution of this state, Telingana became again the seat of an independent government under the name of Golconda, the first sovereign of which, Kooli Kuttub Shah, established the Kuttub Shahy dynasty in 1512. One of his successors, Abdullah Kuttub Shah, who ascended the throne in 1586, became tributary to the Mogul Emperor Shah Jehan; and, in this state, the kingdom remained till 1687, when the reigning sovereign, Abou Houssein, was deprived of his capital Golconda by the Emperor Aurungzebe, and imprisoned for life in the fortress of Dowlatabad. It was not till after a protracted siege, and only, at length, through the treachery of one of the king's sirdars, that the Mogul Emperor obtained possession of the place; and it is related that, when some of the assailants had fought their way into the apartment, where Abou Houssein was seated at supper, he requested them, with much composure, to sit down and partake with him, and that they quietly accepted the invitation. On the destruction of the Mogul empire, after the death of Aurungzebe, Nizam ul Moolk obtained possession of the Mahommedan conquests in the Deccan, about the year 1717. Under his successors, the limits of the state experienced much fluctuation; but its power was gradually declining, and would have been totally annihilated by the Mahrattas, had not the British government interposed for its support. Treaty with East India Government. In 1800, a treaty of perpetual alliance was concluded with Nizam Ali by Major Kirkpatrick on the part of the British; and by this arrangement a British force of 8000 regular infantry, and 1000 regular cavalry, with their proper complement of artillery and warlike stores, is stationed in the Nizam's territories, for their protection against hostile neighbours or turbulent subjects. For the regular payment of these troops, the Nizam ceded to the East India Company all the territories which he had acquired by the treaty of Seringapatam in 1792, and by that of Mysore in 1799. In the event of a war taking place, the Nizam engaged to join the British with 6000 infantry, and 9000 cavalry of his own army, with the necessary train of artillery and stores. By this treaty it was also arranged, that all the external political relations of the parties should be exclusively managed by the British, who undertook to protect his highness's dominions from every annoyance, and particularly to procure a total exemption from all claims of Choute on the part of the Mahrattas. In 1802, a commercial treaty was negociated, by which the free use of the port of Masulipatam was granted to the Nizam, with a promise of protection to his flag on the high seas; and an equality of duties on the mutual imports and exports was stipulated, the amount of which should not exceed 5 per cent. In 1804, a considerable part of the territories of Dowlet Row Sindia was transferred to the Nizam; by which the Hyderabad sovereignty acquired a great increase of territory, and obtained for the first time a well-defined boundary. At present, the Nizam's dominions, besides the whole of Hyderabad, comprehend Nandere and Beeder, the greater part of Berar, and a portion of Aurungabad and Begapoor, being divided from the Nagpoor territories by the Wurda river, and from the British by the Krishna and Toombuddra. Extent. Hyderabad, which gives the general name to the sovereignty, is about 180 miles in length, and 150 at its average breadth. Climate. The surface of the province is hilly, but not mountainous; and it is an elevated table land, much colder in its temperature than the degree of latitude would indicate. In the city of Hyderabad, and the country to the north of it, the thermometer, during three months of the year, is frequently so low as 45°, 40°, and 35° of Fahrenheit. The soil is fertile and to-

Commerce.

lerably well watered, but indifferently cultivated and thinly inhabited. The cultivators are wretchedly poor, and much oppressed by their Mahommedan superiors, who are subject to little restraint from their nominal sovereign. From the same cause, they are almost destitute of the benefits of commerce; and the average import of European goods into the whole of the Nizam's dominions, prior to 1809, never exceeded £25,000 per annum. The principal towns in the province are Hyderabad, Golconda, Warangol, Meduck, and Niecundah; and the whole population of the district is estimated not to exceed two millions and a half.

Court and government.

The reigning prince, Mirza Secunda Jah, ascended the throne in 1803, and has never been more than a few miles from the city of Hyderabad since the commencement of his reign. His government is absolutely despotic in theory; but, in point of fact, his power is much limited by circumstances. He takes little direct interest in the minutiæ of the executive, which is managed almost entirely by one or other of his ministers, according as their factions prevail, or as they may be able to carry along with them the support of the Company's resident. The influence of the East India Company's government is paramount in the councils of that of their ally, and all great political points are carried with considerable facility; yet, on some late trifling occasions, a lively jealousy has been manifested. While the officer, who had been appointed to conduct the grand trigonometrical survey, was approaching Hyderabad, he had fixed small flags on some points for directing his observations. This gave rise to repeated complaints; as if, in taking a few triangles, he had been taking possession of the country. The political intercourse is carried on by means of a resident, who has a superb mansion on the north-east side of the capital across the river. His suite consists of first and second assistants, a surgeon, and the officers of an escort of two companies of Bengal native infantry. The present Nizam was entertained at the residency on the occasion of paying him his army's share of the Seringapatam prize money, which had been laid out in splendid specimens of English and Chinese manufactures. His Highness was a little alarmed on this occasion, by the accidental firing of a few thousand rockets which happened to lie pointing towards the spectators, but by which fortunately no person near himself was wounded. The entertainment was concluded by laying before him a superbly mounted sabre, which had been sent by Louis XVI. to Tippoo Sultan.

Revenue.

It is difficult to say what is, and what is not, to be reckoned revenue under so irregular a government. Although a very large proportion of the whole produce of the soil be claimed as its share; yet so much of this is stopped for the expences of collection and payment of sebundee, or local troops, and so much is diverted into bye channels, that the sum which finally reaches the treasury is in many cases very small. The produce of the estates granted for military service should be reckoned as part of the revenue, were it not that the service is seldom performed. When lands are not granted to Jaghiredars for specific purposes, the common mode of collection is by Tabood, a farm, in which case any person may make an offer for a lease of a district; and that person is generally preferred who proposes the largest advance of ready money to the minister. Little inquiry is made into the methods which he may use to reimburse himself; and he may do nearly as he pleases, provided he keeps a good understanding at court. Sometimes, however, complaints are listened to if there exist a hope of squeezing a further sum from the fears of the contractor; or, if there be a wish to get rid of him to make way for some other who may have offered a sum of ready money, or a larger portion of his expected profits. The other mode is by Amaunee, and is seldom resorted to unless when a district is in such a rebellious state that no person can be found to farm it. Some military chief is then turned into it to collect what he can, and to account to government for the amount. This, however, is a last resource, as all Indians, whether mussulmans or Hindoos, are adepts at making up accounts so as to suit their own interests.

Mode of collecting.

Military force.

The army of the Nizam, in consequence of the protection afforded by the British troops against the invasions of the Mahrattas, is now on a very inefficient footing. A list of its great officers and their troops, would be merely an enumeration of persons holding estates and emoluments under a nominal agreement to perform services, which they are scarcely expected to fulfil. This is quite true as far as regards the great military jaheridars and risaldars, or cavalry officers, who hold valuable districts in their immediate possession; but there are many corps of mutinous and ill-paid infantry, who have hard service in the collection of the revenue, which the oppressive nature of the government, and the consequent bad faith and turbulence of the zemindars render extremely difficult. These troops are distributed to the different collectorships as occasion may require. With the exception of a few corps patronised by the Company's resident, none of them are either regularly paid, or decently equipped; and many battalions have not one-tenth of their arms in a serviceable state.

Forts.

By a supplementary article in the treaty between the Nizam and the Company's government, it was agreed, that all the forts in the Hyderabad dominions should, in time of a joint war, be open to the British. Of these fortresses, the most important are that of Dowlatabad * and of Golconda. The former, particularly, the most singular perhaps in the world, is situated on a high conical hill, which has its sides pared away perpendicularly in such a manner, that it would now be represented by a whipping-top set upon its head. There is a fortified tower on the plain, through which a passage lies to a tunnel in the bowels of the mountain, affording an ascent to the conical surface above, and opening to the day near the edge of the precipitous side. This upper opening is covered by an iron grating, on which a fire is kept burning when any danger is apprehended. Even after overcoming this obstacle, an enemy would still be required to advance in a path exposed to the whole fire of the fort on the summit. In this fort are lodgments cut in the solid rock for the garrison and their provisions. The fort of Golconda, about five miles west from Hyderabad, though very strong in some places, is, by a strange arrangement, most assailable on the side which at the same time commands all the others. In a piece of broken ground, on the north-west side of the fort, are situated, in an irregular manner, the tombs of the Kootub Shahy kings, which are of such solid masonry, that they would afford bomb-proof lodgment for several battalions, though some of them are within battering-distance of the walls. In the lifetime of the late Nizam ul Moolk, the garrison used to make a great show of watchfulness and jealousy

Dowlatabad.

Golconda.

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* Doulut-abad, "wealth's abode."

of any armed party approaching their walls; and, on one occasion, actually fired on some ladies and gentlemen, who were amusing themselves in looking at the tombs. Some years ago, a detachment of the Company's troops with a convoy of provisions having halted near them, the Killidar, or commandant, sent out a message to the officer in charge, desiring him to remove his encampment to a greater distance, and threatening that the guns on the works would be used to enforce compliance. The officer replied verbally, that he would not decamp until the next morning; and, pointing to a line of spirit carts, added, that, if a single shot were fired at him from the fort, he was ready to return the compliment. The regularity of his line of carriages, and their compact form, made them be mistaken for so many mortars and battering guns, and immediately produced a more conciliatory tone, with quiet possession of the ground.

A great part of the province is occupied by Jaghiredars, some of whom are military officers in the service of the Nizam, as already mentioned; and the rest are Hindoo Rajahs or Zemindars, whose ancestors have long possessed their estates, and over whom the Nizam exercises a very uncertain and undefined authority. As Hyderabad is one of the few remaining Mogul governments, a greater proportion of Mahommedans are to be found among the higher and middle classes of the inhabitants; but the great mass of the lower classes are still Hindoos in the proportion of above ten to one. In the colder season of the year, the lower classes use a coarse woollen blanket made in the country, while the higher ranks wear shawls and quilted silks. A few of the noblemen and military chiefs clothe themselves in broad cloth, as a piece of fashionable luxury; and the regular infantry, as well as the troops of the principal Jaghiredars, are dressed in British red cloth.

HYDERABAD, the capital of the above province, and of the Nizam's dominions, is situated in 17° 15′ N. Lat. and 78° 42′ E. Long. on the Moossee Nuddee, below its junction with the Moosah, which flows past the walls of Golconda. It was founded about the year 1585 by Mahommed Kooli Koottub Shah, and, in consequence of its vicinity to the river, soon acquired the ascendancy over the neighbouring city of Baugnuggin, of which nothing now remains, except a few traces of the strongest buildings. It was taken and pillaged by the army of Aurengzebe in 1687, its principal inhabitants having retired to the neighbouring fortress of Golconda. The late Nizam Ali, father of the reigning prince, made it the seat of the royal residence in place of Aurungabad, which had hitherto been the capital, but which, by the fluctuation of his territories, had become less centrical, and too adjacent to the Mahratta frontier. The new capital has been exempt from plunder and every hostile molestation, ever since it became the residence of the court, (a circumstance rarely paralleled in India for so long a period) and has rapidly increased in wealth and population. It is surrounded by a stone wall, which would afford no defence against artillery, but which serves as a protection from the incursions of cavalry. It is about four miles in length within the walls, and three in breadth. There are large magazines in the city belonging to the Nizam, in which are deposited the presents received at various times from the different native and European powers. The rooms are filled, almost from the floor to the ceiling, with bales of woollens, cases of glass, glass-ware, china-ware, clocks, watches, and other articles of European manufacture, which always continue locked up in the magazines. The houses and gardens of the Company's civil and military officers, and of a few other European gentlemen resident in the place, form the principal ornament of the environs. Hyderabad, having long been the principal Mahommedan station in the Deccan, contains a considerable number of mosques, and exhibits more of the old forms and ceremonies of the Mogul government than any other metropolis in Hindostan. The noblemen of the place have been bred either as soldiers or courtiers; and, as hoarded treasures would expose them to the avaricious machinations of their superiors, they generally spend their fortunes freely, in keeping up large retinues, or in the fashionable profligacy of their court. When any property is laid up, it is commonly in the form of ornaments for their females and children, which are always more remarkable for their weight than workmanship. A few of the wealthier Mahommedans, especially the Nizam's ministers, are fond of furnishing their houses richly with articles of European and Chinese manufacture, such as porcelain, crystal, lustres, chintz sofa covers, and some articles of plate. A favourite piece of luxury among them is to have an Aeena Khana, a room of which the roof and sides are entirely covered with mirror plates.

Manners of the inhabitants.

His Highness's ministers frequently entertain the resident and his suite at their palaces. The amusements at these parties are troops of dancing girls (kunchinees,) wrestlers (puhlwauns,) mimics (bhans,) and musicians of various kinds, who afford some diversion to a newly-arrived European, but soon become tiresome, and often disgusting. A dinner, partly in the English style, and a magnificent display of fireworks, commonly close the day's entertainments. Some of the Mahommedan chiefs sit at table, and partake of the same fare with the Europeans, from which pork in every shape, it may be supposed, is carefully excluded. The inhabitants of the city, both Mahommedans and Hindoos, though very polished in their manners, are both ignorant and profligate. Crimes are here committed every day with impunity, and even without notice, which would strike with wonder and horror the inhabitants of any countryin Europe. A father, who had murdered his wife for not quietly acquiescing in his preference of his daughter, observed, that "no one had a better right to the fruit than the planter of the tree." The government derives a current revenue from licences to carry on the most horrid practices. Amongst such a people, and with such a government, truth and morality, as it may be supposed, are very rare qualities. The present number of inhabitants, including those of the suburbs, is estimated at 120,000. The distance of the city from Calcutta is 900 miles; from Madras, 391; from Bombay, 480; from Seringapatam, 406; from Delhi, 923. See Orme's *History of Military Transactions in India*; *Asiatic Annual Registers*; Sir John Malcolm's *Political History of India*; Ferishta's *History of the Deccan, translated by* J. Scott, Esq.; Rennel's *Memoir of a Map of Hindostan*; and Hamilton's *East India Gazetteer*.* (q)

Character.

HYDRAULICS. See HYDRODYNAMICS.

HYDROCELE. See SURGERY.

HYDROCEPHALUS. See MEDICINE.

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* In drawing up the two preceding articles, we have been indebted for much important information to John Robison, Esq. F.R.S.E. who spent many years in the Nizam's service. ED.

HYDRODYNAMICS.

Hydrodynamics.

HYDRODYNAMICS, from the Greek Ὑδωρ, *water*, and Δυναμις, *power* or *force*, is that branch of natural philosophy which embraces the phenomena exhibited by water and other fluids, whether they are at rest or in motion. It treats of the pressure, the equilibrium, the cohesion, the motion, and the resistance of fluids; and of the construction of the machines by which water is raised, and in which it is the first mover, or the primary agent. This science is generally divided into *Hydrostatics* and *Hydraulics*, the former of which considers the pressure, equilibrium, and cohesion of fluids; and the latter, their motion, the resistance which they oppose to moving bodies, and the various machines in which they are the principal agent.

HISTORY.

History.

The general principles of Hydrodynamics known in the earliest ages.

ALTHOUGH Hydrodynamics is but a modern science, and was studied by the ancients only in its most general principles, yet many of the leading doctrines and phenomena upon which it is founded are familiar to the rudest nations, and must have been well known in the very earliest ages of society. Even at that remote period when man first trusted himself to the waves, the pressure of fluids, and the phenomena of floating bodies, were undoubtedly known to him; and in the more advanced stage of navigation, when the Phenicians were able to colonise the most distant regions of the globe, the directing power of the helm, the force and management of the oars, the action of the wind upon the sail, and the resistance opposed to the motion of the vessel, were well known facts, which implied practical acquaintance with some of the most important doctrines of Hydrodynamics.

Invention of Clepsydræ.

The motion of fluids, as affected by the size of the aperture from which they issued, and by the height of the superincumbent column, formed the fundamental principle of the *Clepsydræ* (from *κλεπτω, to steal*, and *ὑδωρ, water*) or water clocks, which were employed in the earliest ages, before the invention of sun dials, to measure time. The simplest, and probably the earliest form in which the Clepsydræ appeared, is that of two inverted cones, as represented in Plate CCCXIII. Fig. 1. This species of Clepsydra consisted of a hollow cone A, perforated at its vertex, and of a solid cone B, which was made to fill A with the greatest exactness. The aperture of A was so adjusted to the size of the cone, that, when filled with water, it emptied itself in the course of the shortest day in winter. The length of the cone was divided into 12 equal parts, which indicated the hours by the descent of the fluid, or the same result was obtained by divisions upon the vessel into which the water flowed. When the days lengthened, and the hours became longer, the solid cone B was introduced into the hollow cone A, and, according to the depth of its penetration, the water flowed from the aperture with less facility. A graduated index BC enabled the observer to accommodate the position of the solid cone to the varying length of the day.

PLATE CCCXIII. Fig. 1.

PLATE CCCXIII. Fig. 2.

Another Clepsydra, of a more ingenious construction, is represented in Plate CCCXIII. Fig. 2. The water is first received into the reservoir A, which is always kept full, and descends by the pipe B into a hole in the great drum MN. This hole corresponds to one of the openings in the groove round the circumference of the small drum LO, which is drawn out in the figure for the purpose of showing it, but when the machine is in use, it is fitted into the drum MN. The apertures of the groove in LO are of different sizes, so as to admit different quantities of water, according to the length of the day, and the proper aperture for the given day is found by placing the index L opposite the sun's place in the zodiac shewn at N, the index O being used for the night hours. The water which descends through the openings in the drum LO is conveyed by the pipe F, and falls through the aperture at G into the reservoir H. As the water rises in the reservoir, the inverted vessel I, suspended by a chain which passes over the axis R, and balanced by a counterweight P, ascends, and consequently the hour hand X, fixed upon the extremity of the axis, is made to revolve, and indicate the hours upon the dial plate.

History.

Clepsydræ.

Discoverie of Archimedes, A.C. 250.

Notwithstanding the ingenuity of these inventions, and the hydrodynamical knowledge which they indicated, the doctrine of fluids may still be considered as deriving its origin from the discoveries of Archimedes. The history of these discoveries has been rendered ridiculous by vulgar fables, which have long been discredited; but it appears unquestionable, that they originated in the detection of a fraud committed by the jeweller of Hiero, king of Syracuse. Archimedes was applied to by the king to ascertain, without injuring its workmanship, whether or not a new crown, which had been made for him, consisted of pure gold: The method of solving the problem is said to have occurred to him when in the bath, and he applied it successfully in detecting the fraud. The hydrostatical doctrines to which Archimedes was thus conducted, were illustrated in a work consisting of two books, and entitled, *περι οχουμενων, de insidentibus in Fluido.* He maintained, that every particle of a fluid mass in equilibrio is pressed equally in every direction. He examined the conditions in consequence of which a floating body assumes and preserves its position of equilibrium, and he applied it to bodies that have a triangular, a conical, and a paraboloidal form. He shewed that every body plunged in a fluid loses as much of its own weight as the weight of the quantity of water which it displaces; and upon this beautiful principle is founded the process which he employed for ascertaining the impurity of Hiero's crown. When the result was communicated to the king, he exclaimed, *Nihil non dicenti Archimede, credam!* The screw of Archimedes, which is still used in modern times for raising water, is said to have been invented by him when in Egypt, for the purpose of enabling the inhabitants to free themselves of the stagnant water which was left in the low grounds after the inundations of the Nile; and Athenæus informs us, that navigators held the memory of Archimedes in the highest honour, for having furnished them with the means of carrying off the water in the holds of their vessels.

Hydraulic machinery appears to have been first invented in the Alexandrian school, which flourished under the patronage of the Ptolemies. Hippocrates, who was the first person that constructed tables of the sun's motion, enabled astronomers to carry the construction of Clepsydræ to a high degree of perfection; and it was probably in his time that the Anaphorical Clepsydræ were invented. Scipio Nasica, the cousin of Scipio Africanus, is said to have invented Clepsydræ about 200 years before Christ; but it is probable that he only introduced them into Rome, for the Egyptians had used them for many purposes at a much earlier period. This invention was carried to a still higher degree of perfection by Ctesibius, who flourished during the reign of Ptolemy Physcus, near the beginning of the second century before the Christian era. When he was one day amusing himself in the shop of his father, who was a barber in Alexandria, he observed, that, during the descent of a mirror, which was counterbalanced by a weight contained in a cylindrical frame, a musical sound was emitted from the narrow space between the roller and its frame. Hence he was led to conceive the idea of a hydraulic organ, which should operate by means of air and water. Having succeeded in this attempt, he applied the same principles to the construction of Clepsydræ, and invented the very ingenious machine represented in Plate CCCXIII. Figs. 3 and 4. which is probably the first machine to which toothed wheels were applied. Fig. 3. represents the outside of the machine, which consists of a cylinder standing upon a pedestal, and of two figures of children, one of which allows the water to fall drop by drop from his eyes, while the other rises and indicates the hour with a wand upon the vertical line AB. The cylinder AB turns round its axis once in a year, and the inequality of the hours in different days is marked by the unequal distances of the horizontal curve lines on the surface of the cylinder. In Fig. 4, which shews the internal construction of the machine, the water rises through the tube A into the figure of the infant on the right hand, and is discharged from its eyes into the square reservoir M, from which it passes, by a hole near M, into the pipe BCD. In this pipe a piece of wood floats upon the surface, and by its ascent, as the pipe fills, it raises the small pillar CD, on which the left hand figure is made to rest, so that the wand points to different hours as the float rises in the pipe. At the end of 24 hours the vessel BCD is filled, and also the arm FB of the inverted syphon FBE, which communicates with it. The water is therefore drawn off by the syphon, and falling in its descent into the buckets of the wheel K, it puts it in motion. This wheel has six buckets, and therefore performs a revolution in six days. Its axis carries a pinion N of six teeth, which works into the wheel I with 60 teeth; and this wheel, carrying a pinion of ten teeth, drives the wheel GO with 61 teeth, which, by its axis OL, turns the pillar L once round in 366 days.

Anaphorical Clepsydra.

Ctesibius. A. C. 120.

Clepsydra with toothed wheels.

PLATE CCCXIII. Figs. 3, 4.

Fig. 3.

Fig. 4.

Hero.

The subject of Hydrodynamics was successfully cultivated by Hero, the friend and disciple of Ctesibius. Besides his treatise on mechanics, in three books, in which he treated at length of the different mechanical powers, and reduced them all to the lever, he wrote a work entitled *Spiritalia* or *Pneumatica*,[*] which contains an account of the Forcing Pump, and of the Fountain of Compression, commonly called *Hero's Fountain*, in which water was raised above its level by the elasticity of the air, which had been condensed by the water. The idea of the forcing pump was probably suggested by the Noria, or Egyptian wheel, which consisted of a number of earthen pots carried round upon the circumference of a wheel.

Water mills.

Although it has been believed, on the authority of an epigram in the Greek anthology, that water mills were invented in the reign of Augustus, yet there is reason to think that they belong to a much earlier period; for Vitruvius, who flourished under Augustus, and who has given a description of these mills, does not speak of them as a recent invention. The Clepsydra of Ctesibius indeed, which we have already described, contains all the machinery of an overshot water mill. The wheel K is put in motion by the water, which is delivered into its buckets; and the force of the wheel is employed through the intervention of wheels and pinions, to give a rotatory motion to the vertical pillar.

Julius Frontinus. A. D. 110.

The first experiments on the motion of fluids seem to have been made by Sextus Julius Frontinus, who was inspector of the public fountains at Rome under the emperors Nerva and Trajan. His work consists of two short books, and is entitled, *Sexti Julii Frontini viri Consularis de Aqueductibus Urbis Romæ Commentarius.* It contains a full account of the different waters which flowed into Rome, of the nature and form of the aqueducts by which they were conveyed, of the times when they were erected, of the quarters of the city which they supplied, the number of public and private fountains from which they were distributed, and the laws which were ordained by the emperors for the management of the public fountains. After fixing the measures which were then used at Rome for ascertaining the quantity of water which flowed from different adjutages, he shews, that the water which flows in a given time from a given orifice does not depend merely upon the magnitude or superficies of the orifice itself, but also upon the height of the fluid in the containing vessel; and that a pipe employed to carry off a portion of the water of an aqueduct, should, according to circumstances, have a position more or less oblique to the direction of the current. Although Frontinus was unacquainted with the true law of the velocity of running waters, as depending upon the height of the reservoir; yet we may consider the foundation of the science of Hydrodynamics as having been laid by his experiments. As the civil engineer will naturally study with a deep interest the first account which has been given of one of the most important branches of his profession, we would recommend, as an accompaniment to the work of Frontinus, the three learned dissertations of Raphael Fabrettus *De Aquis et Aqueductibus veteris Romæ*, which were published in 1679, and are illustrated by copious maps and engravings.[†]

Although the science of Hydrodynamics is so intimately connected with the wants and comforts of man, even in a state of considerable barbarity; yet, during the dark ages, it seems to have been treated with the same indifference as the more abstract sciences; and when physics revived under the auspices of Galileo in the 17th century, the doctrine of fluids was in the same state in which it had been left by Julius Frontinus.

The attention of Galileo was in no respects particu-

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[*] See Heronis *Spiritalia* cura Fred. Commandini 1575, 4to. and 1647 cura N. Alleoti.

[†] The works of Julius Frontinus and Raphael Fabrettus will be found in Grævii *Thesaurus Antiquitatum Romanarum*, tom. iv. p. 1630—1780. A new edition of Frontinus was published by the Marquis Poleni with copious notes.

Galileo.
Born 1564.
Died 1641.

larly directed to the doctrine of fluids; but his discovery of the uniform acceleration of gravity paved the way for the rapid progress of this branch of science. In the *Systema Cosmicum* of this great astronomer, we find some occasional observations on the oscillation of fluids, which are marked with his usual sagacity; and in the first dialogue of his Mechanics, Sagredo enters into a very interesting inquiry respecting the ascent of water in pumps. Galileo had studied the operation of a sucking pump, which had been erected to raise water out of a cistern. He describes the pump as having its piston raised high above the surface of the fluid, and he remarks, that in this case the water ascends by the attraction of the piston, whereas in pumps where the piston is in the lower part of the tube, the water rises by the impulse of the piston. He was surprised, however, to find, that, when the water descended to a certain point, the pump ceased to act, and continued to lose its power, by any further subsidence of the fluid. Being quite satisfied that the pump was broken, he immediately sent for the pump-maker, who, after examining the machine, assured him, "that the water would not suffer itself to rise to a greater height than 18 cubits, whatever were the dimensions of the pump." After reflecting upon this singular fact, Galileo satisfies himself with the following explanation. When a rod of any solid substance whatever is suspended by one end, it may be made of such a length as to break by its own weight; and, in like manner, if a rod or column of water is raised in a pump to the height of 18 cubits, its weight overpowers the attraction of the piston and the mutual cohesion of the fluid particles.*

Toricelli.
Born 1608.
Died 1647.

This extraordinary explanation of the ascent of water in pumps attracted, no doubt, the attention of his pupil Evangelista Toricelli, by whom the fact was afterwards completely explained; and having learned from his master that the air possessed weight like all other bodies,† he entered upon the study of this branch of Hydrodynamics with very singular advantages. In the year 1643, the year after the death of his master, Toricelli being desirous of making an experiment on a small scale in the vacuum left between the piston of a pump, and the column of water which it raised, it occurred to him, that, if he substituted in place of the water a denser fluid, such as mercury, the same cause which supported the water would support a column of mercury of the same height. He communicated this idea to his friend Viviani, who performed the experiment with success, and Toricelli afterwards repeated it with considerable modifications. He accordingly provided a glass tube about three feet long, and hermetically sealed at one end, and having filled it with mercury, he closed it at the open end with his finger, and inverted it in a basin of mercury. Upon withdrawing his finger, the column of mercury descended, and settled at the height of about 29 inches in the tube. Toricelli was not immediately aware of the cause of this singular result; but a little reflection convinced him that it was owing to the pressure of the external air, and that the weight of the atmospherical column was balanced by the 29 inches of mercury in the tube, and by the 33 feet of water in the bore of the sucking pump. When this explanation was fully impressed upon his mind, Toricelli is said to have regretted, with a feeling of generosity of which there is no other example, that it had not fallen to the lot of his master to complete a discovery of which he had the merit of laying the foundation.

Toricelli.

The labours of Toricelli were not confined to Hydrostatics. Having observed, that when a *jet d'eau* was formed by the ascent of water through a small adjutage, it rose nearly to the same height as the reservoir from which it came, he sagaciously conjectured, that it ought to move with the velocity which it would have acquired by falling through the same height. Hence he deduced the fundamental proposition, that, abstracting all resistances, the velocities of fluids in motion are in the subduplicate ratio of the pressures. This result was published in 1643 at the end of his treatise *De Motu Gravium naturaliter accelerato*, and though true only in small orifices, it was confirmed by the experiments of Raphael Magiotti, and paved the way for the discovery of the more complex law, which regulates the motion of fluids, when the area of the orifice has a considerable magnitude compared with the horizontal section of the vessel.

Castelli.
Born 1577.
Died 1644.

The subject of running water had been previously studied by Benedict Castelli, the disciple of Galileo, and the first master of Toricelli. Pope Urban VIII. had requested him to devote his attention to this interesting subject, when he was employed in teaching mathematics at Rome; and in order to discharge the duty which was thus imposed upon him, he made numerous experiments, of which he published a full account in a small treatise *Della Mesura dell' acque correnti*, which appeared in 1628. In this work he explains several phenomena relative to the motion of fluids in rivers and canals of any shape, and he shews, that when the water has come to a state of permanent motion, the velocities at different sections of the river or canal are inversely as their areas. He applies these general propositions to the course of some rivers, and he explains several phenomena in a manner tolerably satisfactory. The conclusions which he draws are gene-

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[*] As a very different account of this interesting anecdote is given in all the Histories of Hydrostatics and Pneumatics, we have subjoined the account of it given by Galileo himself in his *Discursus et Demonstrationes Mathematicæ*. Dial. vol. i. p. 15.

"Sagr. Et ego hujus discursus ope causam invenio cujusdam effectus, qui diutissime mentem meam admiratione plenam, intellectu vero, vacuam reliquit. Observavi Cisternam, in qua ad extrahendam aquam constructa erat Antlia cujus ope minori cum labore eandem aut majorem aquæ quantitatem, quam urnis communibus, forsan (sed frustra) attolli posse credebam: Habetque hæc Antlia suum Epistomium et lingulam in alto positam, ita ut per attractionem non vero per impulsum adscendat aqua, sicut istæ Antliæ faciunt, quæ a parte inferiori suum opus exercent. Hæc autem magna copia aquam attrahit, donec ea in cisterna ad determinatam quandam constiterit altitudinem; ultra quam si subsederit inutilis est Antlia. Ego, cum prima vice accidens istud observarem, instrumentum fractum esse credens, Fabrum accersivi, ut illud repararet; qui nulli rei istum defectum adscribendum esse mihi respondebat, præterquam ipsi aquæ, quæ nimis depressa ad tantam altitudinem attolli se non patiebatur; subjungens nec Antlia nec quavis allia machina, quæ aquam per attractionem elevat, eam nequidem pili latitudine altius attolli quam octodecim cubitos; et sive largior sive angustior sit Antlia, hanc maxime definitam ejus esse altitudinem. Et ego, licet jam pernoscam, chordam, massam ligneam et virgam ferream eousque prolongari posse, ut in altum erecta proprio diffringatur pondere, ejus imprudentiæ hucusque reum me feci, ut idem in chorda aut virga aquæ multo facilius evenire posse non meminerim: et quid illud quod per Antliam attrahitur, est aliud, quam Cylindrus aqueus qui superne affixus cum magis magisque prolongetur, ad eum tandem attingit terminum ultra quem elevata, a pondere suo excessivo ad instar chordæ disrumpitur."

[†] This important doctrine is demonstrated by Galileo from two experiments, which he describes in his *Discursus et Demonst. Mathemat.* Dial. vol. i. p. 71, 72.

rally correct; but he has committed a mistake in making the absolute velocity proportional to the declivity of the canal, or to the height of the water.*

Pascal. Born 1623. Died 1662.

As soon as the curious results obtained by Toricelli were known in France, the celebrated Pascal, who was then residing at Rouen in Normandy, repeated them with great care, and under various modifications, in the year 1646; and in 1647 he published his *Experiences Nouvelles touchant le vuide*, from which he concluded, that the upper part of the tubes of glass which he used did not contain air similar to that of the atmosphere, nor any portion of water or mercury, and that it is entirely void of every material substance with which we are acquainted. He inferred also, that all bodies have a repugnance to separate into parts, and that this repugnance, which does not vary with the magnitude of the vacuity, is equivalent to the weight of a column of water 33 feet high. This little work was vehemently attacked by Father Noel; and Pascal was led, by the views and experiments of which we have given a detailed account in our article on the BAROMETER, to demonstrate the important principle in Hydrodynamics, that the rise of water in pumps was owing to the pressure of the atmosphere.

The researches of Pascal on the gravity of the air naturally led him to the examination of the laws which regulate the equilibrium and pressure of fluids. Stevinus had already observed, that the force exerted upon the bottom of a vessel by the superincumbent fluid was equal to the weight of a column of fluid, whose base was equal to that of the vessel, and whose height was the height of the fluid, and the quaquaversus pressure of fluids had been generally known; but it was reserved for Pascal to deduce from these principles the general laws of the equilibrium of fluid bodies. He supposes, that two apertures are made in a vessel full of fluid, and enclosed on all sides, and that two pistons applied to these apertures, are pushed with forces proportional to the areas of the apertures; and he demonstrates, in two different ways, that, under these circumstances, the fluid will remain in equilibrium. In the first demonstration he shews, that the pressure of the piston is communicated to every particle of the fluid, so that if the one piston advances through a certain space, the other must retreat; and as the volume of water continues invariable, the spaces described by the two pistons will be reciprocally proportional to the area of their bases, or to the forces which impel them. Hence it follows, from the principles of mechanics, that the two pistons are in equilibrium. This general theorem conducts its ingenious author to the different cases of the equilibrium and pressure of fluids, which flow from it as so many corollaries. These fine results were not published during the life of Pascal, but were found after his death in a MS. entitled *Sur l'Equilibre de Liqueurs*, which appeared in 1663, a year after the death of the author.

Labours of Descartes. Born 1596. Died 1650.

Although Descartes is not entitled to be considered as the discoverer of the pressure of the atmosphere, yet it is obvious from one of his letters, which is dated in 1631, that he considered the suspension of the mercury in a glass tube as arising from the pressure of the superincumbent column of air; and by the same cause he accounts for the force with which a glass filled with air rarefied by heat adheres to the palm of the hand when it is quickly inverted upon it. In another of Descartes' letters, of a date only a little posterior to the publication of Galileo's Mechanics, he criticises this work with unjust severity, and, rejecting the idea of a vacuum as entertained by Galileo, he ascribes the adhesion of two polished surfaces to the pressure of the atmosphere, and attributes to the same cause the elevation of water in the sucking pump; and in another letter he maintains, that, in reservoirs kept full of water by the superior aperture being shut, the fluid is not suspended by the dread of a vacuum, but by the weight of the air.†

Mariotte. Died 1684.

M. Mariotte, who was the first person that introduced experimental philosophy into France, contributed greatly to the progress of practical Hydrodynamics. Possessing the rare talent of contriving and performing experiments, he embraced the opportunity which circumstances presented to him of executing a great number of experiments on fluids at the splendid water-works of Versailles and Chantilly. An account of the results which he obtained was published in 1684 after his death in his *Traité du mouvement des Eaux*. In this work Mariotte employs the theorem of Toricelli; and though he treated some important points very superficially, and committed considerable errors in the discussion of others, yet it contains many valuable materials. He was unacquainted with the diminution of efflux, which arises from the *vena contracta* when the adjutage is a perforation in a thin plate; but he had the honour of being the first who ascribed the discrepancies between the theory and experiment to the effect of friction. Having observed that water suffered considerable retardation even when moving in the smoothest glass tubes, he supposed the retardation to arise from the friction of the particles upon the sides of the tube, in the same way as the velocity of solid bodies is diminished by the friction of the surfaces over which they move. The particles or filaments immediately adjacent to those which rub upon the sides of the tube, outstrip them in velocity, and have their own velocity diminished in a less degree; so that the diminution of velocity arising from friction grows less towards the axis of the tube. Hence the medium velocity of the fluid from which the quantity of efflux is determined, is much smaller than it would have been had there been no friction to retard its motion.

Progress of hydraulics in Italy.

The motion of rivers, or of water in open pipes and canals, is perhaps one of the most interesting subjects in which science can lend her aid to relieve the wants and necessities of man. In Italy, where the fertility of the soil is not more owing to her genial climate than to the numerous canals and rivers with which it is traversed, the attention of her philosophers was imperiously called to the study of moving water. To protect themselves from the inundations with which they were often threatened, it became necessary to divert their rivers into new channels; and the ravages which were thus accidentally made on the territories of their neighbours gave rise to those fierce contentions which never fail to spring from contending interests. The defence of their persons and properties, and the necessity of adjusting the opposing interests of neighbouring states, rendered the cultivation of Hydrodynamics a

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* Several letters from Galileo to Castelli on the motion of fluids, but relating principally to Castelli's opinions, have been published in the *Nuova Raccolta*, tom. iv.

† See *Recueil des Lettres de M. Descartes*, tom. iii. sect. 3. p. 608; tom. ii. lett. 91. *L'eau ne demeure pas dans les vaisseaux par la crainte du vuide, mais a cause de la pesanteur de l'air*, tom. ii. lett. 94.

matter of indispensable necessity among the different states of Italy, and hence a great number of valuable works were produced by the Italian engineers.

Guglielmini. Born 1655. Died 1710.

The most eminent of these engineers was Dominic Guglielmini, who was inspector of the rivers and canals in the Milanese, and who obtained such eminence in his profession, that a new chair on *Hydrometry* was erected for him in the university of Bologna. In his principal work, entitled *La Misura dell' acque Correnti*, he adopts the theorem of Toricelli, and founds upon it a system of Hydraulics sufficiently beautiful in theory, but utterly repugnant to experiment. He regards every point in a mass of fluid as an orifice in the side of a vessel, and as tending to move with the same velocity with which it would issue from the orifice. Hence it follows, that, since the velocities are as the square roots of the depths of the orifices, the velocity must be greatest at the bottom of a stream, and least at its surface; and that the velocity of a river must continually increase as it moves. These results were so hostile to established facts, that Guglielmini himself attempted to reconcile them. He had applied his theory to cases which occurred in the Milanese, and to the motion of the Danube, and he had seen, that the regular progress of the current was often opposed by transverse motions, and by a sort of boiling or tumbling motion which arises from ascending masses of fluid. Hence he supposed that these causes were sufficient to account for the errors of the parabolic theory. Guglielmini had now become acquainted with the labours of Mariotte, and in his work entitled *Della natura dell' Fiumi*, the first part of which appeared in 1697,* and acquired great celebrity to its author, he takes into account the retardation produced by friction and other causes. This work consists of 14 chapters, the three first of which contain definitions and general notions respecting the equilibrium of fluids, and the origin of springs and fountains. In the 4th chapter he treats of the motion of water falling vertically, or descending along an inclined plane; and he examines the various causes, such as friction, the resistance of the air, &c. which extinguish a part of its velocity, and render the theory inconsistent with experiment. The 5th chapter treats of the beds of rivers, their depth, their width, and their declivity. The 6th chapter is an application of the principles laid down in the 5th to the directions which are taken by the beds of rivers. In the 7th chapter he examines the various motions which are observed under different circumstances in the waters of rivers, and he thus follows the current from its source to its embouchure. In chapter 8. he treats of the embouchure of rivers, either when they fall into one another, or into the sea. In chapter 9. he considers the union of several rivers, and the effects which result from it. Chapter 10. treats of the increase or diminution of rivers. Chapter 11. relates to the formation of temporary currents in times of rain. Chapter 12. treats of regular canals, and the methods of deriving them from rivers or reservoirs of water. Chapter 13. treats of the drainage of wet land; and chapter 14. of the precautions which are necessary in changing the bed of a river.

Newton. Born 1642. Died 1727.

Labours of Newton.

In order to demonstrate the inconsistency of the Cartesian system of vortices with the laws of Hydraulics, Sir Isaac Newton directed his particular attention to the investigation of the manner in which the fluid vortices could be produced and preserved, and he has given the results of his inquiries in the 9th section of the second book of the *Principia*, entitled, *De Motu Circulari Fluidorum*. In these elegant propositions, which are the 51st, 52d, and 53d, he lays down the hypothesis, that the resistance which arises from the want of perfect lubricity in fluids is *cæteris paribus* proportional to the velocity with which the parts of the fluid are separated from each other; and he demonstrates, that if a solid cylinder of infinite length revolves, with an uniform motion, round a fixed axis in an uniform and infinite fluid, the periodical times of the parts of the fluid, thus put into an uniform motion, will be proportional to their distances from the axis of the cylinder; whereas, if a solid sphere is made to revolve in a similar manner, the periodical times of the fluid particles will be proportional to the squares of their distances from the centre of the sphere. Hence it follows, from the equality of action and reaction, that the velocity of any stratum of the circulating fluid is a mean between the velocities of the strata by which it is bounded. In considering, therefore, the velocity of water in a pipe, as affected by viscidity and friction, it is obvious that the filaments immediately adjoining to the pipe will be greatly retarded. The contiguous filaments will be kept back by their adhesion to the others, and the velocity will thus increase towards the centre of the pipe, according to a law which is easily deducible from the principle, that the velocity of any filament is a mean between the velocities of the filaments which surround it. M. Pitot was the first person who took advantage of this important principle, and, in the Memoirs of the Academy for 1728, he shewed, that the total diminution of velocity in pipes of different kinds is inversely as the diameters of the pipes.

Newton's *Cataract*.

In the second book of the *Principia*, (See Prop. 36.) Newton has investigated the motion of fluids when issuing from an orifice made in the bottom of a vessel, without limiting himself to the hypothesis of an infinitely small orifice. Supposing the water to be always kept at the same height in the vessel, he considers the cylindrical mass of fluid as divided into two parts, one of which is in the centre of the vessel, and moveable; while the other, which is immoveable, is formed by the part of the fluid in contact with the sides of the vessel. The central portion, which Newton calls the *Cataract*, is supposed to have the form of a hyperboloid, formed by the revolution of a hyperbola of the 4th degree round the axis of the cylinder. The horizontal strata of the cataract are always in a state of gradual descent; while all the rest of the fluid is absolutely at rest, as if it had been converted into ice. From this manner of considering the subject, it followed, that the water ought to issue with a velocity equal to that which it would acquire by falling through the height of the fluid; but when Newton came to investigate the subject experimentally, he concluded, that the velocity of efflux was only that which was due to half the height of the fluid. This result, however, was in direct opposition to the known fact, that jets of water rise to nearly the same height as their reservoirs, and the error arose from his not having attended to the contraction of the fluid vein, (or *vena contracta*) which he afterwards found to take place in such a manner, that, at the distance of nearly a diameter of the orifice from the orifice itself, the section of the vein of issuing fluid is reduced or contracted in the ratio of 1 to the square root of 2, or of 1 to 1.4142. He accordingly corrected

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* The second part of this work did not appear till after his death in 1712. The whole was published with notes by Manfredi in the *Nuova raccolta di autori che trattano del moto dell' acque*, tom. ii.

this error in the edition of the *Principia* which appeared in 1714; and, considering the area of the section of the *vena contracta* as the true area of the orifice from which the water should be conceived to flow, he made the velocity equal to that of the height of the fluid, and obtained results more agreeable to experience. Notwithstanding this additional accuracy to which Newton had brought his theory, it was still liable to the very serious objections, which have been urged against it by succeeding authors. Giannini has written a dissertation against it in his *Opuscula*, and John Bernoulli, in the 4th volume of his works, has demonstrated, that, if such a *cataract* existed, the part of the fluid without the cataract would be stagnant, and consequently would exert a pressure, in virtue of its gravity, against the cataract itself in which the fluid ought to experience no pressure. But, independent of this species of argument, it may be shewn, as Bossut has done, by direct experiment, that when a vessel of water empties itself by an orifice in the bottom, every fluid particle descends vertically, whether it is situated near the axis or the side of the vessel; and that this vertical motion is not changed into a lateral one till the particles are very near the orifice itself.

Newton's enquiries respecting the resistance of fluids.

The subject of the resistance of fluids, one of the most important and difficult in Hydrodynamics, was likewise investigated by Sir Isaac Newton. He first considers the fluid as a rare medium, composed of equal parts, situated at equal distances from each other, and possessing the property of perfect intermobility, so that one particle may strike the solid, without being prevented by any of the adjacent ones. Hence he finds, that if a globe and a cylinder, of equal diameters, move in such a medium with equal velocities, the resistance of the globe will only be one half of that of the cylinder. He next proceeds to determine the absolute resistance which the globe will experience, whether the parts of the fluid are perfectly elastic, or absolutely inelastic. In the case of perfect elasticity, he shews, that the resistance of the globe is to the force by which its total motion may be produced or destroyed in the time that it takes to describe two-thirds of its diameter by a uniform velocity, as the density of the medium is to the density of the globe. In the case of absolute inelasticity, he shews that the resistance is twice as small. After examining the resistance in different mediums, as water, mercury, oil, &c. he advances another theory suited to those mediums in which the globe does not immediately strike all the resisting parts of the fluid, but only communicates to the neighbouring particles a pressure which is transmitted to all the rest. From this theory it follows, that the resistance of a globe is equal to that of the circumscribed cylinder. This hypothetical theory, though it exhibits much of Newton's characteristic ingenuity, is still founded on false principles, and is radically inconsistent with the results of experiment.

Oscillation of waves investigated by Newton.

With the exception of a few observations by Galileo in his *Systema Cosmicum*, we are indebted to Sir Isaac Newton for all that was known in his time respecting the oscillation of waves. In order to investigate this difficult subject, he considers the fluid as at rest in the two vertical branches of a syphon connected by a horizontal branch. If the one column is raised to a greater height than the other, and is then permitted to descend, it will obviously fall below its original level, and raise the other column to a greater height than that at which it formerly stood. This column will in like manner descend, and the opposite column will rise, till, after a certain number of oscillations, the fluid will return to a state of rest. In order to determine the time in which these oscillations are performed, Newton considered the water as in the same state with a pendulum vibrating in a cycloid, and he shews, by a very simple demonstration, that a pendulum, whose length is equal to half the length of the column of water in the syphon, will perform its oscillations in the same time with the fluid. Hence it follows, that all the oscillations of the fluid will be isochronous, whatever be the intensity of the motions of the fluid; and that the velocity of waves will vary as the square roots of their breadth.

Labours of Michelotti. A. D. 1720

The motion of fluids was treated, both experimentally and theoretically, by Michelotti, a celebrated Italian physician, in his work entitled, *De Separatione Fluidorum in Corpore Animali*, published in 1719 or 1720. He rejects Newton's idea of a cataract, and considers the water in a vessel as all frozen, excepting a small part of it immediately above the orifice. This thin plate of water is pressed by the superincumbent solid, which is supposed to melt gradually as the water is discharged. In this work Michelotti criticises, with rather too much severity, a paper "On the Motion of Running Water," published by Dr Jurin in the *Philosophical Transactions* for 1718. Jurin replied to this criticism in the *Phil. Trans.* for 1722, and successfully defended Sir Isaac Newton against the charge of inconsistency which was rashly brought against his doctrine of effluent water by the Italian philosopher.

Couplet. Died 1743.

A series of valuable experiments on the motion of water in conduit pipes, were made on a very large scale by M. Couplet, on the water-pipes at Versailles. These experiments, though not sufficiently varied, shew the great effect which is produced by friction on the motion of water. A full account of them is published in the Memoirs of the Academy for 1732, in the paper entitled *Des Recherches sur le mouvement des Eaux dans les tuyaux de conduite*. The theory which he has founded upon his experiments, and also that which M. Belidor has substituted in its place, are not deserving of notice.

Guido Grandi.

Italy produced about this time several authors on Hydrodynamics, that have acquired considerable celebrity. The most distinguished of these was Guido Grandi, who wrote a geometrical treatise on the motion of water, deduced from the theorems of Galileo and Toricelli. He invented also a method of measuring the velocity of a river at different depths by a tin parallelopiped, which had an aperture that could be opened and shut by a moveable plate. The box was sunk to the required depth, and the orifice opened. After a certain time had elapsed, the orifice was again shut, and the velocity was determined from the quantity of water in the box. Grandi was also the author of several dissertations on the river Æra, and on other small Italian rivers. All these works are published in the *Nuovo Raccolta*, already referred to. Eustachio Manfredi, another Italian author, contributed to the progress of Hydrodynamics. He added valuable notes to Guglielmini's work on rivers. He published a dissertation in conjunction with Zendrini, on the means of preventing the inundations of the Ronco and the Montone in the town of Ravenna; and he was the first person who proved, by decisive experiments made on several of the ancient buildings of Ravenna in 1731, that the bottom of the Adriatic Sea was continually rising. The names of Zendrini, and Frisi, deserve to be mentioned among the Italian writers on Hydrodynamics. Bernard Zendrini, a Venetian mathematician,

Manfredi.

Zendrini.

Frisi.

wrote a very ample work, both theoretical and practical, entitled *De Motu Aquarum,* which contains many excellent practical observations. Frisi composed a work on the method of regulating rivers and torrents, in which he has endeavoured to prove that gravel and sand are original productions, and not the detritus of pre-existing materials. A selection of practical observations from the work of Zendrini will be found in the 5th volume of the *Nuova Raccolta,* and the whole of Frisi's work in the 7th volume of the same collection.

Experiments of the Marquis Poleni. Born 1683. Died 1761.

One of the most celebrated writers on Hydraulics that Italy produced, was the Marquis Poleni, professor of mathematics at Padua. In the year 1695 he published a treatise in 4to, entitled, *De Motu Aquæ mixto,* which, though it contains nothing that possesses much novelty, yet the reader will find in it many observations both of local and general utility. He supposes, that the bed of a river is a rectangular canal, and regarding any perpendicular section of it as an orifice, he gives the name of *dead water* to that which is comprehended between the surface, and a point in relation to which all the fluid molecules would have equal *momenta,* and would therefore be in equilibrium, according to the laws which are observed in the equilibrium of solid bodies: The rest of the water which is comprehended between this centre of equilibrium and the bottom of the canal or orifice, he calls the *living water.* He then considers the motion of the water that flows through the orifice as partly produced by the action which the *living water* derives naturally from its fall, and partly by the pressure which the *dead water* exerts upon the *living water.* Hence arises the title of Poleni's work, *De motu mixto Aquæ.* After detailing a number of experiments, and comparing the results with the theory, he applies the same principles to the motion of rivers, and to the lakes of Venice. His principal work, however, appeared at Padua in 1718, under the title of *De Castellis per quæ derivantur fluviorum aquæ.* This work contains many important observations and experiments. From an extensive series of experiments on the quantity of water discharged by an orifice in the bottom of a vessel, he concluded, that, instead of being proportional to 2AH, A being the area of the orifice, and H the height of the reservoir in the vessel, it was proportional to $2\text{AH}\times\frac{0.571}{1.000}$, which is only a little more than one-half of what is discharged, upon the supposition that the water issues with a velocity due to the altitude H. Poleni was the first person who observed, that a greater quantity of water issued from a small cylindrical tube, fitted into the orifice in the bottom or sides of a vessel, than from a simple orifice of the same diameter. This remarkable fact may be explained by supposing that the fluid vein, instead of suffering a contraction, flows out in a column of the same diameter as the orifice, from the viscidity of the water, and its capillary adhesion to the sides of the tube. We are indebted also to Poleni for a new edition of the works of Julius Frontinus, which he enriched with ample notes. Poleni is likewise the author of a dissertation on dikes, and of another on the measure of running waters, both of which, along with his first work, are republished in the 3d volume of the *Nuova Raccolta.*

Daniel Bernoulli.

Hitherto the science of Hydrodynamics was founded upon vague and uncertain principles; but it was now destined to receive a more scientific form from the labours of Daniel Bernoulli. So early as the year 1726, he communicated to the Academy of St Petersburgh a memoir entitled, *Theoria Nova de Motu Aquarum per Canales quoscunque fluentes.* In this memoir he informs us, that his father having shewn, that the principle of the *vires vivæ* was of great use in the resolution of problems incapable of being solved by more direct methods, it had occurred to him to employ this principle in discovering a true theory of the motion of running waters, and that he had found it to answer his utmost expectations. After the publication of this memoir, which contains merely the germ of his theory, he made a great number of experiments at St Petersburgh in order to illustrate his theoretical views, and was thus enabled to produce his great work, entitled, *Hydrodynamica seu de viribus et motibus fluidorum Commentarii,* which was published at Strasburg in 1738. In considering the efflux of water from an orifice in the bottom of a vessel, he conceives the fluid to be divided into an infinite number of horizontal strata, which are supposed to move in such a manner, that the upper surface of the fluid always preserves its horizontality; that the fluid forms a continuous mass; that the velocities vary by insensible gradations, like those of heavy bodies; and that every point of the same stratum descends vertically with the same velocity, which is inversely proportional to the area of the base of the stratum. By the aid of these assumptions, which are conformable to experience, Bernoulli obtains an equation from the principle that there is always an equality between the actual descent of the fluid in the vessel, and its vertical ascension, which is the principle of the conservation of living forces. In those cases, where sudden irregularities in the shape of the vessel, or other causes, produce rapid changes in the velocity of the fluid strata, he then considers that there is a loss of living force, and therefore the equations founded on the entire conservation of this force require to be modified. In the whole of this investigation, Bernoulli displays the greatest sagacity and originality of thought, though he has taken it for granted, without sufficient evidence, that the law of the conservation of living forces is really applicable to the motion of fluids (a point which it was reserved for D'Alembert to demonstrate); yet his work will be long regarded as one of the finest specimens of mathematical genius.

Daniel Bernoulli's theory of the motion of fluids. Born 1700. Died 1782.

Daniel Bernoulli on the resistance of fluids.

The important subject of the resistance of fluids was likewise indebted to the genius of Daniel Bernoulli. In the *Commentaria Petropolitana* for 1727, he modestly proposed a new method of determining the resistance of fluids, founded upon principles different from those of Sir Isaac Newton; but having found that it gave results quite hostile to experiment, he afterwards called his determination in question in his treatise on Hydrodynamics, and in the year 1741, in the eighth volume of the Commentaries of St Petersburgh, he proposed a very ingenious and elegant method of determining the impulse of a column of fluid falling perpendicularly upon a plain surface infinitely extended. He considers the curve described by every filament of fluid as a canal in which a body moves, which experiences at each point the action of a centrifugal force, and which he supposes also to be subjected to the action of a tangential force, varying according to a given law. He then calculates all these forces, and finds, that the impulsion against the horizontal plane is equal to the weight of a column of fluid whose base is equal to the section of the fluid vein, and whose altitude is twice the height of the fall due to the velocity of the fluid. Although there are cases in which this proposition may be safely and advantageously used in practice, yet it does not easily apply either to oblique impulses, or to impulses against curved surfaces, and it is of no service whatever in determining the resistance of fluids when the resisting body is completely submerged. In order to put this theory to the test of experience, Daniel Bernoulli, and his pupil Professor Krafft, instituted a series of experiments on the impulse of a stream of water against a plain surface placed horizontally. These experiments, which are highly valuable, are published in the 8th and 11th volumes of the Commentaries of St Petersburgh. The stream of water was received on a plain surface fixed on the arm of a balance, which had a scale suspended at the opposite extremity. The weights in the scale were made to balance the resistance produced by the impulse on the surface, and the velocity of the issuing fluid was determined from the distance to which it was projected on a horizontal plane. These results were wonderfully conformable to the deductions of theory. The experimental was always a little less than the theoretical resistance, as appears from the following results.

Resistance by theory	1701	1780	1681	1608	1520	1072
Resistance by experiment	1403	1463	1486	1401	1403	1081

Labours of John Bernoulli. Born 1667. Died 1748.

John Bernoulli, the father of Daniel, was occupied with the subject of Hydrodynamics at the same time with his son; and there is reason to believe, that so early as the year 1726, he was in possession of the chief part of his theory of running water. The work which he composed upon this subject remained in MS. till his death, when it appeared in 1742 in the fourth volume of his works, under the title of *Hydraulica nunc primum detecta et directe demonstrata ex principiis pure mecanicis.* It was also published in the Memoirs of the Academy of St Petersburgh for 1737 and 1738. The method of John Bernoulli is founded upon an assumption not very unlike to the Newtonian cataract; and the principal results of his theory did not differ very widely from those of his son. In the opinion of the celebrated La Grange, it is defective in perspicuity; but Euler, who had seen the MS. congratulates Bernoulli, in a letter prefixed to the work, for having discovered the true principles of Hydrodynamics. In his discourse on the laws of the communication of motion, John Bernoulli has determined, on the same supposition, the resistance of fluids; but the formula, by which he represents the resistance, though sufficiently simple, is still insufficient.

Maclaurin. Born 1698. Died 1746.

About the same time, our countryman, Colin Maclaurin, objected to the theory of Daniel Bernoulli, in so far as he employed the doctrine of the conservation of living forces, and endeavoured to solve the problem of the motion of fluids that are discharged from reservoirs by a more direct method. This method, which is only an extension of the theory of Newton, was published in his Treatise on Fluxions, which appeared in 1742. It is given under two sections, one of which treats of the motion of water issuing from a cylindric vessel, and the second of the motion of water issuing from any vessel; but the method has not been considered as sufficiently rigorous.

Investigations of D'Alembert. Born 1717. Died 1783.

The science of hydraulics was now destined to receive the most important accessions from the genius of the celebrated D'Alembert. When he was employed in generalising the theory of pendulums given by James Bernouilli, he discovered his famous dynamical principle for determining the motion of a system of solid bodies which act upon each other. He considers the velocity with which each body tends to move, as composed of two other velocities, one of which is destroyed, while the other does not obstruct the motion of the adjacent bodies. In applying this principle to hydraulics, he first enquires what ought to be the motion of the particles of a fluid, in order that they may not obstruct one another's movements. He shews, both from theory and experiment, that when a fluid issues from a vessel, its upper surface always preserves its horizontality, from which he concludes that the velocity of all the points of any horizontal stratum, when estimated in a vertical direction, is the same, and that this velocity, which is that of the stratum, ought to be in the inverse ratio of the area of the base of the stratum itself, in order that it may not obstruct the motions of the other strata. By combining this principle with the general one, D'Alembert has reduced all the problems relative to the motion of fluids to the ordinary laws of hydrostatics. The problems which relate to the pressure of fluids against the sides of vessels in which they run, and to the motion of a fluid which escapes from a vessel moveable and carried by a weight, though they had formerly been solved only by indirect method, flow as corollaries from D'Alembert's general principles. This theory has also the great advantage of enabling us to demonstrate, that the doctrine of the conservation of living forces applies to the motion of fluids as well as to that of solids; and the principles of the theory are applicable to elastic as well as inelastic fluids, and to the determination of the motion of fluids in flexible pipes, a case which applies to the mechanism of the human frame. These fine views were first published at the end of D'Alembert's Dynamics in 1743, and they were afterwards more fully developed in his *Traité de l'equilibre et du Mouvement des Fluides*, which appeared at Paris in 1744.

D'Alembert on the resistance of fluids.

After having established the laws of the equilibrium and motion of fluids, D'Alembert next directed his attention to the resistance which they oppose to the motion of solid bodies. This eminent mathematician attributes the slow progress of discovery in this branch of hydrodynamics to those unphilosophical investigations, in which a greater fondness was shewn for the calculus than for the physical principles on which it is founded; and he does not scruple to say, that the choice of these principles was often made, more from their forming a good ground work for the application of the calculus, than from their having a real foundation in nature. In order to avoid this error, D'Alembert first investigated the principles upon which he was to proceed before he thought of the analysis which he was to apply to them; and by this truly philosophical mode of enquiry, he has established a theory founded upon no arbitrary suppositions. He merely supposes that a fluid is a body composed of very small particles, detached, and capable of moving freely among one another. D'Alembert regards the resistance which one body suffers from another as nothing more than the quantity of motion which it loses; and when the motion of a body is changed, he considers this motion as composed of that which the body will have in the following instant, and of another which is destroyed. This principle he found applicable to the resistance of fluids, and the investigation of this resistance he reduces to the laws of equilibrium between the fluid and the solid body. He supposes at first, that a body is by some external means kept at rest in the middle of a fluid which is about to strike it. When the filaments of the fluid strike the solid, they bend themselves round it in different directions, and that part of the fluid which covers the anterior part of the body is, to a certain extent, stagnant. The pressure experienced by the solid, or the resistance which it opposes to the motion of the fluid particles, is occasioned by the loss of velocity which each of these particles sustains. The problem is then reduced to this, to find the velocity of the fluid which slides immediately over the surface of the body, which D'Alembert has done by two different methods, and he then obtains a formula exhibiting the pressure exerted upon the solid. By a little modification of the general method, D'Alembert determines the action of a vein of fluid which strikes a plain surface, and he finds it to be a little less than the weight of a cylinder of fluid, the area of whose base is equal to that of the section of the vein, and whose altitude is double of that which is due to the velocity of the fluid; a result which agrees most wonderfully with the experiments of Bossut, who found that it was always a little less than that which was due to twice the height which produces the velocity.* The results of this enquiry were published in 1752, in D'Alembert's *Essai d'une nouvelle theorie sur la resistance des Fluides*, and the theory was afterwards extended in his *Opuscules Mathematiques*.

Labours of Euler. Born 1707. Died 1783.

The celebrated Euler, to whom every branch of science owes such deep obligations, did not fail to exhibit the wonderful resources of his genius on a subject of such difficult investigation as the theory of running water. In the Memoirs of the Academy of St Petersburgh, for 1768, 1769, 1770, and 1771, he has published a new and complete theory of the motion of fluids, which is founded on the laws of mechanics and hydrostatics, and occupies no less than 513 quarto pages. The first of these memoirs is entitled *De Statu Equilibrii Fluidorum*, and is divided into four sections: 1. *De Natura et varietate Fluidorum.* 2. *De Equilibrio Fluidorum, remota gravitate aliisque similibus viribus.* 3. *De Equilibrio Fluidorum a viribus quibuscunque sollicitatorum*; and, 4. *De Equilibrio Fluidorum a sola gravitate sollicitatorum*, in which he applies his reasonings both to compressible and incompressible fluids. The second memoir is entitled, *De Principiis Motus Fluidorum*; the third, *De Motu fluidorum lineari potissimum aquæ*, and the fourth, *De Motu aeris in Tubis.* In the third memoir, he deduces, from his general theory, explained in the preceding memoir, the solution of a great number of beautiful problems upon a particular species of the motion of fluids, which he calls *linear*. The same general theory is applied in his memoir *De Motu Aeris*, to the linear motion of air. In these memoirs, he reduces the whole theory of the motion of fluids to two differential equations of the second order, and he applies the general principles to the discharge of water from orifices in vessels, to its motion in conduit pipes, whether their diameters be constant or variable. In extending his investigation to elastic fluids, and particularly to air, he obtains very simple formulæ respecting the propagation of sound, and its formation in flutes and in the pipes of an organ. It is much to be lamented, that in all these researches, Euler has proceeded on the hypothesis of a mathematical fluidity, which has no existence in nature. Had he only treated the subject in reference to those resistances, such as cohesion and friction, which modify the action of gravity, the solutions which he has given might have been advantageously applied to the motion of water in pipes and canals.

Lecchi. A.D. 1765.

In the year 1765, a very complete work on the theory and practice of hydrodynamics was published at Milan, by P. Lecchi, a celebrated Milanese engineer. It was entitled, *Idrostatica esaminata ne' suoi principi, e stabilita nelle sue regole della mesura delle acque correnti*, and contains a complete examination of all the different theories which have been proposed to explain the phenomena of effluent water, and the doctrine of the resistance of fluids. The author treats of the velocity and the quantity of water, whether absolute or relative, which issues from orifices in vessels or reservoirs, according to their different altitudes, and he afterwards enquires if this law is applicable to large masses of water, which flow in canals and in rivers, and he demonstrates the rules which have been found most useful in practice for the division and the mensuration of running water. This work contains several pieces by the celebrated Italian geometer Father Boscovich, by whom the work was revised and corrected. The extensive and successful practice of Lecchi as an engineer, has stamped a high value upon his work.

Michelotti, A.D. 1771.

A very extensive series of experiments on the motion of water in pipes and canals, was made at Turin by Professor Michelotti, and at the expence of the King of Sardinia. These experiments were performed upon a splendid scale, and with every attention to accuracy. The water issued from orifices and tubes of various shapes and sizes, from a tower of the finest masonry twenty feet high and three feet square, supplied by a canal two feet wide, and under pressures, which varied from five to twenty-two feet. A huge reservoir, whose area was 289 feet square, built of masonry, and lined with stucco, received the effluent waters, which were conveyed in canals of brickwork, lined with stucco, and having various forms and declivities. Michelotti's experiments on the motion of water in pipes, are the most numerous and exact that have yet been performed. The trials which he made in open canals are still more numerous, but they are complicated, with many unnecessary circumstances, and seem to have been made more with the view of examining some disputed points in hydraulics, than of furnishing us with rules for cases which are likely to occur in practice. A full account of these experiments was published at Turin in 1774, in Michelotti's *Sperienze Idrauliche.* Michelotti published also a memoir on the impulse of a vein of fluid, in which he describes some experiments which do not agree with the common theory. It appeared in the Memoirs of the Academy of Turin for 1778.

Bossut. A.D. 1771.

One of the most zealous and enlightened cultivators of hydrodynamics, was the late Abbé Bossut, who has published a full account of his theoretical and experimental investigations, in his *Traité Theorique et Experimental d'Hydrodynamique*, in 2 vols. 8vo. The first edition was published in 1771; the second edition appeared in 1786, considerably enlarged; and a third edition, with very considerable alterations, was published in 1796. The experiments of Bossut, though made on a much less scale than those of Michelotti, have, in as far as they coincide, afforded similar results; and while they have the merit of equal accuracy, they are much more applicable than those of the Italian philosopher to cases which are likely to occur in practice. In order to determine the motion of the particles of a fluid which was in the act of being discharged from an orifice, Bossut employed a glass cylinder about eight inches high, and six inches diameter, to

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* See Bossut's *Hydrodynamique*, Chap. xiv. Exp. 5, 6, 7, 8.

the bottom of which he fitted different adjutages for the efflux of the water. Whether this vessel was kept constantly full, or emptied itself without any supply, he observed that all the particles descended at first vertically, but at a certain distance from the orifice the lateral particles began to turn from their vertical direction towards the orifice; so that they entered the orifice near its circumference with an oblique motion, which, continuing during a certain time, caused the effluent vein of fluid to have the form of a truncated conoid, whose greatest base was the orifice itself, the smaller base being a vertical section of the fluid, at a certain distance from the orifice. Beyond this section, which Newton called the *vena contracta*, the fluid vein preserved its cylindrical form. Bossut found the height of the conoid to be nearly equal to the radius of the orifice, and its bases to be in the ratio of three to two. He expected to have been able to employ this conoid as one of the elements for determining the quantity of water discharged; but subsequent experiments convinced him that this was impracticable. The contraction of the fluid vein, which Bossut has so well explained, cannot be removed, as Daniel Bernoulli maintained, by applying a small tube to the orifice; for though the quantity of water discharged is thus increased, yet it is never so great as if all the filaments of the fluid had issued in lines perpendicular to the plane of the orifice. Bossut's next object was to perform a complete set of experiments on the quantities of water discharged by orifices in thin plates, and by additional tubes fitted to these orifices. When the orifice was very small in comparison with the size of the vessel, he found that the theoretical law—that the quantity of water discharged was as the product of the line by the orifice, and the square root of the height of the reservoir—was sufficiently correct, and might be employed in ordinary practice. But when the water flowed through an orifice in a thin plate, the contraction of the vein of fluid diminished the theoretical discharge in the ratio of sixteen to ten; and when the fluid was discharged through an additional tube, two or three inches long, so as to follow the sides of the tube, the theoretical discharge was diminished only in the ratio of sixteen to thirteen. In examining the effects of friction and contraction, Bossut found, that small orifices discharged less water in proportion than great ones, on account of friction; and that as the height of the reservoir augments, the contraction of the fluid vein also augments, and consequently the quantity of water discharged diminishes. By combining these two circumstances, he has furnished us with the means of measuring with precision the quantities of water delivered, either by simple orifices or tubes, whether the vessel is kept constantly full, or allowed to empty itself without any supply.

Bossut next proceeds to consider the motion of jets of water. He determines the most suitable form that can be given to the adjutages, and the best proportion between the diameter of the adjutage and that of the pipe in which the water is conveyed. Hence we are able to obtain the best possible effects for the decoration of gardens or public buildings.

As the conducting of water is one of the most important and useful branches of hydraulics, Bossut made a great variety of experiments on the motion of water in canals and pipes. The effect of friction, and of sinuosities or bendings in the pipes, is so remarkable, that the quantity of water actually delivered may be twenty or thirty times less than what might have been expected from theory. M. Bossut has shewn, that when the height of the reservoir is increased, the diminution in the discharge of the water is less sensible. He points out the law, according to which the discharge diminishes as the pipe becomes longer, or as the number of its bendings is increased. In considering the motion of water in open canals, he first examines the law, according to which the friction diminishes the velocity of the stream in rectangular canals; and he shews, that in an open canal, with the same height of reservoir, the same quantity of water is always discharged, whatever be its declivity and its length; whereas in pipes there is a very remarkable variation, by a variation in its declivity and its length. He found, that the velocities in a canal are not as the square roots of the declivities; and that at an equal declivity and an equal depth of the canal, the velocities are not as the quantities of water discharged. The subject of rivers next occupies the attention of our author. He considers the variations which take place in the velocity and level of the waters when two rivers unite, and the manner in which rivers form and establish their beds. He next treats of the formation of bars at the mouths of rivers, or at the junction of two rivers; he points out the means which may be successfully employed, either in removing wholly or in part these dangerous banks; and he concludes this part of his work, by determining the change which takes place in the depth of a river, when any change takes place in the width of its bed, as happens from the construction of a bridge; and by ascertaining the depression of its level when a part of the river is turned aside for any useful purpose.

Experiments of Bossut, D'Alembert, and Condorcet, on the resistance of fluids. A.D. 1775.

The experiments of Bossut, on the resistance and percussion of fluids, were made with singular care. His first trials, which were published in 1771, related chiefly to the impulse of a vein of fluid against a plain surface; but he afterwards extended them to many more useful questions. In the year 1775, the celebrated Turgot, comptroller-general of the finances of France, appointed Bossut, D'Alembert, and Condorcet, as a commission, for the purpose of executing a new set of experiments on the resistance which fluids oppose to the motion of bodies of various forms. These experiments were made almost solely by Bossut, within the grounds of the Ecole Militaire at Paris, in a bason of water 100 feet long, 53 feet wide, and 6½ feet deep; and the results which they obtained were published in 1777, in a separate work, entitled *Experiences sur le resistance des Fluides*. According to theory, the impulse upon a plane surface is equal to the area of the surface multiplied by the square of the velocity of the fluid, and the square of the sine of the angle of incidence. Bossut found that this measure of the resistance was sensibly correct, when the fluid impinged perpendicularly upon the surface; that the deviation from the theory increased with the angle of incidence; but that the theory might still be employed when this angle was not less than 50°. As the funds intrusted to the commission had been managed with the utmost economy, Bossut employed the surplus in determining the resistance experienced by all kinds of prows, whether plane, angular, or curvilineal. These experiments were performed in 1778, and were published in the Memoirs of the Academy for that year. He next made a number of experiments on the effects of undershot and overshot water wheels. The former he found to give a maximum effect when the velocity of the stream was to that of the wheel as five to two, while the effect of the latter increased with the slowness of their motion. The valuable labours of Bossut were recompensed by M. Turgot, who established for him in the Louvre a professorship of Hydrodynamics, to which he was appointed in 1775.

Labours of La Place. Born 1749.

We have already seen, that Newton was the first philosopher who investigated the laws of the motion of waves. His theory was, however, only an approximation to the truth, and, as he himself was aware, was suited only to the hypothesis, that the particles of the fluid ascended and descended vertically in the course of their vibrations. When the ascent and descent is made in curve lines, the velocity of the waves cannot be accurately determined by Newton's method. It is only by means of the general laws of the motion of fluids that this subject can be properly treated. M. De La Place was the first who applied this mode of investigation to rectilineal undulations, in the Memoirs of the Academy of Sciences for 1776. This investigation is contained in a separate section, *Sur les ondes*, published in his paper entitled *Suite des Recherches sur plusieurs points du Systeme du Monde*. He supposes the water to be shut up in a canal infinitely narrow, and of an indefinite length, but of a constant depth and breadth. He imagines that the wave is produced by immersing a curve in the fluid to a very small depth. The curve being kept in its place till the water has recovered its equilibrium, it is then drawn out, and waves are formed by the water while it recovers its equilibrium. When the curve is plunged more or less deep into the fluid, the time of the propagation of the waves to a given distance will be always the same, as the oscillations of a pendulum are constant, whatever be the length of the arcs which they describe, provided they are very small. If the depth of the canal is very great, in proportion to the radius of curvature of the curve at its lowest point, the times of the propagation of waves generated by different curves, or by the same curves in different situations, are reciprocally as the square roots of the radii of curvature; and the velocities of the waves are directly as the same roots. Hence La Place concludes, that the velocity of waves is not like that of sound, independent of the primitive agitation of the air.

Flaugergues on Waves. A. D. 1789.

The subject of the oscillation of waves was now examined experimentally by M. Flaugergues, who endeavoured to overturn the opinions of Sir Issac Newton. In a memoir on the motion and figure of waves, of which an abstract is given in the *Journal des Sçavans* for October 1789, Flaugergues gives an account of a series of experiments which he made upon this subject. He combats the opinion of Newton, that waves arise from a motion of the particles of the fluid, in virtue of which they ascend and descend alternately in a serpentine line, while they move from their common centre; and he attempts to prove, that they are a kind of intumescence raised round the common centre, by the depression which the impulse has occasioned; and that this intumescence is afterwards propagated circularly from the centre of impulse. A portion of the intumescence, or elevated water, flows, as he conceives, from all sides into the cavity formed at the centre of impulse; and this water being, as it were, heaped up, produces another intumescence, which occasions a new wave, that is propagated circularly as before. M. Flaugergues proceeds to determine the figure of a wave, and gives the equation of it, and also the equation of the curve which the centre of gravity of a vessel describes from the motion of waves. From this theory he deduces the conclusion, that all waves, whether great or small, have the same velocity; whereas Newton made their velocity proportional to the square roots of their breadth. In order to examine this result, our author made the following experiment on a branch of the Rhone, shut up at one end to make the water stagnant. Having measured a distance or base of thirty feet, he threw into the water small stones at the end of this base, and he found that the waves which they produced, whether they were great or small, occupied exactly twenty-one seconds in moving over the space of thirty feet.

La Grange. Born 1736. Died 1813.

In the Memoirs of the Academy of Berlin for 1781 and 1786, and also in his *Mecanique Analytique*, M. De La Grange, one of the most distinguished mathematicians of the last century, has endeavoured to determine the oscillation of waves in a canal. He found that it is the same as that which a heavy body would acquire by falling through a height equal to half the depth of the water in the canal. Hence, if the depth of the canal is 1 foot, the velocity of the wave will be 5.495 feet, and, at greater or less depths, the velocity will be as the square roots of the depth, provided it is not very great. If it is admitted, that when waves are formed, the water is affected only to a small depth, the theory of La Grange will give tolerably correct results whatever be the depth of the water in the canal, and the figure of its bottom; but although this supposition is countenanced by experience, and derives probability from the viscidity of water, yet La Grange's theory does not harmonize with experiment. Dr Wollaston observed, that in a place where the depth of the water was said to be 50 fathoms, a bore, or large wave, moved at the rate of one mile in a minute; whereas La Grange's theory gives only 40 fathoms as the depth which corresponds with the velocity. Dr Thomas Young has also observed, that the waves, or oscillations of water in a cistern, always move with a velocity smaller than that of a body falling through half the depth, but nearly in the same proportion.

Experiments and formulæ of Chezy. A. D. 1775.

The first engineer who examined experimentally the motion of water in canals, in reference to the resistances arising from the cohesion of water, and to that kind of friction of which fluids are capable, was M. Chezy, the predecessor of M. Prony, in the direction of the School of Roads and Bridges. Towards the year 1775, when he was working with Perronet on the subject of the canal of Yvette, he was anxious to determine from observation and calculation, the relation which subsisted between the declivity and length of a canal, the width and figure of its transverse section, and the velocity of the water which it conveyed. In the course of this investigation, he obtained a very simple expression of the velocity, involving these different variable quantities, and capable, by means of a single experiment, of being applied to all currents whatever. He assimilates the resistance of the sides and bottom of the canal to known resistances, which follow the law of the square of the velocity, and he obtains the following very simple formula,

$V=\sqrt{\frac{g\,d}{\beta\,s}}$, where g is $=16.087$ feet, the velocity acquired by a heavy body after falling one second; d, the hydraulic mean depth, which is equal to the area of the section divided by the perimeter of the part of the canal in contact with the water; s, the slope or declivity of the pipe; and β, an abstract number to be determined by experiment.

Researches of the Chevalier Buat. A. D. 1779.

The attention of the Chevalier Buat, Lieutenant Colonel of the Royal Corps of Engineers, was called to the subject of hydraulics by the publication of Bossut's *Hydrodynamique* in 1771. In studying the motion of canals and rivers, it occurred to him, that if water possessed perfect fluidity, and flowed in a channel infinitely smooth, its motion would be constantly accelerated like that of heavy bodies descending upon an inclined plane. But as the velocity of a river is not accelerated *ad infinitum*, but soon arrives at a state of uniformity, and is not afterwards increased without some cause, it follows that there is some obstacle which destroys its accelerating force, and prevents it from impressing upon the water new degrees of velocity. This obstacle must therefore be the viscidity of the water, which gives rise to two kinds of resistance, one, namely, which proceeds from the intestine motion of an imperfect fluid, and the other from the natural adhesion of its parts to the channel in which it flows. Our author, therefore, found it to be a general principle, "that when water runs uniformly in any channel, the accelerating force which obliges it to run, is equal to the sum of all the resistances which it experiences, either from its own viscidity, or from the friction of its channel." Encouraged by the discovery of this principle, and by its application to the solution of many important problems, it occurred to M. Buat, that the motion of water in a conduit pipe had a great analogy to the uniform motion of a river, and upon this idea he composed a formula founded on the experiments of Bossut on conduit pipes and artificial canals. The result of this investigation was published in 1779, in the first edition of his *Principes d'Hydraulique*. M. Buat, however, was speedily convinced that a theory so new, and which led to results so different from the common theory, required the sanction of new experiments, more direct and varied than those which had hitherto been made. Through the influence of M. de Fourcroy, director of the Royal Corps of Engineers, the French Minister ordered an annual sum to be put at the command of the Chevalier Buat, for the purpose of performing a set of experiments upon this important subject; and during the years 1780, 1781, 1782, and 1783, he was constantly occupied with these experiments, with the assistance of Messrs Dobenheim and Benezech de St Honoré, two officers of the Royal Engineers. The latter took a particular interest in these researches, and from his great mathematical knowledge, he was of particular service to M. Buat, not only by the general aid which he gave him, but from the number of beautiful problems and important researches which he communicated to the work.

As the experiments of Bossut had been made only on pipes of moderate declivity, M. Buat supplied this defect by using declivities varying from 90° to the 40,000th part of a right angle, and channels which varied from a line and a half in diameter to areas of seven or eight square toises. Experiments were also made with syphons and pipes bent at various angles, and on the resistance both of compressible and incompressible fluids. In this way our author has collected an immense number of facts, which he classed according to their resemblance in one particular point; and by studying the cause of the differences which accompanied their differences in other circumstances, he was led to general rules, by which these differences formed a regular series. The experiments were again classed under another point of resemblance, and the same method followed; and by pursuing this plan, he obtained the following general formula, which represents, in a most surprising manner, the great variety of facts which he has collected; namely,

$$V = \frac{\sqrt{ng}\,(\sqrt{d} - 0.1)}{\sqrt{s} - \text{Log.}\sqrt{s+1.6}} - 0.3(\sqrt{d} - 0.1) \text{ in which}$$

V is the mean velocity in inches per second.

d the hydraulic mean depth, or the quotient which arises from dividing the area of the section of the canal in square inches by the perimeter of the part in contact with the water in linear inches.

s the slope or declivity of the pipe, or of the surface of the water.

$g = 16.087$, the velocity in inches per second which a heavy body acquires by falling in one second.

n An abstract number which was found by experiment to be $= 248.7$.

In 1783, when M. Buat's experiments were finished, they were submitted to the Academy of Sciences through the minister of war, and were afterwards published in 1786, under the title of *Principes d'Hydraulique verifiés par un grand nombre d'experiences faites par ordre du gouvernement*. A third volume of this work was published in 1816, under the title of *Principes d'Hydraulique et Pyrodynamique*. It relates chiefly to the phenomena of heat and elastic fluids.

M. L'Espinasse, A. D. 1784.

In the year 1784, M. L'Espinasse, corresponding member of the Academy of Thoulouse, published two memoirs in the Transactions of that society, which contain very interesting observations on the motion of water through large orifices, and on the junction and separation of rivers. The experiments which are contained in these two memoirs were made in the Fresquel and Aude, two rivers in the department of the Upper Garonne, and on part of the *Canal du Midi*, which is below the lock of Fresquel, towards the point where it meets with the bed of that river.

Don George Juan D'Ulloa. Born 1713. Died 1773.

Don George Juan D'Ulloa, an eminent mathematician, and inspector of the naval academies of Spain, proposed a new physico-mathematical theory of collision, in his *Examen Maritimo*, a work which was published at Madrid in 1771, in 2 vols. 4to. This theory includes all the circumstances of motion, both during the continuance of the shock and after the shock, and embraces the laws of the collision of hard bodies, of soft bodies, and of bodies perfectly or imperfectly elastic, whether they are moved in virtue of constant velocities and accelerating forces, or by both of these causes combined. This theory is however not applicable, as might at first sight have been expected, to the impulse of fluids; but the same author has favoured us with a new theory of the resistance of fluids, which has been adopted by Prony and several other French writers. This theory has, in Prony's opinion, been confirmed by very good experiments, and also by its conformity with the progress and other motions of vessels. It has also, as Prony has remarked, the advantage of presenting the discussion of the question with the different physical circumstances which it involves, an advantage which is not possessed by the ordinary theory. In order to confirm his theory, Don George Juan made the following experiments: He exposed a plane surface of the form of a parallelogram a foot wide, to the action of a current of water which moved with the velocity of two feet per second. When it was immersed just one foot under the water, it supported a weight of 15½ pounds (English measure). When the same plane was sunk two feet in a current of water moving with the velocity of one foot four inches in a second, it supported a weight of $26\frac{1}{4}$ pounds. The following Table shews the theoretical and practical results.

	Velocity of Water.	Depth of Submersion.	Observed Resistance.	Calculated Resistance.
Exp. 1.	2—0 feet.	1 foot.	$15\frac{1}{2}$ pounds.	$20\frac{1}{2}$ pounds.
Exp. 2.	1—4	2	$20\frac{1}{4}$	$39\frac{1}{4}$

The ratio of the observed resistance is as $15\frac{1}{2} : 26\frac{1}{2}$, while that of the calculated results is as 15 to 28. Don George Juan has printed two appendices at the end of his first volume, in one of which he applies his theory to the resistance of elastic fluids; and in the other he examines the experiments of our countryman Smeaton on the maximum effect of water mills. He shews, from this theory, that the velocity of the floatboards ought to be a little less than one half the velocity of the water, in order to produce a maximum effect; a result which is almost exactly the same which Smeaton found from experiment. It is a singular circumstance, that the experiments of Don George Juan give resistances much greater than those of Bossut, D'Alembert, and Condorcet, which were made under great pressures; so that his theory will differ very widely from the best experiments which have been made on the resistance of fluids. Dr Robison has remarked, (see his *System of Mechanical Philosophy,* vol. ii. art. *Resistance of Fluids,* which contains an examination of this new theory), that Don George Juan's equation exhibits no resistance in the case of a fluid without weight. A new edition of the *Examen Maritimo,* with copious notes and additions, was published at Paris in 1783, by M. L'Eveque, entitled, *Examen Maritime, Theorique et Pratique, ou Traité de Mecaniqué, appliquè a la Construction et a la Manœuvre des vaisseaux et autres batimens.*

Researches of Venturi. A.D. 1798.

In the year 1798, M. J. B. Venturi, Professor of Natural Philosophy at Modena, published his experiments and observations on fluids, in a work entitled *Sur la communication laterale du Mouvement dans les Fluides,* which was some time afterwards translated into English by Mr Nicholson. This work contains many new and valuable results, of which the following are the most important. He found, that in any fluid, the parts which are in motion carry along with them the lateral parts which are at rest. This proposition he established by introducing a current of water, with a certain velocity, into a vessel filled with stagnant water. The current, after passing through a portion of the fluid, was received in a curvilineal channel, the bottom of which gradually rose till it passed over the rim of the vessel; and in a short time there remained in the vessel only that portion of the fluid which was originally below the aperture at which the current was introduced. By the aid of this principle, which he calls the lateral communication of motion in fluids, and which he thinks is not sufficiently accounted for by the cohesion of the fluid particles, he explains many facts in hydraulics. In examining the effect of additional tubes, Venturi found, that if the part of an additional tube, near the orifice, has the form of the *vena contracta,* the quantity of water discharged will be the same as if there was no contraction; that atmospherical pressure increases the expenditure through a simple cylindrical tube, compared with that which is seen through an orifice in a thin plate; that in descending cylindrical tubes, whose upper ends have the form of the *vena contracta,* the expenditure corresponds with the height of the fluid above the lower end of the tube; that, with additional conical tubes, the expenditure is increased by the pressure of the atmosphere, in the ratio of the exterior section of the tube to the section of the contracted vein; that cylindrical pipes discharge less water than conical pipes which have the same exterior diameter, and diverge from the place of the contracted vein; that, by suitable adjutages applied to a horizontal cylindrical tube, the expenditure may be increased in the ratio of 24 to 10, the head of water remaining invariable; that the expenditure by a straight tube, a quadrantal arc, and a rectangular tube, each of which is placed horizontally, is nearly as the numbers 70, 50, and 45; and that the expenditure is diminished by the internal roughness of a pipe,—an effect which he conceives is not produced by the friction of the water against the asperities themselves.

Experiments of Coulomb on the resistance of fluids, A.D. 1800.

Although, as M. Prony has remarked, "the results obtained by the Chevalier Du Buat, and his sagacious mode of classifying the different kinds of resistances which appear in the motion of fluids, might have conducted him to express the sum of these resistances by a rational function of the velocity composed of two or three terms only, yet the glory of this discovery was reserved for M. Coulomb." This eminent philosopher, who had applied the doctrine of torsion with such distinguished success in investigating the phenomena of electricity and magnetism, entertained the idea of examining in a similar manner the resistance of fluids; and in the year 1800 he laid before the National Institute of France his memoir upon this subject, entitled *Des Experiences destinées a determiner la coherence des Fluides, et les lois de leurs resistances, dans mouvemens tres lents,* which was published in the third volume of the *Memoires de l'Institut.* In determining the resistance of the air to the oscillations of a globe, Sir Isaac Newton employed a formula of three terms, one of which varied as the square of the velocity; the second, as the $\frac{1}{2}$ power of the velocity; and the third, as the simple velocity: and in another part of the *Principia* he reduces his formula to two terms, one of which is constant, while the other is as the square of the velocity. Daniel Bernoulli [*] has employed a formula similar to this of Newton's; and M. S'Gravesende [†] makes the pressure of a fluid in motion against a body at rest, partly proportional to the simple velocity, and partly to the square of the velocity; while, when the body moves in a fluid, he makes the resistance in proportion to a constant quantity, and to the second power of the velocity. M. Coulomb, however, has proved, by many fine experiments, that there is no constant quantity of sufficient magnitude to be detected, and that the pressure sustained by the moving body is represented by two terms, one of which varies with the simple velocity, and the other with its square. The apparatus by which these results were obtained, consisted of discs of various sizes, which were fixed to the lower extremity of a brass wire, and were made to oscillate under a fluid by the force of torsion of the wire. By observing the successive diminution of the oscillations, the law of the resistance was easily found. The oscillations which Coulomb found to be best suited for this kind of experiments, continued for twenty or thirty seconds; and the amplitude of the oscillations that gave the most regular results, was between 480, the entire division

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[*] *Comment. Petropol.* tom. iii. and v.

[†] *Physices Elementa Mathematica,* tom. i. § 1911.

of the disc, and 8 or 10 divisions, reckoned from the zero of the scale. The following are the principal results which Coulomb has obtained:

1. That in extremely slow motions, the part of the resistance proportional to the square of the velocity is insensible, and therefore the resistance is proportional merely to the simple velocity.
2. That the resistance is not sensibly increased by increasing the height of the fluid above the resisted body.
3. That the resistance arises solely from the mutual cohesion of the fluid particles, and not from their adhesion to the body upon which they act. This result was obtained by covering the oscillating disc with grease, and at other times with coarse sand. In these cases the oscillations suffered no particular change.
4. That the resistance in clarified oil, at the temperature of 69° of Fahrenheit, is to that in water as 17.5 to 1; which expresses the ratio of the mutual cohesion of the particles of oil to the mutual cohesion of the particles of water.

M. Coulomb concludes his experiments, by ascertaining the resistance experienced by cylinders that move very slowly and perpendicular to their axes; but for an account of the results which he obtained, we must refer the reader to the memoir itself, or to the subsequent part of the present article.

Researches of M. Girard.

The first person who thought of applying the law of the resistance of fluids, discovered by Coulomb, to the determination of the velocity of water flowing in natural or artificial channels, was M. Girard, chief engineer of roads and bridges, and director of the works on the canal of Ourcq. In his *Essai sur le mouvement des Eaux Courantes,* and his *Rapport sur le Canal de l'Ourcq,* he adopts as a measure of the resistance the product of a constant quantity, by the sum of the first and second powers of the velocity; and after determining the value of the constant quantity, from twelve experiments of Chezy and Du Buat, he obtains a formula much more simple than that of Du Buat, but representing the experiments with equal precision. Considering that the water which moves over the wetted sides of the channel, or over the film of water which adheres to these sides (*paroi mouillée*), is at first retarded by the viscidity, which tends to keep it upon this film, he concludes, that from this cause the water will experience a retardation proportional to the simple velocity. From the roughness of the channel he deduces a second retardation, (analogous to friction in solid bodies, but differing from it in so far as it does not vary with the pressure,) which is proportional to the second power of the velocity, as it is in the compound ratio of the force and number of impulsions which the asperities receive during a given time. He then expresses the resistance produced by cohesion by $R \times p V$; R being a quantity to be determined by experiments; p, the perimeter of the fluid section in contact with the channel; and V, the velocity; and considering the adhesion of the asperities to the wetted sides of the channel as the same with that of the fluid particles to each other, he makes the resistance due to these asperities equal to $R \times p V^2$, whence he obtains the formula $\frac{g\,d}{p\,s} = R\,(V + V^2)$. M. Prony is of opinion, that the adhesion of the asperities to the *paroi mouillée*, or wetted sides of the channel, ought to be supposed greater than that of the fluid particles; for if the two adhesions were equal, the asperities would have no more tendency to unite to the wetted sides than to the mass of fluid in motion.

Labours of M. Prony. A. D. 1804.

Such was the state of hydrodynamics, when M. Prony published, in 1804, his *Recherches Physico-Mathematiques sur la Theorie des Eaux Courantes.* In order to establish the theory of running waters on a proper foundation, this eminent mathematician collected the best experiments that had been published on the motion of water in conduit pipes, and in natural and artificial channels. Out of this collection he selected 82 of the best, viz. 51 on conduit pipes, and 31 on open canals; and he endeavoured to combine these data with the principles of physics and mechanics, so as to deduce from them general formulæ, from which the velocity might in every case be obtained by calculation. By these means he has been able to express the velocity of water, whether it flows in pipes or open canals, by a simple formula, free of logarithms, and requiring merely the extraction of a square root. The formula, which is applicable both to pipes and canals, is,

$$V = -0{,}0469734 + \sqrt{0{,}0022065 + 3041{,}47 \times G},$$

which gives the velocity in metres; or, when reduced to English feet,

$$V = -0.1541131 + \sqrt{0{,}023751 + 32806{,}6 \times G}.$$

When this formula is applied to pipes, we must take

$G = \frac{1}{4}DK$, which is deduced from the equation

$$K = \frac{H + Z = H}{L}.$$

When it is applied to canals, we must take $G = RI$, which is deduced from the equation $I = \frac{Z}{L}$, R being equal to the mean radius of Buat, or the hydraulic mean depth, as already explained.

M. Prony has drawn up extensive tables, in which he has compared the observed velocities with those which are calculated from the preceding formulæ, and from those of Du Buat and Girard; and it is surprising to observe their agreement with the observed results, and their decided superiority to those of Du Buat and Girard. The progress of hydrodynamics has likewise been greatly indebted to the *Nouvelle Architecture Hydraulique* of M. Prony, which appeared in the year 1790. This able work is divided into two parts; the first of which is a treatise on mechanics, in which the author has explained the general principles of equilibrium and motion, which are necessary for engineers. The second part is divided into four sections: The first section treats of statics, the second of dynamics, the third of hydrodynamics, and the fourth of machines and first movers, considered under the different physical circumstances, which have an influence upon their equilibrium and motion. In the chapter on hydrodynamics, he resolves the general problem of the efflux of water through an orifice in one of the sides of a vessel, upon the supposition that the fluid strata preserve their parallelism, and that their particles descend with the same velocity; and from this he deduces, as a corollary, all the ordinary theory of the motion of fluids. He next gives an account of the experiments of Bossut on the efflux of water, and deduces formulæ by which the results may be expressed with all the accuracy that practice requires. In treating of the impulse and resistance of fluids, he adopts and explains the theory of Don George Juan, and afterwards gives an account of the ordinary theory of resistance, with the experiments by which it has been corrected and rendered applicable to practice. M. Prony then proceeds to give an account of the general and rigorous theory of the motion of fluids, and he applies the equations to the motion of fluids in narrow pipes. In the 5th section, which contains much valuable practical information, the author has treated at great length the subjects of friction and of the strength of men, and has given a detailed account of the history and construction of the steam engine, from the rude form in which it came from the hands of the Marquis of Worcester to the almost perfect state to which it has been brought by our celebrated countryman Mr Watt.

Experiments of Mr Vince, A. D. 1795 and 1798.

In the year 1795, Mr Vince of Cambridge published in the Philosophical Transactions his *Observations on the Theory of the motion and resistance of Fluids, with a Description of the Construction of Experiments in order to obtain some fundamental principle*; and in the year 1798, he published, in the Transactions of that year, another paper, entitled, *Experiments on the Resistance of Bodies moving in Fluids.* The experiments contained in the first of these papers, were made chiefly with the view of ascertaining how far the theory of the motion of fluids could be applied to the discharge of water from vessels. Mr Vince has concluded, from the results of this inquiry, that the great difference between the experimental and theoretical results, in most of the cases which respect the times in which vessels empty themselves through pipes, leads us to suspect the truth of the theory of the action of fluids under all other circumstances. In the second memoir, he gives an account of a variety of experiments on the resistance of fluids, when the resisted body is immersed at some depth in the fluid made with a particular apparatus which he contrived for this purpose. The results which he obtained differ widely from those obtained by Bossut with bodies floating on the fluid, which Mr Vince explains, by supposing, that at the surface, the fluid from the end of the body may escape more easily than when the body is immersed below the surface.

Experiments of Dr Matthew Young.

The late Dr Matthew Young, Bishop of Clonfert, made a number of experiments on the efflux of fluids from orifices of different kinds, of which he has published an account in the 7th volume of the *Transactions of the Royal Irish Academy.* In order to explain the increase in the discharge by inserting an additional tube in an orifice in the bottom of a vessel, he filled a cylindrical vessel with mercury to the height of 6 inches, and inserted in its bottom a tube 7.8 inches long. Having closed the orifice of the pipe, he placed the apparatus under the receiver of an air pump, when the barometer was at 30 inches, and the gauge at 28½, the time of the efflux was in this case 26 seconds; but when the experiment was repeated in the open air, without any variation, the time of the efflux was only 19 seconds. Unless the gauge stood higher than 22½ inches, no difference was observed in the times of the efflux in the open air and in the receiver. When the efflux was made *in vacuo,* the pipe was not filled during the efflux, as it was when the discharge was made in the open air. Hence Dr Young concludes, that the plate of fluid at the orifice, where the additional tube is inserted, has its perpendicular pressure increased by the weight of the column of fluid in the additional pipe, without any increase of its lateral pressure; and, consequently, the quantity of water discharged by a pipe of this kind must exceed that which is discharged by a simple orifice. The results of experiments, therefore, made with additional tubes, will be more consonant to theory than when they are made with a simple orifice, unless when the tube has such a length that a sensible effect is produced by the friction of the fluid against the sides of the tube, or when the additional tube is so short as not to be capable of giving a vertical direction to the particles of water. Dr M. Young found, that this view of the subject agreed remarkably well with the experiments of Mr Vince.

Researches of M. Eytelwein.

In the year 1801, M. Eytelwein, of Berlin, who was known to the public as the translator of Du Buat's works into German, and who was honoured with several employments and titles relative to the public architecture of the Prussian dominions, published a work entitled, *Handbuch der Mechanik und der Hydraulik*, which contains not merely an exposition of the labours of preceding writers, but an account of many new and valuable experiments made by the author himself. The second part of this work, which treats of hydraulics, is divided into 24 chapters. Chap. 1. Treats of the efflux of water from reservoirs, and of the contraction of the fluid vein. Chap. 2. Of the discharge of water from horizontal and lateral orifices in a vessel constantly full. Chap. 3. Of the discharge of rectangular orifices in the side of a reservoir extending to the surface. Chap. 4. Of the discharge from reservoirs with lateral orifices of considerable magnitude, the head of water being constant. Chap. 5. Treats of the efflux from reservoirs which receive no supply of water. Chap. 6. Of the discharge from compound or divided reservoirs. Chap. 7. Of the motion of water in rivers. In this chapter, M. Eytelwein has shewn that the mean velocity of water in a second in a canal, or river, flowing in an equable channel, is $\frac{10}{11}$ths of a mean proportional between the fall in two English miles, and the hydraulic mean depth; and that the superficial velocity of a river is nearly a mean proportional between the hydraulic mean depth and the fall in two English miles. Chap. 8. Treats of the discharge and the swell in the case of falls, weres, and contractions in rivers and canals. In Chap. 9. On the motion of water in pipes, our author expresses the velocity in English feet by the following simple formula: $v=50\sqrt{\frac{dh}{l+50d}}$, where l is the length of the pipe, d the hydraulic mean depth, and h the height of the reservoir. If the pipe is bent into angles or sinuosities, the value of v must be corrected by taking the product of its square multiplied by the sum of the sines of the several angles of inflection, and then by 0.0038. This will give the degree of pressure employed in overcoming the resistance occasioned by the angles, and by subtracting this height from that which is due to the velocity, we may thence find the corrected velocity. Chap. 10. Treats of jets of water. Chap. 11. Of the impulse or hydraulic pressure of water. Chap. 12. Of overshot water-wheels. Chap. 13. Of undershot water-wheels. Chap. 14. Of the properties of air, in so far as they are connected with hydraulic machines. Chap. 15. Of syphons. Chap. 16. Of sucking pumps. Chap. 17. Of forcing pumps. Chap. 18. Of mixed pumps, or the combination of sucking or forcing pumps. Chap. 19. Of acting columns of water. Chap. 20. Of the spiral pump. Chap. 21. Of the screw of Archimedes. Chap. 22. Of bucket wheels or throwing wheels. Chap. 23. Of cellular pumps and Paternoster works. Chap. 24.

Of instruments for measuring the velocity of currents of water.*

Experiments of M. Girard on the motion of water in capillary tubes. A.D. 1814.

During the year 1814, a very extensive series of experiments was made by M. Girard, on the motion of fluids in capillary tubes. We have already seen, that M. Coulomb had given a common co-efficient to the two terms of his formula representing the resistance of fluids, one of which was proportional to the simple velocity, and the other to the square of the velocity. M. Girard has, however, found, that this identity between the co-efficients, which may suit particular fluids under particular circumstances, is not generally admissible; and this idea is confirmed by the researches of M. Prony; from which it follows, that the co efficients ought to be different. M. Prony has deduced the value of these co-efficients from a great number of experiments; but as his formula gives only the mean velocity, which is much greater than the velocity of the fluid contiguous to the pipe or canal, which ought alone to enter into an expression of the retarding force, it follows that the co-efficients deduced from all the experiments hitherto made, have a value greatly inferior to what they ought to have, for the motion of the fluid contiguous to the side of the pipe. The object of M. Girard's experiments was to determine this velocity. He observes, that the velocity of the central filament in conduit pipes differs less from the velocity of the sides of pipes as the diameter of the tube is diminished; and that the theory of the linear motion of fluids, which was first given by Euler in 1770, is strictly applicable to the case where the water flows in very small tubes. Hence the experimental results obtained with tubes of a small diameter, ought to accord best with the formula deduced from theory. In order to make a correct series of experiments of this kind, M. Girard constructed two sets of tubes made of copper, and of uniform calibre, and drawn upon maundrels of steel. The first series was composed of tubes 2.96 millimetres in diameter, and 2 decimetres long. These tubes were made to screw on to one another, and form as many tubes of different lengths, from 20 to 222 centimetres. The second series was composed of tubes 1.83 millimetres in diameter, and capable of being screwed together. These tubes were then fixed horizontally on the sides of a reservoir, which was a cylinder of white iron 25 centimetres in diameter, and 5 decimetres high. The reservoir was kept full by the usual contrivances; and the water discharged by the tube subjected to trial, was received into a copper vessel placed horizontally, and whose capacity had been accurately ascertained. The filling of the vessel was indicated by the instant when the water which it contained had wetted equally a plate of glass which covered almost the whole of its surface, and the time employed to fill this vessel was measured with great accuracy. The temperature of the water was also carefully noted. The results thus obtained amounted to 1200, and were arranged by M. Girard into thirty-four tables, according to the different circumstances of the experiment. When the capillary tube has such a length, that the term proportional to the square of the velocity disappears in the general formula, the velocity with which the fluid is discharged, is affected in a very singular manner by a variation of temperature. If the velocity is expressed by 10, when the temperature is 0° of the centigrade thermometer, the velocity will be so great as 42; or increased more than 4 times when the temperature amounts to 85°. When the length of the capillary tube is below the above mentioned limit, a variation of temperature exercises but a slight influence upon the velocity of the issuing fluid. If the length of the adjutage, for example, is 55 millimetres, and if the velocity is represented by 10 at 5° of the centigrade thermometer, it will be represented only by 12 at a temperature of 87°. In conduit pipes of the ordinary diameter, a change of temperature produces almost no perceptible change in the velocity of efflux. M. Girard also found, that the quantity of water discharged by capillary tubes, varied not only with the fluids which were used, but with the nature of the solid substance of which the tubes were composed. A full account of these valuable experiments will be found in the *Memoires des Sçavans Etrangers* for 1815, which is not yet published.

Investigations of M. Poisson. 1815.

In the year 1815, the National Institute of France proposed as the subject of one of its annual prizes for 1816, *the theory of waves at the surface of a heavy fluid of an indefinite depth.* The prize was gained by M. Augustin Louis Cauchy, a young mathematician of great promise. The differential equations which he has given apply rigorously only to the case, where the depth of the fluid is infinite; and he has treated only of that species of waves which are propagated with velocities uniformly accelerated. The same subject had occupied the attention of M. Poisson, who, before he had seen the Memoir of M. Cauchy, had laid before the Institute formulæ similar to his for the case of infinite depth. M. Poisson has himself studied the subject under a more extended aspect, and has laid before the Institute other memoirs, which we have no doubt, will throw much light upon this difficult branch of hydraulics. He supposes that the water has not received any percussion at the commencement of its motion, and that the waves have been produced in the following manner. A piston of any form is supposed to be plunged in the water to a small depth, and is left there till the equilibrium of the fluid is restored. The piston is then suddenly withdrawn, and waves are formed round the place which it occupied. In determining the propagations of these waves, whether at the surface, or in the interior of the fluid mass, M. Poisson considers only the case where the agitations of the water are so small, that the second and the higher powers of the velocities, and of the displacements of the molecules, may be neglected; for, without such a restriction, the problem would be so complicated, that no solution of it could be expected. He supposes the depth of the water constant throughout its whole extent, so that the bottom is a fixed horizontal plane, situated at a given distance below its natural level. He then treats successively in his memoir, the case of a fluid contained in a vertical canal of an invariable width, and of an indefinite length; and that of a fluid, whose surface is indefinitely extended in every direction. This valuable memoir will, we trust, be published in the Memoirs of the Institute for 1815.

Having thus given a general view of the history and progress of hydrodynamics, we shall conclude this part of the article, by a list of the best works and most important memoirs which have been written on the subject.

Works on hydrodynamics.

Archimedes *De Insidentibus in Fluido.* Id. *De iis quæ in humido vehuntur.* Heronis *Spiritalia.* Edit. Commandini, 1575; Sexti Julii Frontini, *De Aqueductibus Urbis Romæ Commentarius* (Poleni's edit.); Stevini *Hydrostatica;* Schotti *Mechanica Hydraulico-*

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* This abridged account of M. Eytelwein's work, is taken from an excellent abstract of it, drawn up by Dr Thomas Young, and published in the Journals of the Royal Institution.

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Works on hydrodynamics.

Pneumatica, 1657; Baliani *De Motu Gravium*, Geneva, 1646; Toricelli *De Motu Gravium naturaliter accelerato*, 1643; Castelli *Della Mesura dell' acque correnti*, 1628; Pascal *Sur L'Equilibre des Liqueurs*; Descartes *Recueil des Lettres de M. Descartes*, tom. iii.; Mariotte *Traité du mouvement des eaux*, Par. 1686, and *Mem. Acad. Par.* I. 69. II.; Guglielmini *La Mesura dell' acque correnti*; Guglielmini *Della natura dell' Fiumi*. Bologn, 1697; Polenus *De Motu aquæ mixto* Patav. 1697, 1718, 1723; Parent *Mem. Acad. Par.* 1700; Varignon *Mem. Acad. Par.* II. p. 162; *Id.* 1703, p. 238; Picard *De aquis effluentibus, Mem. Acad. Par.* VII. 323; Newtoni *Principia*, lib. ii.; Raccolta *Di Autori che trattano dell moto dell acque*, 3 vols. 4to. Flor. 1723. This collection contains the works of Archimedes, Albici, Galileo, Castelli, Michelini, Borelli, Montanari, Viviani, Cassini, Guglielmini, Grandi, Manfredi, Picard, and Narducci. Polenus *De Castellis per quæ derivantur fluviorum aquæ*, Patav. 1718; Michelotti *De separatione fluidorum in corpore animali*, 1719; Jurin, *Phil. Trans.* 1718, 1722; Couplet, *Mem. Acad. Par.* 1732, p. 113; Daniell Bernoulli *Hydrodynamica seu de viribus et motibus fluidorum commentarii*, Strasb. 1738; *Id. Comment. Petrop.* 1727, 1741; Pitot, *Mem. Acad.* 1727, p. 49; 1730, p. 306; 1732, 1738; John Bernoulli, *Opera*, tom. iv.; and *Comment. Petrop.* 1737, 1738; Cotes *Hydrostatical and Pneumatical Lectures*, 1747; S. Gravesende *Physices Elementa Mathematica*, Leid. 1719, 1742; Maclaurin's *Fluxions*, vol. ii. book ii. chap. xii. § 537—550, Edin. 1742; D'Alembert *Traite de L'Equilibre et du mouvement des Fluides*, Par. 1744; D'Alembert *Essai d'une Nouvelle Theorie sur la resistance des Fluides*, and also his *Opuscules Mathematiques*, tom. vi; Switzer's *Hydrostatics*; Euler, *Mem. Acad. Berlin*, 1752, p. 111; 1755, p. 217; Id. *Nov. Comment. Petrop*. 1768, 1769, 1770, 1771; Id. *Theorie complette de la construction et Manœuvre des vaisseau*; Bouguer, *Mem. Acad. Par.* 1755, p. 481; Lecchi *Idrostatica esaminata ne suoi principi e stabilita nelle sue regole della mesura delle acque correnti*, 1765: Borda, *Mem. Acad. Par.* 1763, p. 358; 1766, p. 579; 1767, p. 595; Käestner *Anfangsgrunde der Hydrodynamik*, Gotting. 1769, and *Nov. Comment. Gotting*. 1769, I. 45.; *Nuova Raccolta di autori che trattano del moto dell' acque*, 7 vols. Parma, 1766. The 1st vol. of this excellent collection contains, 1. Castelli's treatise *Della Mesura*, &c. 2. Several letters of Castelli and other authors. 3. A paper by Montanari on the Adriatic Sea and its currents. 3. A discourse by Viviani on the method of preventing the filling up and the corrosion of rivers applied to the river Arno. 5. Several papers by J. D. Cassini, on the regulation of the courses of rivers; and, 6. Guglielmini's treatise, entitled, *La Mesura*, &c. The 2d volume contains Guglielmini on rivers, illustrated with the notes of E. Manfredi. The 3d volume contains, 1. Guido Grandi's geometrical treatise on the motion of water; 2. Several dissertations, by the same author, on the River Era and the streams in Italy; 3. The Marquis Poleni's treatise *de motu aquæ mixto*; 4. A treatise, by the same author, on dikes, &c.; 5. A letter, by Poleni, on the measure of running waters; 6. A paper, by J. Buteon, on the same subject. Tom. IV. contains, 1. Several hydraulic dissertations by Castelli; 2. Several letters from Galileo to Castelli; 3. A paper, by E. Manfredi, on the construction of a dike upon the River Era; 4. A reply, by Manfredi, to a criticism by Ceva and Moscatelli; 5. A reply, by the inhabitants of Bologna, to those of Ferrara on the course of the Reno; 6. An examination of a book entitled, The Injurious Effects of the Reno, 7. A refutation of another work, published at Modena, on the same subject. Tom. V. contains, 1. A report, by Cardinals Adda and Barberini, on the state of the waters in the countries of Romagna, Ferrara, and Bologna; 2. A report, by Riviera, on the state of the Reno, the Panaro, and the Po; 3. A selection of practical information from the work of Zendrini on running waters; and, 4. A memoir on preventing the inundations of the Ronco and the Montone, by Zendrini and Manfredi. Tom. VI. contains, 1. A translation of Picard's book on levelling; 2. A translation of Gennete's experiments on the course of rivers; 3. Experiments of Bonati in opposition to those of Gennete; 4. Gennete's reply; 5. Remarks, by Manfredi, on the constant elevation of the bottom of the sea; 6. A discourse, by Zanotti, on the beds of rivers near their embouchure; 7. A memoir, by Bolognini, on the ancient and present state of the Pontine Marshes, and on the means of draining them; 8. A comparison of canals, by Narducci; 9. A paper, by Perelli, on a torrent called the Maroggia. Vol. VII. contains, 1. A discourse on the ancient and present state of the Valdichiana; 2. A memoir, by Lecchi, on the Tradate, the Gardaluso, and the Bozzenti; 3. A paper on the inundations of the Adige, by Lorgna; and, 5. A paper, by Frisi, on the management of rivers and torrents. Bossut et Viallet, *Recherches sur la Construction des digues*, 1764. Silberschlag, *Theorie des Fleuves, avec l'art de batir dans leur eaux et de prevenir leur ravages*, 1769; translated from the German. Michelotti, *Sperienze Hydrauliche*, Turin, 1774; and *Mem. Taurinens*, 1788. Bossut, *Traité Theorique et Experimental d'Hydrodynamique*, 2 vols. 8vo. 1771, 1786, and 1796. Fontana, *Dissertazione Idrodinamica*, Mant. 1775. Chevalier Buat's *Traité d'Hydraulique et Pyrodynamique*, 2 vols. 8vo. 1786, and vol. iii. 1816. La Grange, *Mecanique Analytique*; and *Mem. Acad.* Berlin, 1781, p. 151, and 1786, p. 192. Ximenes, *Nuove Sperienze Idrauliche fatte ne canali e né fiumi per verificare le principale leggi e fenomeni delle acque correnti*, Siena, 1780. Id. *Act. Sien.* iii. 16, iv. 31, vii. 1. Lorgna, *Memorie intorno all' acque correnti*, Veron. 1777. Lorgna, *Ricerche intorno alla distributione delle velocita nella sectione de Fiumi.* Id. *Soc. Italian*, iv. p. 369, v. 313, vi. 218. Lambert, *Sur les Fluides considerées relativement a l'Hydrodynamique, Mem. Acad. Berlin*, 1784, p. 299. Langsdorf, *Theorie der Hydrodynamischen grundlehren*, Frankf. 1787. Langsdorf, *Hydraulik*, Altenb. 1794. Cousin Mem. Acad. Par. 1783, p. 665. Parkinson's *Hydrostatics*, 1789. Dr Mathew Young, *Irish Transactions*, 1788, vol. ii. p. 81, and vol. vii. p. 53. Bernhard, *Nouveau Principes d'Hydraulique*, 1787. This work contains a historical and critical discourse upon the different works which have been published on this subject. Prony, *Nouvelle Architecture Hydraulique*, 2 vols. 4to. Paris, 1790. Prony, *Recherches Physico-Mathematiques sur la Theorie des Eaux Courantes*, 4to, Paris, 1804. Burja, *Grundlehren der Hydrostatik*, 1790. Vince, *Phil. Trans*, 1795, p. 24, 1798, p. 1. Atwood, Phil. Trans. 1796, p. 46, *On the Stability of Vessels*, 1798, p. 301. Don George Juan, *Examen Maritimo*, Madrid 1771. This work was translated into French by M. l'Evesque in 1783. La Place, *Mem. Acad. Par.* 1776, and *Mecanique Celeste*, liv. i. chap. iv. viii. liv. iii. chap. iii. iv. Flaugergues, *Journal des Sçavans*, Oct. 1789. Venturi, *Recherches experimentales sur la communication lateral du mouvement dans les Fluides*, Paris, 1797. This work was translated by Nicholson, and published separately in 1798. It appeared also in his *Philosophical Journal*, 4to, vol. ii. p. 172. Fabre, *Sur les Torrens et*

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Works on hydrodynamics.

les Rivieres, Paris, 1797. Mazzuchelli, *Idrodinamico*, 9 vols. Patav. 1795. Coulomb, *Experiences destinées a determiner la coherence des Fluides et les lois de leur resistance dans les mouvemens tres lents*, published in the *Memoires de l'Institut*, tom. iii. p. 246. Eytelwein's *Handbuch der Mechanik und der Hydraulik*. Berlin, 1801. An excellent abstract of this work, by Dr Thomas Young, will be found in the *Journals of the Royal Institution*, No. I. and in Nicholson's *Journal*, vol. iii. p. 25. and 79. Gregory's *Mechanics*, vol. i. Lond. 1806. Dr Thomas Young's *Elements of Natural Philosophy*, 2 vols. Lond. 1807. Mollet's *Hydraulique Physique*, Lyons, 1810. Girard, *Memoires des Sçavans Etrangers* for 1815, and *Journal des Mines*. Poisson, *Mem. de l'Institut*, 1815. Robison's *System of Mechanical Philosophy*, vol. ii. and iii. Art. *Resistance of Fluids, Rivers, and Water-works.*

PART I. HYDROSTATICS.

Hydrostatics.

HYDROSTATICS, from the Greek *ὑδωρ*, *water*, and *ἱστημι*, *I stand*, is that branch of the science of hydrodynamics which treats of the properties of fluids at rest. It comprehends the pressure and equilibrium of non-elastic fluids, the doctrine of specific gravities, the phenomena of cohesion and capillary attraction, and the equilibrium of floating bodies.

Definitions and Preliminary Observations.

Definition of a fluid.

A *fluid* is a collection of very minute material particles, (probably of a spherical form,) which cohere so slightly to each another, that they yield to the smallest force, and are easily moved among one another in every direction.

No polarity indicated by the mechanical phenomena of fluids.

The phenomena exhibited by fluids, whether they are at rest or in motion, afford us no reason to believe, that the particles of which they are composed possess any polarity, or any tendency to arrange themselves in one particular manner more than another. When a mass of water is in a state of perfect equilibrium, a certain point of one particle is in physical contact with a certain point of another particle; but if the equilibrium is destroyed by violent agitation, there is no ground even for conjecturing, that the same points of the particles will return into contact when the equilibrium is restored.

A polarity in certain fluids indicated by their optical properties.

The recent discoveries, however, which have been made in optics, decidedly prove, that in many fluids the particles assume a particular arrangement, analogous to that which is exhibited in some of the crystals of the mineral kingdom, and that they may also be made to assume another arrangement, similar to that which is produced in glass, &c. by compression and dilatation. When these fluids are inclosed in a vessel, the particles uniformly affect a certain arrangement, which is unequivocally indicated by their action upon polarised light. See OPTICS and POLARISATION.

Fluids divided into elastic and inelastic.

Fluids are divided into *elastic* and *inelastic*, or *compressible* and *incompressible* fluids. The class of elastic and compressible fluids consists of atmospherical air, and the various gaseous or aëriform bodies with which chemists have made us acquainted; while the class of inelastic or incompressible fluids comprehends water, mercury, alcohol, and the various oils and liquid acids. The first class, in virtue of their elasticity, are capable of expanding themselves when they are unconfined, so as to fill any given space, or of having their bulk greatly diminished by mechanical compression;* while the second class possess this property in such a small degree, that the diminution of their bulk by mechanical force is scarcely susceptible of accurate mensuration. The science of PNEUMATICS considers the mechanical properties of the first class, and that of HYDRODYNAMICS those of the second class.

Water formerly thought incompressible.

Lord Bacon's experiment.

Florentine experiment.

Till within the last fifty years, it was considered as an established fact, that the class of incompressible fluids could not be reduced in bulk by the application of the most powerful forces. This conclusion was deduced from an experiment by Lord Bacon, who filled a leaden globe with water, and attempted to compress it by a great external force. The fluid, however, made its way through the pores of the metal, and stood like dew upon the surface of the globe. The Florentine academicians repeated the same experiment with a silver globe, and, by violent hammering, they succeeded in altering its form, and expelling the water through the pores of the silver. These trials seem to have established the doctrine of the incompressibility of fluids in its most strict acceptation; but Lord Bacon deduced from them the very opposite conclusion, for, after giving an account of the experiment which we have mentioned, he tells us, that he afterwards computed into how much space the water was driven by this violent pressure.†

Experiments of Canton.

Although the experiment of the Florentine Academy of Del Cimento was considered as decisive of this point, yet it occurred to Mr Canton, about the year 1761, that it was not hostile to the idea of a small degree of compressibility; for the academicians were unable to determine whether or not the water forced into the pores, and through the gold, was exactly equal to the diminution of the internal space by pressure. He accordingly set about a series of experiments on this subject. Having procured a small glass tube about two feet long, and 1¼ inch in diameter, and with a ball at one end of it, he filled the ball and part of the tube with mercury, brought the whole to the temperature of 50° of Fahrenheit, and observed that the mercury stood at a point exactly 6½ inches above the ball. The mercury was then raised by heat to the top of the tube, and the tube was hermetically sealed. The mercury was then brought to the same degree of heat as before, and it now stood in the tube $\frac{12}{100}$ of an inch higher than it did before. By performing the same experiment with water exhausted of air, instead of mercury, he found that the water stood in the tube $\frac{41}{100}$ of an inch above the

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* Air is said to have been reduced to $\frac{1}{1838}$ of its bulk in Hales's experiments.

† See Bacon's *Works*, by Shaw, vol. ii. p. 521, or the *Novum Organum*, Part II. Sect. ii. Aphorism 45, § 222. Bacon seems to have considered all bodies as in some measure elastic; for, after having explained what he calls the motion of liberty, and applied it to the phenomena of tension, he says, "that this motion was unscientifically called by the schools the motion of the *elementary forms*: for it does not only apply to air, water, and flame, but to all the diversities of consistent bodies, as wood, iron, lead, cloth, skins, &c. each body having its own measure of extent or dimension, *from* whence it is with difficulty stretched to any considerable distance." Bacon's *Works*, vol. ii. p. 527. Aph. 48. § 245.

Canton's experiments on the compressibility of water.

mark. Hence it is obvious, that the weight of the atmosphere, or 73 pounds avoirdupois, pressing on the outside of the ball, and not on the inside, had squeezed it into less compass, and that, by this compression of the ball, the mercury and the water would be equally raised in the tube. But the water rose $\frac{11}{100}$ of an inch more than the mercury, and consequently the water must have expanded so much more than the mercury by removing the weight of the atmosphere. In order to determine how much compression was produced, either by the weight of the atmosphere, or by a greater weight, he took a glass ball about 1.6 inch in diameter, joined to a cylindrical tube 4.2 inches long, and $\frac{1}{100}$ of an inch in diameter, and, by weighing the quantity of mercury that exactly filled the ball, and also the quantity that exactly filled the whole length of the tube, he found that the mercury in $\frac{21}{100}$ of an inch of the tube was the 100,000th part of that contained in the ball, and he divided the tube accordingly with the edge of a file. When the ball and part of the tube was filled with water exhausted of air, he placed it in the receiver of an air pump, and also in the receiver of a condensing engine, and he observed the degree of expansion of the water that corresponded with any degree of rarefaction, and the degree of compression that corresponded with any degree of condensation. In this way he found, from repeated trials, that, when the mercury was at a mean height, and the temperature of the air 50° of Fahrenheit, the water rose four divisions and 6-10ths, or one part in 21740, by removing the weight of the atmosphere; consequently the compression of water, under twice the weight of the atmosphere, is one part in 10870 of its own bulk.

In combining these experiments, Mr Canton found, that water was more compressible in winter than in summer, while, on the contrary, alcohol and oil of olives were more compressible when expanded by heat, and less so when contracted by cold. The results were, as expressed in the following Table, suited to the mean weight of the atmosphere.

Temperature in Fahrenheit's scale.	Compression in millionth parts of their own bulk.	
	Water.	Alcohol.
34°	49	60
64°	44	71

The following Table contains all the results which Mr Canton obtained. It is suited to a temperature of 50° of Fahrenheit, and to 29½ inches of the barometer.

Names of fluids.	Compression in millionth parts of their own bulk by the weight of 29½ inches of mercury.	Specific gravities at the same temperature.
Alcohol	66	0.846
Oil of olives	48	0.918
Rain water	46	1.000
Sea water	40	1.028
Mercury	3	13.595

From these results it appears, that the compressions are not, as might have been imagined, in the inverse ratios of the specific gravities. If the law of compression in water is the same as that in air, it would follow, that, at a depth of 100 miles, the density of the water would be doubled, and at the depth of 200 quadrupled.

In the year 1774, the Ex-Jesuit Herbert published at Vienna a treatise entitled *De Aquæ Elasticitate*, in which he confirmed the general result of Canton's experiments, and in 1779 M. Zimmerman published an account of similar experiments at Leipsic, under the title of *Traité de l'Elasticité de l'eau et d'autres fluides.* He found, that sea water, when inclosed in the cavity of a strong iron cylinder, and pressed by a force equal to a column of sea water 1000 feet high, was compressed $\frac{1}{340}$th part of its own bulk, a result much greater than we should have expected from the experiments of Canton. A number of results similar to these were obtained by the Abbé Mongez, who has printed an account of them in the 9th volume of Rozier's Journal.

As the doctrine of the compressibility of water has long been considered as a fact rigorously established, we were surprised to find its incompressibility stated by the Abbé Hauy, without the slightest reference to any of the preceding experiments. "One of the experiments," he observes, "which has served to shew the incompressibility of water, consists in charging that liquid with a column of mercury, by employing a bent tube in the form of a syphon, the shortest branch of which is closed at its superior part, and contains water, at the same time that the longest branch is occupied by the mercury, which presses the surface of the water. The column formed by this latter fluid was not shortened by the smallest perceptible quantity, even when that of the mercury was 227 centimètres, or about seven feet high, in which case it exerted upon the water an effect triple of that of a column of water 33 feet high."* In this experiment, which must have been carelessly made, the compression ought to have been thrice as great as in the experiments of Canton.

Perfect and imperfect fluids.

Fluids have also been divided into *perfect* and *imperfect*; but this division is quite arbitrary, as there is no body which possesses the character of perfect fluidity. Boiling water approaches nearer to a state of perfect fluidity than water in any other state. As its temperature diminishes, its viscidity increases, and its fluidity becomes less perfect. In many of the oils, varnishes, and in melted glass, the fluidity is extremely imperfect; whereas it may be considered as nearly perfect in water, alcohol, mercury, &c.

CHAP. I.

ON THE PRESSURE AND EQUILIBRIUM OF FLUIDS.

FUNDAMENTAL PRINCIPLE.

When a mass of fluid, in a state of equilibrium, is subjected to the action of any forces, every particle of the fluid mass is pressed equally in every direction, and vice versa *if every particle of the fluid mass is pressed equally in every direction, the whole mass will be in equilibrio.*

THIS principle, which has been adopted as the foundation of hydrostatics by Euler, D'Alembert, Bossut, and Prony, is a necessary consequence of the definition which we have already given of fluidity; for, since the parts of a fluid yield to the smallest pressure, any particle which is more pressed in one direction than another, would move to the side where the pressure was least, and consequently the equilibrium would be destroyed. If the particles are equally pressed in every direction, it is equally evident, that the mass of which they are composed must be in equilibrium.

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* Hauy's *Elementary Treatise on Natural Philosophy*, translated by Dr O. Gregory, vol. i. § 174.

Although the preceding principle is rigorously true only of perfect fluids, yet, in the case of water, alcohol, &c. where the cohesion of the particles is not very great, the inequality of pressure under which an equilibrium might exist, must be extremely small; and it is accordingly found, that the principle is experimentally true in these fluids. For if, at a given depth below the surface of water in a vessel, an aperture be made, and a piston be applied to the aperture to prevent the water from flowing out, it will be found, that the piston will be pressed outwards with the same force, whether the aperture is horizontal or vertical, or inclined at any angle to the horizon.

Cor. If a number of pistons E, F, G, are applied to apertures of different sizes in the sides of a vessel ABCD full of water, the forces with which the pistons are applied will be in equilibrio, if they are proportional to the apertures to which they are applied.

PLATE CCCXIII. Fig. 1.

Since the pressure of every part of the piston E is transmitted to every part of the piston F, and *vice versa*, it follows, that these pressures will be in equilibrio if they are equal. But the sum of the pressures propagated by E is proportional to the area of the aperture E, and the sum of the pressures propagated by F proportional to the area of the aperture F; consequently there must be an equilibrium between these opposing pressures, when E : F=area of E : area of F. The same is true of any number of apertures.*

SECT. I. *On the Pressure and Equilibrium of Fluids of Uniform Density.*

PROP. I.

When any fluid, influenced by the force of gravity, is in equilibrio in any vessel, its surface is horizontal, or at right angles to the direction of gravity.

Let the surface of the fluid have the curvilineal form A *p* B, Fig. 2, and let the force of gravity with which any particle *p* is influenced be represented by the vertical line *po*. This force *po* may be resolved into the forces *pm*, *pn*, coinciding with the elementary portions of the surface on each side of *p*. Now, the particle *p* being in equilibrium, it is pressed equally in every direction; and, therefore, the equal and opposite forces *mp*, *np*, exerted against *p* by the neighbouring particles, must be equal to *pm*, *pn*; hence the force *pm* is equal to *pn*, the angle *mpn* must be bisected by *po*, (See DYNAMICS, Sect. III.) and the elementary portion of the curve must be perpendicular to *po*. As the same is true of every other part of the fluid surface, it follows that this surface must be a *horizontal straight line*, if the directions of gravity at different points are considered as parallel, or a portion of a spherical surface, if the directions of gravity meet in one point.

Fig. 2.

Cor. It follows from this proposition, that the surface of a fluid must be perpendicular to the resultant of all the forces which act upon it. Hence the general surface of the ocean will not be perpendicular to the direction of gravity, but to a line which is the resultant of the action of gravity, of the centrifugal force, and of the attraction of the planetary bodies.

The effect of the centrifugal force, combined with gravitation, is such, that the surface of the water assumes a parabolic form, as shewn in Fig. 3. When any number of fluids of different densities are put in the same vessel, and are made to revolve round an axis, or if they are put into a glass globe, and turned by the whirling table, their separating surfaces always assume the form of parabolic conoids, when the axis of rotation is vertical.

Fig. 3.

SCHOLIUM.

The depression of the surface of a fluid or D beneath a horizontal straight line for any given length L, may be found from the following simple formula: $D=\frac{2L^2}{3}$.

PROP. II.

If a fluid influenced by the force of gravity is inclosed in a syphon, or in any number of communicating vessels, the surface of the fluid in each branch will be in the same horizontal plane.

Let ABCD, Fig. 4, be a syphon with three branches, AB, CB, DB, communicating with each other at B. If water is poured into this vessel till it rises to A in one branch, it will rise to the same height in the other branches, so that ADC is a horizontal line perpendicular to the direction of gravity. Let the syphon be removed, and let the water which it contained form part of the fluid in the vessel *abcd*, in which it has the horizontal surface *a*ADC*b*, it is easy to suppose that a portion of the water, of the same form and thickness as the syphon, may be converted into ice, without changeing its place or its volume. The equilibrium of the water is obviously not affected by such a change; and, therefore, the water will stand at the same height ADC in a syphon of ice; and, consequently, the same will happen whatever be the substance of which the syphon is composed. The same conclusion would have been obtained, by supposing all the water frozen, excepting that portion which was at first included in the syphon.

PLATE CCCXIII. Fig. 4.

SCHOLIUM.

The arts of levelling and of conducting water are founded upon the preceding proposition. As water will always rise to the same level as the spring from which it flows, it may be conveyed in pipes through the deepest vallies, and over the highest eminences, provided the pipe never rises to a greater height than the source of water. Had the ancients been acquainted with this simple principle, they might have saved the construction of those expensive aqueducts with which their towns were supplied with water.

Levels are sometimes made upon the principle contained in the proposition. Mr Keith's mercurial level is nothing more than a syphon filled with mercury, with a float on each branch, which supports two sights. See *Edinburgh Transactions*, vol. ii. p. 14; and our article LEVELLING.

PROP. III.

If a mass of fluid contained in a vessel is in equilibrio, any one particle of the fluid is pressed in every direction, with a force equal to a weight of the column of the fluid, whose base is equal to that particle, and whose height is the depth of the particle below the surface.

Let *p*, Fig. 5, be the particle of fluid whose depth in the vessel of fluid ABCD is *cp*. We may suppose, as for-

Fig. 5.

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* In the two following sections, as well as in other parts of this article, our readers will perceive that we have been under great obligations to the admirable work of the Abbé Bossut, to which we must refer those who wish to obtain a more profound and extensive view of the subject.

merly, that a portion of the water is frozen, so as to form a tube of ice *ep*, whose diameter is equal to that of the particle *p*, without any change taking place in the pressure sustained by *p*. In this case, the particle *p* is obviously pressed downwards with the weight of the column *ep*; and, consequently, the measure of this pressure is the absolute weight of the column *ep*. But as the particle is in equilibrio, it must be pressed with this force in every direction.

PLATE CCCXIII. Fig. 5.

The proposition is also true of a particle situated at *m*, for drawing the horizontal line *mg*; and supposing a syphon of ice *fghm* to be formed, it is obvious that the column of fluid in the branch *mh* is in equilibrio with, or balanced by, the column in *gh*; consequently the particle of water at *m* is pressed with the same force as the particle at *g*, that is, with a column of water whose height is *fg*.

Cor. Hence it follows, that every particle of a vessel containing fluid is pressed with a force equal to a column of fluid, whose base is the particle, and whose height is the depth of the particle below the surface; for, since the particle of fluid adjacent to this particle of the vessel is pressed in every direction with this force, it must exert the same force against that particle of the vessel.

PROP. IV.

The pressure exerted by a fluid upon any given portion of the vessel which contains it, is equal to a column of the fluid whose base is the area of the given portion, and whose altitude is the depth of the centre of gravity of the portion below the fluid surface.

Fig. 6.

Let *mn* be the given portion of the vessel ABCD filled with fluid, and let us conceive this portion to be occupied by any number of particles *m, o, p, n,* &c. then the pressure sustained by each of these particles, by Prop. III. will be $m\times\overline{mu}+o\times\overline{ox}+p\times\overline{py}+n\times\overline{nz}$, &c.; but, by the property of the centre of gravity or inertia, (See MECHANICS,) the sum of these products is equal to the distance EF of the centre of gravity E, from the surface at F, multiplied into the number of particles *m, n, o, p*; that is, $m\times\overline{mu}+o\times\overline{ox}+p\times\overline{py}+n\times\overline{nz}=EF\times m,n,o,p$; consequently, since *m, n, o, p* represents the area or the number of particles in the given portion *mn*, the pressure upon $mn=EF\times mn$.

Fig. 7.

Cor. 1. It follows from this proposition, that the pressure sustained by the bottom of the vessel is not the same as the weight of the fluid contained in the vessel. In the cylindrical vessel shewn in Fig. 7, or in any vessel, whatever be its shape, in which the sides are perpendicular to its bottom, the pressure upon the bottom is accurately measured by the weight of the water which it contains; but in vessels of all other shapes, such as Fig. 8, 9, the pressure on the bottom is measured by $mn\times mx$, which in Fig. 8 is much less than the weight of water in the vessel, and in Fig. 9 much greater.

Fig. 8, 9.

Hydrostatic paradox. Fig. 10.

Cor. 2. The truth of what is called the Hydrostatic Paradox, is easily deduced from the preceding proposition. Let ABCDEFGH, Fig. 10, be a vessel filled with water, then, by the proposition, the pressure upon GF $=$ GF $\times$ GI, however narrow be the column ABCD, that is, *the pressure exerted upon the bottoms of vessels filled with fluid does not depend upon the quantity of the fluid which they contain, but solely upon its altitude.* In like manner, it is obvious from Prop. II. that the water will stand at the same level *ab* AB, Fig. 11, in the two communicating vessels *abcd*, ABCD, consequently, *any portion of fluid* abcd, *however small, will balance any portion of fluid* ABCD, *however great.*

Fig. 11.

Cor. 3. The pressure exerted upon the sides of a vessel, perpendicular to its base, is equal to the weight of a rectangular prism of the fluid, whose height is equal to that of the fluid, and whose base is a parallelogram, one side of which is equal to the height of the fluid, and the other to half the perimeter of the vessel.

Cor. 4. The pressure against one side of a cubical vessel is equal to half the pressure against the bottom; and the pressure against the sides and bottom together, is equal to three times the pressure against the bottom alone. Hence, by Cor. 1. the pressure against both the sides and bottom together, is equal to three times the weight of fluid in the vessel.

Cor. 5. The pressure exerted upon the surface of a hemisphere full of fluid, is equal to the product of that surface multiplied by its radius.

Cor. 6. The pressure sustained by different parts of the sides of a vessel, are as the squares of their depths below the surface. Hence, these pressures will be represented by the ordinates of a parabola, when the depths are represented by its abscissæ.

DEFINITION.

Centre of pressure.

The *centre of pressure* is that point of a surface exposed to the action of a fluid, to which, if a force equal to the whole pressure upon the surface were applied, the effect would be the same as it is when the pressure is distributed over the whole surface.

PROP. V.

To find the centre of pressure.

PLATE CCCXIII. Fig. 11.

Let it be required to find the centre of pressure P, Fig. 11, on the side of a cubical vessel ABCD. Let G be the centre of gravity of the surface, then the pressure exerted against this surface will be $BC\times BC\times GB$, or $\frac{BC^3}{2}$, since in the case of a cube or rectangle, $GB=\frac{BC}{2}$, and since the pressure must be equal to the sum of all the elementary pressures upon the elementary portions F *f*, we have $\frac{BC^3}{2}\times PB=\int BC\times Ff\times FB\times FB$, or $\frac{BC^3}{2}=\int Ff\times FB^2$. But the sum of the elementary pressures $Ff\times FD^2$ compose a pyramid whose base is $=BC^2$, and whose altitude is BC, consequently, by the property of the centre of inertia (See MECHANICS) $\frac{DC^2\times PB}{2}=\frac{DC^3}{3}$, and $PB=\frac{2\ DC}{3}$, that is the centre of pressure, is two-thirds of the depth of fluid in the vessel.

COR. The centre of pressure coincides with the centre of percussion, as the centre of percussion is also two-thirds of the height of the body.

SECT. II. *On the Pressure and Equilibrium of Fluids of Variable Density.*

DEFINITION.

THE absolute weights of different bodies that have the same bulk are called their *specific gravities* or *densities*, and any body that, under the same bulk, is heavier than another, is said to be *specifically heavier*.

Pressure and Equilibrium of Fluids.

PROP. I.

If two fluids of different densities are included in the separate branches of a syphon, they will be in equilibrio, when the altitudes above their common junction are reciprocally proportional to their specific gravities.

PLATE CCCXIII. Fig. 12.

Let ABCD. Fig. 12, be the syphon, and AB, CD the heights of the two fluids of different densities, which may be supposed separated from each other by the common junction $m\,n$. Then, if G is the centre of gravity of the surface $m\,n$, the pressure exerted by the fluid in AB is, by Prop. IV. $m\,n \times G\,s$, and that of the fluid in CD, $m\,n \times GB$; but since their specific gravities S, S′ are, by the hypothesis, reciprocally as their altitudes, that is, $S : S' = G\,r : G\,s$, we have $S \times G\,s = S' \times G\,r$; but the pressure of the one column is $m\,n \times G\,s \times S = m\,n \times G\,r \times S$, the pressure of the other, consequently they will be in equilibrio.

If $o\,p$ be the junction of the two fluids, then, by drawing the horizontal line $o\,p\,\gamma\,t\,v$, we may regard the columns $o\,p\,m\,n$, $t\,v\,n\,m$ as balancing one another, since they are composed of the same fluid, and then consider the columns AB$p\,o$, CD$v\,t$ of different densities, as resting upon the surfaces $o\,p$, $t\,v$. In this case, $\gamma\,s \times S' = \gamma\,r \times S'$, and consequently the pressures $op \times \gamma\,s \times S = op \times \gamma\,r \times S'$.

In the case of water and mercury, the values of S, S′ are 1 and 13.58 at a temperature of 60°, consequently $G\,s : G\,r = 13.58 : 1$; and therefore to balance 33 feet of water, a column of mercury 29.16 inches will be required.

PROP. II.

The pressure on the bottom of a vessel containing horizontal strata of fluids of different densities, is equal to the area of the bottom multiplied by the sum of the products of the thickness of every stratum and their specific gravities.

Fig. 13.

Let ABCD, Fig. 13, be the vessel, and AB$f\,e$, $e\,f\,h\,g$, $g\,h\,l\,k$, and $k\,l\,c$D strata of different densities, S, S′, S″, S‴. Then since, by the last Prop. any column of fluid is in equilibrio with another, or has the same pressure when their heights are reciprocally as their densities, calling H, H′, H″, &c. the heights of the strata, we have $S : S' = H' : H$, and $H = \frac{S' \times H'}{S}$. We may therefore substitute a column of fluid of the same kind as the lower stratum kC, and having an altitude $\frac{S' \times H'}{S}$ instead of the column $g\,l$, and in like manner, instead of the other columns $e\,k$, Af we may substitute columns whose heights are $\frac{S'' \times H''}{S}$, $\frac{S''' \times H'''}{S}$, and therefore calling DC the area of the bottom, the whole pressure on the bottom will be $= S \times DC \times H + \left(\times H + \frac{S' \times H'}{S} + \frac{S'' \times H''}{S} + \frac{S''' \times H'''}{S}\right) = DC \times (S \times H + S' \times H' + S'' \times H'' + S''' \times H''')$, which is the truth announced in the proposition.

PROP. III.

If a fluid contained in a vessel consists of an infinite number of strata whose densities vary according to any law, the fluid will be in equilibrio, when the surfaces of the strata are perpendicular to the direction of gravity.

Specific Gravities.

PLATE CCCXIII. Fig. 13,

If the lower stratum of $k\,l\,c$ D (Fig. 13.) were placed alone in the vessel, its surface $k\,l$ would be horizontal. Let us now suppose that every point of the surface $k\,l$ is pressed downwards by equal forces, which it will be when it is pressed down by the weight of the superior strata with horizontal surfaces, then since there can be no reason why one point should yield more than another to these forces, it follows that the stratum kC will still be in equilibrio. In like manner, it may be shewn, that the stratum $g\,h\,l\,k$ will be in equilibrio, and so on with all those above it, so that we may conclude that the whole fluid in the vessel is in equilibrio.

PROP. IV.

To find the pressure exerted by a fluid composed of an infinite number of strata of variable density against any part of the vessel which contains it.

Fig. 13.

Let S, S′, S″, &c. be the specific gravities of the different strata $q\,p$, $p\,o$, $o\,n$, &c. then since the point q sustains the weight of all the columns $q\,p$, po, &c. above it, it will be pressed down by a force equal to $S \times qp + S' \times p\,o + S'' \times o\,n$, &c. $= S \times \left(\frac{qp + S' \times po}{S} + \frac{S'' \times on}{S} + \text{\&c.} = S' \times (po + \frac{S \times qp}{S'} + \frac{S'' \times on}{S'} + \text{\&c.} = S'' \times (o\,n + \frac{S \times qp}{S''} + \frac{S' \times po}{S''} + \text{\&c.})\right.$ Hence it follows, that we may substitute in place of the fluid of variable density a fluid whose density is uniform through the whole height $q\,m$.

Let us take an infinitely small elementary stratum $e\,n\,f\,\phi\,\phi\,\iota$ contained between the horizontal lines $e\,n\,f$, $\iota\,\nu\,\phi$, then the pressure upon $e\,\iota$ is the absolute weight of the column $m\,\iota$; but making $m\,n = x$, and $\Sigma =$ the specific gravity of the fluid in n, the weight of $m\,n$ will be $\int \Sigma\,\dot{x}$, and therefore the sum of the pressures against Ae will be $\int A\,e \times \int \Sigma\,\dot{x}$. Thus to find the pressure upon the bottom DC, let $q\,m = a$, and $S =$ the specific gravity of the fluid in DC, then $\Sigma = \frac{S\,x}{a}$, and $\int \Sigma\,\dot{x} = \int \frac{S\,x\,\dot{x}}{a} = \frac{S\,x^2}{2\,a}$; and since, in the case of a pressure upon the bottom, $x = a$, we have $\frac{S\,x^2}{2\,a} = \frac{S\,a}{2}$ and the whole pressure upon the bottom $= \frac{S\,a}{a} \times DC$.

CHAP II.

ON SPECIFIC GRAVITIES.

PROP. I.

On specific gravities.

If any object floats upon a fluid, or is wholly immersed in it without sinking, it is pressed upwards with a force equal to the weight of the fluid displaced.

Fig. 14.

Let EF (Fig. 14.) be a body floating in the vessel ABCD. Then by Prop. III. Chap. I. any point or particle n is pressed upwards with a force equal to a column of particles whose height is $m\,n$, and as this is true of every part of the surface EnF, then since the part of the solid immersed is made up of these elementary columns, it follows that the sum of all the pressures exerted upon E n F is equal to a quantity of fluid of the same size as the immersed part, which is the same as the quantity of fluid displaced.

PLATE CCCXIII. Fig. 15.

When the body EF is wholly immersed, as in Fig. 15, it is obvious, that any part o is pressed downwards with a column of fluid whose height is mo, while any part n is pressed upwards with a column of fluid whose height is mn; consequently the point n is pressed upwards with a column $no=mn-mo$. But the sum of all the elementary columns no, make up a quantity of fluid equal to that which is displaced by the body.

Cor. When a solid floats on a fluid, the quantity of fluid which it displaces is equal to the weight of the body. Since the whole weight of the solid pressing upon the surface of water E n F is in equilibrio with the fluid mass, it must be equal in weight to the quantity of fluid E n F, which is also in equilibrium with the same fluid mass, but this quantity of fluid is the quantity which is displaced.

Prop. II.

When a body floats upon a fluid, the centre of gravity of the body and of the fluid displaced are in the same vertical line.

For since the upward pressure which supports the floating body is the same as if it were applied to the centre of gravity of the part immersed, or of the quantity of fluid displaced, then since the whole floating body is in equilibrio, its centre of gravity must be supported by this upward pressure; that is, the centres of gravity of the fluid displaced and of the floating body must be in the same vertical line.

Prop. III.

The specific gravity of any floating body is to that of the fluid, as the volume of the part immersed is to the whole volume of the body.

Fig. 14.

Calling S the specific gravity of the fluid, and s that of the solid, we have by Cor. Prop. I. $S\times EnF=s\times EpFn$, and therefore $s:S=EnF:EpFn$; that is, as the part immersed is to the whole volume of the body.

Prop. IV.

If a solid is weighed in a fluid, it will lose as much of its weight as is equal to the quantity of fluid displaced.

It appears from Prop. I. that the body is pressed upwards with a force equal to the weight of the fluid displaced; and as this force acts in opposition to the natural gravity or absolute weight of the body, its absolute weight must be diminished by a quantity equal to the weight of the fluid displaced. The weight which the body in this case loses is not destroyed, but is sustained by an equal and opposite force.

If we call s the specific gravity of the solid, S that of the fluid, B the bulk of the solid, and m B the part of it which is immersed; then since $B\times s$ is the absolute weight of the solid, and $m\,B\times S$ the absolute weight of the quantity of fluid displaced, in order that an equilibrium may take place, we must have $B\times S=m\,B\times S$, and $S:S=m\,B:B$. Hence if $s=S$, we have $mB=B$; that is, *if the specific gravity of the solid is equal to that of the fluid, the part immersed is equal to the whole body*; or, in other words, *the solid will be completely immersed, and will remain wherever it is placed.* If $s>S$, then $m\,B>B$; that is, *when the specific gravity of the solid is greater than that of the fluid*, the body will sink to the bottom: and if $S>s$, then $mB<B$; that is, *when the specific gravity of the fluid is greater than that of the solid, then the part immersed is less than that of the whole solid*, or the body will float.

Prop. V.

If a body is held beneath the surface of a fluid, the force with which it will ascend, if it is lighter than the fluid, or with which it will descend if it is heavier, is equal to the difference between its own weight and the weight of an equal quantity of the fluid.

The body held beneath the water obviously descends with its own weight $=B\times s$, while it is pressed upwards with the weight of the quantity of fluid displaced $=B\times S$; consequently the force with which it ascends must be $\overline{B\times S}-\overline{B\times s}$, and the force with which it descends $=\overline{B\times s}-B\times S$, which are the differences between the weight of the body and the weight of the fluid displaced.

Scholium.

On the truth contained in this proposition is founded the construction of the Camel for raising sunk vessels, or for lifting ships over high sand banks. (See our article Camel.) A similar effect is exhibited in some of the American rivers, where the ice is formed upon the stones at their bottom. Ice is specifically lighter than water, and therefore, when it accumulates to a certain degree round the stones, the upward pressure upon the stones exceeds their pressure downwards, and they are brought to the surface, having been sometimes torn up with great force. Huge masses of stones appear in many cases to have been floated by the ice adhering to them, and carried to a great distance from the place of their formation.

Prop. VI.

The specific gravity of a solid is to that of the fluid in which it is weighed, as the absolute weight of the solid is to the loss of weight which it sustains.

In the equation $B\times s=m\,B\times S$, we have $B=mB$ when the body is weighed in a fluid, and of course wholly immersed; consequently if W be the weight of the body in the fluid, or the weight necessary to keep it in equilibrio with the fluid, then $B\times s=B\times S+W$, (and transposing and multiplying by s,) we have $s\times\overline{B\times s-W}=s\times B\times S$, and (Euclid, Book VI. 16.) $s:S=B\times s:B\times s-W$; consequently since $B\times s-W$ is the loss of weight which it sustains, the specific gravity of the solid is to that of the fluid, as the weight of the solid is to its loss of weight.

This Proposition may also be demonstrated, by considering that the weight lost, or $B\times s-W$, is the weight of a bulk of fluid equal to the bulk of the solid, whose weight is $B\times s$; and therefore as the specific gravities are to one another, by the definition, as the weight of equal bulks, we have $s:S=B\times s:B\times s-W$.

Prop. VII.

If the same solid body is weighed in two fluids, the specific gravities of the fluids are to one another as the losses of weight which the solids respectively sustain in each.

Making B the bulk of the body as before, S, S′ the specific gravities of the two fluids, and W, w the weights of the solids in each fluid, then the weight of the quantities of fluid displaced will be $B \times S$, $B \times S'$, and since these weights are the weights lost by the body, if we add the weights of the body in the fluid, vis. W, w, to these weights, we shall have an expression which will be equal to $B \times s$, the real weight of the body. Thus:

$$B \times S + W = B \times s \text{ and } B \times S' + w = B \times s.$$

Hence we have the two equations,

$$B \times S = B \times s - W \text{ and } B \times S' = B \times s - w; \text{ hence}$$

$$S \times B : S' \times B = B \times s - W : B \times S' - w,$$ consequently, (Eucl. B. V. 16.) $S : S' = B \times s - W : B \times s - w$, that is, the specific gravities, or as the losses of weight sustained by the solid, for these losses must always be equal to the difference between the real weights and the weights W, w in the fluid.

Cor. Hence, if two solid bodies lose equal parts of their weights in the same fluid, they have equal volumes.

PROP. VIII.

If a solid body is immersed in two fluids of different specific gravities, so as to be partly in the one and partly in the other, it will be in equilibrio, if the part in the lighter fluid is to the part in the heavier fluid, as the difference between the specific gravities of the solid and the heavier fluid is to the difference of the specific gravities of the solid and the lighter fluid.

PLATE CCCXIII. Fig. 16.

Let EF, Fig. 16, be the solid immersed in two fluids, and having the part M in the lighter fluid, whose specific gravity is S, and the part N in the heavier fluid, whose specific gravity is S′, and let s be the specific gravity of the solid. Now the weight of the solid is $s \times \overline{M+N}$, the weight of the heavier fluid displaced by N is $S' \times N$, and the weight of the lighter fluid displaced by M is $S \times M$. But as the solid is, by the hypothesis, suspended in the fluids, the whole of its weight is lost; and consequently the part lost in the lighter fluid, added to the part lost in the heavier fluid, must be equal to its whole weight, that is, $\overline{S \times M + S' \times N} = s \times \overline{M+N}$; then, by transposition, and Euclid, B. VI. 16, we have $M \times \overline{S-s} = N \times S' - s$ and $M : N = S' - s : S - s$.

Cor. 1. Since $M : N = S' - s : S - s$, then, by inversion and composition, Eucl. B. V. Prop. B and 18, $M : M + N = S' - s : S' - S$, that is, *the part in the lighter fluid is to the whole solid as the difference between the specific gravities of the solid and the heavier fluid is to the difference between the specific gravities of the two fluids.*

Cor. 2. If the specific gravity S of the lighter fluid is very small when compared to S′, as in the case of air and water, then we may, for ordinary purposes, take the analogy $M : N = S' - s : s$.

PROP. IX. PROB.

To detect the adulteration of the precious metals.

Let us suppose, as in the case of Hiero's crown, that a mass of pure gold is adulterated by the admixture of silver. If we take a quantity of pure gold of the same weight as the adulterated mass, it will obviously have less bulk, as its specific gravity is greater than that of the mixture, (silver having a less specific gravity than gold) and therefore the quantity of pure gold, when weighed in water, will displace less of the fluid than the adulterated mass. Hence it follows, that we have only to weigh the suspected mass, and a mass of pure gold of the same weight; and if there is any difference in their weight, we must conclude that the mass is adulterated.

If the gold is heavier in water than the suspected mass, it has obviously lost less weight, and has therefore less bulk than the mass; consequently the adulterating mixture has a less specific gravity than gold. If, on the contrary, the gold loses more weight than the mass, it will have a greater bulk, and therefore the adulterating metal must have a higher specific gravity than gold, such as platinum.

PROP. X.

If two substances of any kind be compounded together, the bulk of the heavier of the two ingredients is to the bulk of the lighter ingredient as the difference between the specific gravities of the compound and the lighter ingredient is to the difference between the specific gravities of the compound and the heavier ingredient.

Calling S, S′ the specific gravities of the ingredients, B, B′ their bulks, and Σ the specific gravity of the compound, then the weight of the compound is $\Sigma \times B + B'$, and as the weight of the compound must be equal to the sum of the weights of its ingredients, we have $\Sigma B + \Sigma B' = B \times S + B' \times S'$, and by transposition, &c. we have $B \times \Sigma - S = B' \times S' - \Sigma$ and (Eucl. VI. 16.) $B : B = S' - \Sigma : \Sigma - S$.

SCHOLIUM.

The supposition in the preceding reasoning, that the bulk of the compound is equal to the sum of the bulks of its ingredients, is not physically true. A pint of alcohol or of sulphuric acid, mixed with a pint of water, will not make so much as two pints of the compound fluid; and, on the other hand, a cubical inch of tin, mixed with a cubical inch of lead, will make a compound containing more than two cubical inches of metal. A certain bulk of water is diminished by the addition of $\frac{1}{57}$ of sal ammoniac; and 40 parts of platinum and 5 of iron will make but 39 parts by measure.

PROP. XI. PROB.

To determine accurately the specific gravity of gaseous or aeriform bodies.

As the specific gravities of gaseous bodies are measured in relation to that of air, we must first determine the weight of a given volume of this gas. In order to do this, take a large glass vessel, containing at least five or six litres, and having exhausted it of its air by a good air-pump, weigh it in a delicate balance, and call its weight W. Let the air be now admitted to the glass vessel, and let its weight, as ascertained by the balance, be now called W′. The difference between these weights, or $W - W'$, will obviously be the weight of the atmospherical air contained in the vessel. Let it now be required to measure the specific gravity of another gas. Weigh the glass vessel when empty as formerly, and also when full of the gas, and let these weights be w, w', then $w - w'$ will be the weight of the gas, and $\frac{w-w'}{W-W'}$ will be its specific gravity compared with that of the air, which is taken at 1.000. This specific gravity is that which corresponds with the state of the atmosphere at the time when the experiment was made.

It is obvious, however, that all these measures are affected by a variation in the density, the temperature, and the humidity, of the external atmosphere. The weight, too, of the gases, when they are introduced into the receiver, is affected by the temperature and pressure of the air. The contraction and dilatation of the glass vessel requires also to be computed; and the weight of the gas itself is affected by the temperature and the degree of drying which it has experienced. These various sources of error likewise affect the results, in so far as they affect the external atmospherical air in which both the air itself and the gas must be weighed. Some allowance must also be made for the imperfect exhaustion of the glass vessel, which is always visible by its effect upon the barometer.

It will readily be seen, that it must require no small degree of trouble to calculate the combined influence of these different causes, though, in order to obtain accurate results, such a calculation becomes absolutely necessary. As it would be impracticable in the present article to enter into any lengthened examination of the subject, we must refer such of our readers as wish to study it profoundly, to the 19th, 20th, and 21st chapters of M. Biot's valuable work entitled, *Traité de Physique,* which not only contain the method of deducing the necessary formulæ, but also many excellent remarks and suggestions which could only have been given by one who had investigated the subject both theoretically and practically. The following are his principal formulæ, which are suited to a temperature of 32⁰ of Fahrenheit, or that of melting ice, and to a state of the atmosphere when the barometer stands at 0.76 metres, or 29.94 English inches.

In these formulæ,

X = the absolute weight of atmospheric air contained in the glass vessel at a temperature of 32^0, and under a pressure of 29.94 inches of mercury, as calculated from the formulæ.
Y = the absolute weight of any gas under the same circumstances.
V = the interior volume of the glass vessel at the same temperature.
K = the cubical dilatation of glass for every degree of the centigrade thermometer.

At the time when the glass vessel is weighed empty.
P = the absolute weight of the glass vessel, which never changes.
h = the atmospherical pressure.
t = the temperature of the air.
p = the state of the hygrometer.
θ = the tension in the interior of the glass vessel, after a vacuum is made by the air pump.

At the time of the introduction of the gas into the glass vessel.
p = external pressure exerted upon the gas.
t' = temperature of the gas.
p' = its hygrometric state.

At the time when the glass is weighed full of gas.
P'' = the weight of the glass vessel filled with gas.
p'' = the atmospherical pressure.
t'' = the temperature of the external air.
h'' = the state of the hygrometer.

When the glass vessel is weighed empty a second time, after it has been weighed full of gas.
P''' = the weight of the glass vessel empty observed in air
p''' = atmospherical pressure.
t''' = temperature.

1. *Formulæ suited to the case where the Gases are perfectly dry.*

$$X=\frac{P''-P\,0^{m}.76}{\frac{(1+Kt)p}{1+t.0,00375}+\frac{(1+Kt')p'}{1+t'.0,00375}-\frac{(1+Kt'')p''}{1+t''.0,00375}} \qquad \text{(No. 1.)}$$

$$2Y=\frac{(2P''-P-P''')\,0^{m}.76+\frac{2X(1+Kt'')p''}{1+t''.0,00375}-\frac{X(1+Kt)\,p}{1+t\,.0,00375}-\frac{X(1+Kt''')p'''}{1+t'''.0,00375}}{\frac{(1+Kt)p}{1+t'.0,00375}} \qquad \text{(No. 2.)}$$

In the ordinary state of the atmosphere, the barometer and thermometer indicate only very small and progressive changes, so that in the short time which can elapse between the different weighings of the gas, we may safely suppose the atmospherical pressure p'', and the temperature t'', corresponding to the intermediate weighing of the glass vessel, as arithmetical means between the extreme pressures p, p''', and the extreme temperatures t, t'''. In proportion, therefore, as the variations in these elements have been inconsiderable, we may consider them as compensating themselves in the terms of X: These terms will consequently disappear, and the formula will be reduced to the following simple form;

$$Y=\frac{\left(P''-\frac{(P+P''')}{2}\right)(1+t'.0,00375)\,.0''',76}{(1+Kt')\,p'} \qquad \text{(No. 3.)}$$

This formula will be found sufficiently exact when the gases and the atmospherical air are perfectly dry; but as this is never the case, and as the aqueous vapour has a very considerable influence upon the weight at a temperature above 50⁰ of Fahrenheit, it is necessary to compute its effect.

2. *Formulæ suited to the case where the Gases are perfectly saturated with Water.*

In the following formulæ, X is the weight of a volume of dry atmospherical air contained in the glass vessel, at the temperature of 32°, and the barometrical pressure of 0.76 metres or 29.994 English inches.

T = the real tension of aqueous vapour at the weighing of the glass vessel empty.
T′ = the tension at the introduction of the gas.
T″ = the tension at the weighing of the glass vessel full of gas.

$$X = \frac{P'' - P\,.0_{m}.76}{\frac{(1+Kt)(p-\frac{1}{8}T)}{1+t\,.0{,}00375} + \frac{(1+Kt')(p'-\frac{1}{8}T')}{1+t'\,.0{,}00375} - \frac{(1+Kt'')(p''-\frac{1}{8}T'')}{1+t''\,.0{,}00375}}. \qquad \text{(No. 4.)}$$

$$Y = \frac{(P''-P)_{m}0.76 - \frac{5X(1+Kt')T')}{8(1+t'\,.0{,}00375)} + \frac{X(1+Kt'')(p''-\frac{1}{8}T''}{1+t''\,.0{,}00375} - \frac{X(1+Kt)(p-\frac{1}{8}T)}{1+t\,.0{,}00375}}{\frac{(1+Kt')(p'-T')}{1+t'\,.0{,}00375}}. \qquad \text{(No. 5.)}$$

These formulæ will answer, when the external air, in which the air and the gas are weighed, are not saturated with moisture. In this case, T′ and T″ will express the tension of the aqueous vapour really suspended in this air.

The preceding results may be rendered independent of the quantity of aqueous vapour contained in the atmosphere at the time of the experiment, by the method employed above, namely, by weighing a second time the glass vessel empty, immediately after it has been weighed full of the gas. Then, if t''' is the temperature at which this is done, p''' the atmospherical pressure, T''' the tension of the aqueous vapour, and P''' the weight observed, the resulting formula will be

$$Y = \frac{\left(P'' - \frac{(P+P''')}{2}\right)0^{m}.76 - \frac{5X(1+Kt')T'}{8(1+t'\,.0{,}00375)}}{\frac{(1+Kt')(p'-T')}{1+t'\,.0{,}00375}} \qquad \text{(No. 6.)}$$

This formula becomes exactly the same as No. 3, when T′ = .0; that is, when the gases are perfectly dry.

3. *Formulæ suited to the Case when the Gases are perfectly dry, but the exhaustion not complete.*

The above formulæ will be sufficiently correct, if the exhaustion of the glass vessel is made with a very fine air pump; but as this is not generally to be met with, let us suppose θ to be the tension of the little air which remains in the glass vessel, as marked by the gauge. Then

$$Y = \frac{(P''-P''')\,0^{m}.76 + \frac{X(1+Kt'')(p''-\frac{1}{8}T'')}{1+t''\,.0{,}00375} - X\frac{(1+Kt''')(p'''-\frac{1}{8}T''')}{1+t'''\,.0{,}00375}}{\frac{(1+Kt')(p'-\theta)}{1+t'\,.0{,}00375}} \qquad \text{(No. 7.)}$$

which, by the means formerly described, may be reduced to

$$Y = \frac{\left(P'' - \frac{(P+P''')}{2}\right)(1+t'\,.0{,}00375)\,0_{m}.76}{(1+Kt')(p'-\theta)}.$$

M. Biot has exemplified the use of the formula No. 5. by an experiment which he made on the 3d July 1806, for the purpose of determining the specific gravity of hydrogen gas. In this experiment, the different quantities had the following values.

At the weighing of the empty glass vessel,
$P = 662.262$ grammes.
$t = 20°\ 9$ centigrade.
$p = 0.7616$ metres.

At the introduction of the gas into the glass vessel
$t' = 21°\ 4$ centigrade.
$p' = 0.7630$ metres.

At the weighing of the glass vessel when full
$P'' = 662.823$ grammes.
$t'' = 20°\ 6$
$p'' = 0.7622$

The gas was saturated with water, and the hygrometer indicated a state of the atmosphere approaching to extreme humidity.

Weight of the atmospherical air in the glass vessel, as determined by preceding experiments } $X = 7.2532$ grammes.

Log. $X = 0.8605315$

Cubical dilatation of glass for one degree of the centigrade thermometer } $K = 0.0000262716$

Log. $K = 5.4194865$

Specific Gravities.

Elastic forces of the aqueous vapour at the temperatures t, t', t'', calculated from a formula given by Biot, vol. i. p. 27.

$$\left.\begin{array}{l} \\ \\ \\ \end{array}\right\}\begin{array}{l} \mathrm{T} = 0.0185 \text{ metres.} \\ \mathrm{T'} = 0.0190 \\ \mathrm{T''} = 0.0182. \end{array}$$

Consequently $\frac{3}{8}\mathrm{T} = 0.0069$. $\frac{3}{8}\mathrm{T''} = 0.0068$. Hence

$$p - \tfrac{3}{8}\mathrm{T} = 0.7547 \text{ metres};$$
$$p' - \tfrac{3}{8}\mathrm{T'} = 0.7440;$$
$$p'' - \tfrac{3}{8}\mathrm{T''} = 0.7554.$$

But as the pressures p, p', p'', or the altitude of the mercury in the barometer, were observed at different temperatures, they must be reduced to that of 32° of Fahrenheit, by subtracting from each of them the corresponding dilatation of mercury. Hence we shall have

$$p = \frac{0.7547 \,.\, 20^{0}.9}{5412} = 0.0029 \text{ metres.}$$

$$p' = \frac{0.7440 \,.\, 21^{0}4.}{5412} = 0.0029.$$

$$p'' = \frac{0.7554 \,.\, 20^{0}.6}{5412} = 0.0029;$$

so that the barometrical columns thus reduced will be

$$p - \tfrac{3}{8}\mathrm{T} = 0.7518;\ p' - \tfrac{3}{8}\mathrm{T'} = 0.7411;\ p'' - \tfrac{3}{8}\mathrm{T''} = 0.7525.$$

We have also . . . .

$$1 + \mathrm{K}\,t = 1.000549;\ 1 + t \cdot 0{,}00375 = 1.078375$$
$$1 + \mathrm{K}\,t' = 1.000562;\ 1 + t' .0{,}00375 = 1.080250$$
$$1 + \mathrm{K}\,t'' = 1.000541;\ 1 + t'' .0{,}00375 = 1.077250.$$

With these elements, and with X, which has been found, we have

$$\frac{\mathrm{X}\,(1 + \mathrm{K}\,t'')\,(p'' - \tfrac{3}{8}\mathrm{T''})}{1 + t'' .0{,}00375} = 5.088935 \text{ grammes.}$$

$$\frac{\mathrm{X}\,(1 + \mathrm{K}\,t)\,(p - \tfrac{3}{8}\mathrm{T})}{1 + t\,0.00375} = 5.078947$$

$$\text{Difference} \;.\;.\;.\; \overline{0.009988}$$

Hence we have the difference of these two terms, or

$$\frac{\mathrm{X}(1 + \mathrm{K}\,t'')\,(p'' - \tfrac{3}{8}\mathrm{T''})}{1 + t''\,0.00375} - \frac{\mathrm{X}\,(1 + \mathrm{K}\,t)\,(p - \tfrac{3}{8}\mathrm{T})}{1 + \mathrm{K}\,t\,.0{,}00375} = 0.009988 \text{ grammes.}$$

By adding to this $(\mathrm{P''} - \mathrm{P})\,.0.76$ metres . . . . $= 0.43016$

we have 0.440148

which is the sum of all the positive terms of the numerator.

By subtracting the negative term, or $\dfrac{5\,\mathrm{X}\,(1 + \mathrm{K}\,t')\,\mathrm{T'}}{8\,(1 + t' .0.00375)}$ . . . . $= 0.0797783$

The difference is 0.360370

which is the value of the numerator of the formula.

The denominator, or $\dfrac{(1 + \mathrm{K}\,t')\,(p' - \mathrm{T'})}{1 + t' .0.00375}$ . . . $= 0.6891163$

we have $\mathrm{Y} = \dfrac{0.36037}{0.6891163}$ . . . . . . $= 0.522945$ grammes,

which is the weight of the volume of hydrogen gas contained in the glass vessel at 32° of Fahrenheit, and 0.76 metres, or 29.994 inches of the barometer. Hence we have the specific gravity of hydrogen gas, or

$$\frac{\mathrm{Y}}{\mathrm{X}} = \frac{0.522945}{7.25323} = 0.720982.$$

PROP. XII. PROB.

To determine accurately the specific gravity of liquids.

The accurate determination of the specific gravity of liquids is like that of gaseous bodies, attended with considerable difficulty. As the specific gravities of the gases are referred to that of atmospheric air, so in liquid and solid bodies the specific gravities are referred to that of water, when at the temperature of + 3°.42 of the centigrade scale, or 38°.15 of Fahrenheit, which corresponds to the maximum density of that fluid.

In measuring the specific gravities of liquids, a glass vessel with a narrow neck, after having been accurately weighed when empty, is successively weighed when filled with distilled water, and with the liquid whose specific gravity is required, and the temperature and atmospherical pressure are carefully marked. The volume of water and of fluid may then be obtained by the following formulæ which have been given by M. Biot. In these formulæ,

V = the interior capacity or volume of the glass vessel in cubic centimetres, at the temperature of 32° of Fahrenheit, or that of melting ice.

L = the apparent weight of the liquid when it is weighed.

λ = dilatation of the liquid at 32° of Fahrenheit, taking its volume at this temperature for unity.

δ' = the dilatation of water from its maximum density to the temperature t'.

F = the apparent weight of the water at the temperature t'.

Specific Gravities.

t = the temperature when the liquid is weighed.

t'' = the temperature reckoned from the point of maximum density, or $t'' = t - 3^{\circ}.42$.

a = the weight of a volume of dry or moist air in the glass vessel at the time the liquid is weighed.

(a) = the weight of a cubic centimetre of dry air, at the temperature of 32°, and the pressure of 0.76 metres, or 29.994 inches.

K = the cubical dilatation of glass for every degree of the centigrade thermometer.

p = the height of the column of mercury when the liquid is weighed.

p' = the height of the column of mercury in the barometer, reduced to the temperature of 32° of Fahrenheit.

α' = the relation of the weight of air to that of water, at the temperature t'.

T = the tension of the vapour of water in the air where the liquid is weighed.

π = the weight of a cubic centimetre of the liquid at the temperature of 32° of Fahrenheit.

Then we have

$$\gamma = 0.00000634750\, t''^{2} - 0.00000002708\, t''^{3} \qquad \text{No. 1.}$$

$$\alpha' = \frac{(a)\, p'\, (1+\gamma')}{(1+t' \,.\, 0.00375)\, 0^{m}.76} \qquad \text{No. 2.}$$

$$V = E + E\,\alpha' + \frac{E\,(1+\gamma')\,(\alpha' - K\,t' + \alpha'\,K\,t')}{(1-\alpha')\,(1+K\,t')} \qquad \text{No. 3.}$$

$$a = \frac{(a)\, V\, (1+K\,t)\, (p - \frac{1}{4}\,T)}{(1+t \,.\, 0.00375)\, 0^{m}.76} \qquad \text{No. 4.}$$

$$\pi = \frac{(L+a)\,(1+\lambda)}{V\,(1+K\,t)} \qquad \text{No. 5.}$$

Specific Gravities.

The use of these formulæ will be best seen by applying them, as M. Biot has done, to the following experiments on mercury and water by him and M. Arago.

Liquids.	Apparent weight of air in grammes, or values of L.	Temperature in degrees of the centigrade, or values of t.	Height of the mercury in the barometer, or values of p.
			Metres.
Exp. 1. Mercury	1342,989	12°.5	0.7439
Exp. 2. Mercury	1340,893	20 .6	0.7580
Exp. 3. Water	98,721	20 .1	0.7600
Exp. 4. Water	98,716	20 .9	0.7589

In calculating the value of V, from the formula No. 3, we have

(a)=0.001299541 grammes, and Log. (a)=3.1137902, and by the formula No. 1.

$\gamma' = 0.0017017$ for Exp. 3. since $t'' = 20^{\circ}.1 - 3^{\circ}.42 = 16^{\circ}.68$

$\gamma' = 0.0018654$ for Exp. 4. $\quad t'' = 20\,.9 - 3\,.42 = 17\,.48$

The height of the mercurial columns, or p, being reduced to the temperature of 32° of Fahrenheit, we have

$$p' = 0.760 - 0.0028 = 0.7572 \quad \text{Exp. 3.}$$
$$p' = 0.7589 - 0.0029 = 0.7560 \quad \text{Exp. 4.}$$

With these values, and the temperature t' observed at the time of the weighing, we have by the formula No. 2.

$$\alpha' = 0.001206079$$
$$\alpha' = 0.001192953$$

$$\text{Now } K\,t' = 0.0005281 \quad \text{Exp. 3.}$$
$$K\,t' = 0.0005491 \quad \text{Exp. 4.}$$

$$\text{Hence} \quad \alpha'\,K\,t' = 0.0000006369, \quad \alpha' + \alpha'\,K\,t' - K\,t' = 0.00067861 \quad \text{Exp. 3.}$$
$$\alpha'\,K\,t' = 0.0000006551, \quad \alpha' + \alpha'\,K\,t' - K\,t' = 0.00064451 \quad \text{Exp. 4.}$$

By substituting these values in the formula No. 3. we have, in cubic centimetres,

$$V = 98.721 + 0.1679935 + 0.0671518 = 98.9561453 \quad \text{Exp. 3.}$$
$$V = 98.716 + 0.1841449 + 0.0637819 = 98.9639268 \quad \text{Exp. 4.}$$

The arithmetical mean between these results is $V = 98.960036$. The capacity of the glass vessel at the temperature of 32° of Fahrenheit.

The absolute weight of mercury or any other liquid weighed in the same glass vessel, at a given temperature, may now be easily deduced from the formula No. 5. We shall follow M. Biot in applying the formula to Experiments 1. and 2. on mercury.

In order to calculate the value of a, we have (a) V=0,1286201 grammes, or the weight of dry air contained in the glass vessel at the standard temperature of 32° of Fahrenheit, and $0^{m}.76$ or 29.994 inches of atmospherical pressure.

Hence we shall have by the formula No. 4.

a=0,12004 Exp. 1. and a=0.11872. Exp. 2. Hence

$$\text{Exp. 1.} \left\{ \begin{array}{ll} L = 1342{,}989 & \text{grammes} \\ a = \quad 0{,}12004 & \\ \hline L + a \quad 1343{,}10904 & \end{array} \right\} \text{Exp. 2.} \left\{ \begin{array}{ll} L = 1340{,}93 & \text{grammes} \\ a = \quad 0{,}11872 & \\ \hline L + a \quad 1341{,}01172 & \end{array} \right.$$

As these weights contain a great number of grammes, it is necessary to calculate the corrections with regard to K t and λ more exactly than would otherwise have been necessary. We have

$$\frac{L+a}{1+K\,t} = L + a - \frac{(L+a)\,K\,t}{1+K\,t}$$

The second of these terms, which is always very small, is the correction sought. Now

$$\frac{L+a}{1+K\,t} = \overset{\text{grammes}}{1343{,}10904} - 0{,}440919 = 1342{,}66812 \quad \text{Exp. 1.}$$

$$\frac{L+a}{1+K\,t} = 1341{,}01172 - 0{,}725363 = 1340{,}286357 \quad \text{Exp. 2.}$$

By adding to each of these results its product by the dilatation $\lambda=\frac{t}{5412}$ in mercury, we have

$$\frac{(\mathrm{L}+a)\ (1+\lambda)}{1+\mathrm{K}\,t}=1342{,}66812+3{,}10113=1345{,}7692 \quad \text{Exp. 1.}$$

$$\frac{(\mathrm{L}+a)\ (1+\lambda)}{1+\mathrm{K}\,t}=1340{,}28636+5{,}10160=1345{,}3880 \quad \text{Exp. 2.}$$

The arithmetical mean between these results is 1345,5786 grammes, which, being divided by V, already found to be 98,960036, we have

$$\pi=\frac{1344{,}5786}{98{,}960036}=13{,}597190$$

which is the weight of a cubic centimetre of mercury in grammes, at the temperature of melting ice.

If we wish to compare this weight with that of water, we have only to calculate the last for the temperature of melting ice, or for —3°.42 of the centigrade thermometer. But if δ is the dilatation of water from its maximum density to its freezing point, or for 3°.42, the weight of water required will be $\frac{1}{1+\delta}$, and the relation between the weights of mercury and water at the temperature of melting ice will be $\pi\,(1+\delta)$. But, by substituting —3°.42 in the formula of dilatation, No. 1. we shall have $\delta=0{,}0000748$. Hence

$$\pi\,(1+\delta)=13{,}597190+0{,}001017=13{,}598207,$$

which is the exact ratio between the weights of equal volumes of mercury and water at the temperature of melting ice.

Prop. XIII. Prob.

To determine accurately the specific gravities of solid bodies.

In determining the specific gravities of solid bodies, we may adopt two methods. 1. We may weigh them successively in air and in some other fluid, which is the ordinary method; and then, if P is the apparent weight of the solid in air, and p the weight of the volume of water which it displaces, we have $\frac{\mathrm{P}}{p}$ for the specific gravity of the body, neglecting the necessary reductions; or, 2. After having weighed the solid in air, we may place the solid in a glass vessel, and weigh them conjointly, and then weigh the same glass vessel when filled only with water. If then D is the weight of the solid in air, p the weight of the vessel containing the water and the solid, and p' the weight of the vessel containing water alone; then $p-p'$ is the weight of the quantity of water displaced, and $\frac{\mathrm{P}}{\mathrm{P}-p+p'}$ will be the specific gravity required.

When the body is soluble in water.

If the substance is soluble in water, like many of the salts, it is necessary to use alcohol, or some other fluid, such as the essential or fat oils, which are not capable of dissolving it. The specific gravity of the oil being known, that of the salt will be immediately found.

When the body imbibes water.

If the solid imbibes water, without either dissolving or decomposing it, it is necessary first to weigh the body when perfectly dry, which weight we may call P, and then weigh it when it has imbibed as much water as possible. Let this weight be P′. We must next find how much water the body displaces, which we may call a, then the apparent specific gravity of the body is $\frac{\mathrm{P}}{a}$, as it has really displaced the quantity of water a. But, in order to know the specific gravity of the solid parts of the body which do not admit water, such as the real fibrous part of sponges, then we must consider, that the quantity of water displaced is not merely a, but $a-\mathrm{P}'$, and therefore $\frac{\mathrm{P}}{a-\mathrm{P}}$ is the real specific gravity, neglecting the necessary reductions.

In order to explain the formulæ given by M. Biot for solid bodies, let us take

t = temperature at which the solid is weighed.
V = the volume of the solid body in cubic centimetres at the temperature t.
(s) = the absolute weight of a cubic centimetre of its substance at the temperature of melting ice.
K = the cubical dilatation of the solid for one degree of the centigrade thermometer.
(e) = the weight of a cubical centimetre of water at the temperature of melting ice.
δ = the dilatation of water from 32° to t.
α = the ratio of the weight of air to that of water in the circumstances under which the experiment is made.
λ = the dilatation of any other liquid employed instead of water.
(π) = the weight of a cubical centimetre of another liquid at the temperature of melting ice.
S = the weight of the solid in air.
S′ = the weight of the solid in water.

Case 1. When the body is weighed successively in air and water,

$$\frac{(s)=(1+\mathrm{K}\,t)\left(\frac{\mathrm{S}(\pi)}{1+\lambda}-\frac{\mathrm{S}'(e)a}{1+\delta}\right)}{\mathrm{S}-\mathrm{S}'} \qquad \text{No. 1.}$$

If the body has been weighed successively in water and in air at the same temperature, then $(\pi)=(e)$ and $\lambda=\delta$, consequently

$$(s)=\frac{(e)(1+\mathrm{K}\,t)\ (\mathrm{S}-\mathrm{S}'\alpha)}{(1+\delta)\quad(\mathrm{S}-\mathrm{S}')} \qquad \text{No. 2.}$$

Case 2. When there are three weighings, 1st of the solid body, 2d of the glass in a vessel filled with a liquid, and 3d of the same vessel containing the solid and the liquid;

$$\text{Then } \frac{(s)=(1+\mathrm{K}\,t)\left(\frac{\mathrm{S}(\pi)}{1+\lambda}-\frac{(\mathrm{P}-\mathrm{L})\ (e)\alpha}{1+\delta}\right)}{\mathrm{S}-\mathrm{P}+\mathrm{L}} \qquad \text{No. 3.}$$

If the body has been weighed successively in water and in air, then $(\pi)=(e)$ and $\lambda=\delta$, and the formula is reduced to

$$(s)=\frac{(e)(1+\mathrm{K}\,t)[\mathrm{S}-(\mathrm{P}-\mathrm{L})\alpha]}{(1+\delta)(\mathrm{S}-\mathrm{P}+\mathrm{L})} \qquad \text{No. 4.}$$

Case 3. When there are only two weighings, 1st of the solid in air, and 2d of the solid in liquid in the same vessel: In this case let M be the weight of the solid and liquid,

$$(s)=\frac{(e)\,(1+K\,t)[S-(P-M+S)s]}{(1+\delta)\,(S-P+M-S)} \quad \text{No. 5.}$$

This formula differs from No. 4. only in the substitution of M — S in place of L.

CHAP. III.

ON THE THEORY AND CONSTRUCTION OF AREOMETERS, OR HYDROMETERS, FOR MEASURING SPECIFIC GRAVITIES.

SECT. IV. *On the Construction of different Hydrometers.*

The names *areometer*, *hydrometer*, *gravimeter*, have been indiscriminately applied to those instruments which are employed, when very great accuracy is not required, for determining the specific gravities of spirituous liquors, and other fluids.

Before we enter upon the description of these instruments, we shall first explain the general principles of their construction, as exhibited in the hydrometer of Fahrenheit.

1. *Fahrenheit's Hydrometer.*

Fahrenheit's hydrometer. PLATE CCCXIV. Fig. 1.

This instrument is represented in Plate CCCXIV. Fig. 1. It may be constructed either of glass or metal, and consists of a cylindrical stem AB, Fig. 1. connected with two hollow balls C, D. A small quantity of mercury, or of leaden shot, is introduced into the lower ball D, so as to prevent it from overturning, and to make it float steadily when it is immersed in a fluid. In using this instrument, we may either load it with different weights, or have a scale of equal parts engraven upon its stem. Fahrenheit adopted the first of these methods. He made a mark *w* upon the stem AB, and having immersed it in the lightest liquor, (Fahrenheit used spirits or wine and spirits of turpentine,) such as ether, he introduced mercury into the ball D. till the surface of the light fluid stood at the mark *w*. The tube AB was then hermetically sealed, and the instrument weighed in a nice pair of scales. This weight will obviously be the weight of the quantity of fluid which it displaces. When the instrument was placed in a denser fluid, such as water, he placed weights in the small box at A, till the hydrometer sunk to the same mark *w*. By again weighing the hydrometer with the additional weights, he obtained the weight of a quantity of the denser fluid which was displaced; but as the part immersed was the same in both cases, the two weights which he had obtained were the absolute weights of equal quantities of two fluids, and were, therefore, the ratios of their specific gravities. Thus if W be the weight of the loaded instrument in distilled water at the temperature of 60° of Fahrenheit, when it has sunk to any mark upon the stem, and *w* the weight, which must either be taken from the box at A, or added to it, in order to make the instrument sink to the same point in another fluid, and B the volume or bulk of the part immersed, then S, *s*, being the specific gravities, we have $W=S\times B$, and $W\pm w=s\times B$. Hence $B=\frac{W}{S}$ and $B=\frac{W\pm w}{s}$, and $\frac{W\pm w}{s}=\frac{W}{S}$, and by reduction $s=\frac{S\times W\pm w}{W}$; or since $S=1.00$ in water, $s=\frac{W\pm w}{W}$. In the thermometer of Fahrenheit which we have described, the stem AB is made very short, and is only one-third of the length of a tube which he places between the balls C and D.

Hydrometers. PLATE CCCXIV. Fig. 1.

The results obtained with this hydrometer, may be reduced to the temperature of 32° of Fahrenheit, and allowance made for the effects of heat, both upon the liquid and the hydrometer itself. The following formula, given by M. Biot, includes these effects.

$$(\pi)=\frac{(P+P')\,(1+\lambda)}{(P)\,(1+Kt.)}$$

In this formula, (π) is the weight in grammes of a cubic centimetre of the liquid subjected to experiment; λ is the dilatation of this liquid from 32° to the temperature *t*, P is the absolute weight of the hydrometer when weighed *in vacuo*, or its weight in air diminished by the weight of the quantity of air which it displaces, and it also expresses, in cubic centimetres, the value of the part immersed in the liquid; (P) is the absolute weight of the part immersed at 32° of Fahrenheit; and K the cubic dilatation of the substance of the areometer.

2. *Clarke's Hydrometer.*

Clarke's hydrometer for spirituous liquors.

The hydrometer invented by Mr Clarke, and described in the Philosophical Transactions by Dr Desaguliers, was made of metal instead of glass. The principal ball was made hollow and of copper, and the brass wire of about $\frac{1}{4}$th of an inch thick, was soldered into it. Upon the stem a mark is made, to which the instrument sinks when it is placed in proof spirits, and another mark is made above and below this, at which it sinks when the spirit is $\frac{1}{10}$th under proof, or $\frac{1}{10}$th above proof. The lower ball could be screwed off, and other balls of different weights screwed on, for liquors that differ more than $\frac{1}{10}$th from proof, so as to give the specific gravities of all the mixtures of spirituous liquors that are used in trials. See the *Phil. Trans.* 1730, No. 413, p. 277.; and Desaguliers' *Course of Experimental Philosophy*, edit. 3d, vol. ii. p. 233.

3. *Desaguliers' Hydrometer.*

Desaguliers' hydrometer.

The object of this instrument was to ascertain the specific gravities of different kinds of water; and in order to give it a high degree of sensibility, Dr Desaguliers made the hollow glass ball less than three inches in diameter, while the stem to which it was attached was a long slender wire, whose diameter was only the 40th part of an inch, and whose length was 10 inches. Under the great ball is placed a small ball, about one inch in diameter, to contain shot for floating the instrument in a vertical position. In river or soft spring water, the hydrometer sinks to a fixed point in the middle of its stem. If a single grain weight is added, the stem will descend a whole inch. Now, as the hydrometer weighs 4000 grains, and as one inch of the stem weighs *ten* grains, the part of it immersed must weigh 4000—50=3950 grains, 50 grains corresponding to half the length of the stem. But the quantity of water displaced must weigh 4000 grains, equal to the whole weight of the hydrometer; consequently the instrument will serve to compare together the different bulks of 4000 grains of water; and since one tenth of an inch in the scale corresponds to one tenth of a grain, it will obviously distinguish the strength of a grain in 4000, or the 40,000th part of the whole bulk of water. By altering the quantity of shot in the ballast ball, this hydrometer may be fitted for comparing any other two liquors that have nearly the same specific gravity. See Dr Desaguliers' *Course of Experimental Philosophy*, vol. ii. p. 234.

4. *Deparcieux's Hydrometer.*

Deparcieux's hydrometer.

Plate CCCXIV. Fig. 2.

This instrument, which was intended by its author for measuring the specific gravities of different kinds of water, is represented in Plate CCCXIV. Fig. 2. where AB is a glass phial about seven or eight inches long, and two inches in diameter. It is loaded with shot at the bottom to prevent it from overturning, and its lower part is rounded to prevent the air from lodging below. A brass wire AC, about 30 inches long, and $\frac{1}{12}$ of an inch in diameter, is fixed in the cork of the phial, which is well varnished to prevent the penetration of the water. The length of the wire ought to be such, that, when the phial is loaded and immersed in spring water at a medium temperature, the whole phial, and about an inch of the wire, should be below the scale, while, when it is plunged in very light river water, the wire should be immersed about 20 inches. To the summit of the wire is fixed a cup C, which contains the small weights with which it may be found necessary to load the instrument in order to make it sink to a fixed point in different kinds of water. A tube of white iron DEFG, about 3 feet long, and 3 inches in diameter, is used to hold the water whose specific gravity is to be determined, and there is attached to it a scale EH, divided into inches and parts of an inch, for the purpose of measuring the different depths to which the instrument sinks. This instrument is so sensible, that, if a small quantity of spirits of wine, or a pinch of sugar or salt, are added to the water in the tin tube, the phial will ascend or descend a very sensible quantity. M. Deparcieux made use of a hydrometer which weighed 23 ounces, 2 gros, and 26 grains (French). A weight of 38 grains made it descend through a height of 19 inches, 6 lines, which was equal to $6\frac{3}{19}$ lines for every grain, or the $\frac{1}{17428}$th part of the volume of water displaced. The results given in our general Table of specific gravities, p. 455, for different waters in France, were obtained by means of this instrument. See Prony's *Architecture Hydraulique*, tom. i. § 614—627.

5. *Jones's Hydrometer.*

Jones's hydrometer.

This hydrometer, which was invented by Mr William Jones of Holborn, is constructed so as to apply the correction which is necessary from a change of temperature. This correction had hitherto been applied only in a rough manner; but upon considering that 32 gallons of spirits in winter will expand to nearly 33 gallons in summer, Mr Jones fixed a thermometer to his instrument, and by adjusting the divisions experimentally, he has obtained it pretty correctly. Mr Jones has also taken into account the diminution of bulk which takes place in mixing alcohol and water, which is so great as to produce a loss of four gallons in the 100. Thus, if to 100 gallons of spirit of wine, which are 66 gallons in the 100 over proof, 66 gallons of water are added to reduce it to proof spirit; the compound of water and alcohol will consist only of 162 gallons instead of 166, four gallons having been lost by the mutual penetration of the two fluids.

Fig. 3.

Mr Jones' hydrometer is represented in Plate CCCXIV. Fig. 3. It consists of a stem AC of the form of a parallelopiped, on the five sides of which the different strength of spirits are marked. One of these sides is shewn in Fig. 3. and the other three separately. This stem is fixed to the oval ball CD, which is made of hard brass, and has its conjugate diameter about one and a half inches. A thermometer DE is attached to the stem DB below the ball, and the whole length AB of the instrument is about $9\frac{1}{2}$ inches. Three weights W, W′, W″ are suited to the three sides of the stem shewn separately. Let us now suppose that the instrument is plunged in a spirituous liquor; then, if it floats, so that the surface of the liquor is somewhere between A and C, the division on the side of the stem marked 0 (viz. the side of the stem attached to the instrument) will indicate the strength of the liquor if it is between 74 gallons in the 100, and 47 in the 100 above proof. But if the surface of the fluid stands below the extremity C of the scale, it must be loaded with any of the weights W, W′, W″, till the surface of the liquor rises above C; then, if the weight W, or No. 1. is required to produce this effect, the side of the stem marked No. 1. will shew the strength of the spirituous liquor from 46 gallons in the 100 to 13 in the 100 above proof. If the weight No. 2. is required to raise the surface of the spirits above C, the divisions on the side marked No. 2. will shew the strength from 13 gallons in the 100 above proof to 29 gallons in the 100 under proof; and if the weight No. 3. is required, the division on the side marked No. 3. will shew the strength of the spirits from 29 under proof down to water, which is marked W at the bottom of the scale No. 3. The thermometer DE has four scales engraven upon it, marked No. 1, 2, 3, corresponding with the similarly numbered scales on the stem. Two of these scales only are seen in the figure. The zero or 0 of each scale is at the middle of each column, and corresponds with a temperature of 60° of Fahrenheit; then whatever number of divisions the mercury in the thermometer stands above the zero, so many gallons in the 100 must the liquor be reckoned weaker than the hydrometer indicates; and whatever number of divisions the mercury in the thermometer stands below the zero, so many gallons in the 100 must the spirits be reckoned stronger than the hydrometer indicates.

Jones's hydrometer.

Plate CCCXIV. Fig. 3.

The diminution of bulk occasioned by the mutual penetration of the two fluids, is marked by the small figures on the different scales of the stem. Thus the figures $2\frac{1}{2}$ at 48, $3\frac{1}{2}$ at 61, and 4 at 66, indicate, that if the spirit be 48 gallons in the 100 over proof, the bulk of the compound will be $2\frac{1}{2}$ gallons less than the sums of the two ingredients, that is, instead of being 148 it will be $145\frac{1}{2}$. This instrument is adjusted, like other hydrometers, to the temperature of 60° of Fahrenheit, and requires only three different weights to determine the strength of spirituous liquors from alcohol to water.

6. *Dicas's Hydrometer.*

Dicas's hydrometer.

The hydrometer constructed by Mr Dicas of Liverpool, possesses all the advantages of Jones' hydrometer, but exhibits, with more accuracy, the correction which it is necessary to apply for a change of temperature. It is constructed of metal, with a stem and ball of the ordinary form. It has 36 different weights, which are valued from 0 to 370, including the divisions on the stem; but the chief improvement which distinguishes this hydrometer is its ivory sliding scale, which adjusts it to different temperatures, and indicates the diminution of bulk arising from the mutual penetration of the combined fluids.

7. *Quin's Universal Hydrometer.*

Quin's universal hydrometer.

The object of this hydrometer is to ascertain with the greatest expedition the strength of any spirit from alcohol to water, the diminution of bulk, and the specific gravity of each different strength, and also the specific gravity of worts. In its general appearance, it is nearly the same as Jones' hydrometer, shewn in Fig. 3. The stem has four sides, one of which indicates the strength of any spirit, from alcohol to water, while the other three shew the specific gravities of worts. The stem has a conical form, in order to make the degrees upon it more equal than they would otherwise have been. A sliding rule, differing very little from that of Mr Dicas, exhibits the variations of density arising from changes of temperature. In using this instrument, place any of the weights, if necessary, upon the top of the part of the stem below the ball; observe the temperature of the spirit with a thermometer, and bring the star of the sliding rule to the degree of heat on the thermometric scale; then the strength of the spirit will be found opposite to the number of the weight and the letter on the stem. See a full account of this hydrometer in the *Transactions of the Society of Arts*, vol. viii. p. 98.

8. *Nicholson's Hydrometer.*

Nicholson's hydrometer. PLATE CCCXIV. Fig. 4.

The hydrometer invented by the late Mr Nicholson, is superior to the ordinary instruments, both in its general construction, and from its being capable of ascertaining the specific gravities of solids. This instrument, which is shewn in Fig. 4. of Plate CCCXIV. consists of a hollow copper ball CD attached to the dish AB by means of a stem AC, made of hardened steel, and about $\frac{1}{40}$th of an inch in diameter. An iron stirrup E, fixed to the lower extremity of the ball, carries another dish F, sufficiently heavy to keep the instrument in a vertical position. The parts of the instrument are so adjusted, that when 1000 grains are placed in the upper dish AB, the whole will sink in distilled water at the temperature of 60° of Fahrenheit, to the point *m* in the middle of the stem.

In order to find the specific gravity of a fluid, immerse the instrument in it, and place weights in the dish AB till it sinks to the point *m*; then, since the quantity of fluid displaced is always the same, we shall have $W+1000 : W \pm w = S : s$; W being the weight of the instrument, *w* the weight necessary to make it sink to *m*, S the specific gravity of water, and *s* that of the fluid.

To determine the specific gravities of solids that do not exceed 100 grains in weight, place the instrument in distilled water, and, having put the solid in the dish AB, throw weights into the same dish till the instrument sinks to *m*. The sum of the weights added being subtracted from 1000 grains, will obviously be the weight of the solid, which we may call W. Let the solid be now placed in the lower dish F, and weights added in the upper dish AB till the instrument again sinks to *m*. The weights now added, which we may call *w*, will be the loss of weight which the solid sustains, or the weight of an equal bulk of distilled water, consequently $s : S = W : w$. As the cylindrical stem of this instrument is only $\frac{1}{40}$th of an inch in diameter, the instrument will rise or fall nearly one inch by the subtraction or addition of $\frac{1}{10}$th of a grain. It will therefore indicate changes in weight less than $\frac{1}{10}$th of a grain, or $\frac{1}{10000}$th of the whole; which will give the specific gravities correct to five places of figures. See *Manchester Memoirs*, vol. ii. p. 570; and Nicholson's *Natural Philosophy*, vol. ii. p. 16.

9. *Atkins' Hydrometer.*

Atkins' hydrometer.

This instrument, which is of brass, consists of an elliptical bulb and stem, with a small loaded bulb below, for keeping it in a vertical position. The total length is 8 inches, the elliptical bulb is 1¼ inches in diameter and 2 inches long, and the square stem is $\frac{1}{8}$th of an inch wide. One of the faces of the scale is used for liquors that are specifically lighter than water. On this face are engraven the 26 letters of the alphabet, with an 0 or zero at the beginning and end of the letters, thus—0, A, B, C, D, &c. Z, 0. Opposite to each letter, and between each of them, is a division for marking the point of the stem to which the instrument sinks, so that the total number of divisions is 55. The weight of the hydrometer is 400 grains, and it is furnished with four weights, viz. No. 1, 2, 3, 4, which weigh respectively 20, 40, 61, and 84 grains, which are placed on the instrument, below the elliptical bulb, as occasion requires. These weights are adjusted in such a manner, that when with one of them, such as No. 2, the instrument emerges to the lower division 0, it will, upon changing the weight for the next heavier one, No. 3, sink exactly to the other division 0, at the top of the stem. Hence the stem is virtually extended to five times its real length, and the number of divisions increased to 272; thus, without any weight at all, it will sink exactly to the upper division 0 in a liquor whose specific gravity is .806, and to the lower division 0 in a liquor whose specific gravity is .843, the intermediate specific gravities being indicated by intermediate divisions on the scale. By applying the weight No. 1, we obtain all the specific gravities from .843 to .880; No. 2. gives them from .880 to .918; No. 3. from .918 to .958; and No. 4. from .950 to 1.000. When the last weight is used in water, the instrument sinks to the lower 0 at 55° degrees of Fahrenheit. Each of the divisions on the stem will be found to correspond to considerably less than an unit in the third place of the specific gravity, and to indicate a difference of about one-half per cent. or two quarts in a hundred gallons. The correction for temperature is obtained from a sliding rule, by an ingenious application of two scales of equal parts to each other; and the diminution of bulk, or penetration as it is called, is obtained by the same rule. The specific gravities, corresponding to the divisions on the stem, are likewise pointed out by the sliding rule.

Mr Atkins afterwards made considerable changes upon this instrument. Instead of making the weights circular, he made them of different figures, viz. round, square, triangular, and pentagonal, so as to prevent any mistake being committed; and he stamps upon the sliding rule, the figure of the weight opposite to every letter in the series to which it belongs. He has also made the form of the great bulb cylindrical, and rounded off at the upper and lower sides; and instead of the alphabetical scale, he has engraven the real specific gravities on the stem of the instrument. A full account of this instrument will be found in Mr Atkins' pamphlet on the *Relation between the Specific Gravities and the Strength of Spirituous Liquors*, Lond. 1803; and in Nicholson's *Journal*, 8vo, vol. ii. p. 276, and vol. iii. p. 50.

10. *Guyton's Gravimeter.*

Guyton's gravimeter.

This instrument, which was invented by the late celebrated chemist M. Guyton Morveau, is made of glass, and carries two basins like the hydrometer of Nicholson. The bulb is cylindrical, and is connected with the upper basin by a slender stem, in the middle of which is the fixed point of immersion. The lower basin, which terminates in a point, contains the ballast, and is attached to the cylinder by two branches. The cylinder is 6.85 inches long, and 0.71 in diameter. The upper basin carries an additional constant weight of 115 grains.

Guyton's gravimeter.

To this apparatus, M. Guyton has added another piece, which he calls the *Plongeur*, or plunger, which is a ball of glass loaded with mercury, till its total weight may be equal to the additional weight of 115 grains, added to the weight of the volume of water displaced by the plunger. The plunger is always placed in the lower basin when it is used; and it will readily be seen, that the gravimeter will sink to the same mark on the stem whether it is loaded with the constant weight of 115 grains in the upper basin, or with the plunger in the lower basin.

The object of this instrument is to ascertain, 1st, The specific gravities of solids, whose absolute weight is less than 115 grains; 2d, Of liquids inferior to water in specific gravity; 3d, Of liquids of greater specific gravity than water; 4th, The absolute weight of bodies below 115 grains; and, 5th, The degree of rarefaction and condensation of water in proportion to its bulk, the purity of the water being previously known.

In order to find the specific gravity of any solid by this instrument, place the solid in the upper basin, and add weights till the instrument sink to the fixed point of immersion. Subtract these weights from the constant weight of 115 grains, and the remainder is the absolute weight of the solid. Multiply this by the specific gravity of the fluid, and reserve the product, place the solid in the lower basin, and add weights in the upper basin till the instrument sinks to a fixed point of immersion; and subtracting these additional weights from the additional weights when the body was in the upper basin, the remainder will be the loss of weight by immersion. Divide the reserved product by this loss of weight, and the quotient will be the specific gravity of the solid with regard to distilled water at the standard temperature and pressure.

In order to find the specific gravity of a fluid, immerse the gravimeter in the fluid, and having observed the weight which is necessary to sink it to the fixed point of immersion, add this weight to that of the gravimeter. To the weight required to sink it in distilled water, add also the weight of the gravimeter. Divide the first sum by the second, and the quotient will be the specific gravity of the fluid. See the *Annales de Chimie*, vol. xxi. p. 3; and Nicholson's *Journal*, 4to, vol. i. p. 110.

11. *Speer's Hydrometer.*

Speer's hydrometer.

This instrument consists of a ball and stem, with a counterpoise underneath. The stem is cut into an octagonal form; and upon each of the eight faces of the octagon is engraved a scale of per centages, by the inspection of which the strength of the spirit may be found. The scale upon each of the faces is suited to the temperatures of 35°, 40°, 45°, 50°, 55°, 60°, 65°, and 70°. When the temperature of the spirits is found by the thermometer, their strength must be sought on that face of the octagon which corresponds with the temperature. As the temperature is indicated only to every five degrees, there is an index which performs the office of a weight, for pointing out the effect for intermediate temperatures. The precision of a single degree of the thermometer may also be obtained by four small pins, which are inserted in holes in the counterpoise below, where they operate as weights of adjustment, and produce the same effect as a variation of temperature. For a full account of this hydrometer, see Speer's *Enquiry into the Causes of the Errors and Irregularities which take place in ascertaining the Strength of Spirituous Liquors by the Hydrometer.* Lond. 1802; *Philosophical Magazine*, vol. xiv. p. 151; and the *Repertory of Arts*, 2d series, vol. iii. p. 81.

12. *Mr Adie's Statical Hydrometer.*

Adie's statical hydrometer. PLATE CCCXIV. Fig. 5.

This hydrometer, which is one of the neatest and most correct instruments that we have seen, was first constructed about the year 1799 by Mr Adie, optical instrument maker in Edinburgh. It is made entirely of brass, and consists of a lever AB 10½ inches long, resting upon a fulcrum C, so that the shorter arm AC is 2½ inches, and the longer one CB 8 inches long. At the extremity A of the shorter arm is suspended a brass ball, whose solid content is $\frac{1}{100}$ of a gallon. This ball is immersed in the fluid which is held in the cylindrical brass jar FG. Two moveable weights *m*, *n*, slide along each arm of the balance. When the temperature of the spirits is found by the thermometer, the weight *m* is set to the corresponding degree upon the thermometric scale AC. The weight *n* is then moved along the other arm CB, till the ball E is in equilibrium in the fluid, which is indicated by the coincidence of the arm CB with the horizontal index *o*, fixed to the bar *b*. The whole of this instrument is nicely packed into a mahogany box 11 inches long and 2½ square, which serves as a stand for the balance.

13. *Mr Adie's Sliding Hydrometer.*

Adie's sliding hydrometer.

The sliding hydrometer, invented by Mr Adie, differs from all other hydrometers, in requiring no weights whatever for its adjustment. It is a floating hydrometer, of the usual form; but instead of being adjusted by weights, the volume of the instrument is increased by drawing out a tube, while its weight is invariable. If the instrument sinks to the fixed point of immersion in distilled water, before the tube is drawn out, it is obvious that in spirituous liquors, it may be made to sink to the same point, merely by drawing out a tube below the principal bulb; for the same effect is thus produced by increasing the volume of the instrument, as if its weight were diminished.

14. *Charles's Thermometrical Hydrometer.*

Charles's thermometrical hydrometer.

This instrument, which, we believe, has been described for the first time by M. Biot in his *Traité de Physique*, tom. i. p. 414, was invented by M. Charles, to whom experimental philosophy is under great obligations. It is called a thermometrical hydrometer, from its being employed to measure the densities of water at different temperatures. In order to give a very high degree of sensibility to the instrument, M. Charles makes the ball very large, and the stem very small; the augmentation of the ball rendering the absolute effects of the dilatation more considerable, and the smallness of the stem enabling us to measure these dilatations upon a greater scale. The whole instrument, with the basin for holding the weights, weighed in air 90.303 grammes, or 90.4209 when reduced to a vacuum. An account of the results obtained with this instrument will be found in M. Biot's work.

15. *Charles's Balance Areometer.*

Charles's balance areometer.

This hydrometer, which is intended to measure the specific gravities of solids, does not differ very essentially from the hydrometer of Nicholson. It has a contrivance, however, for inverting the lower basin, when the solid whose specific gravity is required is lighter than water. In this case the basin is inverted, and the solid presses upwards against its bottom, and tends to elevate the hydrometer. See Biot's *Traité de Physique*, tom. i. p. 433.

16. *Dr Wilson's Hydrometer with Glass Beads.*

Dr Wilson's hydrometer with glass beads.

The late Dr Wilson, professor of astronomy in the university of Glasgow, proposed to measure the specific gravities of fluids by a series of small glass beads, or hollow balls, differing from each other in specific gravity. When any of the beads are thrown into the fluid, all those that are heavier than the fluid sink to the bottom, while those that are lighter float upon the surface. By holding the vessel either in the warm hand, or near a fire or candle, the fluid will dilate, and one of the glass beads will sink. Hence it follows, that the specific gravity of this bead, which is marked upon it, was either equal to, or a little less than that of the fluid before the heat was applied. If any of the beads should happen to be broken, the specific gravity of the liquor may be determined by the other beads; for the liquor in which No. 4. sinks will also allow No. 2. to sink by heating it a few degrees, so that No. 3. may be dispensed with. Complete sets of these bubbles, with a small treatise pointing out the method of using them, were made by Mr Brown, an artist in Glasgow, and have been pretty generally used by spirit-dealers. In some of these sets, the numbers upon each bead are the number of gallons of proof spirits contained in 100 gallons of the liquor; while in other sets, the number expresses the gallons of water which will make a liquor of that strength, if added to 14 gallons of alcohol.

17. *Lovi's Patent Areometrical Beads.*

Lovi's patent areometrical beads.

The patent areometrical beads have been brought to a very high degree of perfection by Mrs Lovi. They are now used by many of the first distillers and practical chemists, and have been honoured with the highest approbation of some of the principal philosophers and chemists in Scotland. The patent beads are fitted up in boxes, containing different quantities, according to the purposes for which they are wanted, and they are always numbered to every two units in the 3d place of specific gravity; for example, 920, 922, 924, &c. If they are required merely for spirituous liquors, thirty beads will be sufficient; but if they are required for all fluids, from ether to the most concentrated sulphuric acid, three hundred at least will be required. As these beads are marked with their respective specific gravities, we have only to throw a parcel of them into the fluid till we find the one that stands in the middle of the liquid without either rising to the top or sinking to the bottom. The number marked upon this bead will indicate the specific gravity of the fluid. The beads are accompanied by a sliding rule and a thermometer for making the corrections for differences of temperature, and for finding the strength of the spirits, in the language of spirit dealers and excise-officers. The superiority of this hydrometer to every other instrument with which we are acquainted, is very great. If the ordinary hydrometer meets with any accident, it is incapable of being repaired; but if any of the areometrical beads are broken, they can easily be replaced, and the specific gravity may be determined with sufficient accuracy, if one or even two beads of the series are destroyed.

The areometrical beads have been applied with great success by Mr Hutton to an improved method of ascertaining the quantity of spirituous liquors by weighing instead of measuring them.

"The weight of a very large quantity," says Mr Hutton, "may be ascertained at one operation, in a short time, and comparatively with little trouble. Now, if the weight of a cask be ascertained when empty, and afterwards when filled with spirits, the difference of these weights will be the weight of the spirits the cask contains; and since the specific gravity of spirits is easily found by means of the patent beads, we can thus obtain with the greatest facility both the weight and specific gravity of the spirits; and from these data, it is easy to calculate the quantity which a cask may contain, in terms of any given measure.

	C.	Qr.	lb.	oz.
Thus, suppose that a cask weighs, when empty, ...	1	3	2	2
And when filled with spirits, . . .	12	3	0	0
The difference or weight of the spirits will be	10	3	25	14

And suppose that the spirit is of the specific gravity 920, and that it is required to find the number of wine gallons which the cask contains,

We may proceed in this manner:

Since a cubic foot, or 1728 cubic inches, of spirit of this strength weighs 920 ounces, and a wine gallon contains 231 cubic inches; to ascertain the weight of a wine gallon of such spirits we have this proportion:

$\overset{\text{In.}}{1728} : \overset{\text{Oz.}}{920} :: \overset{\text{In.}}{231} : \overset{\text{Oz.}}{\frac{920 \times 231}{1728}}$ the weight of a wine gallon of spirits of the specific gravity 920.

And to ascertain the number of wine gallons or quantities of the weight $\frac{920 \times 231}{1728}$ ounces, contained in 10 C. 3 qrs. 25 lb. 14 oz. or 19,678 ounces, we have this proportion:

$$\overset{\text{Oz.}}{\frac{920 \times 231}{1728}} : \overset{\text{Gall.}}{1} :: \overset{\text{Oz.}}{19{,}678} : \overset{\text{Gall.}}{\frac{19{,}678}{\frac{920 \times 231}{1728}}} = \frac{1728 \times 19678}{920 \times 231} = \overset{\text{Gallons.}}{160.}$$

A quantity of spirits, therefore, of the specific gravity 920, and which weighs 10 C. 3 qrs. 25 lb. 14 oz. will measure exactly 160 wine gallons.

It is easy also, the number of wine gallons and specific gravity being given, to calculate the weight. Thus, in the above example, all the alteration that this state of the question would have occasioned, would have been in the second proportion, which would have stood thus:

$$\overset{\text{Gall.}}{1} : \overset{\text{Oz.}}{\frac{920 \times 231}{1728}} :: \overset{\text{Gall.}}{160} : \overset{\text{Oz.}}{\frac{160 \times 920 \times 231}{1728}} = \overset{\text{C.}}{10}\ \overset{\text{Qr.}}{3}\ \overset{\text{lb.}}{25}\ \overset{\text{oz.}}{14}$$

In this manner Mr Hutton has calculated a series of tables for giving the quantity of spirits by inspection. At the top, in the centre, is the specific gravity of the spirits, commencing at 906, and ending with 934, and embracing the different specific gravities at which spirits are usually met with in commerce. On the right of the number denoting the specific gravity, and on the same line with it, is the approximate weight of one gallon of spirits of that specific gravity, expressed in pounds and ounces. The tables consist of two sets of columns; one contains the number of gallons, and the other their weight: they begin with 30 gallons, being the smallest quantity it is considered necessary to weigh, and increasing by single gallons, they extend to 185 gallons, being the contents of the largest cask used in trade.

18. *Dr Brewster's Capillary Hydrometer.*

Dr Brewster's capillary hydrometer.

This instrument is founded upon a principle which was never before employed in hydrometrical measurements. It is well known that alcohol is a much more perfect fluid than water, possessing much less viscidity, in consequence of the small force of cohesion which exists between its particles. Hence it follows, that if a vessel containing alcohol is emptied through a capillary tube, so as to discharge the fluid only by drops, the drops will be much smaller, and consequently much more numerous, than when the same vessel is filled with water and emptied through the same tube. The capillary hydrometer, which is founded on this principle, is represented in Fig. 6. where ABC is a glass vessel three, or four, or five inches long, having a hollow bulb B about half an inch or an inch in diameter. This instrument is filled by suction at the lower end C, and the water is discharged at C till it stands nearly at the point *m*, the zero of the scale. By removing the finger from the lower end C, the water is discharged by drops, and the number of drops which fall till the fluid descends to another fixed point *n* are accurately counted. This experiment is carefully repeated at different temperatures, so that the number of drops of distilled water contained in the vessel between the points *m* and *n* is known for various temperatures. Hence, if N is the number of drops of water whose specific gravity is S, and *n* the number of drops of alcohol whose specific gravity is *s*, and *d* the number of drops given by any other mixture of alcohol and water, then $n—N : S—s = d—N : \frac{(d—N)\,(S—s)}{n—N}$, and therefore $S—\frac{(d—N)\,(S—s)}{n—N}$ will be the specific gravity of the mixture required. The same experiment is made with the purest alcohol, and the number of drops carefully marked. With an instrument of this kind, the number of drops necessary to empty it when filled with water was 724, whereas when it was filled with ordinary proof spirits, the number of drops amounted to 2117. This experiment, which was performed rudely, for the purpose of obtaining a general idea of the magnitude of the scale, was made nearly at a temperature of 60°. Now as the specific gravity of the spirit was about .920, and that of water 1.000, we have in the present case no less than a scale of 1393 drops for measuring specific gravities between .920 and 1.000; that is, a variation in the fifth figure, or in the fourth place of decimals of the specific gravity, nearly corresponds with a variation of two drops. With another instrument made on a very small scale, the number of drops amounted to 47 with water and 122 with spirit, whose specific gravity was 928. As this instrument was too large, I was obliged to incline it, in order to prevent the fluid from issuing in a continued stream. In the first experiment, $N=724$, $n=2117$, $S=1.000$, $s=920$. Hence if $d=1500$, we have

Plate CCCXIV. Fig. 6.

$$S—\frac{(d—N)\,(S—s)}{N—n}=\frac{1.000—776\times 0.080}{1393}=.9555.$$

The bulk of a drop of water will be about 2.93 times as large as the bulk of a drop of the spirit used in the first experiment. In the 2d experiment, the drop of water was 2.6 times greater than the drop of the spirit. See Chapter V. p. 473 of this article.

19. *Sikes' Hydrometer.*

Sikes' hydrometer.

As this hydrometer is now universally used in the collection of the revenue in both kingdoms, we shall lay before our readers a drawing and description of it, although it does not differ much in principle from the ordinary hydrometers. It is represented in Plate CCCXIV. Fig. 7. where AB is a flat stem 3.4 inches long, which is divided on both sides into 11 equal parts, each of which is subdivided into 2, the scale being numbered from 0 to 11. This stem is soldered into a brass ball 1.6 inch in diameter, into which is fixed a small conical stem CD, 1.13 inch long, at the end of which is a pear-shaped loaded bulb DE, half an inch in diameter. The whole instrument, which is made of brass, is 6.7 inches long. The instrument is accompanied with 8 circular weights, numbered 10, 20, 30, 40, 50, 60, 70, 80, and another weight of the form of a parallelopiped. Each of the circular weights are cut in to their centre, so that they can be placed on the conical stem C, and slide down to D; but in consequence of the enlargement of the cone they cannot slip off at D, but must be brought up to C for this purpose. The square weight, of the form of a parallelopiped, has a square notch in one of its sides, by which it can be placed upon the summit A of the stem. In using this instrument, it is immersed in the spirit, and pressed down by the hand to 0, till the whole divided part of the stem be wet. The force of the hand required to sink it will be a guide in selecting the proper weight. Having taken one of the circular weights which is necessary for this purpose, it is slipped on the conical stem at C. The instrument is again immersed and pressed down as before to 0, and is then allowed to rise and settle at any point of the scale. The eye is then brought to the level of the surface of the spirit, and the part of the stem cut by the surface, *as seen from below*, is marked. The number thus indicated by the stem is added to the number of the weight employed, and with this sum at the side, and the temperature of the spirits at the top, the strength per cent. is found in a Table of six quarto pages. "The strength is expressed in numbers denoting the excess or deficiency per cent. of proof spirit in any sample; and the number itself (having its decimal point removed two places to the left) becomes a factor whereby the gauged content of a cask or vessel of such spirit being multiplied, and the product being added to the gauged content if overproof, or deducted from it if under proof, the result will be the actual quantity of proof spirit contained in such cask or vessel."

Plate CCCXIV. Fig. 7.

The instrument is also accompanied with three sliding rules made of boxwood, which may be used instead of the Table. "The officers of excise are directed to estimate the temperature by the nearest degree *above* the surface of the mercury, when it stands between any two degrees of the thermometer, and the indication (or numbers on the stem) by the nearest division *below* the surface of the sample, when its level cuts the stem of the hydrometer between one division and another, thus giving the difference in favour of the trader in both cases. The square weight or cap shews the difference between the weight of proof spirit and that of water, as described in the first clause of the hydrometer act, and being one-twelfth part of the total weight of the hydrometer and weight 60. If this weight is placed upon the top of the stem at A, and if the hydrometer is loaded with weight No. 6, it will sink in distilled water at the temperature of 51° to the proof point P, at that temperature, as marked on the narrow edge of the stem."

20. *On the Hydrostatic Balance.*

On the hydrostatic balance.

Although the hydrostatic balance can scarcely be called a hydrometer, yet as it is employed for measuring specific gravities when great accuracy is required, we shall give a description of it in this place. The hydrostatic balance, of which we have given a front and a side view in Figs. 8. and 9, of Plate CCCXIV. is nothing more than a good balance, with some additional apparatus for enabling it to measure specific gravities with accuracy and expedition. The support of the balance is a pillar AB, fixed into a stand or base CD. By a silken string *P p e*, Fig. 9, attached to a screw S, and passing over the pullies P, *p*, is suspended the balance by means of the horizontal arm EF, on which the hook *e* is hung: *a f*, *f b*, are the arms of the balance, *e f* its tongue, *c*, *d*, the scales, and *m n* a slender curved rest, which prevents any of the arms from descending too far on either side. By means of the screw S, a vertical ascent or descent of the balance can be obtained; but when it is necessary to raise it much higher or lower, the whole sliding-piece into which the screw S is fixed, may be moved either forward or backward in a groove, or upon a brass rod placed upon the stand CD. A board GH is fixed upon the projecting arm L beneath the two scales, and being moveable up and down in a groove, it can be fixed in any position by a screw. In the middle of the lower surface of each scale is fixed a hook, to which are suspended brass wires *c k*, *d g*, which pass freely through two openings in the board GH. To the wire *c k* is suspended a cylindrical wire K *k*, about 5 inches long, perforated at each end, and covered with paper, containing a scale of equal parts. A brass tube MN is fixed on the corner of the board GH, in which a wire MN is made to move. On the lower part of the wire moves another tube W, carrying an index NO, which can be moved either horizontally by turning round the tube, or vertically by pushing it up or down; so that the index MN can be made to point to any division on the scale K *k*. A weight *k* is suspended to the wire K *k*, to which is fixed the wire *k l*, (of such a size that one inch of it will weigh about 4 grains,) with a small brass ball *l* about ¼ of an inch in diameter. A large glass bubble *h*, is in like manner suspended by a horse hair to the wire *d g*. The length of these wires is such, that the ball *l*, and the bubble *h*, hang about the middle of the cylindrical glass vessels X, Y, in the ordinary position of the balance. Since brass is nearly eight times heavier than water, it is evident, that for every inch that the wire *k l* sinks in the water in the vessel X, it will become half a grain lighter, and for every inch that it rises out of the water it will become half a grain heavier: consequently if it sinks 2 inches below its middle point *x*, or rises two inches above it, the wire will become one grain lighter or heavier. Let the middle point *x*, therefore, be brought to the surface of the water, and the index NO set to the middle of the scale K *k*, and let the distances OK, O *k* be each divided into 100 parts, then if it is required to weigh bodies to the accuracy of the 100th part of a grain, it may be done in the following manner. Let the body to be weighed be placed in the scale *c*, and let its weight be between 52 and 53 grains as determined by the weights in the opposite scale, then if we move the balance gently up and down by the screw S, till the tongue of the balance *e f* indicates a perfect equilibrium, the distance of the index NO from *k*, as measured upon the scale, will indicate the number of hundredth parts of a grain which the real weight of the body is above 52, or below 53, according as either of these weights is placed in the scale *d*. If 52 be the weight in the scale *d*, then since the weight of the body in the scale *c* exceeds 52, the scale *c* will preponderate, and the balance being let down until the equilibrium is restored by the loss of weight sustained by the immersed wire *k l*, the index NO will rise as it were from the middle part of K *k*. Hence if it points to 12 divisions above the middle of K *k*, the weight of the body will be 52.12 grains. Had the weight 53 been placed in the scale, it would have been necessary to raise the balance, so that the scale *c* might acquire an equilibrium with 53 grains, by an addition to the weight of the wire *k l* in consequence of its ascent from the water. In this case, the index NO would have pointed to division 88 below the middle point of the scale, and the weight of the body would have been 53.00 — 0.88 = 52.12 as before.

Plate CCCXIV. Figs. 8, 9.

The weight of the body in air being thus obtained with the utmost accuracy, it is next to be suspended to the hook *g* by means of the horse hair, and weighed when immersed in the water in the jar Y. The difference between these two weights, when they have been corrected by the methods formerly described,* will lead to an accurate determination of the specific gravity of the body. The wire *k l* should always be oiled, and the oil wiped off, so that a thin film may adhere to it, in order to prevent the adhesion of the water.

Sect. II. *On the Table of Specific Gravities.*

The determination of the specific gravities of bodies is of the greatest use, not only in many of the sciences, but also in most of the practical arts of life. Hence it has been the object of philosophers to determine, with all the accuracy in their power, the specific gravities of the various solid and fluid substances which occur in nature. The following Table, which we have collected with great labour from the tables of Brisson and other sources, contains the most important specific gravities that have been determined. All the measures are related to that of water, whose specific gravity is 1.000, excepting the gases or aëriform bodies, whose specific gravities are determined in relation to that of atmospheric air, which is taken at 1.00. The bodies are arranged in an alphabetical order for the sake of more easy reference.

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* See Prop. XII. and XIII. p. 434, 435.

Table of Specific Gravities.

Specific Gravities.

Specific Gravities.

A		
Acacia, inspissated juice of,		1.5153
Acid, nitric,		1.2715
nitric, highly concentrated,		1.583
muriatic,		1.1940
red acetous,		1.0251
white acetous,		1.0135
distilled acetous,		1.0095
acetic,		1.007 1.0095
sulphuric,		1.8409
highly concentrated,		2.125
fluoric,		1.500
phosphoric, liquid,		1.417
solid,		2.852
citric,		1.0345
arsenic,		3.391
of oranges,		1.0176
of gooseberries,		1.0581
of grapes,		1.0241
prince,		0.705
boracic, in scales,		1.479
do. melted,		1.803
molybdic,		3.460
benzoic,		0.667
formic,		1.102 1.113
Actinolite, glassy,	*Kirwan.*	2.950 3.903
Adularia, See *Felspar.*		
Agalmatolite,		2.800
Agate, oriental,		0.5901
onyx,		2.6375
speckled,		2.607
cloudy,		2.6253
stained,		2.6324
veined,		2.6667
Icelandic,		2.348
of Havre,		2.5881
jasper,		2.6356
Mocha,		2.5891
iridescent,		2.5535
Air, atmospheric,		
Barom. 29.75 Thermom. 32.		0.00122
Barom. 29.85 Thermom. 54°.5	*Lavoisier.*	0.0012308
Alabaster of Valencia,		2.638
veined,		2.691
of Piedmont,		2,693
of Malta,		2.699
yellow,		2.699
Spanish saline,		2.713
oriental white,		2.730
ditto, semi-transparent,		2.762
stained brown,		2.744
of Malaga, pink,		2.8761
of Dalias,		2.6110
Alcohol, absolute,	*Lowitz.*	0.791
highly rectified,		0.8293
commercial,		0.8371
15 parts, Water 1 part		0.8527
14 2		0.8674
Alcohol 13 parts, Water 3 parts		0.8815
12 4		0.8947
11 5		0.9075
10 6		0.9199
9 7		0.9317
8 8		0.9427
7 9		0.9519
6 10		0.9594
5 11		0.9674
4 12		0.9733
3 13		0.9791
2 14		0.9852
1 15		0.9919
Alder-wood,	*Muschenbroek.*	0.8000
Allanite,	*Bournon.*	3.119 4.001
	Thomson.	3.533
	Jardine.	3.665
Aloes, hepatic,		1.3586
socotrine,		1.3795
Alouchi, an odoriferous gum,		1.0604
Alumine, sulphate of,	*Muschenbroek.*	1.7140
saturated solution of, temp. 42°,	*Watson.*	1.033
Amber, yellow transparent,		1.0780
opaque,		1.0855
red,		1.0834
green,		1.0829
Ambergris,		0.7800 0.9263
Amethyst, common. See *Rock* crystal.		2.750
Amianthus, long,		0.9088
penetrated with water,		1.5662
short,		2.3134
penetrated with water,		3.3803
Amianthinite from Raschau,		2.584
Bayreuth,		2.916
Ammonia, liquid,		0.8970
muriate of,	*Muschenbroek.*	1.4530
saturated solution of, temp. 42°,	*Watson.*	1.072
Amphibole. See *Hornblende* basaltic		
Amphigene. See *Leucite.*		
Analcime,		2.0 3.0
Andalusite, or hardspar	*Haüy.*	3.165
Anhydrite, or Muriacite,		2.95
Anime, oriental,		1.0284
occidental,		1.0426
Anthophyllite,		3.20
Antimony, glass of,		4.9464
in a metallic state, fused,		6.624 6.860
native,	*Klaproth.*	6.720
grey,		4.3
sulphur of,		4.0643
ore, grey and foliated,	*Kirwan.*	4.368
radiated,	*Kirwan.*	4.440
red,	*La Metherie.*	3.750
	Klaproth.	4.090
Apatite. See *Phosphorite.*		
Aplome		3.45
Apophyllite. See *Fish Eye Stone.*		

Specific Gravities.

Apple-tree, wood of the,	*Muschenbroek.*	0.7930
Aquamarine. See *Beryl.*		
Arcanson,		1.0857
Areca, inspissated juice of,		1.4573
Arctizite, or Wernerite,	*Dandrada.*	3.606
Argillite, or slate clay,	*Kirwan.*	2.600 2.680
Arnotto,		0.5956
Arragonite,	*Haüy,*	2.946
	Thenard and *Biot.*	2.9267
	Malus.	2.94686
Arsenic bloom, Pharmacolite,	*Klaproth.*	2.640
fused,	*Bergman.*	8.310
native,	*Kirwan.*	5 670
	La Metherie.	5.600
	Brisson.	6.522
glass of, (arsenic of the shops),		3.5942
Arsenical pyrites, or Mispickel,		6.5
See *Realgar.*		
Asbestinite,	*Kirwan.*	3.000 3.310
Asbestos, mountain cork,	*Bergman.*	0.6806 0.9933
penetrated with water,		1.2492 1.3492
ripe,	*Brisson.*	2.5779
penetrated with water,		2.6994
starry,		3.0733
penetrated with water,		3.0808
unripe,		2.9958
penetrated with water,		3.0343
Ash trunk,	*Muschenbroek.*	0.8450
dry,	*Turin.*	0.800
Asphaltum, cohesive,		1.450 2.060
compact,		1.070 1.165
Assafœtida,		1.3275
Aventurine, semitransparent,		2.6667
opaque,		2.6426
Augite, or Pyroxene,	*Häüy.*	3 226
	Werner.	3.471
	Reuss.	3.777
Automalite, Gahnite, or Fahlunite,		4 200
Axinite, or Thumerstone,		4.690
	Haüy.	3.213 3.296
	Gerard.	3.250
Azure stone, or lapis lazuli,	*Brisson.*	2.7675
	Kirwan.	2.896
oriental,		2.7714
of Siberia,		2.9454

B

Barolite, or Witherite. See *Barytes*, Carbonate of.		
Barytes, or Baroselenite,		4.400 4.865
white,		4.4300
grey,		4.4909
rhomboidal,		4.4434
octaedral,		4.4712
in stalactites,		4.2984
sulphate of, native,	*Kirwan.*	4.000 4.460
	Malus.	4.48141
carbonate of, native,		4.300 4.338
Basaltes,	*Kirwan.*	2.979
	Bergman.	3.000
Basaltes, from the Giant's Causeway,		2.864
prismatic from Auvergne,		2.4215
of St Tubery,		2.7948
Baras, a juice of the pine,		1.0441
Bay tree, Spanish,	*Muschenbroek.*	0.8220
Bdellium,		1.1377
Beech-wood,	*Muschenbroek.*	0.8520
Beer, red,		1.0338
white,		1.0231
Benzoin,		1.0924
Beryl, oriental,		3.5491
occidental,		2.723
or aquamarine,	*Werner.*	2.650 2.759
schorlous, or shorlite. See *Pycnite.*		
Bezoar oriental,		1.666
occidental,		2.233
Bismuth, native,	*Kirwan.*	9.570
sulphuretted,	*Kirwan.*	6.131
ochre,	*Brisson.*	4.371
in a metallic state, fused,		9.756 9.822
Bismuth,	*Brisson.*	9.070
Bitumen of Judea,		1.104
Black-coal, pitch coal,	*Wiedemann.*	1.308
slate coal, English,	*Kirwan.*	1.250 1.370
Bielschowitz,	*Richter.*	1.321 1.382
cannel coal,	*La Metherie.*	1.270
Blende, yellow,	*Gellert.*	4.044 4.048
brown, foliated,	*Gellert.*	3.770 4.048
black,	*Gellert.*	3.930
	Brisson.	4.166
auriferous from Nagyag,	*Van Muller.*	5.398
Blood, human,	*Jurin.*	1.054
crassamentum of,	*Jurin.*	1.126
serum of	*Jurin.*	1.030
Blood Stone. See *Heliotrope.*		
Boles,	*Kirwan.*	1.400 2.000
Bone of an ox,		1.656
Boracite,	*Westrumb.*	2.566
Borax,		1.714
saturated solution of, temp. 42°,	*Watson.*	1.010
Bournonite,		5.576
Boxwood, French,	*Muschenbroek.*	0.9120
Dutch,	*Muschenbroek.*	1.3280
dry,	*Jurin.*	1.030
Brass, common cast,		7.824
wiredrawn,		8.544
cast, not hammered,	*Brisson.*	8.395
Brasil wood, red,	*Muschenbroek.*	1.0310
Bronzite,		3.20
Brick,		2.000
Butter,		0.9423

C

Cacao butter,		0.8916
Cachibou, gum,		1.0640
Calamine,	*Brisson.*	3.525
	La Metherie.	4.100
Calcareous spar. See *Spar.*		
Calculi urinary,		1.700 1.240 1.434
Campeachy wood, or logwood,	*Muschenbroek.*	0.9130

Camphor,*		0.9887
Caoutchouc, elastic gum, or India rubber		0.9335
Caragna, resin of the Mexican tree caragna,		1.1244
Carbon of compact earth,		1.3292
Carnelian, stalactite,		2.5977
speckled		2.6137
veined,		2.6234
onyx,		2.6227
pale,		2.6301
pointed,		2.6120
arborized,		2.6133
Cat's eye,	*Klaproth.*	2.600 2.625
grey,		2.5675
yellow,		2.6573
blackish,		3.2593
Catchew, juice of an Indian tree,		1.3980
Caustic ammoniac, solution of, or fluid volatile alkali,		0.897
Cedar tree, American,	*Muschenbroek.*	0.5608
wild,	*Muschenbroek.*	0.5608
Palestine,	*Muschenbroek.*	0.5960
Indian,	*Muschenbroek.*	1.3150
Celestine. See *Strontian*, sulphate of.		
Cerite,		4.500
Ceylanite, or Pleonaste,	*Hauy.*	3.765 3.793
Chabasie,		2.718
Chalcedony, bluish,		2.5867
onyx,		2.6151
veined,		2.6059
transparent,		2.6640
reddish,		2.6645
common,	*Kirwan.*	2.600 2.655
Chalk,	*Muschenbroek.*	2.252
	Watson.	2.657
Chiastolite. See *Macle.*		
Cherry-tree,	*Muschenbroek.*	0.7150
Chrysoberyl. See *Cymophane.*		
Chrysolite of the jewellers,	*Brisson.*	2.782
of Brasil,		2.692
	Werner.	3.340 3.410
Chrysoprase, a variety of Chalcedony,		2.489 3.250
Chrystal. See *Rock Crystal.*		
Chrystalline lens,		1.100
Cimolite,		2.0
Cinnabar, dark red, from Deux-Ponts,	*Kirwan.*	7.786
from Almaden,	*Brisson.*	6.902
crystallized,	*Brisson.*	10.218
hepatic,		7.1
Cinnamon, volatile oil of,		1.044
Cinnamon-stone,		2.6
Citron-tree,	*Muschenbroek.*	0.7263
Clinkstone,	*Klaproth.*	2.575 2.620
Cloves, volatile oil of,		1.036
Cobalt, in a metallic state, fused,		7.645 7.811
ore, grey,	*Hauy.*	5.511 7.721
	Kirwan.	5.309
earthy, black, indurated,	*Gellert.*	2.019 2.425
vitreous oxide of,		2.4405
Cocoa wood,	*Muschenbroek.*	1.0403
Coccolite,	*Dandrada.*	3.316
Columbium,	*Hatchet.*	5.918
Copal, opaque,		1.1398
transparent,		1.0452
Madagascar,		1.0600
Chinese,		1.0628
Copper. native,	*Kirwan.*	7.600 7.800
from Siberia,	*Hauy.*	8.5084
Hungary,	*Gellert.*	7.728
ore, compact vitreous,	*Kirwan.*	4.129
Cornish,	*Kirwan.*	5.452
purple, from Bannat,	*Kirwan.*	4.956
from Lorraine,	*La Metherie.*	4.300
	Kirwan.	4.983
	Wiedemann.	5.467
glance,		5.6
pyrites,	*Kirwan.*	4.080
	Brisson.	4.344
ore, white,	*La Metherie.*	4.500
grey,	*Hauy.*	4.865 4.5
yellow,		4.3
blue,		3.2 3.4
foliated, florid, red,	*Wiedemann.*	3.950
azure, radiated,	*Wiedemann.*	3.231
	Brisson.	3.608
emerald,	*La Metherie.*	2.850
	Hauy.	3.300
muriate of,		4.4
arseniate of, hexahedral,		2.549
octahedral,		2.88
trihedral,		4.2
prismatic,		4.2
partial arseniate,		3.4
sulphate of, saturated solution of, temp. 42°,	*Watson.*	1.150
drawn into wire,		8.878
fused,		7.788
	Hatchet.	8.895
Copper sand, muriate of copper,	*La Metherie.*	3.750
	Herrgen.	4.431
Cork,	*Muschenbroek.*	0.2400
Corundum of India,	*Klaproth.*	3.710
	Bournon.	3.875
of China,		3.981
Cross stone. See *Harmotome.*		
Cryolite,	*Karsten.*	2.957
Cube iron ore,	*Bournon.*	3.000
spar,	*Hauy.*	2.964
Cubizite. See *Analcime.*		
Cyanite, Sappare, or Disthene,	*Saussure, jun.*	3.517
	Hermann.	3.622
Cyder,		1.0181
Cymophane, or Chrysoberyl,	*Werner.*	3.600 3.720
	Hauy.	3.796
Cypress wood, Spanish,	*Muschenbroek.*	0.6440
D.		
Datolite,		2.98
Dipyre,		2.63 2.84
Diallage. See *Smaragdite.*		
Diamond, oriental, colourless,		3.5212
rose-coloured,		3.5310

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* M. Venturi found, that when camphor was deprived of the air which adhered to it, by placing it under the receiver of an air-pump, it was heavier than water deprived of its air by the same air-pump. See *Memoires presentés a l'Institut.* tom. . p. 125, Paris, 1805.

Specific Gravities.

Diamond, oriental, orange-coloured,		3.5500
green-coloured,		3.5238
blue-coloured,		3.5254
Diamond, Brazilian,		3.4444
yellow,		3.5185
orange,	*Hauy.*	3.55
Dichroite. See *Iolite.*		
Disthene. See *Cyanite.*		
Dolomite		2.800
Dragons blood,		1.2045
Ether, sulphuric,	from	0.716
	to	0.745
nitric,		0.9088
muriatic,		0.7296
acetic,		0.8664
Ebony, Indian,	*Muschenbroek.*	1.2090
American,	*Muschenbroek.*	1.3310
Elder tree,	*Muschenbroek.*	0.6950
Elemi,		1.0182
Elm trunk,	*Muschenbroek.*	0.6710
Emerald,	*Gahn and Berzelius.*	2.673
		2.683
	Werner.	2.600
	Hauy.	2.723
of Brasil,		3.1555
pseudo,	*Gahn and Berzelius.*	2.701
Epidote. See *Zoisite.*		
Euclase,	*Hauy.*	3.0625
Euphorbium, gum		1.1244
F.		
Fahlunite. See *Automalite.*		
Fat of beef,		0.9232
veal,		0.9342
mutton,		0.9235
hogs,		0.9368
Felspar, fresh,	*Hauy.*	2.438
Adularia,	*Struve.*	2.500
		2.600
Labrador stone,	*Brisson.*	2.607
		2.704
glassy		2.518
		2.589
Fettstein,	*Borkowski.*	2.563
	Haüy.	2.614
Filbert tree,	*Muschenbroek.*	0.6000
Fir, male,	*Muschenbroek.*	0.5500
female,	*Muschenbroek.*	0.4980
Fish eye stone, Ichthyophthalmite, or Apophyllite,		2.5782
	Haüy.	2.467
Flint,	*Blumenbach.*	2.594
olive,		2.6057
spotted,		2.5867
onyx,		2.6644
of Rennes,		2.6538
of England,		2.6087
variegated of Limosin,		2.2431
veined,		2.6122
Egyptian,		2.5648
black,		2.582
Fluor spar. See *Spar.*		
G		
Gabbronite,		2.94
Gadolinite,		4.00
		4.20
Gahnite. See *Automalite.*		
Galbanum,		1.2120
Galena. See *Lead glance.*		
Galipot, a juice of the pine,		1.0819
Gamboge,		1.2220
Garnet, precious, of Bohemia,	*Klaproth.*	4.085
		4.188
	Werner.	4.230
	Kastner.	4.352
volcanic,		2.468
24 faces.		
of Syria,		4.000
in dodecahedral crystals,		4.0637
common,	*Werner.*	3.576
	Kastner.	3.688
Gas, atmospheric,[*] or common air,		1.000
phosgene, or chloro carbonic gas,	*J. Davy.*	3.3888
nitrous acid gas, calculated,	*Gay Lussac.*	3.176
	Sir H. Davy.	2.427
vapour of sulphuret of carbon,	*Gay Lussac.*	2.6447
sulphuric ether,	*Gay Lussac.*	2.5860
iodine, calculated,	*Gay Lussac.*	8.6195
hydriodic ether,	*Gay Lussac.*	5.4749
oil of turpentine,	*Gay Lussac.*	5.0130
hydriodic acid gas,	*Gay Lussac.*	4.4430
fluosilicic acid gas,	*John Davy.*	3 5737
chlorine,	*Gay Lussac* and *Thenard.*	2.470
euchlorine,	*Sir H. Davy.*	2.409
	Gay Lussac.	2.3144
fluoboracic gas,	*J. Davy.*	2.3709
vapour of muriatic ether.	*Thenard.*	2.219
chloro cyanic vapour,	*Gay Lussac.*	2.111
sulphurous acid,	*Sir H. Davy.*	2.193
	Gay Lussac and *Thenard.*	2.1204
vapour of alcohol,	*Dalton.*	2.1
absolute alcohol,	*Gay Lussac.*	1.613
cyanogen,	*Gay Lussac.*	1.806
nitrous oxide, or prolixite of azote,	*Sir H. Davy.*	1.614
	Colin.	1.5204
carbonic acid,	*Saussure.*	1.518
	Allan and *Pepys.*	1.524
	Biot and *Arago.*	1.51961
muriatic acid, or hydro chloric gas,	*Sir H. Davy.*	1.278
	Biot and *Arago.*	1.2474
sulphuretted hydrogen,	*Gay Lussac* and *Thenard.*	1.1912
	Sir H. Davy.	1.777
oxygen, mean,		1.104
	Saussure.	1.114
	Kirwan and *Lavoisier.*	1.103
	Biot and *Arago.*	1.0359
	Allan and *Pepys.*	1.127
nitrous gas, or deutoxide of azote,	*Berard.*	1.0388
	Sir H. Davy.	1.094
olefiant gas,	*Theodore, Saussure.*	0.97804
azote,	*Biot* and *Arago.*	0.96913
carbonic oxide,	*Cruickshank.*	0.9569
hydrocyanic vapour,	*Gay Lussac.*	0.9476
phosphuretted hydrogen,	*Sir H. Davy.*	0.870
steam,	*Tralles.*	0.6896
	Gay Lussac.	0.62349

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[*] The specific gravities of the gases are taken from Biot's *Traité de Physique*, tom. i. p. 363; from Gay Lussac's Table in the *Annales de Chimie et de Physique*, vol. i. p. 218; and from Thomson's *Annals of Philosophy*, vol. i. p. 118. The measures for the gases, taken by MM. Biot and Arago, are calculated from Biot's formulæ, which we have given in p. 432, 433 of this article. They are given in relation to atmospheric air which is supposed to be unity. Their relation to water is easily computed.

Gas, ammoniacal	*Sir H. Davy.*	0.590
	Biot and *Arago.*	0.59669
carburetted hydrogen,	*Thomson.*	0.555
	Sir H. Davy.	0.491
	Cruickshank.	0.678
	Dalton.	0.600
arsenical hydrogen,	*Trommsdorf,* *Dalton.*	0.529
phosphuretted hydrogen,	*Haüy.*	0.852
	Sir H. Davy.	0.435
hydrogen,	*Thomson.*	0.073
	Sir H. Davy.	0.074
	Biot and *Arago.*	0.072098
Gehlenite,	*Fuchs.*	2.78
Girasol,	*Brisson.*	4.000
Glance-coal, slaty,	*Metherie.*	1.300
	Klaproth.	1.530
Glass, crown of St Louis,	*Cauchoix, Biot.*	2.487
flint of M. Dartigues	*Cauchoix, Biot.*	3.20
flint used by Mr Tully for his achromatic telescopes,		3.192 3.334 3.354 3.437
white flint,		3.00
crown,		2.520
common plate,		2.760
yellow plate,		2.520
white or French crystal,		2.8922
St Gobins,		2.4882
gall,		2.8548
bottle,		2.7325
Leith crystal,		3.189
green,		2.6423
borax,		2.6070
fluid,		3.329
of Bohemia,		2.3959
of Cherbourg,		2.5596
of St Cloud,		3.2549
animal,		2.5647
mineral,		2.2694
tears, or Rupert's drops of flint glass,		
Glauberite,		2.700
Gold, native,		17.00 19.00
pure, of 24 carats, fine, fused, but not hammered,	*Haüy.*	19.2587
the same hammered,		19.342
English standard, 22 carats, fine, fused, but not hammered,		18.888
guinea of George II.		17.150
guinea of George III.		17.629
Parisian standard 22 carats, not hammered,		17.486
the same hammered,		17.589
Spanish gold coin,		17.655
Holland ducats,		19.352
trinket standard, 20 carats, not hammered,		15.709
the same hammered,		15.775
Portuguese coin,		17.9664
French money $21\frac{2}{3}$ carats fused,		17.4022
coined,		17.6474
French, in the reign of Louis XIII.		17.5531
Granite, red Egyptian,		2.6541
grey Egyptian,		2.7279
beautiful red,		2.7609
of Girardmor,		2.7163
violet of Gyromagny,		2.6852
red of Dauphiny,		2.6431
green, ———		2.6836
Granite, radiated, of Dauphiny,		2.6678
red of Semur,		2.6384
grey of Bretagne,		2.7378
yellowish,		2.6186
of Carinthia, blue,	*Kirwan.*	2.9564
Granitelle,		3.0626
of Dauphiny,		2.8465
Graphic ore.	*Muller.*	5.723
Graphite. See *Plumbago.*		
Grenatite. See *Staurotide.*		
Gum Arabic,		1.4523
tragacanth,		1.3161
seraphic,		1.201
cherry tree,		1.4817
Bassora,		1.4346
Acajou,		1.4456
Monbain,		1.4206
Gutte,		1.2216
ammoniac,		1.2071
Gayac,		1.2289
liquid, from Botany Bay	*Thomson.*	1.196
lac,		1.1390
animè, Eastern		1.0284
Western		1.0426
Gunpowder in a loose heap,		0.836
shaken,		0.932
solid,		1.745
Gypsum, opaque,		2.1679
compact, specimen in the Leskean collection,		2.939
compact,		1.872 2.288
impure,		2.473
foliated, mixed with granular limestone,	*Kirwan.*	2.725
semitransparent,		2.3062
fine ditto.		2.2741
opaque,		2.2642
rhomboidal,		2.3114
ditto, 10 faces,		2.3117
cuniform, crystallised,		2.3060
striated of France,		2.3057
of China,		2.3088
flowered,		2.3059
sparry opaque		2.2746
semitransparent,		3.3108
Gypsum, granularly foliated, in the Leskean collection,	*Kirwan.*	2.900
mixed with marl, of a slaty form,		2.473

H

Harmotome, or Cross Stone,		2.3333
Hazel,	*Muschenbroek.*	0.606
Hauyne, or Latialite,		3.20
Heavyspar. See *Barytes,* sulphate of.		
Heliotrope, or Blood Stone,	*Kirwan.*	2.629 2.700
	Blumenbach.	2.633
Hematites. See *Ironstone.*		
Hollow spar, Chiastolite,		2.944
Hone, razor, white,		2.8763
penetrated with water,		2.8839
razor, white and black,		3.1271
Honey,		1.4500
Honeystone, or Mellite,	*Haüy.* *Abich.*	1.586 1.666
Hornblende, common,	*Kirwan.*	3.600 3.830
resplendent, Labrador,	*Kirwan.*	3.350 3.434
Schiller spar,	*Kirwan.*	2.882

Specific Gravities.

Hornblende, schistose,	*Kirwan.*	2.909 3.155
basaltic,	*Reus.*	3.150 3.220
	Kirwan.	3.333
Hornstone, or petrosilex,		2.530 2.653
ferruginous,		2.813
veined,		2.747
grey,		2.654
blackish grey,		2.744
yellowish white,		2.563
bluish, and partly yellowish grey,		2 626
dark purplish red iron shot,		2.638
greenish white, with reddish spots, from Lorraine,		2.532
iron shot, brownish red, outside bluish, grey inside		2.813
Hyalite,	*Kirwan.*	2.110
Hyacinth,	*Karsten.*	4.000
	Klaproth.	4.545 4.620
Hydrargillite. See *Wavellite.*		
Hypersthene. See *Hornblende, Labrador.*		
Hypocist,		1.5263
I		
Jade, or Nephrite, white,		2.9592
green,		2.9660
olive,		2.9829
from the East Indies,	*Kirwan.*	2.977
of Switzerland,	*Brisson.*	3.310 3.389
combined with the boracic acid and boracited calx,		2.566
Jasmin, Spanish,	*Muschenbroek.*	0.7700
Jasper, veined,		2.6955
red,		2.6612
brown,		2.6911
yellow,		2.7101
violet		2.7111
grey,		2.7640
cloudy,		2.7354
green,		2.6274
bright green,		2.3587
deep green,		2.6258
brownish green,		2.6814
blackish		2.6719
blood coloured,		2.6277
onyx,		2.8160
flowered, red and white,		2.6228
red and yellow,		2.7500
green and yellow,		2.6839
red, green, and grey,		2.7323
red, green, and yellow		2.7492
universal,		2.5630
agate,		2.6608
Idocrase. See *Vesuvian.*		
Jenite,		3.80 4.00
Jet, a bituminous substance,		1.2590
Indigo,		0.7690
penetrated with water,		1.0095
Inspissated juice of liquorice,		1.7228
Iolite, or Dichroite		2.56
Iridium, ore of, discovered by Mr Tennant,	*Wollaston.*	19.500
Iron, native, meteoric,		6.48
chromate of, from the department of Var,		4.0326
Iron, chromate of, from the Uralian mountains, in Siberia,	*Lauguier.*	4.0579
sulphate of, saturated solution, temp. 42.	*Watson.*	1.157
arseniate of,		3.000
fused, but not hammered,		7.200
forged into bars,		7.600 7.788
pyrites, dodecahedral,	*Hatchet.*	4.830
from Freyberg,	*Gellert.*	4.682
Cornwall,	*Kirwan.*	4.789
cubic,	*Brisson.*	4.702
radiated,	*Hatchet.*	4.698 4·775
magnetic,	*Hauy.*	4.518
white,		4.
sand, magnetic sand, from Virginia,		4.600
	Bergman.	7.800
magnetic,		4.200 4.900
ore specular,	*Kirwan.*	4.793 5.139
ore specular,	*Brisson.*	4.939 5.218
micaceous,	*Kirwan.*	4.728 5.070
Ironstone, red, ochry,	*Wiedemann.*	2.952
compact,	*Kirwan.*	3.423
from Siberia,	*Kirwan.*	3.760
Lancashire,	*Brisson.*	3.573
	Wiedemann.	3.863
compact, brown, from Bayreuth,	*Kirwan.*	3.551
from Tyrol,	*Kirwan.*	3.753
cubic,	*Brisson.*	3.503 3.477
red hematites,	*Kirwan.*	5.005
	Gellert.	4.740
brown hematites,	*Kirwan.*	3.951
	Gellert.	3.789
	Wiedemann.	4.029
sparry, or calcareous,	*Kirwan.*	3.640 3.810
	Brisson.	3.672
decomposed,	*Kirwan.*	3.300 3.600
black, compact,	*Wiedemann.*	4.076
clay reddle,	*Brisson.*	3.139
	Blumenbach.	3.931
clay, lenticular,	*Kirwan.*	2.673
clay, common, from Cathina at Raschau,	*Kirwan.*	2.936
from Roscommon in Ireland,	*Rotheram.*	3.471
Carron in Scotland,	*Rotheram.*	3.205 3.357
clay, reniform iron ore,	*Wiedemann.*	2.574
clay, pea ore,	*Molinghof.*	5.207
Iron, native, (Heleachen mass)	*Monheim.*	6.723
ore, lowland, from Sprottau,	*Kirwan.*	2.944
Iserine, an oxide of titanium from the Iser in Bohemia,		4.500
Juniper tree,	*Muschenbroek.*	0.5560
Ivory, dry,		1.8250
Ivy gum, from the hedera terrestris,		1.2948
K		
Keffekil, or Meerschaum,	*Klaproth.*	1.6000
Kinkina,	*Muschenbroek.*	0.7840
Kyanite. See *Cyanite.*		

Specific Gravities.

L

Labdanum, resin,		1.1862
in tortis,		2.4933
Lapis nephriticus,		2.894
hæmatites,		4.360
judaicus,		2.500
manatis,		2.270
hepaticus,		2.666
lazuli. See *Azure stone.*		
Laumonite,		2.20
Lard,		0.9478
Latialite. See *Hauyne.*		
Lazulite. See *Azure stone.*		
Lead glance, or galena, common,	*Gellert.*	7.290
from Derbyshire,	*Watson.*	6.565 7.786
compact,	*Gellert.*	6.886 7.444
	Kirwan.	4.319 5.052
crystallised,	*Brisson.*	7.587
radiated,	*La Metherie.*	5.500
from the Hartz,	*Kirwan.*	7.448
Kautenbach,	*Vauquelin.*	6.140
Kirschwalder,	*Vauquelin.*	5.820
ore, corneous,	*Chenevix.*	6.065
reniform,	*Bindheim.*	3.920
of black lead,		6.745
blue,	*Gellert.*	5.461
brown,	*Wiedemann.*	6.974
from Huguelgoet,	*Klaproth.*	6.600
	Haüy.	6.909
black,	*Gellert.*	5.770
white, from Leadhills,	*Chenevix.*	7.236
	Haüy.	6.559
phosphorated, from Wanlockhead,	*Klaproth.*	6.560
Zschoppau,	*Klaproth.*	6.270
Brisgaw,	*Haüy.*	6.941
red, or red lead spar,	*Bindheim.*	5.750
	Brisson.	6.027
yellow, molybdenated,		5.092
Lead,	*Fischer, Wollaston.*	11.352
	Gellert.	11.445
arseniate of,		5.00 6.40
carbonate of		6.00 7.20
muriate of,		6.00
sulphate of,		6.3
chromate of,		6.00
acetate of,	*Muschenbroek.*	2.3953
vitriol, from Anglesea,	*Klaproth.*	6.300
Lemon tree,	*Muschenbroek.*	0.7033
Lenticular ore (arseniate of copper)	*Bournon.*	2.882
Lepidolite, lilalite,	*Klaproth.*	2.816
	Haüy.	2.854
Leucolite. See *Dipyre.*		
Leucite, or Amphigene,	*Klaproth.*	2.455 2.490
Lignum vitæ,	*Muschenbroek.*	1.3330
Limestone, compact,		1.3864 2.7200
foliated,		2.710 2.837
granular,		2.700 2.800
green,		3.182
arenaceous		2.742
white fluor. See *Calcareous spar.*		
Linden, wood,	*Muschenbroek.*	0.604
Lithomarge,		2.50
Logwood, or Campeachy wood,	*Muschenbroek.*	0.9130

Specific Gravities.

M

Macle,		2.9444
Madder root,	*Muschenbroek.*	0.7650
Mahogany,		1.0630
Magnesia, sulphate of, saturated solution, temp. 42°,	*Watson.*	1.232
native, hydrate of,		2.330
Magnesite, or carbonate of magnesia,		2.200
a new species, from Baumgarten in Silesia,	*Haussmann.*	2.95
Magnetic pyrites. See *Iron.*		
Malachite,	*Brisson.*	3.572
compact,	*Brisson.*	3.641
	Muschenbroek.	3.994
Manganese,	*Bergman.*	6.850
	Hielm.	7.000
grey ore of, striated,	*Brisson.*	4.249 4.756
	Rinmann.	4.181
grey, foliated,	*Hagen.*	3.742
red from Kapnick,	*Kirwan.*	3.233
black,	*Dolomieu.*	2.0000 3.0000
	Brisson.	3.7076
penetrated with water,		3.9039
scaly,		4.1165
sulphuret of		3.95
white		2.8
phosphate of		2.6
Maple wood,	*Muschenbroek.*	0.7550
Marble Carrara,	*Brisson.*	2.716
Pyrenean,		2.726
black Biscayan,		2.695
Brocatelle,		2.650
Castilian,		2.700
Valencian,		2.710
Grenadian white,		2.705
Siennian,		2.678
Roman violet,		2.755
African,		2.708
Italian, violet,		2.858
Norwegian,		2.728
Siberian,		2.728
French,		2.649
Switzerland,		2.714
Egyptian, green,		2.668
yellow of Florence,		2.516
Mastic,		1.0742
tree,	*Muschenbroek.*	0.8490
Medlar tree,	*Muschenbroek.*	0.9440
Meerschaum. See *Kessekil.*		
Meionite,		3.10
Melanite, or black garnet,	*Karsten.*	3.691
	Werner.	3.800
Mellite. See *Honeystone.*		
Menachanite,	*Lampadius.*	4.270
	Gregor.	4.427
Mercurial hepatic ore, compact,	*Kirwan.*	7.186 7.352
	Gellert.	7.937
Mercury at 32^0 of heat,		13.619
at 60^0		13.580
at 212^0		13.375
at 3^0.42, centigrade,	*Fischer.*	13.58597
in a solid state, 40^0 below 0 Fahr.	*Biddle.*	15.612

Specific Gravities.

Mercury in a fluid state, 47° above 0,	*Biddle.*	13.545
native,	*Haüy.*	13.5681
corrosive muriate of, saturated solution, temp. 42°	*Watson.*	1.037
natural calx of,		9.230
precipitate *per se*,		10.871
red,		8.399
mineralized by sulphur, native Ethiops. See also Cinnabar,	*Hahn.*	2.233
Mesotype,		2.0833
Mica, or glimmer,	*Brisson.*	2.791
	Haüy.	2.6546 2.9342
Milk, woman's		1.0203
mare's,		1.0346
ass's,		1.0355
goat's,		1.0341
ewe's,		1.0409
cow's,		1.0324
Mineral pitch, elastic, or asphaltum,	*Halchet.*	0.905 1.233
	La Metherie.	0.930
tallow,		0.770
Molybdena in a metallic state, saturated with water,		7.500
native,	*Kirwan.*	4.048
	Shumacher.	4.667
	Brisson.	4.7385
Mountain crystal. See *Rock Crystal.*		
Mulberry tree, Spanish,	*Muschenbroek.*	0.8970
Muriacite. See *Anhydrite.*		
Muricalcite, crystallized, or rhomb spar,		2.480
Myrrh,		1.3600

N

Natrolite Swedish,	*Thomson.*	2.779 2.790
Naphtha,		0.8475
Nepheline, or Sommite	*Haüy.*	3.2741
Nephrite. See *Jade.*		
Nickel in a metallic state,		7.421 8.500
	Bergman.	9.3333
copper,	*Brisson.*	6.6086 6.6481
	Gellert.	7.560
Nickel, ore of, called arsenical nickel, or Kupfernickel of Saxony,		6.648
Kupfernickel of Bohemia,		6.607
sulphuretted,		6.620
Nickeline, a metal discovered by Richter, cast,	*Richter.*	8.55
forged,	*Richter.*	8.60
Nigrine, or calcareo-siliceous titanic ore,	*Vauquelin.*	3.700
	Klaproth.	4.445
	Lowitz.	4.673
Nitre,	*Muschenbroek.*	1.9000
quadrangular,	*Muschenbroek.*	2.2460
saturated solution of, temperature 42°,	*Watson.*	1.095
Novaculite, or Turkey hone. See *Slate Whet.*		

O

Oak, 60 years old, heart of,	*Muschenbroek.*	1.1700
Obsidian,		2.348
Octohedrite,	*Haüy.*	3.857
Oil of filberts,		0.916
walnut,		0.92
Oil of hemp-seed,		0.9258
poppies,		0.9238
rape-seed,		0.9193
lint-seed,		0.9403
poppy-seed,		0.929
whale,		0.9233
ben, a tree in Arabia,		0.9119
beechmast,		0.9176
codfish,		0.9233
olives,		0.9153
almonds, sweet,		0.9170
volatile of mint, common,		0.8982
volatile of sage,		0.9016
thyme,		0.9023
rosemary,		0.9057
calamint,		0.9116
cochlearia,		0.9427
wormwood,		0.9073
tansy,		0.9328
Stragan,		0.9949
Roman camomile,		0.8943
sabine,		0.9294
fennel,		0.9294
fennel-seed,		1.0083
coriander-seed,		0.8655
caraway-seed,		0.9049
dill-seed,		0.9128
anise-seed,		0.9867
juniper-seed,		0.8577
cloves,		1.0363
cinnamon,		1.0439
turpentine,		0.8697
amber,		0.8865
the flowers of orange,		0.8798
lavender,		0.8938
hyssop,		0.8892
Olibanum, gum,		1.1732
Olive tree,	*Muschenbroek.*	0.9270
copper ore foliated,	*Bournon.*	4.281
fibrous,	*Bournon.*	4.281
Olivine. See *Peridot.*		
Opal, precious,	*Blumenbach.*	2.114
common,	*Klaproth.*	1.958 2.015
	Kirwan.	2.144
semiopal, reddish, from Telkobanya,	*Klaproth.*	2.540
ligniform, or wood,		2.600
Opium,		1.3363
Ophites. See *Porphyry Hornblende.*		
Opoponax,		1.6226
Orange tree,	*Muschenbroek.*	0.7059
Orpiment,	*Kirwan.*	3.048 3.435
Orpiment, red. See *Realgar.*		
Osmium and Iridium, alloy of,		19.5

P

Palladium,		11.8
Paranthine. See *Scapolite.*		
Pear tree,	*Muschenbroek.*	0.6610
Pearl stone,		2.34
Pearls, oriental,		2.683
Peat, hard,		1.329
Edinburgh,	*Thomson.*	0.600
Peridot, or Olivine,		3.428
	Werner.	3.225
Peruvian bark,		0.7849
Petrol,		0.8783

Petrosilex. See *Hornstone.*		
Pharmacolite, or arseniate of lime,		2.6
Phosphorite, or Spargel stone, whitish, from Spain, before absorbing water,		2.8249
after absorbing water,		2.8648
greenish, from Spain,		3.098
Saxon,		3.218
Phosphorus,		1.714
Pierre de volvic,		2.320
Pinite,	*Kirwan.*	2.980
Pitch ore, or sulphuretted uranite,	*Guyton.*	6.378
	Hauy.	6.530
	Klaproth.	7.500
Pitch-stone, black,	*Brisson.*	2.0499
yellow,	*Brisson.*	2.0860
red,	*Brisson.*	2.6695
brick red, from Misnia,	*Kirwan.*	2.720
leek green, inclining to olive,	*Kirwan.*	2.298
pearl gray,	*Kirwan.*	1.970
blackish,	*Brisson.*	2.3191
olive,	*Brisson.*	2.3145
dark green,	*Brisson.*	2.3149
Pitchy, iron ore,		3.956
Plasma,		2.04
Platina,	*Klaproth.*	20.722
drawn into wire,		21.0417
a wedge of, sent by Admiral Gravina to Mr Kirwan,		20.663
a bar of, sent by the king of Spain to the king of Poland,		20.722
in grains purified by boiling in nitrous acid,		17.500 18.500
native,		15.601 17.200
fused,		14.626
purified and forged,		20.836
milled and purified,	*Haüy.*	20.98
compressed by a flatting mill,		22.069
Pleonaste. See *Ceylanite.*		
Plum tree,	*Muschenbroek.*	0.7850
Plumbago, or graphite,	*Kirwan.*	1.987 2.267
Pomegranate tree,	*Muschenbroek.*	1.3540
Poplar wood,	*Muschenbroek.*	0.3830
white Spanish,	*Muschenbroek.*	0.5294
Porcelain from China,		2.3847
Seves, hard,		2.1457
tender,		2.1654
Saxony, modern,		2.4932
Limoges,		2.341
of Vienna,		2.5121
Saxony, called *Petite Jaune,*		2.5450
Porcellanite,		2.30
Porphyry, green,		2.6760
red,		2.7651
red of Dauphiny,		2.7933
red from Cordova,		2.7542
green from ditto,		2.7278
hornblende, or orphites,		2.9722
pitch-stone,		2.452
mullen,		2.600 2.728
sand-stone,		2.564
Potash, carbonate of,		1.4594
muriate of,	*Muschenbroek.*	1.8365
tartrite of, acidulous,	*Muschenbroek.*	1.9000
antimonial,		2.2460
sulphate of,		2.2980
Potassium at 15° centigrade,	*Gay Lussac,* and *Thenard,*	0.97223
Potstone,		2.80 3.00
Prasium,		2.5805
Prehnite of the Cape,	*Haüy.*	2.697
	Brisson.	2.9423
of France,	*Haüy.*	2.610
Proof spirit, according to the English excise laws,		0.916
Pumice stone,		0.9145
Pycnite, or shorlous beryl,	*Haüy.*	3.5145
Pyrites. See *Copper* and *Iron.*		
Pyrope.	*Klaproth.*	3.718
	Werner.	3.941
Pyrophysalite,		3.450
Pyroxene. See *Augite.*		

Q

Quartz crystallized, brown, red,		2.6468
brittle,		2.6404
crystallized,		2.6546
milky,		2.652
elastic,	*Gerhard.*	3.750
	Kirwan.	2.6240
Quicksilver. See *Mercury.*		
Quince tree,	*Muschenbroek.*	0.7050

R

Realgar, or red orpiment,	*Bergman.*	3.225
	Brisson.	3.338
Resin, or Guiacum,		1.2289
of jalap,		1.2185
Rock crystal, from Madagascar,		2.6530
clove brown,	*Karsten.*	2.605
snow white from Marmerosch,	*Karsten.*	2.888
crystal, European, pure, gelatinous,		2.6548
	Malus.	2.63717
of Brasil,		2.6526
iridescent,		2.6497
rose-coloured,		2.6701
yellow Bohemian,		2.6542
blue,		2.5818
violet, or amethyst,		2.6535
violet purple, or Carthaginian amethyst,		2.6570
pale violet, white amethyst,		2.6513
brown,		2.6534
black,		2.6536
Roucou,		0.5956
penetrated with water,		1.1450
Ruby oriental,		4.2833
Brazilian, or occidental,		3.5311
spinelle,		3.7600
	Klaproth.	3.5700
ballas,		3.6458
Rutile. See *Titanite,*	*Haüy.*	4.102
	La Metherie.	4.246
Rutilite or Sphene,		3.1 3.5

S

Sahlite,	*Dandrada.*	3.234
Sal gem,		2.143
Salt of vitriol,		1.9000
sedative of Homberg,		1.4797
polychrest,		2.1410
de Prunelle,		2.1480
volatile of hartshorn,		1.4760

Sandarac,		1.0920
Santal, white,	*Muschenbroek.*	1.0410
yellow,	*Muschenbroek.*	0.8090
red,	*Muschenbroek.*	1.1280
Sapagenum,		1.2008
Sappare. See *Cyanite.*		
Sapphire, oriental, white,		3.991
of Puys,		4.076
oriental,		3.994
Brazilian, or occidental,		3.1307
	Haüy.	3.994 4.283
	Hatchet.	4.000
	Greville.	4.083
Sarcocolla,		1.2684
Sardonyx, pure,	*Brisson.*	2 6025
pale,	*Brisson.*	2.6060
pointed,	*Brisson.*	2.6215
veined,	*Brisson.*	2.5951
onyx,	*Brisson.*	2.5949
arborescent,	*Brisson.*	2.5988
blackish,	*Brisson.*	2.6284
Sassafras,	*Muschenbroek.*	0.4820
Saussurite,		3.260
Scammony, of Aleppo,		1.2354
Smyrna,		1.2743
Scapolite, or Paranthine,	*Daudrada.*	3.6800 3.7000
Schistus. See *Slate, Hone, Stone.*		
Schmelstein. See *Dipyre.*		
Schorl, black, prismatic, hexahedral,		3.3636
octahedral,		3.2265
enneahedral,		3.0926
black, sparry,		3.3852
amorphous, or ancient basaltes,		2.9225
cruciform,		3.2861
violet of Dauphiny,		3.2956
green,		3.4529
common,	*Brisson.*	3.092
	Gerhard.	3.150
	Kirwan.	3.212
Selenite, or broad foliated gypsum,		2.322
Serpentine, opaque, green, Italian,		2.4295
penetrated with water,		2.4729
ditto, red and black veined,		2.6273
ditto, veined, black and olive,		2.5939
semitransparent, grained,		2.5859
ditto, fibrous,		2.9997
ditto, from Dauphiny,		2.6693
opaque, spotted black and white,		2.3767
spotted black and grey,		2.2645
spotted red and yellow,		2.6885
green from Grenada,		2.6849
deep green from Grenada,		2.7097
black, from Dauphiny, or variolite,		2.9339
green from Dauphiny,		2.9883
green,		2.8960
yellow,		2.7305
violet,		2.6424
of Dauphiny,		2.7913
Shale,		2.6
Siderocalcite, or brown spar,		2.837
Silver sulphuretted, or silver glance,	*Brisson.*	6.910
	La Metherie.	7.200
brittle,	*Gellert.*	7.208
white,		5.3
red, or ruby,	*Brisson.*	5.564
light red,	*Brisson.*	5.5886
	Gellert.	5.443
Silver, sooty,	*Vauquelin.*	5.592
native, common,	*Gellert.*	10.000
	Selb.	10.333
antimonial,	*Hauy.*	9.4406
	Selb.	10.000
auriferous,	*Kirwan.*	10.600
ore, dark red,	*Gellert.*	5.684
	Brisson.	5.5637
arseniated, ferruginous,		2.178
penetrated with water,		2.340
ore, corneous, or horn ore,	*Brisson.*	4.7438
	Gellert.	4.804
virgin, 12 deniers, fine, not hammered,		10.474
12 deniers, hammered,		10.510
Paris standard, 11 deniers, 10 grains, fused,		10.175
hammered,		10.376
	Klaproth.	10.784
shilling of George II.		10.000
George III.		10.534
French money, 10 deniers, 21 grains, fused,		10.048
French money, 10 deniers, 21 grains, coined,		10.408
Sinople, coarse jasper,		2.6913
Slate clay. See *Argillite.*		
common,		2.6718
or schistus, common,		2.6718
penetrated with water,		2.6905
whet, or novaculite,	*Kirwan.*	0.722 2.609
Isabella, yellow,	*Kirwan.*	2.955
stone,		2.1861
fresh polished,		2.7664
adhesive,	*Klaproth.*	2.080
new,		2.8535
siliceous,	*Kirwan.*	2.596 2.641
horn, or shistose porphyry,	*Kirwan.*	2.512 2.700
Smalt, or blue glass of cobalt,		2.440
Smaragdite,		3.00
Soda, sulphate of,	*Muschenbroek.*	2.2460
muriate of,	*Muschenbroek.*	2.1250
saturated solution, temperature 42°,	*Watson.*	1.198
tartrite of, saturated solution of,	*Watson.*	1.114
fossil		2.1430
saturated solution of, temperature 42°,	*Watson.*	2.054
Sodalite,	*Thomson.*	2.378
Sodium, at 15° centigrade,	*Gay Lussac, and Thenard.*	0.86507
Sommite. See *Nepheline.*		
Spar, brown. See *Sidero-Calcite.*		
white sparkling,		2.5946
red ditto,		2.4378
green ditto,		2.7045
blue ditto,		2.6925
green and white ditto,		3.1051
transparent ditto,		2.5644
adamantine. See *Corundum.*		3.873
schiller. See *Horn-blende Labrador.*		
fluor, white,		3.1555

Spar, fluor, red, or false ruby,		3.1911
octahedral,		3.1815
yellow, or false topaz,		3.0967
green, or false emerald,		3.1817
octahedral,		3.1838
blue, or false sapphire,		3.1688
greenish blue, or false aquamarine,		3.1820
violet, or false amethyst,		3.1757
violet purple,		3.1857
English,		3.1796
of Auvergne,		3.0943
in stalactites,		3.1668
pearl, or bitter, (carb. of lime and magnesia,)		2.8378
calcareous rhomboidal,		2.7151
in tubes,		2.71409
of France,		2.7146
prismatic,		2.7182
and pyramidal,		2.7115
pyramidal,		2.7141
(puant gris,)		2.7121
(puant noir,)		2.6207
or flos ferri,		2.6747
Spargel stone. See *Phosphorite.*		
Spermaceti,		0.9433
Spinelle. See *Ruby.*		
Sphene. See *Rutilite.*		
Spirit of wine. See *Alcohol.*		
Spodumene, or triphane,	*Hauy.*	3.1923
	Dandrada.	3.218
Stalactite transparent,		2.3239
opaque,		2.4783
penetrated with water,		2.5462
Staurotide, staurolite, or grenatite,	*Hauy.*	3.286
Steatites of Bareight,		2.6149
penetrated with water,		2.6657
indurated,		2.5834
penetrated with water,		2.6322
Steel,	*Muschenbroek.*	7.767
soft,		7.8331
hammered,		7.8404
hardened in water,		7.8163
hammered, and then hardened in water,		7.8180
Stilbite,		2.50
St John's wort, inspissated juice of,		1.5263
Strontian, sulphate of,	*Hauy.*	3.583 3.958
carbonate of,	*Hauy.*	3.658 3.675
Stone, sand, paving,		2.4158
grinding,		2.1429
cutlers,		2.1113
Fountainbleau, glittering,		2.5616
crystallized,		2.6111
scythe of Auvergne, mean grained,		2.5638
fine grained,		2.6090
coarse grained,		2.5686
Lorraine,		2.5298
Liege,		2.6356
mill,		2.4835
Bristol,		2.510
Burford,		2.049
Portland,		2.496
rag,		2.470
rotten,		1.981
St Cloud,		2.201
St Maur,		2.034
Notre Dame,		2.378
Stone, Clicard from Brachet,		2.357
rock of Chatillon,		2.122
hard paving,		2.460
Siberian blue,		2.945
touch,		2.415
prismatic basaltes,		2.722
of the quarry of Bourè,		1.3864
of Cherence,		2.4682
Storax,		1.1098
Sugar, white,	*Muschenbroek.*	1.6060
Sulphur, native,	*Hauy.*	2.0332
fused,		1.9907
Sulphuric, or vitriolic acid,		1.841
Sulphuret, triple, of lead, antimony, and copper,	*Hatchet.*	5.766
Sylvanite, or tellurite, in a metallic state, twice fused,		6.343
Sylvan, native,	*Jacquin, jun.*	4.107
	Muller.	5.723
	Klaproth.	6.115
ore, yellow,	*Muller.*	10.678
black,	*Jacquin, jun.*	6.157
	Muller.	8.919
Syringa,	*Muschenbroek.*	1.0989

T

Tacamahaca, resin,		1.0463
	Hauy.	2.8534 2.8729
Talc, black crayon,		2.080
ditto German,		2.246
yellow,		2.655
white,		2.704
of mercury,		2.7917
black,		2.9004
earthy,		2.6325
slaty,	*Gahn* and *Berzelius.*	2.718
common Venetian,		2.700 2.800
indurated,		2.90
Tallow,		0.9419
Tantalite,	*Ekeberg.*	7.953
Tantalium metal,	*Berzelius.*	5.61
in large masses,	*Gahn* and *Berzelius.*	6.291
in small pieces,		6.208
Tartar,	*Muschenbroek.*	1.8490
Telesie, See *Sapphire.*		
Terra Japonica,		1.3980
Tellurium, native,		5.700 6.10
graphic,		5.7
yellow,		10.6
black,		8.9
Thumerstone. See *Axinite.*		
Tin, pure, from Cornwall, fused,	*Watson.*	7.170 7.291
fused and hammered,		7.291
of Malacca, fused		7.296
fused and hammered,		7.306
of Gallicia,	*Gellert.*	7.063
of Ehrenfriedensdorf in Saxony,	*Gellert.*	7.271
pyrites,	*Klaproth.*	4.350
	La Metherie.	4.785
stone,	*Gellert.*	6.300 6.989
	Brunich.	6.750
black,	*Brisson.*	6.901

Tin stone, red,	*Brisson.*	6.9348
	Klaproth.	5.845 6.970
fibrous,	*Werner.*	7.000
	Brunich.	5.800
	Blumenbach.	6.450
new, fused,		7.3013
fused and hammered,		7.3115
fine, fused,		7.4789
fused and hammered,		7.5194
common,		7.9200
called *Claire-etoffe,*		8.4869
ore, Cornish,	*Brunich.*	5.800
	Klaproth.	6.450
from Fahlun,	*Gahn* and *Berzelius.*	6.55
stone, white,		6.008
Titanite, Rutilite, or Sphene,	*Haüy.*	4.102
	Lametherie.	4.246
Topaz, oriental,		4.0106
Brazilian,		3.5365
from Saxony,		3.5640
oriental pistachio,		4.0615
Saxony white,		3.5535
greenish blue,	*Hauy.*	3.5489
red,	*Hauy.*	3.5311
Tourmaline,	*Brisson.*	3.086
green,	*Hauy.*	3.362
blue,	*Werner.*	3.155
Tremolite,		2.9 3.2
Triphane. See *Spodumene.*		
Tungsten,	*Leysser.*	4.355
	Kirwan.	5.800 6.028
	Brisson.	6.066 6.015
	Klaproth.	5.570
Turbeth mineral,		8.235
Turpentine, spirits of,		0.870
liquid,		0.991
Turquoise, ivory tinged by the blue calx of copper,		2.500 2.908
U		
Ultramarine,	*Desormes* and *Clement.*	2.360
Uran glimmer, or Uranite,		2.19
Uranite in a metallic state	*Klaproth.*	6.440
sulphuretted. See *Pitch ore.*		
Uranitic ochre indurated,	*La Metherie.*	3.150
	Hauy.	3.2438
Uranium,		7.500
Urine, human,		1.015 1.026
diabetic,	*Henry.*	1.028 1.040
V		
Vermeille, a kind of oriental ruby,		4.2299
Vesuvian,	*Wiedemann.*	3.575
	Klaproth.	3.420
of Siberia,	*Klaproth.*	3.365 3.339
	Haüy.	3.407
Vine,	*Muschenbroek.*	1.2370
Vinegar, red,	*Muschenbroek.*	1.0251
white,		1.0135
radical,		1.080
Vitriol, Dantzic,		1.715

W		
Walnut-tree of France,	*Muschenbroek.*	0.6710
Water distilled at 32° of Fahr.		1.0000
sea,		1.0263
of Dead sea,		1.2403
wells,		1.0017
of Bareges,		1.00037
of the Seine filtered,		1.00015
of Spa,		1.0009
of Armeil,		1.00046
Avray,		1.00043
Seltzer,		1.0035
Wavellite, or hydrargillite,	*Davy.*	2.7000
Wax, bees,		0.9648
white,		0.9686
shoemakers,		0.897
Whey, cows,		1.019
Willow,	*Muschenbroek.*	0.5850
Witherite. See *Barolite.*		
Wine of Torrins, red,		0.9930
white,		0.9876
Champagne, white,		0.9979
Pakaret,		0.9997
Xeret,		0.9924
Malmsey Madeira,		1.0382
Burgundy,		0.9915
Jurancon,		0.9932
Bourdeaux,		0.9939
Malaga,		1.0221
Constance,		1.0819
Tokay,		1.0538
Canary,		1.033
Port,		0.997
Wolfram,	*Gmelin.*	5.705
	Elhuyar.	6.835
	Leonhardi.	7.000
	Hatchet.	6.955
	Hauy.	7.333
Wolf's eye (name of a mineral)		2.3507
Woodstone,		2.045 2.675
Y		
Yenite. See *Jenite.*		
Yew tree, Dutch,	*Muschenbroek.*	0.7880
Spanish,	*Muschenbroek.*	0.8070
Yttrotantalite,	*Ekeberg.*	5.130
Yttrocerite,	*Gahn* and *Berzelius.*	3.447
Z		
Zeolite from Edelfors, red, scintillant,		2.4868
white scintillant,		2.0739
compact,		2.1344
cubic. See *Chabasie.*		
siliceous,		2.515
Zinc, pure and compressed,		7.1908
in its usual state,	*Bergman.*	6.862
formed by sublimation and full of cavities,	*Kirwan.*	5.918
sulphate of,	*Muschenbroek.*	1.9000
saturated solution of, temp. 42°,	*Watson.*	1.386
See *Blende.*		
Zircon, or Jargon,	*Klaproth.*	4.615
	Karsten.	4.666
	Wiedemann.	4.700
	Hauy.	4.3858 4.4161
Zirconite,		4.24
Zoisite,	*Klaproth.*	3.26 3.31

CHAP. IV.

On the Equilibrium and Stability of Floating Bodies.

We have already seen, (Chap. II. Prop. I. p. 429,) that when a body is in equilibrium in a fluid, its weight is always equal to that of the fluid displaced; and that the centre of gravity of the floating body when homogeneous, must be situated in the same vertical line with the centre of gravity of the part submersed, or of the fluid displaced, Prop. II. p. 430. From the equality between the weight of the body and that of the displaced fluid, the upward pressure of the fluid is exactly capable of balancing the downward tendency of the body; but unless these two forces are directly opposed to each other by passing through the same point, the solid body will have a rotatory motion, instead of a position of perfect equilibrium. In order, therefore, to determine the positions in which a body will float permanently on the surface of a fluid, we have only, after the specific gravity of the body has been ascertained, to discover in what positions the solid can be placed, in order that the centre of gravity of the solid and of the part immersed may be in the same vertical line. The solid, however, will not float permanently in every case, when these centres of gravity are situated in the same vertical line; for there are examples, in which the body cannot remain in this position of equilibrium, but will actually, assume another, in which it will continue to float permanently. Mr Atwood has illustrated this by the case of a cylinder, whose specific gravity is to that of the fluid on which it floats as 3 to 4, and whose axis is to the diameter of its base as 2 to 1. When the cylinder which we suppose to be 2 feet long, and its base 1 foot in diameter, is held in the fluid, with its axis in a vertical line, it will sink to a depth of $1\frac{1}{2}$ feet; but as soon as it ceases to be supported, it instantly oversets, and remains floating with its axis horizontal. If the cylinder, instead of being 2 feet long is only 6 inches, or one-half the diameter of its base, it will sink to the depth of $\frac{3}{8}$ths of its diameter, or $4\frac{1}{2}$ inches, and will float permanently in that position. In this last case, if the axis of the cylinder is not exactly in a vertical line, but a little inclined to it, the cylinder will still settle permanently with its axis in a vertical line.

Hence it is obvious, that there are different kinds of equilibrium.

Definition.

1st, The *equilibrium of stability*, or that which is exhibited in the short cylinder 6 inches long, which floats permanently in a given position.

2d, The *equilibrium of instability*, or that which is exhibited in the cylinder 2 feet long, which oversets, although the centre of gravity of the solid, and that of the part immersed, are in the same vertical line. In this case, the equilibrium is as perfect as in the first case; for while the centres of gravity are in the same vertical line, the solid must continue erect; but the slightest deviation of the centres of gravity from that line creates a rotatory motion, from which the solid necessarily oversets.

3d, The *equilibrium of indifference*, or the insensible equilibrium in which the solid floats indifferent to motion, and without any tendency to recover its position when inclined from it, or to incline itself farther. The equilibrium of indifference takes place, when the proportion between the axis of the cylinder and the diameter of its base is greater than 1 to 2, and less than 2 to 1. This kind of equilibrium is exhibited in a homogeneous sphere, or in a homogeneous cylinder, floating with its axis horizontal.

If a solid floats permanently on a fluid surface, and if it is moved from its position of equilibrium by any external force, the resistance which the solid opposes to this inclination is called the *stability of floating*; and the horizontal line round which it moves, is called the *axis of motion*.

It would be impossible in a work like this, to enter at great length into a subject so difficult and profound as the present. We shall, therefore, content ourselves with stating the general principles relative to the stability of floating bodies, and with investigating the different positions of stability and instability which they assume; and in doing this shall freely avail ourselves of the labours of Mr Atwood, whose papers on the stability of floating bodies are remarkable for their perspicuity. In arranging, abridging, and sometimes simplifying his demonstrations, we trust we shall do an important service to the reader.

Prop. I.

To determine the stability of bodies floating on a fluid at any angle of inclination from a given position of equilibrium.

Plate CCCXV. Fig. 1.

Let EDHF be a vertical section through the centre of gravity G, of a homogeneous solid, whose figure is symmetrical with regard to the axis of motion, and let it float on the surface HABL of the fluid, O being the centre of gravity of the part immersed. The line GOC will therefore be perpendicular to AB. If by an external force the solid is inclined through an angle KGS, the solid will take the position IRLMN, and the part immersed will now be WRMNP. Hence, as the part XWI is raised out of the water, and the corresponding and equal part XNP immersed, the centre of gravity which would otherwise have been at E (taken so that GO = GE) will now be transferred to some other point Q. Having drawn QS parallel to GO, and EY and ZG*z* perpendicular to SQ, it is obvious that the upward pressure of the fluid will be exerted in the line QS, with a force equal to the weight of the body, or that of the fluid displaced, and this force will have the same tendency to turn the body round its axis of motion, as if it were applied at the point Z. In determining, therefore, the position which bodies assume on a fluid surface, and the stability with which they float, it is necessary only to find the perpendicular distances GZ between the two vertical lines which pass through the centre of gravity of the solid and the part immersed.

Since the weight of the body continues the same, the portion IXW, elevated from the fluid in consequence of the inclination, must always be equal to the portion PXN which is immersed. Hence, supposing *a* to be the centre of gravity of IXW, and *f* that of NXP, then the centre of gravity Q will be at a distance from E, corresponding to the change produced, by removing the fluid IWX to the position NXP. In order to determine, by a geometrical construction, the line GZ, let fall the perpendiculars *a b*, *f c*, and in the line EY drawn parallel to AB, take ET, so that ET : *b c* = volume IWX : volume WRMP. Through T draw FTS parallel to GO, then the centre of gravity required will be somewhere in FS, and because ER : EG = sin. KGS : rad. the line GO = EG being supposed given, the line ER will be determined, and being taken from ET already found, will leave RT or GZ the perpendicular distance required.

Equilibrium and Stability of Floating Bodies.

Plate CCCXV. Fig. 1.

Now, when one body of a system is removed from its place, the corresponding motion of the common centre of gravity, estimated in any given direction, is to the motion of the body moved and estimated in the same direction as the weight of that body is to the weight of the whole system. Hence, considering IRMN as a system of bodies whose common centre of gravity is E, and that the body IWX, whose centre of gravity is e, has moved, or been transferred to NXP, whose centre of gravity is f, we shall have volume WRMP or ADHB : volume IWX or WXP $= b\,c$: ET, the motion of one body, the motion of the centre of gravity of the system. Calling, therefore,

V = volume of the part of the floating body immersed,

A = the volume NXP, or the part immersed in consequence of the inclination,

$h =$ GO the distance between the centre of gravity of the whole solid and that of the part immersed,

$s =$ sine of the angle of inclination KGS,

$b = b\,c$ the space through which A has been transferred.

Then, by the proposition $b : \text{ET} = \text{V} : \text{A}$, and $\text{ET} = \frac{b \times \text{A}}{\text{V}}$. But ER : EG or GO $= s : 1$, we have ER $= h\,s$; consequently, RT=ET — ER, or $\text{GZ} = \frac{b\,\text{A}}{\text{V}} - h\,s$.

If the floating solid should be of an irregular form, the same demonstration will hold good; but we must, in this case, consider that the volume or space immersed by the inclination will no longer be WXP, but a space which must be obtained by calculation from the shape and dimensions of that volume. The centres of gravity of the volumes PXN, IXW, will in that case be no longer a and f the centres of gravity of the areas, but must be found by the usual rules. This proposition is applicable either to homogeneous or heterogeneous bodies, and enables us to determine the stability of vessels or other bodies, at any angle of inclination from a given position of equilibrium; for the stability is measured by a force equal to the upward pressure of the fluid, or the weight of the loaded vessel applied perpendicularly at the end of the lever GZ moving round the axis of motion.

Prop. II.

To ascertain the different positions of equilibrium in which a body will float permanently on the surface of a fluid, and to discover in which of these positions the equilibrium is permanent or stable, and in which of them it is momentary or instable.

In order to do this, we must attend to the species of equilibrium in which the solid is placed previous to its being inclined from it. Assuming that the body is in a state of stable equilibrium, let it be inclined through an angle till it is again placed in a position of equilibrium. Then since during this inclination the upward pressure of the fluid acts with a force proportional to GZ to diminish the angular distance from the primitive position of equilibrium, it follows, that the same force must act on the solid, so as to increase the inclination or angular distance from the second position of equilibrium to which the body arrives after revolving through the angle A or any part of it. Hence it is obvious, that the second position of equilibrium must be that of instability, and, in general, that when a floating body is caused by an external force to revolve round its axis of motion, and pass through different positions of equilibrium, the positions of stability and instability must alternate, and no position of either species can follow a position of the same species.

In determining, therefore, the position which a solid will assume after it has been overset from any situation of instable equilibrium, we must ascertain the angle of inclination through which the solid must revolve, so that the distance GZ may become evanescent, and we must also determine whether any position of equilibrium originally given is stable or instable. This may easily be done from the value of GZ already given; for if we take any point t in the line ER, and through t draw $q\,t\,z$ parallel to GO, then it is obvious,

1. That while $\frac{b\,\text{A}}{\text{V}} = \text{ET}$ is *greater* than $h\,s =$ ER, the part Z and the line of support QZ, will be between the axis and the parts of the solid immersed in consequence of the inclination, which gives a *stable equilibrium.*

2. That while $\frac{b\,\text{A}}{\text{V}} = \text{ET}$ is *less* than $h\,s =$ ER, the part q and the line of support $q\,z$ will be on the opposite side of the axis, and will give an *instable equilibrium.* Hence we can always determine, from the value of GZ, what is the particular kind of equilibrium with which the body will float when the angle of inclination, and consequently its sine, are assumed to be evanescent.

Prop. III.

To find an expression for the stability or instability of floating, when the floating solid is not of an uniform figure and dimensions with respect to its axis of motion.

Plate CCCXV. Fig. 1.

Let us suppose in Fig. 1. that another section of the solid is drawn parallel to ADHB, and very near it. A small portion of the solid will be comprehended between these planes; now, since the sine s of the angle KGS is evanescent, and since WXP=IXW, and the angle NXP= the angle IXW, the point X will bisect the line AB, and the points P, B, N will be coincident. Hence, the evanescent area $\text{NXP} = \frac{\text{XB}^2 \times s}{2} = \frac{\text{AB}^2 \times s}{8}$, and if we represent by z a line drawn through the middle of the solid, on a level with the surface of the fluid, and parallel to the larger axis, the evanescent portion of the solid comprehended between the adjacent vertical planes ADHB, and the one supposed extremely near it, will be $\frac{\text{AB}^2 \times s}{8} \times dz$; the perpendicular distance of the centre of gravity of this evanescent solid from the point X is $\frac{\text{AB}}{3}$. In order to find the distance from X of the centre of gravity of the whole volume immersed by the inclination, or the common centre of gravity of the elementary solids $\frac{\text{AB}^2 \times s\,dz}{8}$ corresponding to the length z, we must multiply each elementary solid by the distance of its centre of gravity from the horizontal line passing through X, and divide the sum of these products by the sum of the elementary solids. Hence, in the present case, since the distance from X of the centre of gravity of the elementary solid is $\frac{\text{AB}}{3}$, the product arising from multiplying the distance by the solid itself will be $\frac{AB^3\times s\,dz}{24}$, and the sum of the products corresponding to the whole line z will be fluent of $\frac{AB^3\times s\,dz}{24}$; and since A represents the volume of the part immersed by inclination, and also of the part elevated by inclination, the distance of the centre of gravity, of the immersed part or c X, also of the part elevated, or b X, will be fluent of $\frac{AB^3\times s\,dz}{24\,A}$, and the distance between the two centres of gravity in the line $b\,c$ will be twice this quantity, or fluent of $\frac{AB^3\times s\,dz}{12\,A}$. Substituting this value for b in the general equation, we have GZ $=$ fluent of $\frac{AB^3\times s\,dz}{12\,V}-h\,s$, which is the general expression required.

Application of the formula to the case of uniformity of figure.

Now it follows, 1. That if the first member of this equation, viz. fluent of $\frac{AB^3\times s\,dz}{12\,V}$, is greater than the second $h\,s$, the line of support QZ will be between the axis of motion and the part immersed by inclination, and the solid will float permanently; and, 2. That if the first member is less than the second, the line of support $q\,z$ will be on the contrary side of the axis, and the body will overset. Hence it is obvious, that between these limits, we must have the equilibrium of indifference which takes place when fluent of $\frac{AB^3\times s\,dz}{12V}=h\,s$.

If the solid has an uniform figure and dimensions, then putting D for the area of any of the sections immersed under the fluid, the solid contents of the volume immersed will be Dz, hence V$=$Dz; and since AB is now a constant quantity, we have fluent of $\frac{AB^3\times s\,dz}{12\,Dz}=\frac{AB^3\times s\,z}{12\,Dz}=\frac{AB^3\times s}{12\,D}$, consequently $GZ=\frac{AB^3\times s}{12\,D}-h\,s$.

Prop. IV. Prob.

To determine the limits of stability and instability in a parallelopiped depending on the dimensions and specific gravity of the solid.

Case of a floating parallelopiped with one of its flat surfaces upwards.

Plate CCCXV. Fig. 2.

In applying the preceding expressions to a parallelopiped, let EFDC be its vertical section, with its flat surface EF upwards, and IK the surface of the fluid. Through its centre of gravity G draw SGL parallel to CE, and let us take

$c=$CE

$a=$CD

$n=$ specific gravity of the solid, or $n:1=$ SN : SL.

Then if O be the centre of gravity of the part immersed, and since $n:1=$ SN : SL, or CL, we have SN$=nc$; GO $=\frac{c}{2}-\frac{nc}{2}$, and ABCD $=a\,c\,n$. Substituting these values in the general expression already found, we have $GZ=\frac{a^3s}{12\,a\,c\,n}-\frac{s\times\overline{c-nc}}{2}$; and since the equilibrium is one of indifference, when the first member of the expression is equal to the second, or when $\frac{a^3s}{12\,a\,c\,n}=\frac{s\times\overline{c-nc}}{2}$, we have, by the resolution of this quadratic equation, $n^2-n=-\frac{a^2s}{6\,c^2}$, and $n=\frac{1}{2}\pm\sqrt{\frac{1}{4}-\frac{a^2}{6\,c^2}}$.

Cor. 1. From this proposition, we may infer, that whenever $\frac{a^2}{6c^2}$ is less than $\frac{1}{4}$, or when the height c of the solid has a greater proportion to the base than that of $\sqrt{2}$ to $\sqrt{3}$, two values may be assigned to the specific gravity of the solid, which will cause it to float in the equilibrium of indifference. If, for example, $c=a$, we have $n=\frac{1}{2}\pm\sqrt{\frac{1}{4}-\frac{1}{6}}$, which gives

$$n=\tfrac{1}{2}+0.28868=0.78868$$
$$n=\tfrac{1}{2}-0.28868=0.21132.$$

Cor. 2. If the specific gravity of the solid is very small compared with that of the fluid, the term $\frac{a^3s}{12\,a\,c\,n}$ must be greater than $\frac{s\times\overline{c-cn}}{2}$, and the solid will float permanently with the line EF parallel to the horizon.

Cor. 3. If the specific gravity of the solid is increased beyond .21132, then, since this is the limit at which it ceases to float with stability, if it is placed with its flat surface upward, its equilibrium will be instable, and it will therefore assume a position of permanent equilibrium. By increasing the specific gravity from .21132 to .78868, the instability increases at first, and reaches its maximum when $n=\frac{1}{\sqrt{6}}$; it then diminishes and vanishes at the second limit when $n=.78868$. When n is between .78868 and 1. the body will float permanently with its flat surface EF horizontal. The maximum of instability is found by putting the least increment of the quantity $\frac{a^3s}{12\,a\,c\,n}-\frac{s\times\overline{c-c\,n}}{2}=0$, considering n as variable, and making $a=c$.

Cor. 4. If the height SL of the parallelopiped is in a less proportion to its base CD than that of $\sqrt{2}$ to $\sqrt{3}$, there is no value of n at which the stability will vanish; for in this case the quantity $\sqrt{\frac{1}{4}}-\frac{a2}{6c2}$ become impossible. The solid will therefore always float permanently with its surface EF horizontal.

Prop. V.

To determine the limits of stability and instability of a square parallelopiped when one of its diagonals is in a vertical position.

Plate CCCXV. Fig. 3.

Let EDCF be a vertical section of the parallelopiped floating on the surface AB of the fluid, and let G, as formerly, be the centre of gravity of the solid O, that of the part immersed, and n the specific gravity of the solid. Then if DC$=a$, we shall have GC$=\frac{a}{\sqrt{2}}$. But since HB$=$HC, we have ABC$=$HB^2; and since ABC : DEFC $=n:1$, we have ABC $=a^2n$, HB$^2=a^2n$, HC $=a\times\sqrt{n}$; AB $=2\,a\sqrt{n}$; OC$=\frac{2a\sqrt{n}}{3}$ and GO$=\frac{a}{\sqrt{2}}-\frac{2a\sqrt{n}}{3}=\frac{a\times\overline{3-\sqrt{8n}}}{\sqrt{2}\times 3}$

If we now apply the general expression $GZ=\frac{\overline{AB}^3\times s}{12\,D}-h\,s$ to the present case, we shall obtain $AB^3=8a^3n^{\frac{3}{2}}$; $D=a^2n$; $h=\frac{a\times\overline{3-\sqrt{8n}}}{\sqrt{2}\times 3}$, and consequently $GZ=\frac{8a^3n^{\frac{3}{2}}s}{12a^2n}-\frac{a\times\overline{3-\sqrt{8n}}}{\sqrt{2}\times 3}$. In order, therefore, to obtain the limit between the stability and instability of floating, we must make $\frac{\overline{AB}^3\times s}{12\,D}=h\,s$, as in Prop. IV. or making $\frac{8a^3n^{\frac{3}{2}}}{12a^2n}=\frac{a\times\overline{3-\sqrt{8n}}}{\sqrt{2}\times 3}$, we shall have $\frac{2}{3}\sqrt{n}=\frac{3-\sqrt{8n}}{\sqrt{2}\times 3}$ or $n=\frac{9}{32}=.28123$, the specific gravity at which the equilibrium of indifference begins, or the limit between the specific gravities at which the solid will float with stability and instability.

Cor. 1. It follows from the value of GZ given above, that when n is evanescent or extremely small, the solid will overset when placed on the fluid with the angle uppermost; for the first term of the value of GZ must necessarily be less than the second.

Cor. 2. If $n:1=9:32$ the solid will float with the equilibrium of indifference; and therefore if $n:1$ in a less ratio than that of 9 to 32, the solid will overset; but if n exceeds that limit, then the solid will float permanently, with the angle E uppermost.

Prop. VI.

To determine the limit of stability and instability in a square parallelopiped with one of its angles upwards, when its specific gravity is greater than one half of the specific gravity of the fluid.

Plate CCCXV. Fig. 5.

Let EDCF, Plate CCCXV. Fig. 5. be the square parallelopiped, which having a greater specific gravity than $\frac{1}{2}$, that of the fluid will sink so that the diagonal FD is below the surface of the water IK. Using the same symbols as in the last proposition, we have the area $ABDCFA=a^2n$, and the area $EAB=EH^2=a^2-a^2n$, and consequently $EH=a\sqrt{1-n}$, and $AB=2\,EH=2\,a\sqrt{1-n}$, and $GH=a\times\overline{\frac{1}{\sqrt{2}}-\sqrt{1-n}}$. Now if P be the centre of gravity of the area AEB, then from the property of the centre of gravity we have GH × area EDCF = area ABDCFA × OH — area AEB × HP, or $a^2\times\overline{\frac{1}{\sqrt{2}}-\sqrt{1-n}}=a^2n\times OH-a^3\times\frac{\overline{1-n}^{\frac{3}{2}}}{3}$, and by reduction

$$HO=\frac{a\times\overline{3-\sqrt{18}\times\sqrt{1-n}}+a\times\sqrt{2}\times\overline{1-n}^{\frac{3}{2}}}{\sqrt{18}\times n}$$

Subtracting from this expression the value of $HG=a\times\overline{\frac{1}{\sqrt{2}}-\sqrt{1-n}}=\frac{3n-\sqrt{18n^2}\times\sqrt{1-n}}{\sqrt{18}\times n}$, we shall have the line

$$GO=\frac{a\times\overline{3-3n-\sqrt{18}\times\overline{1-n}^{\frac{1}{2}}+\sqrt{2}\times\overline{1-n}^{\frac{3}{2}}}}{\sqrt{18}\times n}$$

By inserting these values in the general formula $GZ=\frac{AB^3s}{12\,D}-h\,s$, we have $AB^3=8a^3\times\overline{1-n}^{\frac{3}{2}}$; $D=a^2n$, and since $GO=d$ we obtain $GZ=\frac{8a^3\times\overline{1-n}^{\frac{3}{2}}}{12\,a^2n}-\frac{a\times\overline{3-3n-\sqrt{18}\times\overline{1-n}^{\frac{1}{2}}+\sqrt{2}\times\overline{1-n}^{\frac{3}{2}}}}{\sqrt{18}\times n}$. This value of GZ being put $=0$ to obtain the limit, and the whole being multiplied by $\frac{3n\times\sqrt{2}}{\overline{1-n}\times a}$ we shall have

$$2\sqrt{2}\times\sqrt{1-n}=3-3\sqrt{2}\times\sqrt{1-n}+\sqrt{2}\times\sqrt{1-n}$$

or $\sqrt{1-n}=\frac{3}{4\sqrt{2}}$, and $1-n=\frac{9}{32}$ and $n=\frac{23}{32}$, the limit required.

Cor. Hence from this, and the preceding propositions, we have the four limiting values of the specific gravities, viz. $\frac{1}{2}-\sqrt{\frac{1}{4}-\frac{1}{8}}$; $\frac{9}{32}$; $\frac{23}{32}$ and $\frac{1}{2}+\sqrt{\frac{1}{4}-\frac{1}{8}}$, or .211, .281, .718, and .789; that is, if the specific gravity is less than 211, the parallelopiped, with its flat surface upward and horizontal, will float permanently in that position, but will overset if the specific gravity is greater than .211 and less than .789. If the parallelopiped has one of its angles upward, when the specific gravity is less than .281, it will overset; if greater than .281, and less than .718, it will float permanently with an angle upward; but if the specific gravity exceeds .718, it will overset when placed in the fluid with an angle upward.

Prop. VII.

If the parallelopiped is placed in the fluid in a position of instable equilibrium, so as to overset or change its position, it is required to ascertain the position which it will assume when it continues to float permanently; or to ascertain through what angle the solid will revolve till its centre of gravity and the centre of gravity of the part immersed are again in the same vertical line.

Plate CCCXV. Fig. 5.

Let EFDC, Fig. 5. be the vertical section of the parallelopiped when in its position of instable equilibrium; IK the surface of the water; G its centre of gravity; O the centre of gravity of the part immersed. Let the solid, after oversetting, have revolved through an angle UGS into the position YWVH, the part immersed will now be ZHVR, and QXR will be the part now immersed in consequence of the inclination. Bisect PZ and RQ in m and n, join mX, nX, and taking $Xa=\frac{2}{3}Xm$, and $Xf=\frac{2}{3}Xn$, a and f will be the centres of gravity of the triangles PXZ, and QXK. Let fall the perpendiculars ab, fc upon the line AB. In applying the general equation $GZ=\frac{ba}{V}-fs$ to the present case, we have QXR=A; ZHVR or ACDB=V; $bc=b$; $OG=f$; sine of UGO$=s$. Make t equal the tangent of the angle UGO. Then from the similarity of triangles QX=XP; ZP=QR; ZX=XR. Making SL$=c$, and VU or XQ$=a$: then QR$=at$; and $Qn=\frac{at}{2}$; $Xn=\sqrt{a^2+\frac{t^2a^2}{a}}=\frac{a}{2}\sqrt{4+t^2}$. Now, since Rn or Qn : Xn=sin. nXR ; XRn, we have $\frac{ta}{2}:\frac{a}{2}\times\sqrt{4+t^2}$ = sin. n XB : sin. XR n, consequently sin. nXR$=\frac{\text{Sin. } n\text{ RX}\times t}{\sqrt{4+t^2}}$, and substituting in place of sin. n RX its value $\frac{1}{\sqrt{1+t^2}}$, we obtain sin. n XR$=\frac{t}{\sqrt{4+t^2}\times\sqrt{1+t^2}}$, and cos. n XR$=\frac{2+t^2}{\sqrt{4+t^2}\times\sqrt{1+t^2}}$ and since X $d=\frac{2\text{ X}n}{3}=\frac{a\times\sqrt{4+t^2}}{3}$, we have X$c$ $=\frac{a\times\sqrt{4+t^2}\times\overline{2+t^2}}{3n\sqrt{4+t^2}\times\sqrt{1+t^2}}=\frac{a}{3}\times\frac{2+t^2}{\sqrt{1+t^2}}$. But X$b=Xc$ by similar triangles, and therefore $bc=2\text{X}c=\frac{2a\times\overline{2+t^2}}{3\times\sqrt{1+t^2}}=b$. Now the immersed part ACDB$=2acn=$V, and the volume QXR$=\frac{a^2t}{2}=$A. Substituting, therefore, these values in the equation GZ$=\frac{b\text{A}}{\text{V}}-hs$, we have GZ$=\frac{2a\times\overline{2+t^2}}{3\times\sqrt{1+t^2}}\times\frac{a^2t}{4acn}-hs=\frac{a^2t\times\overline{2+t^2}}{6cn\times\overline{1+t^2}}-hs$; but since $h=\frac{c-cn}{2}$; GZ$=\frac{a^2t\times\overline{2+t^2}}{6cn\sqrt{1+t^2}}-\frac{\overline{c-cn}\times s}{2}$. By substituting for t^2 its equal $\frac{s^2}{1-s^2}$, the formula becomes GZ$=\frac{a^2s\times\overline{2-s^2}}{6cn\times\overline{1-s^2}}-\frac{\overline{c-cn}\times s}{2}$. As it may be more convenient to make a express the whole breadth AB or PQ, instead of the half breadth, the equation will, by this change, become GZ$=\frac{a^2s\times\overline{2-s^2}}{24cn\times\overline{1-s^2}}-\frac{\overline{c-cn}\times s}{2}$. By making this value $=0$, we obtain $s^2=\frac{2a^2-12c^2n+12c^2n^2}{12c^2n^2-12c^2n+a^2}$, or $s^2=\frac{12c^2n-12c^2n^2-2a^2}{12c^2n-12c^2n^2-a^2}$.

In the case of a square parallelopiped, we have $a=c$, and therefore $s^2=\frac{12n-12n^2-2}{12n-12n^2-1}$. In order, therefore, to ascertain from this equation the angle through which the solid revolves, let us take $n=.24$, which being between .211 and .789, will place the solid with a flat surface upward and horizontal, and in an instable equilibrium, consequently $s^2=\frac{.1888}{1.1888}$, and $s=\sqrt{\frac{.1888}{1.1888}}=$ the sine of 23° 29′, the angle of revolution, after which the solid will settle in a position of stable equilibrium.

The preceding equation determines also the specific gravity n, which will make the solid float at the angle s; for, by resolving that equation, we obtain $n=\frac{1}{2}\pm\frac{\sqrt{1-2s^2}}{12-12s^2}$, and applying this to the particular angle of 23° 29′, we have $n=0.5\pm0.26=0.76$ and 0.24, the two specific gravities, which will cause it to float in stable equilibrium at the angle of 23° 29′.

Prop. VIII.

To ascertain the position of equilibrium, &c. as in Prop. VII. when the surface of the fluid passes through one of the extremities of the base of the floating solid.

The preceding proposition is applicable only to the case where the surface of the water intersects the parallel sides YH, WV. In order to obtain the angle of inclination from a position of equilibrium, with the flat surface horizontal, and the specific gravity of the solid, when the fluid surface passes through one extremity of the base, let AECD, Fig. 6, be a vertical section of the square parallelopiped, and let the water line IK pass through D. Then putting CD$=a$, and $t=$tangent of KDC the angle required, we have KC$=at$, and area KCD$=\frac{a^2t}{2}$; but area KCD : area AECD$=n:1$, we have $n=\frac{t}{2}$. Substituting this value of n in the formula, or value of s^2 in the preceding proposition, we obtain $s^2=\frac{6t-3t^2-2}{6t-3t^2-1}$, but $s^2=\frac{t^2}{1+t^2}$, consequently $\frac{t^2}{1+t^2}=\frac{6t-3t^2-2}{6t-3t^2-1}$, or $6t^3-3t^4-t^2=6t-3t^2-2+6t^3-3t^4-2t^2$, or $4t^2=6t-2$, which gives $t=\frac{3}{4}\pm\frac{1}{4}$, that is $t=\frac{1}{2}$, and $t=1$. The first of these values corresponds to an angle of 26° 33′ 51″, and the second to an angle of 45°, as shewn in Fig. 7. In the first of these cases, KCD : ABCD, $=1:4$, and therefore $n=\frac{1}{4}$, and the equilibrium is that of stability; in the second case $n=\frac{1}{2}$, and the position of equilibrium is also one of stability.

Plate CCCXV. Fig. 6.

Fig. 7.

Prop. IX.

To find the position of equilibrium as in Prop. VIII. when the fluid surface intersects one of the extremities of the upper side, as shewn in Fig. 8.

Fig. 8.

Putting ABK $=t$, we have areas ABK$=\frac{a^2t}{2}$, and KCDB$=\frac{2a^2-a^2t}{2}$, consequently $n=\frac{2-t}{2}$; which, being substituted for n in the equation of Prop. VIII. gives $\frac{t^2}{1+t^2}=\frac{6t-3t^2-2}{6t-3t^2-1}$, the same as formerly. Hence since $t=\frac{3}{4}\pm\frac{1}{4}$, we have $n=\frac{2-t}{2}=\frac{3}{4}$, or $n=\frac{1}{2}$.

Prop. X.

To determine the position in which the parallelopiped will float permanently with a plane angle obliquely upward, when the specific gravity is between $\frac{8}{32}$ and $\frac{9}{32}$, or between $\frac{23}{32}$ and $\frac{24}{32}$.

It follows from Prop. VI. that when n is between $\frac{8}{32}$ and $\frac{9}{32}$, or between $\frac{23}{32}$ and $\frac{24}{32}$, the solid will float permanently with the diagonal inclined to a vertical line. In order to find the angle, let IVCF represent the square parallelopiped floating with its angle I placed obliquely, and let its inclination to a vertical line be OGT. Let DE be the surface of the fluid, and taking CB a mean proportional between EC and CD, draw BA parallel to FV, and cutting IC in H, CH will be the depth to which the solid sinks when IV is vertical, and therefore area BXE $=$ area XDA. Make CO $=\frac{2}{3}$CH, and O will be the centre of gravity of the volume ABC. Bisect EB in K and AD in R, and draw KX, RX, and take XM $=\frac{2}{3}$XR and XL $=\frac{2}{3}$XK, and M, L will respectively be the centres of gravity of the triangles XAD, BXE. Let fall the perpendiculars MP, QL upon

Fig. 9.

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the horizontal line DE, then making $PQ=b$, sin. $BXE=s$; tang. $BEX=t$, and $EC=a$, we have $CD=ta$; $CB=\sqrt{ta^2}$; $CH=\sqrt{\frac{ta^2}{2}}$; $CO=\frac{2}{3}CH=\sqrt{\frac{2ta^2}{9}}$; area $ABC=CH^2=\frac{ta^2}{2}$. Putting area $BXE=u$, we have area CDE or ABC : area BXE = PQ : OT or $\frac{ta^2}{2}:u=b:OT=\frac{2bu}{ta^2}$, and $OG=\frac{2bu}{ta^2s}$. Adding CO to CG, we obtain $CG=\frac{2bu}{ta^2s}+\sqrt{\frac{2ta^2}{9}}$, and since $GC:CV=1:\sqrt{2}$, we have $CV=GC\times\sqrt{2}$ and $CV=\frac{\sqrt{8}\times bu}{ta^2s}+\sqrt{\frac{4ta^2}{9}}=\frac{\sqrt{72}\times bu+\sqrt{4t^3a^6s^2}}{3ta^2s}$. But since $1:n=$ area CAHB : IFCV, or as $CH^2:CV^2$, we have $\sqrt{n}=\frac{CH}{CV}$ and $\sqrt{n}=\sqrt{\frac{ta^2}{2}}\times$

$$\frac{3ta^2s}{\sqrt{72}\times bu+\sqrt{4t^3a^6s^2}}=\frac{3t^{\frac{1}{2}}a^3s}{12bu+2\sqrt{2}t^{\frac{3}{2}}a^3s}.$$

If we assume the angle OGT or $BXE=15°$, and take $CE=1$, we shall find $BXE=u=.089395$, and $PQ=b=0.73089$, which being substituted in the above value of n, gives $\sqrt{n}=\frac{.34063}{.34552+.32114}=0.51094$ and $n=0.261$, the specific gravity with which the solid will float in stable equilibrium, when its diagonal is inclined 15° to a vertical line.

The preceding solution is applicable to all cases in which n is between $\frac{8}{32}$ and $\frac{9}{32}$; and by a similar process we may obtain an equation for the case when the specific gravity is between $\frac{23}{32}$ and $\frac{24}{32}$. In this case, the solid will float permanently with the line IC upward, but inclined to the vertical at some angle between 0° and 18° 26′ 9″.

Mr Atwood has collected into the following abstract, the various positions which the square parallelopiped assumes as depending upon its specific gravity.

Plate CCCXV. Fig. 10, 11, 12.

1. If n is between 0 and $\frac{1}{2}-\sqrt{\frac{1}{4}-\frac{1}{6}}$, (as shewn in Figs. 10. 11. and 12.), or between 0 and 0.211, the solid will float permanently with a flat surface upwards, and parallel to the horizon.

Fig. 12, 13, 14.

2. If n is between .211 and 25, (as shewn in Figs. 12, 13, 14), it will float permanently with a flat surface upward, but inclined to the horizon at different angles from 0° corresponding to .211 to 26° 34′ corresponding to .25.

Fig. 14, 15, 16.

3. If n is between .25 or $\frac{8}{32}$ and .281 or $\frac{9}{32}$, (as shewn in Figs. 14, 15, 16), the solid will float with only one angle immersed, the diagonal being inclined to the vertical at various angles from 18° 26′, corresponding to .25 or $\frac{8}{32}$, and 0° corresponding to .281 or $\frac{9}{32}$.

Fig. 16, 17.

4. If n is above .281 or $\frac{9}{32}$, (as in Figs. 16, 17), the solid will float permanently with its diagonal vertical, till the specific gravity becomes .718 or $\frac{23}{32}$.

Fig. 17, 18.

5. If n is below .718 or $\frac{23}{32}$ and .75 or $\frac{24}{32}$, (as in Figs. 17, 18), the solid will float with the diagonal inclined to the vertical at angles varying from 0° corresponding to .718 to 18° 26′ corresponding to .75, three angles of the solid being immersed.

Plate CCCXV. Fig. 19, 20, 21.

6. If n is between .718 or $\frac{24}{32}$ and .789 (as in Figs. 19, 20, 21), the solid will float with a flat surface upward and inclined to the horizon at various angles between 26° 34′ corresponding to .75 and 0° corresponding to .789.

7. If n is between .789 and 1.000, the solid will float permanently with a flat surface parallel to the horizon.

8. When the solid revolves round its larger axis, or axis of motion, so as to complete an entire revolution of 360°, it will pass either through 16 or 18 positions of equilibrium. If n is between .211 and .281, or between .719 and .789, the positions of equilibrium will be *sixteen*, eight of which will be positions of stable and the other eight of instable equilibrium, alternating with each other. If n is not within these limits, the solid in the course of its revolution will pass only through *eight* positions, four of which are positions of stable, and the other four of instable, equilibrium.

In the preceding propositions, the solid is supposed to have a uniform figure in respect to the axis of motion, so that all its vertical sections are equal. But when the solid has such a form that the sections are unequal, a different process of investigation, though depending on the same principles, must be employed for determining its positions of equilibrium. We shall content ourselves with giving Mr Atwood's application of the preceding principles to a cylinder.

Prop. XI.

To determine the positions of stable and instable equilibrium, in a cylinder placed on the surface of a fluid, with its axis in a vertical position.

Fig. 22.

Let EFCD represent the cylinder with its axis NP vertical, and let it sink to the depth QP. Make $QA=r$, the distance between the centres of gravity G and O, viz. $GO=h$, and let AIBHSKA represent the circular section of the cylinder formed by the surface of the fluid. Draw any diameter IS, and another diameter AB, perpendicular to IS, and let IS be the direction of the axis round which the cylinder is moveable. Through any point W draw the double ordinate KH, and make $QW=z$, $NP=l$, and $\pi=3.14159$, the ratio of the circumference to the diameter of a circle. Now, from Prop. III. it follows, that the solid will float permanently with the axis vertical, when fluent of $\frac{\overline{KH}^3\times dz}{12V}$ is greater than h, and that the equilibrium will be instable if h is the greater of the two, and therefore when these two quantities are equal, the equilibrium will be the limit between stability and instability. To apply this to the present case, we must find the fluent of $\frac{KH^3\times dz}{12V}$. Now, since $QS=r$, $QW=z$, we have, by Euclid, B. III. Prop. 35. $WH=\sqrt{r^2-z^2}$, $KH=2\times\sqrt{r^2-z^2}$, and $KH^3dz=8\times\overline{r^2-z^2}^{\frac{3}{2}}\times dz$, the fluent of which quantity, when z increases from 0 to r, is $8\times\overline{\frac{\pi r^4}{4}-\frac{\pi r^4}{16}}=\frac{8\times 3\pi r^4}{16}$, and for both semicircles fluent of $\overline{KH}^3\times dz=3\pi r^4$; and since $PQ=ln$, and the area of the circle $AIBS=\pi r^2$, we have $V=\pi r^2 ln$. But

$GP=\frac{l}{2}$, and $OP=\frac{l n}{2}$, consequently $GO=\frac{l-l n}{2}=h$; and since $\frac{\text{fluent } KH^3 \times d z}{12V}=\frac{3\pi r^4}{12\pi r^2 l n}$, by making $\frac{\text{fluent } \overline{KH}^3 \times d z}{12V}=h$, we shall obtain the limits between the stable and instable equilibriums. Thus $\frac{3\pi r^3}{12\pi r^2 l n}=\frac{\overline{l-l n}}{2}$, or $n^2-n=-\frac{r^2}{2l^2}$. But since $2r=b$, or the diameter of the base, we have $n^2-n=\frac{-b^2}{8 l^2}$, and $n=\frac{1}{2}\pm\sqrt{\frac{1}{4}-\frac{b^2}{8 l^2}}$.

Hence, if the diameter of the base bears a greater proportion to the length of the axis than that of $\sqrt{2}$ to 1, there is no value of the specific gravity n, which will cause the solid to float in the equilibrium of indifference: It follows, therefore, from the preceding investigations, that in this case it will always float permanently with its axis in a vertical line.

If the diameter of the base bears a less proportion to the length of the axis than $\sqrt{2}$ to 1, then there are always two values of n, which will be the limits of stability and instability. In order to determine the ratio between the length and diameter of the cylinder which limits the case of stability and instability when the specific gravity is given, we obtain from the equation $n-n^2=\frac{b^2}{8l^2}$, the equation $\frac{b}{l}=\sqrt{8 n-8 n^2}$, from which it follows, that since n is given, the diameter of the base should be to the length of the axis of the cylinder in a greater proportion than that of $\sqrt{8 n-8 n^2}$ to 1, in order that the solid may float permanently with its axis upwards; but if the diameter of the base should be to the length of the axis in a less proportion to that, the solid will overset. For example, if $n=\frac{1}{4}$, then $\sqrt{8n-8 n^2}=\sqrt{\frac{3}{2}}=1.2247$; that is, the diameter of the base should be in a greater proportion to the length of the axis than 1.2247 to 1, in order that it may float permanently. If the proportion is less than this, it will overset.

Application of the preceding principles to the stability of ships.

We shall now conclude this Section by following Mr Atwood in his application of the preceding principles to the stability of ships. We have already seen that the force of stability of a ship or any other body is represented by W × GZ, W being the weight of the vessel and its lading. When the angle of inclination is so small as to be considered evanescent, we have seen that $GZ=\frac{\text{fluent of } AB^3 \times d z \times s}{12V}-h s$; but since the first member of this equation is equal to ET, and since $h=OG=EG$, it follows that $\frac{\text{fluent } AB^3 d z}{12V}=ES$, and $\frac{\text{fluent } AB^3 d z}{12V}-h=GS$, which is an invariable quantity, whatever be the inclination of the floating body, provided it is very small; that is, the point S is immoveable with respect to G. This point S is called the *Metacentre* or centre of equilibrium; for if the centre of gravity G coincides with the point S, the stability, or $GZ \times W=W \times SG \times s$, will be $=0$, or the solid will float in all positions alike, without any effort to restore itself if it is inclined, or to incline itself farther. If the centre of gravity G is situated beneath the metacentre S, the solid will always float with stability, as the measure of that stability $W \times SG \times s$ tends always to turn the body in a direction contrary to that in which it is inclined. If the centre of gravity is placed above the metacentre, the force $W \times SG \times s$ having passed through 0, tends to turn the vessel in the same direction as that in which it is inclined, and it will therefore float with an instable equilibrium.

When the angles of inclination, however, are large, the stability of the vessel will, as has already been shewn, be measured by $W \times GZ=\frac{\overline{b A}}{V}-d s \times W$. In the application of this formula to practice, b A is the only quantity which requires to be determined; for all the other values can be easily ascertained from the nature of the case. In order to find b A, the following observations must be attended to. If a line parallel to the horizon passes from the head to the stern of the vessel when the ship floats uprightly, this line is called the *longer axis*, to distinguish it from the *shorter axis*, which passes through the same centre, but in a direction perpendicular to the former. If we conceive a vertical plane to pass through the longer axis when the ship floats uprightly, it will divide the vessel into two parts perfectly similar and equal. A ship in equilibrium, may also be conceived to be divided into two parts by the horizontal plane which passes through the surface of the water, and this section is called the *principal section of the water*, represented in section by AB, Fig. 1, which will be transferred to IN when the vessel is made to heel or revolve through the angle SGK. The real section of the water will now be AB, which may be called the *secondary section of the water*. These two planes inclined at the angle of heeling SGK, intersect each other in X, and this line of intersection will obviously be parallel to the longer axis.

The position of the point X clearly depends on the shape of the sides of the vessel. In a parallelopiped, with two plane angles immersed, as in Fig. 5, the point X bisects the lines ZR, PQ, corresponding to AB, IN in Fig. 1; but, when the same solid floats with only one plane angle immersed, as in Fig. 10, the point X no longer bisects these lines, but is removed towards the parts immersed by the inclination. As the breadth of vessels, therefore, has no regular proportion from the head to the stern, the position of X, which is necessary to the determination of b A, must obviously be determined practically by approximation. We must therefore conceive the equal volumes NXP, LXW, Fig. 1 and 25, one of which is immersed, and the other raised by the heeling of the ship, to be divided into segments by vertical lines, perpendicular to the longer axis, and at distances of two or three feet. These segments will therefore have the form of wedges, as shewn in Fig. 25, NXP being the inclination of the planes on the faces of the wedges.

Plate CCCXV. Fig. 25.

The solid contents of the immersed wedges NXD must now be found by approximation; and making XI = AB — NX, and XW = AB — PX, the solid contents of all the wedges, IXW raised by heeling, must also be obtained. If the size of the immersed wedges is not equal to the size of the elevated wedges, the position of the point X must be altered, till this equality is obtained. To find b A, therefore, let the area PXNTP, and its centre of gravity f, be determined by approximation. Draw $d c$ perpendicular to PX, and X c will be the distance of the centre of gravity from the point X, estimated in the horizontal direction PX; and $e x$ being found in a si-

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milar manner, $\frac{Xc + ex}{2}$ will be the mean distance of the centre of gravity of the solid segment XPN xpn from the line X x, estimated in the horizontal direction XP. By finding similar distances of the centre of gravity of all the other wedges or segments, from X x, estimated in the same direction, the sum of all these products will be the value of b A required. Hence the measure of the vessel's stability $W \times \frac{\overline{bA}}{V} - ds$ for an angle whose sine is s, is obtained.

Such of our readers as wish to prosecute this subject farther, are referred to the following works: Archimedes *De iis quæ vehuntur in humido*. P. Paul Hoste *Theorie de la Construction des Vaisseaux*, Lyon. 1696. Parent, *Mem. Acad. Par.* 1700. Pitot, *Theorie de la Manœuvre des Vaisseaux, Mem. Acad. Par.* 1731. D. Bernoulli *Comment. Petropol.* 1739, vol. x. p. 147; xi. p. 100. D'Alembert's *Essai sur la resistance des Fluides*, and his *Opuscules Mathematiques*, tom. 1. Bouguer's *Traite de la Manœuvre des Vaisseaux*. Id. *Mem. Acad. Par.* 1754, p. 342; 1755, p. 481; 1757, Hist. p. 165. Clairaut, *Mem. Acad. Par.* 1760, p. 171. Juan *Examen Maritimo*, Madr. 1771. Euler *Theorie Complette de la construction et Manœuvre des Vaisseaux*. This work was translated into English, and published in 1790, Chapman, *Traité de la Construction des Vaisseaux*. Clairbois *Architecture Naval*, part ii. Romme *L'Art de la Marine*, Paris, 1787. Bossut *Traité D'Hydrodynamique*, tom. i. chap. xii. xiii. xiv. Atwood, *Phil. Transactions*, 1796, p. 46; and 1798, p. 201. English *Phil. Mag.* vol. i. p. 371, 393.

CHAP. V.

On Capillary Attraction, and the Cohesion of Fluids.

Capillary attraction.

In our articles on Adhesion and Capillary Attraction, we have already given an account of the principal facts relative to the cohesion of fluids, and the ascent of water in capillary tubes. In the present Chapter, we propose to resume the subject, and after tracing the progress of discovery in this interesting branch of physics, to lay before our readers an account of additional experiments which have either been made since the publication of these articles, or which appear to us necessary for completing the view of the subject which might be expected in the present work.

Experiments on capillary attraction first made at Florence.

The earliest experiments on the ascent of water in capillary tubes, appear to have been first made at Florence,* but we are not acquainted with the name of the philosopher who made them, or with the results which he obtained. The editor of the posthumous tracts of Pascal informs us, that capillary attraction was not known in France when Pascal wrote his posthumous treatise *Sur l'Equilibre des Liqueurs*, which could not have been composed more than a few years before his death in 1662; and he mentions it as if it were a fact well known, that the ascent of water in narrow tubes was first discovered by M. Rohault, a celebrated Cartesian philosopher, who taught mathematics and natural philosophy at Paris. In 1671, Rohault published in 4to his *Traité de Physique*, which was translated into Latin by Dr Clark. This work contains an account of the ordinary experiments on capillary attraction, which Rohault ascribes to the unequal pressure of the air within and without the tube. He states distinctly, that water rises between all bodies which are capable of being wetted with it, whereas it is depressed between substances that are not capable of being wetted. He observed the ascent of water between two plates of glass, and the spherical concavity of the upper surface in capillary spaces; but he nowhere gives the least hint, that he was the discoverer of these phenomena.†

On Capillary Attraction, and the Cohesion of Fluids.

Experiments of Rohault, Born 1620. Died 1675.

Experiments of Robert Boyle, 1660.

In the year 1660, our celebrated countryman, Robert Boyle, published at Oxford his *New Experiments Physico-Mechanical touching the Spring of the Air*, &c. in which he has treated of the ascent of water in capillary tubes. He ascribes the discovery to some men of science in France, on the authority of a celebrated mathematician from whom he received it; and he repeated the experiment with a tube of very small bore, drawn out by means of the blow-pipe. In this tube, the water is said to have sprung instantaneously to the height of *five* inches, to the great surprise of several mathematicians that were present. When the tube was inclined, the water occupied a greater part of it, and it always rose higher in the tube when the inside of it was wetted before hand. These experiments succeeded equally well, when the tubes were placed in an exhausted receiver. Mr Boyle observed also the concavity of the upper surface of the water, the convexity of the surface of mercury, and its depression in capillary tubes. See the above work, p. 262.

Hooke's experiments, 1660, 1662.

Dr Hooke seems to have been one of those who was present at the exhibition of this experiment; and he *is said* to have explained the phenomenon by affinity. In a tract published in 1660, and entitled, "An Attempt for the explication of the Phenomena observable in an experiment published by the Right Hon. Robert Boyle, in the 35th experiment of his Epistolical Discourse touching the Air, in confirmation of a former conjecture made by R. H."‡ Dr Hooke§ accounts for the ascent of water in capillary tubes, by the unequal pressure of the atmosphere on the column of fluid within and without the tube. He supposes that there is a greater incongruity between air and glass than between water and glass, and that, on this account, the air is admitted with more difficulty into the tube than the water, the difficulty always increasing as the diameter of the tube diminishes. This hypothesis Dr Hooke endeavours to support, by the fact which he has determined experimentally, that a much greater force is necessary to force a bubble of water into a narrow tube than into a wide one; and he has illustrated it at great length, in

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* This is stated on the authority of Fabri.

† See Rohaultii *Physica*, edit. 1710, § 69, 70, 71, 80, 81, &c.

‡ In 1662, this work was translated into Latin, and published at Amsterdam, by M. Bohem, entitled, *Conatus ad explicanda Phenomena notabilia in Experimenta publicata ab Honorabili Viro Roberto Boyle.*

§ "In the year 1660," says Dr Hooke in his *Micrographia*, "I printed a little tract, entitled *An Attempt*, &c. and being unwilling then to publish this theory, as supposing it might be prejudicial to my design of watches, which I was then procuring a patent for, I only hinted the principle which I supposed to be the cause of these phenomena of springs, in the 31st page thereof in the English edition, and in 38th of the Latin edition, Amst. 1662; but referred the further explication thereof till some other opportunity."—Hooke on *Springs*, 4to, 1678.

Hooke's experiments, 1667.

the VIth Observation of his *Micrographia*, which appeared in 1667. This observation is entitled, *On Small Glass Canes*, and contains his most mature opinions on the subject. He states that the water, when it enters small capillary tubes, rises rapidly to the height of 6 or 7 inches; that when the tube is extremely fine, it ascends slowly to a much greater height; and that he had never patience to wait till it rose higher than 21 inches, which must have been in a pipe, whose internal diameter was about the $\frac{1}{1488}$th part of an inch. He defines the term *Congruity*, which may be considered the same as affinity, as that "property of a fluid body, whereby any part of it is readily united with any other part, either of itself, or of any other similar fluid or solid body; and *Incongruity*, to be that property of a fluid, by which it is hindered from uniting with any dissimilar fluid or solid body." Dr Robison, and some other authors, are therefore mistaken in claiming for Dr Hooke the merit of explaining the phenomena of capillary attraction by affinity, by which they meant the affinity of water to glass. Dr Hooke indeed, employs a term the same as this in his explanation of these phenomena; but it is employed for a quite different purpose; for he supposes that the water rises in the tube, not because it is attracted by the glass, but because there is a greater affinity between water and glass than between air and glass, in consequence of which, the column of air within the tube is not capable of balancing the corresponding atmospherical column without. "For since the pressure," says he, "of the air every way is found to be equal, that is, as much as is able to press up and sustain a cylinder of quicksilver of 2½ feet high or thereabouts; and since of the pressure so many more degrees are required, to force the air into a smaller than into a greater hole that is full of a more congruous fluid; and, lastly, since these degrees that are requisite to press it in, are thereby taken off from the air within, and the air within left with so many degrees of pressure less than the air without; it will follow, that the air in the less tube or pipe will have less pressure against the superficies of the water therein, than the air in the bigger. The conclusion, therefore, will necessarily follow, viz. that this unequal pressure of the air, caused by its ingress into unequal holes, is a cause sufficient to produce the effect, without the effect of any other concurrent; and therefore is probably the principal (if not the only) cause of these phenomena. This, therefore, being thus explained, there will be divers phenomena explicable thereby: as, the rising of liquors in a filtre; the rising of spirit of wine, oil, melted tallow, &c. in the wick of a lamp, though made of small wire, threads of asbestos, strings of glass, or the like; and the rising of liquors in a sponge, pieces of bread, sand, &c.; perhaps also the ascending of the sap in trees and plants, through their small and some of them imperceptible pores, at least the passing of it out of the earth into their roots."* This hypothesis of Dr Hooke's, which was received at the time with great applause, was afterwards shewn to be unsatisfactory and inconsistent with experiments by Roger Cotes.†

Investigations of Vossius. 1666.

In the year 1666, the learned Isaac Vossius published at the Hague his work entitled, *De Nili et Aliorum Fluminum Origine*, in the second chapter of which he describes the phenomena of capillary attraction, and endeavours to account for them by a theory which approaches more nearly than any other which had been given to the true theory of the action of capillary tubes. Since water, says he, is by its very nature viscid, it adheres to every thing which it touches, so that it adheres to glass, and is sustained by the glass. But since the water is sustained by the action of the glass, it does not press upon the water below it, as the same weight cannot press in two places, and as no body can be heavier than itself. The portion of water therefore which enters the tube, loads the glass tube, to the sides of which it adheres, and is destitute of weight in respect of the subjacent water. Hence it follows, that if capillary tubes are immersed in water, and then taken out of it, the water which has entered them will not all flow out of the tube, but as much will remain as the surface of the tube can sustain. From this hypothesis Vossius concludes, that water will rise higher in narrow than in wide tubes, because the narrow tubes, in proportion to their capacity, present more points of contact of adherence to the water, and that mercury being destitute of viscidity, will not adhere to glass, and will therefore sink below its natural level in capillary tubes.

Experiments of Honoré Fabri. Born 1607.

The first person in France who repeated these experiments, and attempted to investigate their cause, was M. Honoré Fabri, a learned Jesuit, who was born at Bellay near Lyons, in the year 1607. In the year 1669, he published a work entitled, *Dialogi Physici*, the fourth chapter of which is entitled, *De humoris elevatione per Canaliculum*. In this chapter, he observes that water, whether hot or cold, ascends above the level of the water in the vessel; that it rises to a greater height in narrow than in wide capillary tubes; and that the water ascends highest in tubes of the same diameter when the tubes extend farthest above the surface of the water; that the water raised by capillary attraction will never flow out of the top of the tubes, however short; that the water will rise higher in a wet tube than in a dry one; that the water will not rise in a tube if the finger is placed upon the upper end of its bore previous to immersion; and that in two concentric tubes, the water will rise sometimes higher and sometimes lower in the widest of the two tubes, according as the difference of their diameters is less or greater than the diameter of the inner tube. In explaining these phenomena, he maintains, that the external air, acting as a compressed body, has free access to press upon the surface of the water exterior to the tube, whereas it does not act so freely upon the surface of the water in the tube, and therefore the fluid will rise with a force proportional to the difference of these pressures. The cause of this unequal pressure of the air Fabri supposes to be, that only an inverted cone of air touching the fluid in the tube with its vertex, and having the upper orifice of the tube for its base, can press upon the surface contiguous to its vertex.

Experiments of Borelli, 1670.

The celebrated Alphonso Borelli has attempted to explain the phenomena of capillary attraction in his Treatise *De Motionibus a Gravitate naturali pendente*, which was published at Lyons in 1670. He seems, like Vossius, to ascribe the elevation of the water to its adhesion to the sides of the tube, and he considers the attractive force of the tube as extending to the particles of water placed in its axis. "In cavitatibus," says he, "subtilium fistularum internus aquæ contactus grandis est et amplus, respectu illius aquæ moleculæ ibidem existentis: ergo subito ac infimum fistulæ orificium attingit aquam, efficitur, in ejus interna et cava perimetro efficacissimus contactus a cujus adhesione fulciri

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* Hooke's *Micrographia*, p. 21.

† See Cotes' *Hydrostatical Lectures*, Lect. XI. Lond. 1738.

sustinerique potest majus pondus, quam habet pusilla aquæ particula insinuata, et ideo gradus prædictæ virtutis suspensivæ et adhæsionis exercetur in aqua subjecta, et proinde ea reddetur aliquo pacto levis seu, minus ponderosa, quam sit aqua collateralis libere premens. Et, quia minimæ aquæ particulæ porositatibus et asperitatibus internis fistulæ innixæ efficiuntur operanturque ut totidem *vectes*, quæ flecti possunt et interne rotari, necesse est, ut partes aquæ, collaterales magis compressæ a totali energia sui, ponderis vim faciant, impellendo sursum particulas aquæ, quæ minus comprimuntur a vectibus supra dictis; et ideo rotando excurrere possunt inferius efformando tumorem, vel monticulum aqueum, qui excurrendo lateraliter altioribus fistulæ porositatibus insinuabitur adhærebitque et ideo denuo imminuetur ejus vis compressiva, renovabiturque causa ulterioris suspensionis et proinde altius aqua intra fistulam impelletur, et sic de novo eminentioribus lateribus adhærendo successive altius impelletur quousque ad supremam et maximum illam altitudinem aqua perducta, in qua equilibrium, cum aqua collaterali libere premente efficiatur: tunc quidem quies ejus subsequetur nec altius elevari poterit;" and in another place, prop. clxxxviii. p. 243, he accounts for the elevation of water to a greater height in small tubes: "Quia adhærentia et connexio aquæ parietibus internis canalium majorem proportionem ad molem aquæ insinuatæ *extensive* et *intensive* in canaliculis subtilissimis habet quam in amplis et capacioribus. *Extensive* quia vis adhæsionis mensuratur a contactibus, et ideo a superficie interna canaliculorum; e contra resistentia mensuratur a pondere cylindri aquei contenti in iisdem canaliculis; estque proportio cylindrorum aqueorum ejusdem altitudinis duplicata ejus rationis quam habent eorum perimetri internæ, &c. *Intensive* quoniam facultas et energia adhæsionis minus efficax est quanto magis a parietibus removetur."

Experiments of Sinclair, 1669.

Similar experiments made by our countryman Sinclair, are described in his work, entitled *Ars Nova et Magna Gravitatis et Levitatis*, which was published at Rotterdam in 1669; and the experiments were repeated by Johannes Christopher Sturmius, who adopts the hypothesis of Fabri, and gives a full account of the opinions of Hooke, Boyle, Fabri, and Vossius, in the first part of his *Collegium Experimentale sive Curiosum*, which was published at Nuremberg in 1676.

Huygens and Wallis attempt to explain the suspension of mercury at a greater height than 28 inches in Toricellian tubes.

The suspension of mercury in Toricellian tubes, far above the height of 28 inches, had been observed by several philosophers, and which was owing to the attraction of cohesion, and Huygens and Wallis attempted in vain to explain it. The former of these philosophers ascribes it to the pressure of a matter more subtle than air, which penetrates glass, water, quicksilver, and all other bodies, and which, added to the pressure of the air, enables it to sustain 75 inches of mercury. Wallis is equally unsuccessful in his explanation of the phenomena, which he ascribes to a particular spring of the air, which does not exist in the quicksilver.

Experiments of James Bernoulli.

Plate CCCXVI. Fig. 1.

The celebrated James Bernoulli appears to have paid some attention to the subject of capillary attraction. In his *Dissertatio de Gravitate Etheris*, which was published in 1683, he has endeavoured to explain the ascent of water, upon the supposition that the particles of air have a greater magnitude than those of water. In order to do this, he employs the diagram in Fig. 1. where ABCD is a capillary tube plunged in the vessel MN, and EFGH what he calls a similar atmospherical cylinder. He then supposes that the diameter of each tube will only receive a certain number of spherical particles of air, viz. seven for example, so that seven such particles placed in a straight line will exhaust the breadth of the tubes, as shewn at $i\,l$; but according to our author, it will always happen that the *first* and *eighth* globules will rest upon the margin of the tube, as shewn at AB, and therefore only the six intermediate ones will rest upon the surface of the fluid, as seen at $q\,r$. Hence it will happen that the size of the globules of the air which occupies the circumference of the upper orifice of the tubes, with the superincumbent rows A m, B n, which rest upon that ring, will press upon the margin of the tubes, and will not produce the smallest pressure upon the surface $q\,r$ of the fluid. In the imaginary atmospherical cylinder or tube EFGH, nothing prevents the seven particles from acting freely upon the surface of the fluid EF. Hence Bernoulli concludes, that as the water without the tube is affected with a greater pressure than the water within the tube, it must necessarily rise to a height proportional to the excess of pressure. He then concludes from this hypothesis, that the water should not rise in wide tubes, as the portion of air prevented from acting by the margin bears a small proportion to the whole column;—that fluids specifically lighter than water ought to rise to a greater height;—that the water cannot flow over the top of a capillary tube however short; and that the surface of mercury ought to stand below its level in tubes of glass, if its particles are larger than those of water; (this effect he explains by Fig. 2. where the row of particles of mercury $s\,t$ is more pressed down by the weight of the air above than it is by the pressure of the mercury from below;) and finally, that the surface of water in capillary tubes ought to be concave, and that of mercury convex. Bernoulli next proceeds to deduce from this hypothesis the magnitude of a globule of air, and by assuming, from his own experiments, that water rises half an inch in a tube $\frac{1}{8}$ of an inch in diameter, he concludes that the magnitude of a particle of air, or rather the distance between the centres of two adjacent particles, is $\frac{1}{77100}$ of an inch. But having convinced himself by other means, that four particles of a very subtle matter is interposed between every two particles of air, he determines the real magnitude of a particle of air to be $\frac{1}{31100}$ of an inch!

Fig. 2.

Experiments of Carré. Born 1663. Died 1711.

A very interesting memoir on capillary attraction was published by M. Louis Carré in the Memoirs of the Academy of Sciences for 1705, entitled *Experiences sur les tuyaux Capillaires*. He ascribes the ascent of the water to its adhesion to the sides of the tubes, and to the mutual attraction of the particles of water. The portion of water contiguous to the sides of the tube is first raised and supported, and therefore presses less upon the bottom of the vessel than the collateral column. He attributes the higher elevation of the water within than without the tube to the mutual adhesion of the aqueous particles which contributes to their elevation; and he says that water rises higher in small tubes, since the force of adhesion is measured by the internal surface of the tubes, and the resistance by the supported column of fluid; and he supposes that water has a *greater contact* with glass than alcohol, and therefore rises higher. These views are supported by some new and curious facts: he found that when the same surfaces were anointed with grease, the water would not rise above its level; that if only part of the surface was anointed, the water rose only on the side where there was no grease; that if the tube was plunged deeper than the point to which the grease reached, the water rose above its level; and that a drop of water descending on the outside of the tube was drawn into the tube when it was not greased, but refused to enter when the tube was greased.[*]

The following are the principal results which Carré obtained:

WATER. Diameter of tube, which was 12 inches long.	Height of ascent.
$0\frac{1}{3}$ of a line	10 lines
$\frac{1}{4}$	18
$\frac{1}{10}$	30

Diameter of tube in parts of a line.	Fluids employed.	Height of ascent.
	Tube 12 inches long.	
$\frac{1}{3}$	Water . . .	$5\frac{3}{4}$ lines, 1st immersion. 7 lines, 2d immersion. 10 lines, 3d immersion.
$\frac{1}{3}$	Alcohol	$3\frac{1}{2}$ lines.
$\frac{1}{3}$	Spirit of turpentine	4
$\frac{1}{3}$	Oil of tartar . .	5 lines.
	Spirit of nitre . .	4
$\frac{1}{3}$	Oil of olives . .	5
	Tube $9\frac{1}{2}$ inches long	
$\frac{1}{3}$	Water	10 lines
$\frac{1}{3}$	Alchohol . . .	4 lines.
	Tube 15 inches long	
$\frac{1}{6}$	Water	29 lines.
$\frac{1}{6}$	Alcohol	12
	Tube 5 inches lon	
$\frac{1}{6}$	Water	27
$\frac{1}{6}$	Alcohol	12 nearly.

Experiments by Mr Hawksbee, 1706.

On glass plates.

On the motion of a drop of oil of oranges between glass planes.

On the angles at which a drop of oil of oranges is suspended between glass planes.

The phenomena of capillary tubes were investigated with great care by our countryman Mr Hawksbee. In the year 1706, he communicated to the Royal Society an account of some experiments made at Gresham College, by which it was proved that water rose to the same height in capillary tubes *in vacuo* as in the open air; and he likewise observed in bending some small tubes by the flame of a candle in the manner of syphons, that it was necessary for the orifice of the longer leg to be at least so far below the surface of stagnant water as that water in the same tube would spontaneously ascend in it, before it would run. In 1709, Mr Hawksbee laid before the same learned body an account of his experiments on the rise of water between two plates of glass or polished marble, an experiment of which he has the exclusive merit. He shewed that the water rose between them whether the plates were placed *in vacuo* or in the open air; and having found that neither the figure of the vessel, nor the presence of the air, nor the quantity of matter in the tubes or plates, contributed to the production of the phenomena, he endeavours to explain the rise of the water, by supposing the glass to act upon water in the very same way as a magnet acts upon iron.[†] Mr Hawksbee's attention was next directed to the motion of a drop of oil of oranges between two glass planes. The drop always moved towards the sides of the planes that were nearest pressed together. The velocity of the drop increased as it approached the touching sides, and its surface of course increased in a similar manner, from the great proximity of the planes. This experiment was also repeated with the same results *in vacuo.*[‡] Mr Hawksbee next endeavoured to measure the angle required to suspend a drop of oil of oranges at certain stations, between two glass planes placed in the form of a wedge, as shewn in our Plate CX. Fig. 6. "I procured two glass planes," says Mr Hawksbee, "that measured a radius of 20 inches each; their breadth was about three inches; that which I used for the lower plane was placed with its surface parallel to the centre of its axis and to the horizon. The planes being very clean, they were rubbed with a linen cloth dipped in oil of oranges; then a drop or two of the same oil being let fall on the lower plane near the axis, the other plane was laid on it, and as soon as it touched the oil, the drop spread itself considerably between both their surfaces. Then the upper plane being raised a little at the same end by a screw, the oil immediately attracted itself into a body forming a globule contiguous to both surfaces, and began to move toward the touching ends. When it arrived two inches from the axis, an elevation of 15 minutes at the touching ends stopped its progress, and it remained there without motion any way. The planes being let fall again, the drop moved forward till it came to four inches from the centre; then an elevation of 25 minutes was required to give it a fixed station. At 6 inches it required an angle of 35 minutes; at 8 of 45 minutes; at 10 a degree. At 12 inches from the axis the elevation was 1 degree 45 minutes, and so on at the several stations as they stand in the annexed table. This, after numerous trials, I take to be the most correct, though the others succeeded very nearly the same. It is to be observed, that when the globule or drop had arrived to near 17 inches on the planes from their axis, it would become of an oval form; and as it ascended higher, so would its figure become more and more oblong; and unless the drop was small on such an elevation of planes as was required at such a progress of the drop, it would be parted, some of it descending, and the rest of it running up to the top at once; but on a drop that separated these, I found the remaining part of it, at 18 inches, would bear an angle of elevation equal to 22 inches, to balance its weight. Higher than that I could not observe. The planes were separated at their axis about $\frac{1}{10}$ of an inch. I found but little difference between small and larger drops of the oil in

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[*] See Mem. Acad. Par. 1705, p. 241, and 317, 8vo. edit.

[†] See Phil. Trans. 1707, vol. xxvi. p. 258.

[‡] Id. 1711, vol. xxvii. p. 35.

regard to the experiments. The angles were measured by a quadrant marked on paper, of near 20 inches radius, divided into degrees and quarters.

Distance in Inches from the axis.	Angle of Elevation.
2	0° 15′
4	0 25
6	0 35
8	0 45
10	1 0
12	1 45
14	2 45
15	4 0
16	6 0
17	10 0
18	22 0

Brook Taylor's experiment.

In the year 1712,* Dr Brook Taylor communicated to the Royal Society the beautiful experiment (See CAPILLARY ATTRACTION, vol. v. p. 409, and Plate CCX. Fig. 6.) respecting the hyperbolic surface of water elevated between two glass planes, inclined at an angle of 2½ degrees. Mr Hawksbee (*Phil. Trans.* 1712, vol. xxvii. p. 539.) repeated the experiment with great care at two different inclinations, of 20′ and 40′, and obtained the following results:

Hawksbee's experiment on the hyperbolic surface of water.

Angle of 20′.

Distances from the touching ends of the Planes.	Heights of the Water at the preceding Distances.
13 inches	1
9	2
7	3
6	3¾
5	5
4	6¾
3	9
2½	12
2	15½
1¾	18
1½	21½
1¼	27¼
1	35
¾	50
½	76

Angle of 40′.

Distances from the touching ends of the Planes.	Heights of the Water at the preceding Distances.
9 inches	1
6	2
4½	3
3	4¾
2½	6
2	7½
1½	10
1¼	12
1	15
¾	19
½	28
¼	50

Mr Hawksbee afterwards found that the curve was an exact hyperbola in all directions of the planes, the asymptotes being the surface of the water, and a line drawn along the touching sides of the planes. Mr Hawksbee's next experiments were made on the heights to which spirit of wine ascended between two plates of glass separated successively to different distances. The following results were obtained:

Hawksbee's experiments on the ascent of spirit of wine between two plates of glass.

Distance of Plates.	Height of Ascent.
0.0625 of an inch	0.166 of an inch
0.03125	0.333
0.015625	0.666
0.007802	1.333

As a drop of spirits of wine when placed between the two glass planes, did not move so nimbly as a drop of oil of oranges, Mr Hawksbee was enabled to observe the angles at which it remained suspended at different stations between the plates. The following tables contain the results for inclination of 10′ and 18′:

Inclination of the Planes 10′.

Distance in Inches from the touching ends.	Angle of Elevation.
18½	1° 30′
16½	1 50
14½	2 10
12½	2 40
10½	3 10
9½	3 30
8½	4 0
7½	5 5
6½	7 40
5½	10 50
4½	14 0
4	18 0

In this experiment Mr Hawksbee could not observe nearer than 4 inches from the touching ends.

Inclination of the Planes 18′.

Distance in Inches from the touching ends.	Angle of Elevation.
18½	0° 45′
16½	0 55
14½	1 5
12½	1 20
10½	1 30
9½	1 40
8½	2 00
7½	2 30
6½	3 20
5½	4 25
4½	6 0
4	7 23
3¾	8 40
3½	9 25
3¼	10 30
3	12 40
2¾	15 0
2½	18 50
2¼	23 25
2	30 0

The preceding experiments of our author are not only the most numerous but the most correct that have been made on capillary attraction, and have been appealed to by La Place as a proof of the accuracy of his own theory. The opinions of Hawksbee respecting the cause of capillary attraction were equally correct. He ascribed the ascent of the fluid to the attraction of the whole surface of the tube; and he considered the attractive force of the glass as extending, like the refracting force, only to insensible distances.

Observations of Dr Jurin. A. D. 1718.

In the year 1718, Dr James Jurin communicated to the Royal Society his *Inquiry into the Cause of the Ascent and Suspension of Water in Capillary Tubes.* This paper contains many new and ingenious experiments; but its author was unfortunate in the erroneous explanation which he gives of the phenomena. "Since in every capillary tube," says he, "the height to which the water will spontaneously ascend is reciprocally as the diameter of the tube, it follows that the surface, containing the suspended water in every tube, is always a given quantity; but the column of water suspended is as the diameter of the tube, therefore if the attraction of the containing surface be the cause of the water's suspension, it will follow that equal causes produce unequal effects, which is absurd." "Having shewn," continues he, "the insufficiency of this hypothesis, I come now to the real cause of the phenomenon, which is the attraction of the periphery or section of the surface of the tube to which the upper surface of the water is contiguous and coheres. For this is the only part of the tube from which the water must recede upon its subsiding, and consequently the only one which by the force of its cohesion or attraction opposes the descent of the water. This is also a cause proportional to the effect which it produces, since that periphery and the column suspended are both in the same proportion as the diameter of the tube." Dr Jurin afterwards accounts for the spontaneous ascent of the water. He supposes that the water which first enters

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* See Phil. Trans. 1712, vol. xxvii. p. 353.

a capillary tube, when its orifice is immersed in the fluid, has its gravity taken off by the attraction of the periphery with which its upper surface is in contact: Hence it must necessarily rise higher, partly by the pressure of the stagnant water, and partly by the attraction of the periphery immediately above that which is already contiguous to it. These opinions Dr Jurin endeavoured to support by the experiment represented at E, F, G in Fig. 5. of Plate CX. and described under CAPILLARY ATTRACTION, p. 407. (See *Phil. Trans.* vol. xxx. p. 739.) In a subsequent paper he inquires into the cause of the suspension of water in tubes of glass, and seems to adopt the opinion, that the cohesion may depend on the pressure of a medium subtle enough to penetrate the receiver. "For though such a medium," says he, "will pervade the pores of the water as well as those of the glass, yet it will act with its entire pressure on all the solid particles, if I may so call them, of the surface of the water in the cistern; and whereas so many of the solid particles of the water in the tube as happen to lie directly under the solid particles of the water above them, will thereby be secured from this pressure, and consequently there will be a less pressure of this medium on any surface of the water in the tube below the capillary, than in an equal surface of the water in the cistern; so that the column of water suspended in the tube may be sustained by the difference between these two pressures."

Bullfinger's experiments. A. D. 1727.

The subject of capillary attraction was treated at great length by George Bernhard Bullfinger, in a dissertation entitled, *De Tubulis Capillarium, dissertatio experimentalis,* which appeared in the *Commentarii Acad. Petropolitanæ* for 1727. This paper contains an examination of the different hypotheses which had been employed to explain the phenomenon of capillary attraction, and several new experiments illustrative of his own opinion. He found that the relative ascent of spirit of wine, red wine, and water, were as 4, 7 and 12. He seems, upon the whole, to prefer the hypothesis of Dr Jurin, although he states a number of difficulties which attend it. Dr Jurin replied to this paper of Bullfinger's in the volume of the *Commentarii Acad. Petropolitanæ* for 1728; and his paper is published with the annotations of Bullfinger. After examining all the objections which had been stated, and apparently to the satisfaction of Bullfinger, Dr Jurin begs that he will no longer consider his explanation as a hypothesis, but as a true and established theory.*

Theory of Daniel Bernoulli, 1727.

When M. Bullfinger exhibited his experiments before the Academy of St Petersburgh, his colleague, the celebrated Daniel Bernoulli, who was at that time unacquainted with the speculations of his uncle on the same subject, proposed a new theory of capillary attraction. In order to get over the difficulty respecting the ascent of the water under the receiver of an air pump, he ascribed the phenomenon, not to the unequal pressure of the air as his uncle had done, but to the unequal pressure of an ethereal fluid. He considered the base of the fluid as contiguous to the surface of the water; but he supposed that it was not so full at the sides of the pipe as in its axis; or, in other words, that the æther stood at a greater distance from the glass than water did, or was less dense in the neighbourhood of the glass. This effect he attributed to the particles of the æther being greater than those of water. This hypothesis, which differs in no respect from that of James Bernoulli, excepting in the substitution of æther for air, has the advantage of surmounting the difficulty already mentioned. But, in other respects, it is more inadmissible. Daniel Bernoulli attempted to shew that it explained many of the common experiments, and that the proportion between the magnitude of the particles of different fluids might be deduced from the height of their ascent in capillary tubes. He inferred, from a rude and erroneous experiment, that the particles of mercury were twice as small as those of water.

Experiments of Muschenbroek. Born 1699. Died 1761.

An excellent dissertation, entitled *Dissertatio Physica de Tubis Capillaribus Vitreis,* was published by M. Muschenbroek, which contains a great variety of interesting experiments upon this subject. He has committed a mistake, however, in maintaining that the height of ascent increases with the length of the tube. The constant quantity for water, as deduced by Dr Young, from his best experiments, is 0.392.

Weitbrecht's investigation, 1736, 1737.

In the year 1736, Josiah Weitbrecht published a valuable paper in the *Commentarii Acad. Petropolitanæ,* entitled *Tentamen Theoriæ qua ascensus aquæ in tubis capillaribus explicatur.* He shews that water is more strongly attracted by glass than it is by its own particles; that the sphere of activity of the attraction of the glass is extremely small, that is, the action of the glass does not extend to the axis of the tube; that the water must be partly supported by the mutual attraction of its own particles; that the water in the capillary tube is drawn downwards, not only by its own gravity, but by the attraction of the water in the vessel; that the water in the tube is elevated by the attractive force of the whole internal surface of the tube successively applied; but that it is suspended solely by the action of the ring of glass immediately above the fluid column. M. Weitbrecht considers the force which suspends the water as represented by Q—Q′, Q representing the force with which the water is attracted to the glass, and Q′ the force with which it is attracted downwards by the water in the vessel; and as Q is greater than Q′ in water and most fluids, the quantity Q—Q′ is affirmative, and the water rises above its level. When the tube is taken out of the water, the force Q′ he considers as vanishing, and therefore the remaining force is allowed to act without opposition, and consequently the water rises to a greater height in the tube. In mercury Q′ is greater than Q, and therefore the expression is negative, and the fluid consequently sinks below its level. M. Weitbrecht made the following experiments on the ascent of water.

Diameter of the tube. English Inches.	Height of ascent. Inches.	Constant quantity.
0.06	0.72	0.0432
0.045	0.95	0.04275
0.04 0.05 } 0.045	0.92	0.04140
0.05	0.85	0.0425
0.06	0.71	0.0426
0.08	0.53	0.0424
0.025	1.72	0.043
		7) .29785
Mean constant quantity		.04255

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* "Si ista," says he, "quod speramus, Cl. Bullfinger satisfecerint, pollicemur nobis, pro candore et æquitate Viri humanissimi eum in posterum explicationem hanc phenomenon *non amplius pro hypothesi,* sive *futili ingenii commento, sed pro vera et indubita eorundem theoria habitatura.*" Comment. Petrop. 1728, p. 291, 292.

In a subsequent memoir, entitled, *Explicatio Difficilium experimentorum circa ascensum aquæ in tubis Capillaribus*, published in the *Commentarii Acad. Petropolitanæ*, for 1737, M. Weitbrecht resumes the subject. He shews that Muschenbroek was mistaken in considering the height of ascent as affected by the length of the tube. He points out the effects produced by interposing bubbles of air between the different parts of the elevated column; he examines the phenomena exhibited by conical tubes, and tubes where the diameter of the bore changes rapidly; and he terminates his memoir with several interesting experiments on the effects of capillary syphons and bent capillary tubes.

Gellert's experiments, 1740.

Hitherto mercury was the only metallic fluid which had been employed in capillary experiments. M. Gellert, however, communicated a memoir to the Academy of Sciences at St Petersburgh, entitled, *De Phenomenis plumbi fusi in Tubis Capillaribus.* In making these experiments, he employed the thinnest glass tubes he could procure, and heated them gradually before he immersed them into the melted lead. In this way he found, that melted lead always stood below its level in a tube of glass, and that the altitudes in different tubes were nearly in the reciprocal ratio of their diameters. When the diameter of the tube was 10.21 of an English inch, the lead sunk 0.27 of an inch, whereas in a tube 0.07 it sunk 0.73 of an inch. These results give 567 and 510 for the constant quantity, the mean of which is 5385. In another paper, entitled, *De Tubis Capillaribus Prismaticis,* M. Gellert treats of the ascent of water in prismatic tubes of a triangular and quadrangular form made of iron. He found, that they gave results perfectly analogous to those which were made of glass. See p. 477. col. 1.

Labours of Clairaut. A. D. 1743.

Before the time of Clairaut, no attempt had been made to analyse with accuracy the different forces which concur in the elevation of water in capillary tubes, and to subject the phenomena to a rigorous calculation. The merit of doing this belongs wholly to this eminent mathematician, who has published his investigations in the tenth chapter of his *Theorie de la Figure de la Terre tirée des Principes de l'Hydrostatique,* which was published at Paris in 1743, and of which a second edition appeared in 1808. In this chapter, which is entitled, *De l'Elevation ou de l'Abaissement des Liqueurs dans les tuyaux Capillaires,* he begins by pointing out the mistake in the reasoning employed by Dr Jurin in the establishment of his hypothesis, and he then proceeds to the analysis of the forces by which the water is elevated and suspended. An account of this analysis has already been given in our article on CAPILLARY ATTRACTION, p. 411. The resulting formula which he obtains for the altitude Ii, (Plate CX. Fig. 9.) is

$$\text{I}i = \frac{(2Q-Q').\ \int dx\,[b, x] + \int dx\,[b,\ x,\ Q,\ Q']}{p},$$

where

$Q =$ intensity of the attraction of the glass.
$Q' =$ the intensity of the attraction of the water.
$b =$ the interior radius of the tube.
$p =$ the force of gravity.

The function of the distance which expresses the law of attraction both for glass and water is supposed given, and he employs x to denote the distance of a particle from the plane MN, $[x]$ the force at which this particle is attracted by a body, of which this plane is the exterior surface, supposing the intensity of the attraction of this body to be unity. The function $[b\,x]$ expresses the force with which a particle Q, placed at the distance QO or x from the surface CH is attracted by the tube or bulb cylinder CDABGHEF, and $[b,\ x,\ Q,\ Q']$ the force with which a corpuscle p placed at the distance x from VX is attracted by the small mass of water YVXZ.

"Without pushing the calculation farther," says M. Clairaut, "in order to find what will be the quantities $[b, x]$ and $[b,\ x,\ Q,\ Q']$ according to the different functions of the distances by which the law of attraction may be expressed, we may easily see that there will be an infinity of laws of attraction in which the preceding expression of I i will give a sensible altitude when the diameter b of the tube is very small, and on the contrary, a height almost insensible when the tube is very wide." It follows from the value of I i, that if the attraction of the capillary tube is less than that of water, provided it is not twice as small, the water will still ascend; for it is obvious from the term $(2\,Q-Q')$ $\int d\,x\,[b, x]$, that while Q' is less than $2\,Q$, I i will be positive.

Segner, 1751.

In the Transactions of the Royal Society of Gottingen for 1751, M. Segner has referred all the phenomena of capillary attraction to the attraction of the superficial particles of fluids. Considering the resemblance at the surface of the drops of fluids and of fluids contained in capillary tubes to the surfaces, which geometers have named *lintearia* or elastic, he was led to consider fluids as enveloped in such surfaces, which, by their tension and elasticity, gave to fluids the form indicated by experiment. It appears, however, that Segner considered this only as a fiction which might represent the phenomena, but which ought only to be admitted in so far as it belonged to a law in which the attraction is insensible at sensible distances. Segner tried to establish this dependance; but in the opinion of La Place, "in following this reasoning it is easy to discover its inaccuracy, which is also proved by the incorrectness of the results to which he arrives. He finds, for example, that we ought to consider only the curvature of the vertical section of a drop, and not its horizontal curvature, which is not exact; and besides this, he did not perceive that the tension of the surface is the same whatever be the magnitude of the drop."*

Morveau, 1773.

The subject of the adhesion of fluids to plates of solid bodies, which was first investigated by our countryman Dr Brook Taylor,† was now resumed with great success by M. Guyton Morveau, in 1773. The same subject was prosecuted by M. Achard of Berlin, and M. Dutour, the last of whom made a great number of experiments, both on the adhesion of discs, and on the ascent of fluids. An account of the general results which they obtained, will be found in our article ADHESION.

Monge, 1787.

In the year 1787, M. Monge published in the Memoirs of the Academy of Sciences, a paper entitled, *Sur quelques effets d'attraction et de repulsion apparente entre les Molecules de Matiere.* These experiments relate principally to the apparent attraction and repulsion which are exhibited by floating bodies when they approach within a certain distance of each other; to the phenomena of drops; and to the ascent of water between two planes of glass. An account of his experiments will be found in the present Chapter.

Dr Thomas Young, 1805.

The subject of capillary attraction has been ably investigated by Dr Thomas Young, in his paper *On the Cohe-*

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* See *Comment. Getting.* 1751, tom. i. p. 301.

† See *Phil. Trans.* 1721.

sion of Fluids, which appeared in the *Philosophical Transactions* for 1805; and in which he has anticipated many of the views afterwards brought forward by La Place. This paper is divided into 8 sections. Sect. I. Contains the general principles; Sect. II. Treats of the form of the surface of fluids; Sect. III. Contains the analysis of the simplest form; Sect. IV. Contains the application of it to the elevation of particular fluids; Sect. V. Treats of apparent attractions and repulsions; Sect. VI. Treats of the physical foundation of the law of superficial cohesion; Sect. VII. Of the cohesive attraction of solids and fluids; and Sect. VIII. is entitled, additional extracts from La Place, with remarks. A general account of Dr Young's views, and some of his experimental results, will be found under our article on CAPILLARY ATTRACTION, p. 408, 412.

Labours of La Place, 1805.

In December 1805, M. le Comte La Place laid before the National Institute of France a Dissertation on Capillary Attraction, which is marked with the high genius of its distinguished author. In 1806, it was published under the title of *Supplement au dixieme Livre du Traité de Mecanique Celeste, sur l'Action Capillaire.* In the theory advanced by Clairaut, it was supposed that the action of the capillary tube extended to a sensible distance, and even to the fluid particles in its axis; and, instead of attempting to discover the law of that action, he contented himself with observing that there were an infinity of laws of attraction, which, if substituted in his formulæ, would give results corresponding to those obtained from experiment. M. La Place, however, was anxious to ascertain the precise law of attraction which represented the phenomena; and, after long researches, he at last succeeded in discovering, that all the phenomena could be represented by the same law which represents the phenomena of refraction, namely, the law in which the attraction is only sensible at insensible distances; and upon this he has founded a rigorous theory of capillary attraction. The first Section of this work treats of the Theory of Capillary Attraction; and the second contains its application to some of the experiments of Hawksbee, and to others made at La Place's request by MM. Hauy and Tremery. In the year 1807, La Place published his *Supplement a la Theorie de l'Action Capillaire;* the object of which was to perfect the theory which he had given—to extend its application—to confirm it by new comparisons with experimental results—and, in presenting under a new point of view the effects of capillary action, to shew the identity of the attractive force upon which it depends with those which produce chemical affinities.

This Supplement treats, 1. Of the fundamental Equation of the Theory of Capillary Action. 2. Of a new manner of considering Capillary Attraction. 3. Of the Attraction and apparent Repulsion of small Bodies which move on the surface of Fluids. 4. On the Adhesion of Discs to the Surface of Fluids. 5. On the Figure of a large Drop of Mercury, and of the Depression of the Fluid in a Tube of Glass of a great Diameter. The theoretical results obtained from the formulæ investigated by M. La Place agree, in a very wonderful manner, with a series of experiments made, at his request, by M. Gay Lussac, as will be seen from the abstract of this theory with which the present Chapter is concluded.

Having thus given a brief account of the progress of this branch of science, we shall now lay before our readers such additional information on the cohesion of fluids and on capillary attraction, as may appear to be necessary for completing the view of the subject which might be expected in a work of this kind.

SECT. I. *On Capillary Attraction.*

1. *On the Ascent of Fluids in Glass Tubes.*

On the ascent of fluids in glass tubes.

The experiments which were made during the last century on the ascent of fluids in tubes of glass, differed so widely from each other in their results, that no confidence whatever could be placed in them. Some philosophers did not scruple to assign different heights for the same fluid and the same tube;* and even if the proper mode of cleaning the tube had enabled them to observe the highest point to which the water rose, they had no correct method of measuring the difference of level between the summit of the elevated column and the surface of the fluid. The rise of the water on the outside of the glass tube, rendered it particularly difficult to make such a measurement with the accuracy which such delicate observations required.

The first attempt to construct an accurate instrument, appears to have been about the same time by Dr Brewster and M. Gay Lussac, who, without any knowledge of each other's invention, have employed the very same principles for ascertaining, with the utmost accuracy, the altitude of the fluid above its natural level. We do not know which of these inventions are entitled to the merit of priority. Dr Brewster's instrument was invented some time in 1806. An account of it was submitted to the Royal Society of Edinburgh in February 1811, and a drawing and description of it was published in our article CAPILLARY ATTRACTION in 1812. Gay Lussac's instrument must have been invented in 1807, and probably much earlier, as the experiments contained in La Place's second supplement, which appeared in that year, seem to have been made with it; but so far as we know, no description of the instrument was published till 1816, when it appeared in M. Biot's *Traité de Physique.*

Gay Lussac's instrument for measuring the ascent of fluids in capillary tubes.

PLATE CCCXVI. Fig. 3.

This instrument is represented in Plate CCCXVI. Fig. 3, where ABCD is a large cylindrical vessel of glass for containing the liquid. It is placed upon a base, which can be adjusted by the three *adjusting* screws V, V, V, so that its orifice AB may be perfectly horizontal, which can easily be ascertained by placing a level upon it. The capillary tube TSH with which the experiment is to be made, has a vertical motion in a groove CC, perpendicular to a plate *a b*, which is placed on the orifice AB of the glass vessel. By this means the tube is kept in a vertical position, and it is required only to measure the height of the column HS above the level NN of the fluid. For this purpose Gay Lussac employs a divided rule RR, which can be placed in a vertical position by means of two adjusting screws *v v*, and a plumb line FP. Along the divided scale, a small telescope GH of a short focal length, and with cross wires in the focus of the eye-glass, is made to move by the screw nut *s*, so that the horizontal wire may be made just to touch the lowest point of the surface of the fluid. In order to determine the point H which corresponds to the natural level of the fluid surface, the plate *a b*, along with the tube TT, is pushed aside till it is stopped by the side of the glass vessel, (for if it were taken out, the surface NN would descend,) and the bar *t t* resting upon the plate *a' b'* is placed on

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* See our account of Carré's experiments, p. 466.

On Capillary Attraction and the Cohesion of Fluids.

the side of the vessel from which the tube has been moved. The bar *tt* is made to descend by a screw cut upon it, till the lower point *t* touches the water, which is known by the water rising instantaneously round it. When this contact is effected, a small portion of the water is removed by the small measure M, at the end of a crooked wire, so that the lower extremity *t* is above the surface of the liquid by a very small quantity. The horizontal wire of the telescope is then made to come into apparent contact with the end *t* of the bar, and the distance between this and the division corresponding to S, is a true measure of the altitude HS of the fluid.

It is obvious from the method now described that the altitude thus found must always be too small, and that a correction depending upon the quantity of water removed by the measure M should be made. This correction must be very small if the diameter of the glass vessel is great. This instrument is obviously liable to a source of error, from the interposition of the glass vessel between the telescope and the fluid column, as the least inequality or difference of parallelism in the parts of the glass opposite to S and H, would produce a sensible error in the result. This, however, may be easily obviated by cutting a piece out of the glass vessel, and cementing upon it a plate of parallel glass. We would also recommend, in making very accurate observations, that the sides of the glass tube next the telescope should be either ground flat about S, or have any inequality of refraction removed, by cementing upon it a plate of parallel glass.

The method of measuring the cohesion of fluids, which we have described for the first time under CAPILLARY ATTRACTION, vol. v. p. 410, col. 2. will, we have no doubt, be found the most correct. The apparatus will be greatly improved by using two solids of the same kind and form instead of one. By this means the termination of the elevated circle of fluid will be more easily ascertained.

Gay Lussac's experiments on the ascent of water in capillary tubes.

With the instrument shewn in Fig. 3, M. Gay Lussac has made several experiments on the ascent of water and alcohol in tubes of glass, of which the following are the results. In these experiments, the tubes were well wetted with the fluid.

WATER.

	Diameter of the Tubes in Millimetres.	Height of the Water in Millimetres above the lowest point of its Concavity.	Temperature in Degrees of the Centigrade Thermometer.
Exp. 1.	1.29441	23.3164	8°.5
Exp. 2.	1.90381	15.5861	

The first of these experiments gives a constant quantity of 0.04641 in English inches, and the second a constant quantity of 0.04604. We have inserted these in the following table of constant quantities, for the purpose of giving a general view of the different results which have been obtained.

Constant quantity in inches.	Observers.
0.020	Newton. See *Optics*, p. 366, 3d edit.
0.021	MM. Hauy and Tremery.
0.026	M. Hallstrom.*
0.033	Dr Brewster, with a tube 0.0561 of an inch in diameter.
0.0392	Muschenbroek. This is given by Dr T. Young as the result of Muschenbroek's best experiment.
0.040	Average assumed by Dr T. Young.
0.042407	Average of Weitbrecht's seven experiments.
0.04641	Gay Lussac, with a tube 1.90 millimetres in diameter, and for the lower surface of the meniscus.
0.04604	Do. with a tube 1.29 millimetres in diameter.
0.048	Benjamin Martin
0.053	Mr Atwood.
0.0645	James Bernoulli.

Our readers will no doubt be much surprised at the great discrepancy among the results in the preceding table, and particularly between those obtained by Dr Brewster and M. Gay Lussac, which were made with instruments founded on the same principle. M. La Place has ascribed these differences to the greater or less degrees of humidity on the sides of the tubes; and he informs us that, in Gay Lussac's experiments, the tubes were very much wetted. Now, it appears to us, that though by this method the water will always stand nearly at the same height in the same tube, yet it does not afford us an accurate measure of the height of ascent. Let us suppose that a tube $\frac{1}{100}$ of an inch in diameter is so perfectly cleared of all grease and extraneous matter, that the attractive force of the glass is allowed to exert itself without any diminution, and that the water stands at the height of 3.3 inches. Let us now suppose that by some means or other a film of water of the thickness of $\frac{1}{100}$ of an inch is introduced at the upper end of the tube, and equably diffused over its interior surface, it is obvious that the water will rise above its former level, and consequently to a height greater than that which is due to the force exerted by the tube and the mutual action of the fluid. We conceive, therefore, that M. Gay Lussac's measures err in excess; and that the error increases inversely as the diameter of the tube.

The discrepancies in the table appear to us also to be partly owing to the different kinds of glass employed. The flint glass, of which tubes are composed, varies very much in its density; and there is every reason to believe, both from analogy and from some direct experiments which we have made, that the substance of the tube has a very perceptible influence on the height to which the fluid ascends.

The following were the results which M. Gay Lussac obtained for alcohol.

ALCOHOL.

Exp.	Diameter of the Tube in Millimetres.	Height of the Alcohol in Millimetres above the lowest part of its Concavity.	Density of the Alcohol.	Temperature in degrees of the Centigrade Scale.
1.	1.29441	9.18235	0.81961	8°.5
2.	1.90381	6.08397	0.81961	8°.5
3.	1.29441	9.30079	0.8595	
4.	1.29441	9.99727	0.94153	
†5.	10.508	0.3835	0.813467	

The results of experiments 1 and 2, when reduced to English inches, give .01798 and .01840 for the value of the constant quantity. The constant quantity for Al-

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* M. Hallstrom found that water rose 11.7 Swedish lines in a tube 0.7 of a line in diameter.

† This is a mean of 5 experiments.

cohol found by Dr Brewster is almost the same as this, namely .0178. Benjamin Martin makes the constant quantity 18, and Muschenbroek 10.

M. Gay Lussac obtained the following result for oil of turpentine.

OIL OF TURPENTINE.

Diameter of Tube in Millimetres.	Altitude.	Density.
1.29441	9.95159	0.869458

Experiments of MM. Hauy and Tremery.

The following are the experiments which were made at the desire of La Place, by Messrs Hauy and Tremery:

Diameter of Tube in Millimetres.	Height of the Water in Millimetres.	Constant Quantity or Height for a Tube 1 millimetre in Diameter.
	WITH WATER.	
2.0000	6.75	13.500
1.3333	10.00	13.333
0.7500	18.50	31.875
		Mean 13.5693
	WITH OIL OF ORANGES.	
2.0000	3.400	6.8
1.3333	5.000	6.6667
0.7500	9.00	6.75

Experiments by Dr Robison.

The following experiments were made by Dr Robison with a tube of a very slender bore.

Oil of turpentine	1.35 inches.
Spirits of wine	2.5
Water	5.5
Caustic volatile alkali	6.25
Solution of sal ammoniac	8.07

2. *On the Ascent of Fluids between Two Plates of Glass.*

Parallel plates. Newton.

It appears from the experiments mentioned by Newton in his *Optics*, (p. 366. edit. 3d, 1721,) that water rose one inch between two plates of glass, whose distance was $\frac{1}{100}$ of an inch, and that water rose to the same height in a capillary tube, the semi-diameter of whose bore was equal to the distance of the plates, which gives .010 as the constant quantity for the glass plates, and .020 as the constant quantity for capillary tubes.

Experiments of Monge.

The following experiments were made by M. Monge, on the rise of water between two plates of glass. The plates of glass were first cleaned with caustic alkali, and carefully washed, and, when separated to different distances, by the interposition of silver wires of different thicknesses, they were plunged in the water of the Seine, which had been previously filtered. The diameters of the silver wires, from which the distance of the plates was inferred, were obtained by rolling the wire round a tube of glass, and finding the number of thicknesses which occupied an exact number of lines. By dividing the number of lines by the number of revolutions, he obtained the exact diameter of the wire, and consequently the distance of the plates. The following are the results which he obtained.

Distance between the plates of glass in parts of a line.	Height of the water above its level, in lines.	Constant quantity.
$\frac{4}{33}$ or 0.1212 inch	15.5 lines.	18.786
$\frac{4}{49}$ 0.0802	33.5	26.80
$\frac{1}{28}$ 0.03571	74	26.427.

Messrs Hauy and Tremery likewise observed the height to which water ascended between two parallel plates of glass placed vertically, at the distance of 1 millimetre, and obtained the following result:

Experiments of MM. Hauy and Tremery.

Distance between the Plates, Millimetre.	Height of ascent in Millimetres.	Constant quantity in Millimetres.
1	6.5	6.5

Experiments of Gay Lussac on the rise of water between parallel plates.

M. Gay Lussac measured with great care the rise of water between two plates of glass ground perfectly flat, and placed exactly parallel to each other. In order to do this with accuracy, he kept the plates separate by four very fine iron wires cut consecutively from the same piece, so as to have their diameters as equal as possible; and in order to find the thickness of the wire, he placed a great number of them together, and measured the sum of their diameters. The following was the result of his observations.

Distance of the Plates of Glass in Millimetres.	Height of the Water to the lowest point of the Concavity in Millimetres.	Temperature in the Centigrade Scale.
1.069	13.574	16°

The constant quantity is here 14.51, or 0.02251, when reduced to English inches, for a distance of $\frac{1}{100}$th of an inch.

It is obvious from these experiments, that water ascends to twice the height in capillary tubes that it does between two plates whose distance is equal to the diameter of the tube.

Inclined plates.

PLATE CCCXVI. Fig. 4.

We have already seen, under CAPILLARY ATTRACTION, that if the two plates of glass are inclined to each other at a small angle, the water will rise between them in such a manner that its surface is a hyperbola. Thus, in Plate CCCXVI. Fig. 4. let ABEF, CDEF be the two plates of glass, and DE the surface of the water, then $EnpD$, $EmoB$ will be the surface of the fluid, which Mr Hawksbee found to be hyperbolic, by measuring the ordinates of abscissæ of the curves.

The hyperbolic form of the surface may be deduced from the observed fact, that the altitudes of the fluid in capillary tubes, or between parallel glass plates, are inversely as the diameters of the tubes, or the distance of the plates. The distance of the plates at m is obviously mn or st, and their distance at o is op or qr. But ms and oq, being the altitudes of the fluid at m and o, we have $ms : oq = op : mn$, but $Ft : Fr = st$ or $mn : qr$, or op. Hence $Ft : Fr = mn : op$. But in the Apollonian hyperbola, the ordinates are inversely proportioned to their respective abscissæ, and therefore $EmoB$ is the Apollonian hyperbola. Mr Hawksbee's experiments have already been given in p. 467.

3. *On the Depression of Mercury and Melted Lead in Capillary Tubes.*

Depression of mercury.

Lord Charles Cavendish's experiments.

If a capillary tube of glass is immersed in mercury, or any of the metals in a fluid state, the metallic fluid, instead of being elevated like water, stands considerably lower in the tube than in its natural surface. The most correct experiments on the depression of mercury were made by Lord Charles Cavendish. The following are the results which he obtained:

On Capillary Attraction and the Cohesion of Fluids.

Inside Diameter of the Tube in Inches.	Grains of Quicksilver in one Inch of the Tube.	Depression of the Surface of the Mercury in Inches.
0.6	972	0.005
0.5	675	0.007
0.4	432	0.015
0.35	331	0.025
0.30	243	0.036
0.25	169	0.050
0.20	108	0.067
0.15	61	0.092
0.10	27	0.140

Hauy and Tremery's experiments.

Messrs Hauy and Tremery found the following depression of mercury:

Diameter of the tube.	Depression of the mercury.
2 millimetres.	3.666 millimetres.
1.333	5.5

The ultimate product or constant quantity inferred by Dr T. Young from Lord C. Cavendish's experiments is 0.015, whereas Hauy's experiments make it 0.01137.

The results of the experiments of Gellert have already been given in p. 468.

Water suffers also a depression like mercury in tubes of glass that have been coated with grease. This was first observed by Carré, and was afterwards verified by the experiments of Cigna and Dutour.

Water depressed in greasy tubes of glass.

M. Dutour took two tubes, each of which was about two lines in diameter, and having lined one of them with a thin film of wax, and the other with grease, he plunged them about four lines deep in water. The water was depressed in both the tubes, but less in the first than in the second.

4. *On the Adhesion of Discs to the Surface of Fluids.*

Adhesion of discs to fluids.

In our article ADHESION, we have already given an account of the experiments of Taylor, Morveau, Achard, and Dutour.

The following results were obtained by M. Gay Lussac for a circular plate of white glass, with water, alcohol, and oil of turpentine.

Gay Lussac's experiments.

Fluids.	Diameter of the circular plate. Millimetres.	Weight necessary to raise it. Grammes.	Specific Gravity.
Water	118.366	59.40	
Alcohol	118.366	31.08	0.81961
Alcohol	118.366	32.87	0.8595
Alcohol	118.366	37.152	0.94153
Oil of turpentine	118.366		

The following result was obtained for a disc of copper:

	Diameter of disc of copper.	Weight necessary to raise it.	Temperature centigrade.
Water	116.604	57.945	18°.5

M. Gay Lussac made many experiments on the adhesion of a disc of glass to mercury, but the results which he obtained differed widely from one another. In making his experiments on the adhesion of discs of glass, the disc was suspended at one scale of a balance, and raised vertically by placing, successively and slowly, small weights in the other scale. The sum of these weights at the moment when the disc detached itself, indicated the force of adhesion. In making these experiments on mercury, however, he observed, that the sum of the weights was more or less great according to the slowness with which they were successively added; and in adding them at very great intervals, the sum varied from 158 grammes to 296 grammes for a disc 118.366 millimetres in diameter.

Besile's experiments.

Besile found, that the adhesion of 25 square lines of mercury was 82 French grains, while that of the same surface of water was 8¼ grains. In some cases, he found that the apparent adhesion was diminished under the exhausted receiver of an air pump.

5. *On the Magnitude and Form of Drops of Fluids.*

Phenomena of drops.

The effect of the cohesion of fluids is very finely exemplified in the formation of drops. It is obvious, that drops of fluids that have the least force of cohesion, will have the least magnitude, provided their specific gravities are the same; for the effect of the force of cohesion must be diminished by the weight of the drop which will be sooner detached, and therefore of a less magnitude than if the fluid had less weight. Dr Young infers, from the law of the superficial cohesion of fluids, "that the linear dimensions of similar drops depending from a horizontal surface, must vary precisely in the same ratio as the heights of ascent of the respective fluids against a vertical surface, or as the square roots of the heights of ascent in a given tube. Hence the magnitudes of similar drops of different fluids must vary as the cubes of the square roots of the heights of ascent in a tube." In water, for example, Dr Young found the weight of a drop to be 1.8 grains, and the weight of a drop of diluted alcohol 0.85 of a grain; whereas the height of the same alcohol was to the height of water in the same tube as 100 to 64. The weight of the drop should have been .82, as inferred from the consideration of the heights of ascent combined with that of the specific gravities. This result is widely different from that which was obtained by Dr Brewster (See p. 442.) with his capillary hydrometer. The magnitude of a drop of water was to the magnitude of a drop of spirit nearly proof as 2.93 to 1; and, therefore, taking the specific gravity of spirit at 0.920, the weights of the drops were to one another as 3.255 to 1, or as 100 to 31 nearly.

The magnitude of drops of fluids depends also upon the form of the surface from which they fall. If the fluid is collected at the extremity of a very minute fibre of glass, the drop will fall when its weight balances the attractive force exerted by the glass, and therefore, in the present case, the drop will be very small; but if the fluid is collected on a hemispherical surface, the surface of glass which is in contact with the fluid is greater; and, therefore, the drop must contain a much greater quantity of water before its weight balances the attractive force of the hemispherical surface.

The form of a drop of fluid, abstracting the consideration of its weight, would always be that of a perfect sphere; and we accordingly find that the drops of rain by which the rainbow is formed, and very small drops of fluids lying upon a surface which does not attract them, have a shape almost perfectly spherical. In other cases the form of a drop is modified by its weight. Dr Young has given the following as the equation of the surface of a drop of water:

$$a\,a\,x\,\ddot{x} + a\,a\,\dot{y}\,\dot{y} = x\,y\,\dot{y}\,\ddot{z}, \text{ when } \ddot{z} = 0, \text{ or}$$

$$a^4 x^2 \ddot{x}^2 + 2\,a^4 x\,\dot{y}^2 \ddot{x} + (a^4 - x^2 y^2)\,\dot{y}^4 - x^2 y^2\,\dot{x}^2 \dot{y}^2 = 0.$$

Monge's experiments on drops.

In order to shew that two drops of water do not attract each other when at a distance, M. Monge put some spirit of wine into a cup, and having taken a capillary tube containing some of the same fluid, he allowed it to fall from a height of a few lines, drop by drop, into the cup; the drops did not immediately mix with the rest of the fluid, but preserved their form, which was nearly spherical; rolled over the surface with great freedom, like balls over a billiard table, impinged against each other; changed their form by the force of impact; and, after being reflected from each other, continued to move upon the surface till they were again mixed with the general mass. This experiment does not succeed so well when the spirit of wine is warm. M. Monge explains this phenomenon by supposing that a thin film of air adheres to the drop; and, by diminishing its specific gravity, causes it to float upon the fluid surface; and hence he concludes that the experiment will succeed best with those liquids which are most evaporable, or which have the greatest affinity for the surrounding air. A similar phenomenon, as M. Monge observes, is seen in the drops of water which fall from the oars during the rowing of a boat, and in the drops produced by the condensation of the steam of any warm fluid, such as coffee, &c. These drops are real spheres of fluid, and not spherical vesicles like those formed on the surface of water with heavy rains. These results are hostile to the idea of M. Saussure, who, in his Essays on Hygrometry, has stated that drops of the same liquid cannot be pushed against one another, nor remain simply in contact without instantly uniting; and that only hollow vesicular globules are capable of floating upon the surface of the same fluid with themselves.

Dr Brewster's experiments on drops.

In repeating the experiments of Monge, Dr Brewster found that the appearances were most beautiful when the capillary tube discharged the drops upon the inclined plane of fluid, which is elevated by the attraction of the edge of the cup. They ran down the inclined plane with great velocity, and sometimes even ascended the similar plane on the opposite side of the vessel. When the drop was discharged at the distance of one or two-tenths of an inch from the surface of the water, they had always the same magnitude when the tube was held in the same position; but when the point of the tube was brought within a tenth of an inch of the surface of the spirit of wine, this surface, instead of attracting the drop to it instantly, as Saussure would have predicted, actually resisted the gravity or weight of drop, and allowed it to attain a diameter nearly twice as great as it would have had, if it had been discharged in the ordinary manner. This swoln globule floated upon the surface in the same manner as the smaller drops, surrounded with a depression of the fluid surface similar to what is produced by a glass globule floating on mercury, or by the feet of particular insects, that have the power of running upon the surface of water. (See Fig. 5.) The floating globules are often produced even when they are discharged from a height of three or four inches; and by letting them fall upon the inclined plane of fluid formerly mentioned, they will often rebound from the surface, and fall over the sides of the cup.

PLATE CCCXVI. Fig. 5.

When a drop of mercury is laid upon glass, it assumes a flat spheroidal form, in consequence of its weight. The section of its surface, as M. La Place observed, by a vertical plane drawn through its centre, is very much curved at its summit. The curvature increases on receding from that point, till the tangent to the curve is vertical. At this point, the curvature and the width of the section will be a maximum. Below that point it will approach its axis, and will at last coincide with the plane of the glass, and form with it an acute angle. M. Gay Lussac observed at the temperature of 12°.8 of the centigrade thermometer, the thickness of a large drop of mercury, circular, and a decimeter in diameter, resting upon a plane surface of white glass perfectly horizontal. By a very accurate micrometer, he found its thickness to be 3.378 millimetres. M. Segner had long before obtained nearly the same result, viz. 3.40674 millimetres.

Form of a drop of mercury.

Form of an opening in a film of fluid.

The cohesion of fluids is beautifully shewn in a phenomenon, which is the very reverse of the formation of a drop, and which was first observed by Dr Brewster. If we take a phial, with a wide mouth, half filled with Canada balsam, and allow the balsam to flow to the mouth of the phial and fill it up, then when the phial is placed on its bottom, a fine transparent film of balsam will be seen extending over the mouth of the phial. If we now take a piece of slender wire, and touch the film near the middle, so as to tear away a little part of it, the remaining part of the film which has been elevated by this force will descend to its level position, and the ragged aperture from which the balsam has been torn will be seen to assume a form perfectly circular, having its edge in a slight degree thickened, like a circle with a raised margin turned out of a piece of wood. This fine circular aperture grows wider and wider, and continues to preserve its circular form till the mouth of the phial is again opened.

New experiment on capillary attraction.

PLATE CCCXVI. Fig. 6.

The following curious experiment, which was performed by Dr Brewster, is intimately connected with the subject of capillary attraction. Above a vessel MNOP, Fig. 6. nearly filled with water, a convex lens LL was placed at the distance of the 10th of an inch, and rays R, R, R, were incident upon its upper surface. The focus of these rays was at F, a little beyond the bottom of the vessel, so that a circular image of the luminous object was seen on the bottom of the vessel, having AB for its diameter. If the lens is now made to descend gradually towards the surface of the water, and the eye kept steadily upon the luminous image AB, a dark spot will be seen at ϕ in the centre of AB, a little while before the lens attracts and elevates the water MN. Sometimes this spot may be seen playing back and forwards by the slight motion of the hand, so that the lens can even be withdrawn from the fluid surface without having actually touched it. In general, however, the sudden rise of the water to the lens follows the appearance of the black spot. When the water is in contact with the glass, the focus of the rays R, R is now transferred to f, and the circular image on the bottom is now $a\,b$, and the intensity of the light in this circle is to that in the circle AB, as $AB^2 : a\,b^2$. Now it is obvious, that the darkish spot at ϕ is just the commencement of the transference of the focus from F to f; or when the dark spot is produced, the progress of the rays is the same as if the focus were transferred to f. This remarkable effect may arise from two causes. 1. The approach of the lens to the surface MN, may occasion a depression $m\,o\,n$ in the surface of the fluid of the same curvature as L l L, which would have the effect of transferring the focus from F to f. This depression may be produced by a film of air

PLATE CCCXVI. Fig. 5.

adhering to the lens, in the same manner as the depression is produced on the surface of alcohol, by a drop of alcohol rolling over it, as shewn in Fig. 5, or by some other repulsive force with which we are unacquainted. 2. The transference of the focus from F to f, may be occasioned by the optical contact of the glass and water taking place at a greater distance from the lens than the distance at which the capillary attraction commences. For if the surfaces $l\,l$, $m\,n$, at a certain distance, act upon the rays of light as if they were one surface, then it is manifest that a dark spot ought to appear at ϕ, if this distance is less than that at which capillary attraction begins.

6. *Account of La Place's Theory of Capillary Attraction.*

La Place's theory of capillary attraction.

In the first supplement published by M. le Comte La Place, his method of considering the phenomena was founded on the form of the surface of the fluid in capillary spaces, and on the conditions of equilibrium of this fluid in an infinitely narrow canal, resting by one of its extremities upon this surface, and by the other on the horizontal surfaces of an indefinite fluid, in which the capillary tube was immersed. In his second supplement, he has examined the subject in a much more popular point of view, by considering directly the forces which elevate and depress the fluid in this space. By this means, he is conducted easily to several general results, which it would have been difficult to obtain directly by his former method. Of this method we shall endeavour to give as clear a view as possible.

Analysis of the forces by which the water is raised.

Fig. 7.

Let AB, Fig. 7. be a vertical tube whose sides are perpendicular to its base, and which is immersed in a fluid that rises in the interior of the tube above its natural level. A thin film of fluid is first raised by the action of the sides of the tube; this film raises a second film, and this second film a third film, till the weight of the volume of fluid raised exactly balances all the forces by which it is actuated. Hence it is obvious, that the elevation of the column is produced by the attraction of the tube upon the fluid, and the attraction of the fluid for itself. Let us suppose that the inner surface of the tube AB is prolonged to E, and after bending itself horizontally in the direction ED, that it assumes a vertical direction DC; and let us suppose the sides of this tube to be so extremely thin, or to be formed of a film of ice, so as to have no action on the fluid which it contains, and not to prevent the reciprocal action which takes place between the particles of the first tube AB and the particles of the fluid. Now, since the fluid in the tubes AE, CD is in equilibrium, it is obvious that the excess of pressure of the fluid in AE is destroyed by the vertical attraction of the tube and of the fluid upon the fluid contained in AB. In analyzing these different attractions, M. La Place considers first those which take place under the tube AB. The fluid column BE is attracted, 1. by itself; 2. by the fluid surrounding the tube BE. But these two attractions are destroyed by the similar attractions experienced by the fluid contained in the branch DC, so that they may be entirely neglected. The fluid in BE is also attracted vertically by the fluid in AB; but this attraction is destroyed by the attraction which it exercises in the opposite direction upon the fluid in BE, so that these balanced attractions may likewise be neglected. The fluid in BE is likewise attracted vertically upwards by the tube AB, with a force which we shall call Q, and which contributes to destroy the excess of pressure exerted upon it by the column BF raised in the tube above its natural level.

Analysis of the forces by which the water is raised. PLATE CCCXVI. Fig. 7.

Now, the fluid in the lower part of the round tube AB is attracted, 1. By itself; but as the reciprocal attractions of a body do not communicate to it any motion if it is solid, we may, without disturbing the equilibrium, conceive the fluid in AB frozen. 2. The fluid in the lower part of AB is attracted by the interior fluid of the tube BE, but as the latter is attracted upwards by the same force, these two actions may be neglected as balancing each other. 3. The fluid in the lower part of BE, is attracted by the fluid which surrounds the ideal tube BE, and the result of this attraction is a vertical force acting downwards, which we may call $-Q'$, the contrary sign being applied, as the force is here opposite to the other force Q. As it is highly probable that the attractive forces exercised by the glass and the water vary according to the same function of the distance, so as to differ only in their intensities, we may employ the constant co-efficients ρ, ρ' as measures of their intensity, so that the forces Q and $-Q'$ will be proportional to ρ, ρ'; for the interior surface of the fluid which surrounds the tube BE, is the same as the interior surface of the tube AB. Consequently, the two masses, viz. the glass in AB, and the fluid round BE, differ only in their thickness; but as the attraction of both these masses is insensible at sensible distances, the difference of their thicknesses, provided their thicknesses are sensible, will produce no difference in the attractions. 4. The fluid in the tube AB is also acted upon by another force, namely, by the sides of the tube AB in which it is inclosed. If we conceive the column FB divided into an infinite number of elementary vertical columns, and if at the upper extremity of one of these columns we draw a horizontal plane, the portion of the tube comprehended bethe plane and the level surface BC of the fluid, will not produce any vertical force upon the column; consequently, the only native vertical force is that which is produced by the ring of the tube immediately above the horizontal plane. Now, the vertical attraction of this part of the tube upon BE, will be equal to that of the entire tube upon the column BE, which is equal in diameter, and similarly placed. This new force will therefore be represented by $+Q$. In combining these different forces, it is manifest that the fluid column BF is attracted upwards by the two forces $+Q$, $+Q$, and downwards by the force $-Q'$; consequently the force with which it is raised upwards will be $2\,Q-Q'$. If we represent by V the volume of the column BE, D its density, and g the force of gravity, then $g\,DV$ will represent the weight of the elevated column; but as this weight is in equilibrio with the forces by which it is elevated, we have the following equation:

$$g\,DV=2\,Q-Q'.$$

If the force $2\,Q$ is less than Q', then V will be negative, and the fluid will sink in the tube; but as long as $2\,Q$ is greater than Q', V will be positive, and the fluid will rise above its natural level; as was long before shewn by M. Clairaut.

Since the attractive forces, both of the glass and the fluid, are insensible at sensible distances, the surface of the tube AB will act sensibly only on the column of fluid immediately in contact with it. We may therefore neglect the consideration of the curvature, and consider the inner surface as developed upon a plane. The force Q will therefore be proportional to the width of this plane, or what is the same thing, to the interior circumference of the tube. Calling c, therefore, the circumference of the tube, we shall have $Q = \varrho c$; ϱ being a constant quantity, representing the intensity of the attraction of the tube AB upon the fluid, in the case where the attractions of different bodies are expressed by the same function of the distance. In every case, however, ϱ expresses a quantity dependent on the attraction of the matter of the tube, and independent of its figure and magnitude. In like manner we shall have $Q' = \varrho' c$; ϱ' expressing the same thing with regard to the attraction of the fluid for itself, that ϱ expressed with regard to the attraction of the tube for the fluid. By substituting these values of Q, Q′, in the preceding equation, we have

$$g\,D V = c\,(2\,\varrho - \varrho').$$

If we now substitute, in this general formula, the value of c in terms of the radius if it is a capillary tube, or in terms of the sides if the section is a rectangle, and the value of V in terms of the radius and altitude of the fluid column, we shall obtain an equation by which the heights of ascent may be calculated for tubes of all diameters, after the height, belonging to any given diameter, has been ascertained by direct experiment.

Application of the formula to cylindrical tubes.

In the case of a cylindrical tube, let π represent the ratio of the circumference to the diameter, h the height of the fluid column reckoned from the lower point of the meniscus, q the mean height to which the fluid rises, or the height at which the fluid would stand if the meniscus were to fall down and assume a level surface, then we have πr^3 for the solid contents of a cylinder of the same height and radius as the meniscus, and as the meniscus, added to the solid contents of the hemisphere of the same radius, must be equal to πr^3, we have $\pi r^3 - \frac{2\pi r^3}{3}$, or $\frac{\pi r^3}{3}$, for the solid contents of the meniscus. But since $\frac{\pi r^3}{3} = \pi r^2 \times \frac{r}{3}$, it follows that the meniscus $\frac{\pi r^3}{3}$ is equal to a cylinder whose base is πr^2, and altitude $\frac{r}{3}$. Hence, we have

$$q = h + \frac{r}{3};$$

or what is the same thing, the mean altitude q in a cylinder is always equal to the altitude h of the lower point of the concavity of the meniscus increased by one third of the radius, or one sixth of the diameter of the capillary tube. Now, since the contour c of the tube $= 2\pi\varrho$, and since the volume V of water raised is equal to $q \times \pi r^2$, we have, by substituting these values in the general formula,

$$g\,D\,q\,\pi r^2 = 2\pi r\,(2\,\varrho - \varrho'), \quad \text{(No. 1.)}$$

and dividing by πr and $g\,D$, we have,

$$r\,q = 2\,\frac{2\,\varrho - \varrho'}{g\,D} \text{ and } q = 2\,\frac{2\,\varrho - \varrho'}{g\,D} \times \frac{1}{r}. \quad \text{(No. 2.)}$$

Application of the formula to Gay Lussac's experiments on water.

In applying this formula to Gay Lussac's experiments, we have the constant quantity $2\frac{2\,\varrho - \varrho}{g\,D} = r\,q = 647205 \times \overline{23{,}1634 + 0{,}215735} = 15{,}1311$ for Gay Lussac's 1st experiment. In order to find the height of the fluid in his 2d tube by means of this constant quantity, we have $r = \frac{1.90381}{2} = 0.951905$, and

$$2\;\frac{2\,\varrho - \varrho'}{g\,D} \times \frac{1}{3} = q = \frac{15{,}1311}{0.951905} = 15.8956, \text{ from which,}$$

if we subtract one sixth of the diameter, or 0.3173, we have 15.5783 for the altitude h of the lower point of the concavity of the meniscus, which differs only 0.0078 from 15.861 the observed altitude.

Application of the formula to Gay Lussac's experiments on alcohol.

If we apply the same formula to Gay Lussac's experiments on alcohol, we shall find the constant quantity $2\,\frac{2\,\varrho - \varrho'}{g\,D} = 6.0825$ as deduced from the 1st experiment, and $h = 6.0725$, which differs only 0.0100 from 6.08397, the altitude observed.

From these comparisons, it is obvious, that the mean altitudes, or the values of q, are very nearly reciprocally proportional to the diameters of the tubes; for, in the experiments on water, the value of q deduced from this ratio is 15.895, which differs little from 15.9034, the value found from experiment; and that in accurate experiments, the correction made by the addition of the sixth part of the diameter of the tube is indispensibly requisite.

Application of the formula to rectangular capillary spaces.

If the section of the pipe in which the fluid ascends is a rectangle, whose greater side is a, and its lesser side d, then the base of the elevated column will be $= a\,d$, and its perimeter $c = 2\,a + 2\,d$. Hence, the value of the meniscus will be $\frac{a\,d^2}{2} - \frac{a\,\pi\,d^2}{8} = \frac{a\,d^2}{2}\left(1 - \frac{\pi}{4}\right)$, that is $q = h + \frac{d}{2}\left(1 - \frac{\pi}{4}\right)$. Hence, if in the general equation No. 1. we substitute for c its equal $2\,a + 2\,d$, and for V its equal $a\,d\,q$, we have

$$g\,D\,q\,a\,d = \overline{2\,\varrho - \varrho'} \times \overline{2\,a + 2\,d},$$

and dividing by a and by $g\,D$, we have

$$d\,q = 2\,\frac{2\,\varrho - \varrho'}{g\,D} \times 1 + \frac{d}{a}, \text{ and}$$

$$q = \frac{2\,\frac{2\,\varrho - \varrho'}{g\,D} \times 1 + \frac{d}{a}}{d}$$

In applying this formula to the elevation of water between two glass plates, the side a is very great compared with d, and therefore the quantity $\frac{d}{a}$ being almost insensible, may be safely neglected. Hence the formula becomes

$$q = 2\,\frac{2\,\varrho - \varrho'}{g\,D} \times \frac{1}{d}.$$

By comparing this formula with the formula No. 2. it is obvious, that water will rise to the same height between plates of glass as in a tube, provided the distance d between the two plates of glass is equal to r, or half the diameter of the tube. This result was obtained by Newton, and has been confirmed by the experiments of succeeding writers.

Comparison of the formula with Gay Lussac's experiments.

As the constant quantity $2\,\frac{2\,\varrho - \varrho'}{g\,D}$ is the same as already found for capillary tubes, we may take its value, viz. 15,1311, and substitute it in the preceding equation, we then have

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$$q = \frac{15.1311}{1.060} t = 14.1544 \text{; and since}$$

$$h = q - \frac{d}{2}\left(1 - \frac{\pi}{4}\right), \text{ subtracting}$$

$$\frac{d}{2}\left(1 - \frac{\pi}{4}\right) = 0.1147, \text{ we have}$$

$h = 14.0397$, which differs very little from 13.574, the observed altitude.

It will be seen from the formula No. 2. that of all tubes that have a prismatic form, the hollow cylinder is the one in which the volume of fluid raised is the least possible, as it has the smallest perimeter. It appears also, that if the section of the tube is a regular polygon, the altitudes of the fluid will be reciprocally proportional to the homologous lines of the similar base, a result which, as we have seen, M. Gellert obtained from direct experiment. Hence in all prismatic tubes whose sections are polygons inscribed in the same circle, the fluid will rise to the same mean height. If one of the two bases is, for example, a square, and the other an equilateral triangle, the altitudes will be as 2 : 3¾; or very nearly as 7 : 8,

luids may e alternatey in a state f stable nd instable equilibrium in he same ube.

M. La Place has remarked, that there may be several states of equilibrium in the same tube, provided its width is not uniform. If we suppose two capillary tubes communicating with one another, so that the smallest is placed above the greatest, we may then conceive their diameters and lengths to be such, that the fluid is at first in equilibrium above its level in the widest tube, and that in pouring in some of the same fluid, so as to reach the smaller tube, and fill part of it, the fluid will still maintain itself in equilibrium. When the diameter of a capillary tube diminishes by insensible gradations, the different states of equilibrium are alternately stable and instable. At first the fluid tends to raise itself in the tube, and this tendency diminishing, becomes nothing in a state of equilibrium. Beyond this it becomes negative, and consequently the fluid tends to descend. Thus the first equilibrium is stable, since the fluid, being a little removed from this state, tends to return to it. In continuing to raise the fluid, its tendency to descend diminishes, and becomes nothing in the second state of equilibrium. Beyond this it becomes positive, and the fluid tends to rise, and consequently to remove from this state which is not stable. In a similar manner it will be seen, that the third state is stable, the fourth instable, and so on.

onnection etween the ise of fluids nd the curature of heir surces in capilary spaces.

Although the preceding method of considering the phenomena of capillary attraction is extremely simple and accurate, yet it does not indicate the connection which subsists between the elevation and depression of the fluid, and the concavity or convexity of the surface which every fluid assumes in capillary spaces. The object of M. La Place's first method, contained in his first supplement, is to determine this connection.

By means of the methods for calculating the attraction of spheroids, he determines the action of a mass of fluid terminated by a spherical surface, concave or convex, upon a column of fluid contained in an infinitely narrow canal, directed towards the centre of this surface. By this action La Place means the pressure which the fluid contained in the canal would exercise, in virtue of the attraction of its entire mass upon a plane base situated in the interior of the canal, and perpendicular to its sides, at any sensible distance from the surface, this base being taken for unity. He then shews that this action is smaller when the surface is concave than when it is plane, and greater when the surface is convex. The analytical expression of this action is composed of two terms: the first of these terms, which is much greater than the second, expresses the action of the mass terminated by a plane surface,* and the second term expresses the part of the action due to the sphericity of the surface, or, in other words, the action of the meniscus comprehended between this surface and the plane which touches it. This action is either additive to the preceding, or subtractive from it, according as the surface is convex or concave. It is reciprocally proportional to the radius of the spherical surface; for the smaller that this radius is, the meniscus is the nearer to the point of contact.

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From these results relative to bodies terminated by sensible segments of a spherical surface, La Place deduces this general theorem. "In all the laws which render the attraction insensible at sensible distances, the action of a body terminated by a curve surface upon an interior canal infinitely narrow, perpendicular to this surface in any point, is equal to the half sum of the actions upon the same canal of two spheres, which have for their radii the greatest and the smallest of the radii of the osculating circle of the surface at this point."

By means of this theorem, and the laws of hydrostatics, La Place has determined the figure which a mass of fluid ought to take when acted upon by gravity, or contained in a vessel of a given figure. The nature of the surface is expressed by an equation of partial differences of the second order, which cannot be integrated by any known method. If the figure of the surface is one of revolution, the equation is reduced to one of ordinary differences, and is capable of being integrated by approximation, when the surface is very small. La Place next shews, that a very narrow tube approaches the more to that of a spherical segment as the diameter of the tube becomes smaller. If these segments are similar in different tubes of the same substance, the radii of their surfaces will be inversely as the diameter of the tubes. This similarity of the spherical segments will appear evident, if we consider that the distance at which the action of the tube ceases to be sensible, is imperceptible; so that if, by means of a very powerful microscope, this distance should be found equal to a millimetre, it is probable that the same magnifying power would give to the diameter of the tube an apparent diameter of several metres. The surface of the tube may therefore be considered as very nearly plane, in a radius equal to that of the sphere of sensible activity; the fluid in this interval will therefore descend, or rise from this surface, very nearly as if it were plane. Beyond this the fluid being subjected only to the action of gravity, and the mutual action of its own particles, the surface will be very nearly that of a spherical segment, of which the extreme planes being those of the fluid surface, at the limits of the sphere of the sensible activity of the tube, will be very nearly in different tubes equally inclined to their sides. Hence it follows that all the segments will be similar.

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* M. La Place is of opinion, that the suspension of mercury in a barometer tube, at a height two or three times greater than that which is due to the pressure of the atmosphere, depends on this term. He conceives too, that the refracting force of transparent bodies, cohesion, and in general chemical affinity, depend also upon it.

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Plate CCCXVI. Fig. 7.

The approximation of these results gives the true cause of the ascent or descent of fluids in capillary tubes in the inverse ratio of their diameter. If in the axis of a glass tube we conceive a canal infinitely narrow, which bends round like the tube ABEDC in Fig. 7. the action of the water in the tube in this narrow canal, will be less on account of the concavity of its surface, than the action of the water in the vessel on the same canal. The fluid will therefore rise in the tube to compensate for this difference of action; and as the concavity is inversely proportional to the diameter of the tube, the height of the fluid will be also inversely proportional to that diameter. If the surface of the interior fluid is convex, which is the case with mercury in a glass tube, the action of this fluid on the canal will be greater than that of the fluid in the vessel, and therefore the fluid will descend in the tube in the ratio of their difference, and consequently in the inverse ratio of the diameter of the tube.

In this manner of viewing the subject, the attraction of capillary tubes has no influence upon the ascent or depression of the fluids which they contain, but in determining the inclination of the first planes of the surface of the interior fluid extremely near the sides of the tube, and upon this inclination depends the concavity or convexity of the surface, and the length of its radius. The friction of the fluid against the sides of the tube may augment or diminish a little the curvature of its surface, of which we see frequent examples in the barometer. In this case the capillary effects will increase or diminish in the same ratio.

The differential equation of the surfaces of fluids inclosed in capillary spaces of revolution, conducts La Place to the following general result; that if into a cylindrical tube we introduce a cylinder which has the same axis as that of the tube, and which is such that the space comprehended between its surface and the interior surface of the tube has very little width, the fluid will rise in this space to the same height as in a tube whose radius is equal to this width. If we suppose the radii of the tube and of the cylinder infinite, we have the case of a tube included between two parallel and vertical planes, very near each other. This result has been confirmed, as we have already seen, by the experiments of Newton, Hauy, and Gay Lussac. La Place then applies his theory to the phenomena presented by a drop of fluid, either in motion or suspended in equilibrium, either in a conical capillary tube, or between two plates, and inclined to each other, as discovered by Mr Hawksbee;—to the mutual approximation of two parallel and vertical discs immersed in a fluid;—to the phenomena which take place when two plates of glass are inclined to each other at a small angle;—and to the determination of the figure of a large drop of mercury laid upon a horizontal plate of glass.

In the application of his theory to the experimental results obtained by Hawksbee respecting the angles required for suspending a drop of oil of oranges at different stations between two inclined planes of glass.* La Place obtained the results contained in the following Table.

Column 1st contains the number of the first column of Hawksbee's table, subtracted from 20 inches; and column 2d contains Hawksbee's 2d column, diminished by 5′ 22″.

Distance in inches from the middle of the drop to the intersection of the plane.	Angles of Elevation observed.	Angles of Elevation calculated by La Place's formula.	Differences in aliquot parts of the calculated angles.
18	0° 9′ 38″	0° 17′ 44″	$\frac{1}{2.2}$
16	0 19 38	0 22 27	$\frac{1}{8}$
14	0 29 38	0 29 20	$\frac{1}{99}$
12	0 29 38	0 39 55	$\frac{1}{140}$
10	0 54 38	0 57 29	$\frac{1}{20}$
8	1 39 38	1 29 53	$\frac{1}{30}$
6	2 39 38	2 39 45	$\frac{1}{1369}$
5	3 54 38	3 50 6	$\frac{1}{51}$
4	5 54 38	5 59 58	$\frac{1}{66}$
3	9 54 38	10 42 31	$\frac{1}{13}$
2	21 54 38	24 42 49	$\frac{1}{8.8}$

On Capillary Attraction and the Cohesion of Fluids.

Sect. II. *On the Approximation and Recession of Bodies floating near each other in a Fluid.*

On the approximation and recession of bodies floating near each other in a fluid.

It was long ago observed by philosophers, that when bodies floating on the surface of a fluid approached either one another or the sides of the vessel, they moved rapidly into contact, as if they had been two floating magnets. This phenomenon, which was in general ascribed to the mutual attraction of the floating bodies, was tolerably well explained by M. Marriotte in his *Traité du Mouvement des Eaux.* It was reserved, however, for M. Monge to describe and explain these phenomena with accuracy, which he has done in his *Memoire sur quelques effets d'attraction ou de repulsion apparente entre les Molecules de Matiere.*

The following are the principal experiments upon this subject:

1. If two light bodies, capable of being wetted with water, are placed one inch distant on the surface of water perfectly at rest, they will float at rest, and experience no motion but what is derived from the agitation of the air; but if the distance at which they are placed is only a few lines, they will approach each other with an accelerated motion. If the vessel which contains the water is capable of being wetted by it, such as glass, and if the floating body is placed within a few lines of the edge of the vessel, it will move towards the edge with an accelerated motion.

2. If the two floating bodies are not susceptible of being wetted with fluid, such as two balls of iron in a vessel of quicksilver, and if they are placed at the distance of a few lines, they will move towards each other with an accelerated motion; and if the vessel is made of glass, in which the surface of the mercury is always convex, the bodies will move towards the sides when they are placed within a few lines of it.

3. If one of the bodies is susceptible of being wetted with water, and the other not, such as two globules of cork, one of which has been carbonised by the flame of a taper, then if we attempt, by means of a wire or any other substance, to make the bodies approach, they will fly from each other as if they were mutually repelled. If the vessel is of glass, and if the carbonised piece of cork is placed in it, it will be found impossible to bring the cork in contact with the sides of the vessel.

In these experiments, it is obvious that the approxi-

These results are given in p. 467, top of col. 1.

mation and the recession of the floating bodies are not produced by any attraction or repulsion between the two; for if the bodies, instead of floating on the fluid, are suspended by long and slender threads, it will be found that they have not the slightest tendency either to approach or recede when they are brought extremely near each other. From these experiments the following laws are deducible:

1. If two bodies, floating on the surface of a fluid, and capable of being wetted by the fluid, are placed near each other, they will approach as if they were mutually attracted.

2. If the two bodies are not susceptible of being wetted by the fluid, they will still approach each other when brought nearly into contact, as if they were mutually attracted.

3. If one of the two bodies is susceptible of being wetted and the other not, they will recede from each other as if they were mutually repelled.

ATE CCXVI. g. 8.

Explanation of the first law.—If two plates of glass AB, CD, Fig. 8. are brought so near each other that the point H, where the two curves of elevated fluid meet, is on a level with the rest of the water, they will remain in perfect equilibrium. If they are brought nearer each other, however, as in Fig. 9. the water will rise between them to the height G. The mass of water which is thus raised attracts the sides of the glass plates, and causes them to approximate in a horizontal direction, the mass of water having always the same effect as a curved chain hung to the two plates. The same thing is true of two floating bodies, when they come within such a distance that the fluid is elevated between them. This case is shewn in Fig. 10, where the bodies A, B, placed at a capillary distance, have the water raised between them, and are therefore brought together by the attraction of the fluid upon the sides of the globules.

g. 9.

g. 10.

g. 11.

Explanation of the second law. If the two floating bodies A, B, Fig. 11, are not capable of being wetted by the liquid, the liquid will be depressed between them at H, below its natural level, when they are placed at a capillary distance. The two bodies, therefore, are more pressed inwards by the fluid which surrounds them, than they are pressed outwards by the fluid between, and in virtue of the difference of these pressures they mutually approach each other.

g. 12.

Explanation of the third law. If one of the floating bodies A, Fig. 12. is capable of being wetted, while the other B is not, the fluid will rise round A, and be depressed round B: Hence the depression round B will not be symmetrical; and therefore the body B, being placed as it were on an inclined plane, its equilibrium is destroyed, and it will move towards the right hand, where the pressure is the least.

Place's eorems.

The results of M. Monge's experiments have been completely confirmed by the theory of capillary attraction given by La Place. From this theory it follows, that whatever be the nature of the substances of which the floating planes are made, the tendency of each of them to one another is equal to the weight of a prism of fluid whose height is the elevation of the fluid between the planes, measured to the extreme points of contact of the interior fluid with the plane, *minus* the elevation of the fluid on the exterior sides of the tube, whose depth is half the sum of these elevations, and whose width is the horizontal distance between the planes. The elevation must be reckoned negative when it changes into a depression as in mercury. If the product of the three preceding dimensions is negative, the tendency of the planes becomes repulsive. La Place also concludes, that when the planes are very near each other, the elevation of the fluid between them is in the inverse ratio of their mutual distance, and is equal to half the sum of the elevation which would have taken place, if we suppose the first plane of the same matter as the second, and the second of the same matter as the first.

It follows from these theorems, that the repulsive force of floating planes is much more feeble than the attractive force which is developed when the planes are very near each other, and which occasions them to approach each other with an accelerated motion. In this case, the elevation of the fluid between the planes is very great, relative to its elevation on the outside of the same plane. In neglecting, therefore, the square of this last elevation in relation to the square of the first, the fluid prism, whose weight expresses the mutual tendency of the planes, in virtue of the first of the two preceding theorems, will be equal to the product of the square of the elevation of the interior fluid, by half the horizontal distance of the planes. This elevation being, by the second theorem, reciprocally proportional to the mutual distance of the planes, the prism will be proportional to their horizontal distance divided by the square of that distance. The tendency of the two planes to each other will consequently be in the inverse ratio of the square of their distance; and therefore, like the forces of electricity and magnetism, it will follow the law of universal attraction.

When the two planes are of such a nature that the one is capable of being wetted with the fluid, while the other is not capable of being wetted, then, in consequence of these two opposite actions, the surface of the intermediate fluid will have a point of inflexion; and it follows, from the theory, that they will repel each other at every distance. But if they are brought near each other by force, the point of inflexion will approach more and more to one of the planes, and will at last coincide with it. If the planes are then brought still nearer each other, the fluid will begin either to ascend, or be depressed between them. From this arises another force which pushes the planes towards each other, and which, when it comes to surpass the pressure of the exterior fluid, causes the planes to approach each other with an accelerated motion. This change of repulsion into attraction appeared to M. La Place so singular, that he requested M. Hauy to examine the subject experimentally. In order to do this, he employed planes of ivory and talc, the first of which is capable of being wetted with water, while the other possesses that kind of unctuosity which prevents the water from adhering to it.

M. Hauy suspended, by a very fine thread, a small square plate of talc, so that the lower part of it was immersed in the water. Into the same vessel, at the distance of some centimetres, he immersed the lower part of a parallelopiped of ivory, so that one of its faces was parallel to the plate of talc. The ivory was made to advance towards the talc in this state of parallelism, and was stopped at short intervals, in order to shew that the effect of the motion communicated to the fluid was insensible in the experiment. When the parallelopiped of ivory, moving with great slowness, approached very nearly to the talc, the latter moved suddenly into contact with the ivory. In separating the two bodies, the ivory was wetted to a certain height above the level; and in repeating the experiment before wiping the ivory, the attraction commenced sooner, and sometimes exhibited itself at the very first, without being preceded by any sensible repulsion. This experiment was repeated several times with the same result.

Another series of phenomena, which indicate apparent attraction and repulsion, are seen in the motion of small lighted wicks when swimming in a bason of oil, and in the motion of camphor upon the surface of water. Although these phenomena are not produced by capillary attraction, yet we shall give a short account of them at present, on account of their general similarity.

Dr Wilson's experiments on the motion of lighted wicks swimming in a bason of oil.

The phenomena of lighted wicks were carefully observed, and minutely described, by Professor Wilson of Glasgow in the Transactions of the Royal Society of Edinburgh. His *Hydrostatical Lamp*, as he calls it, consists of a small circular disc of common writing paper, about $\frac{1}{8}$ of an inch in diameter, having about a quarter of an inch of soft cotton thread rising up through a puncture in the middle of the disc to answer the purpose of a wick. If this wick is lighted, and the disc placed in a shallow glass vessel filled with pure salad oil, it will immediately sail briskly forward in one direction till it meets the side of the vessel, and will afterwards take a circular course, always bearing up to the sides, and will thus perform many revolutions. The circulation is sometimes from right to left, and sometimes from left to right. When the wick is placed out of the centre of the disc, it will sail to that part of the disc which is farthest from the wick, and if the disc is made of an oval form, and the wick placed in one of its foci, the disc will sail in the direction of the nearest extremity of the transverse axis. Dr Wilson observed a very active repulsion between the stem of the disc and the oil of the surface contiguous to it. When fine charcoal dust was scattered around the disc, it left behind it a diverging wake clear of all dust. Other fluids, such as oil of turpentine, ether, alcohol, or any of the inflammable fluids possessing much tenuity, also double rum, melted tallow, bees wax, and rosin, exhibit the same effects when the discs float upon their surface.

Dr Wilson accounts for these phenomena in the following manner: When the oil has an uniform temperature, all its parts are in equilibrio; but when the lamp is lighted, the oil below the disc being most heated, will expand itself, and will be raised above the general level, from the diminution of its specific gravity, and the unbalanced upward pressure of the fluid. The weight of the disc will therefore press down the oil, or even the weight of the oil itself will cause it to rise as it were from below the wick in a thin superficial stream. Hence Dr Wilson conceives, that this constant stream will flow most readily and copiously towards that side of the base of the lamp where the resistance is least, or where it has the shortest way to press forwards, that is from under the wick or flame, or the edge of the disc, which is the nearest. The reaction of the stream of rarefied oil rising most rapidly and most copiously from one side of the disc, will therefore impel the lamp in the contrary direction. When the discs are soaked with oil, or when they are made of a thin plate of talc, they always sink to the bottom as soon as the flame is extinguished. If a wafer much heated is thrown upon any of the fluids above mentioned, it will immediately glide away, and continue in motion till it cools.*

Venturi's experiments on the dissolution and motion of camphor floating on water.

The singular motions of pieces of camphor floating upon the surface of water, have been long observed; but they were never completely described and explained till M. Venturi published in the Memoirs presented to the Institute of France his ingenious memoir, entitled *Precis de quelques experiences sur la section que des cylindres de camphre eprouvent a la surface de l'eau et reflexions sur les mouvemens qui accompagment cette section.*

Having cut some pieces of camphor into the shape of small cylinders, a line in diameter, and an inch high, he fixed each of them to a base of lead, and placed them vertically in plates. He then poured water into the plates, till it reached about half way up each cylinder. After two or three hours the cylinders began to diminish at the place where they were cut by the surface of the water, and after about twenty-four hours they were entirely cut through into two parts, none of which had suffered any sensible diminution.

He next took three pieces of camphor, each of which weighed twenty-four grains, and he placed one of them in dry air, another in water, and the third on the surface of water. After four days the piece on the surface of the water was entirely dissipated, while each of the other two had lost only four or five grains.

M. Venturi next placed some of his camphor cylinders on the surface of water, in vessels of different sizes, and he always found that the cylinder was cut through soonest in those vessels that presented the greatest surface. This singular fact arises from the camphor being dissolved by the water, and extending itself over all the fluid surface, when it is the more readily evaporated by its coming into contact with a greater quantity of air. The dissolution of the camphor may be seen detaching itself from the cylinder in the form of a very transparent liquid oil, and spreading itself over the whole surface of the water. When in the contour of the cylinder, there is some place which furnishes this oil more abundantly; if small light substances are thrown upon the surface, they are repelled from this place with great briskness, and then turning round, they come back to the same place, and again enter the current, where they continue to circulate in this manner. If a small piece of camphor previously wetted at its extremity approaches the margin of the vessel, and then touches the vessel itself, it deposits a fluid visible to the eye. This fluid is oily; and on attaching itself to the vessel, it destroys its capillary attraction for the water, and the water retires from it and becomes convex at this place. When the piece of camphor is taken away, the water does not return to its place till the oily liquor is evaporated. When the cylinders of camphor are half immersed in water, the oily liquor which issues from it destroys the cohesion between the water and the cylinder, and a small depression takes place round the cylinder. The dissolution stops for a moment till the oily liquor expanded over the water has evaporated. The water then returns to its elevated state round the cylinder; the camphor is dissolved and diffused; and the same operations are repeated.

The motions of small pieces of camphor observed by M. Romieu are produced by the mechanical reaction of the jet of dissolution against the camphor; and

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* See the *Edinburgh Transactions*, vol. iv. p. 144, &c.

if the centre of percussion of all the jets do not coincide with the centre of gravity, a rotatory and progressive motion will be produced. As the jets are generated only on the circumference of the section of the piece of camphor, it ought to revolve round an axis perpendicular to the horizon; and the smallest pieces will obviously turn round with more velocity than larger ones.

MM. Lichtenberg and Volta ascribed this rotation to an emanation from the camphor, and also from the benzoic and succinic acids, which have the same property. Brugnatelli discovered, that the bark of aromatic plants when thrown upon water, moved round like camphor; and Venturi remarked a similar motion in the saw-dust of different woods, that had imbibed either a fixed or a volatile oil. Romieu ascribed these motions to electricity. He found that the camphor sometimes refused to turn, and at other times its movements were suddenly stopped, by touching the water with particular bodies. The cause of these irregularities, which long perplexed philosophers, was discovered by Venturi. He found, that whenever the water was touched by any body which was fat or oily, or which diffused a small portion of fixed oil, or a great portion of volatile oil over the surface, the dissolution and the motion of the camphor were immediately stopped. In order to prove that this effect was not produced by electricity, as Romieu and several Italian philosophers believed, Venturi touched the surface of the water both with conductors and non-conductors of electricity, which were well cleared of all oily or greasy matter, and the motions of the camphor were never in the slightest degree affected. When the same substance was afterwards greased with a small drop of oil of olives, and again brought into contact with the water, an oily film immediately advanced over the whole surface of the water, repelled the small bits of camphor, and, as if by a magic stroke, deprived them of their apparent vitality. Venturi repeated this experiment in a basin of water 20 feet in diameter. The camphor turned round in one end of the basin, and when an ounce of oil was poured in at the other extremity, the motions of the camphor were speedily stopped.

If the surface of the water on which the camphor swims, is not sufficiently extensive to allow the liquor from the camphor to evaporate, the dissolution of the camphor is either retarded or stops altogether, or the undissipated liquor forms itself into a thin film upon the surface of the water. In like manner, the particles of the saw-dust of wood soaked in oils, moves quickly when they touch the water; but their motions do not continue, because the film of oil which they spread over the water is not dissipated.

If the water is very pure, and is exposed to a heat even so high as that of boiling water, the dissolution and the motions of the camphor are not prevented. On the contrary, they are often promoted by the application of this heat.

M. Venturi applies the preceding principles to the explanation of the motion of the tremellæ observed by Adanson and by Corti. This aquatic plant rises to the surface of the water during the day, and descends to the bottom at night. If the plant is shut up in a box whose sides are opaque, and if a pencil of light is admitted through an opening in one of its sides, the tremelli changes its situation in a few hours, and advances to the hole at which the light penetrates. M. Venturi observed with a microscope, that its branches have a small motion belonging to each of them, in virtue of which they sometimes oscillate from one side to another, and sometimes advance to free themselves from the pencil when they are interlaced. These appearances are explained by Venturi on the supposition that the water which it absorbs is decomposed by the assistance of light, and that the plant gives out the oxygen in a direction always opposite to the light. Hence it will follow that the plant must always move towards the quarter from which the light is admitted.

In addition to the works quoted under the article Capillary Attraction, vol. v. p. 412, the reader is referred to the following: Pascal, *Traitez de L'Equilibre de Liqueurs et de la pesanteur de la Masse de L'Air*, Avertissement, 2d edit. Paris, 1664. Rohault, *Traité de Physique*, or Dr Clarke's translation of it, under the title of Rohaulti *Physica*, Lond. 1710, Part I. chap. xxii. § 69, 70, 71, 80, 81. Boyle's *New Experiments Physico-Mechanical, touching the spring of the air, and its Effects, made for the most part in a New Pneumatical Engine*, exp. 35. p. 262. Oxford, 1660. Boyle, *Phil. Trans.* 1676, vol. xi. p. 775. Hooke's *Attempt for the explication of the phenomena observable in an experiment published by the Right Hon. Robert Boyle, in the 35th experiment of his Epistolical Discourse, touching the air, in confirmation of a former conjecture made by R. H.* Lond. 1660. Hooke *On Springs*, 4to. 1678. Vossius *De Nili et aliorum fluminum origine*, Hag. 1666. Fabri, *Dialogi Physici*, Lyons, 1669. Borelli, *De motionibus a Gravitate naturali pendenté*, Lyons, 1670. Sinclair's *Ars nova et magna Gravitatis et Levitatis*. Rotterdam, 1669. Joh. Christophorus Sturmius, *Collegium Experimentale sive Curiosum*, pars i. tentamen viii. p. 44. et auctorium tentam. viii. p. 77. Norimbergæ, 1676. The second part of this work was published at Norimberg in 1685. James Bernoulli, *Dissertatio de Gravitate Etheris*, 1683. De La Hire, *Mem. Acad. Par.* tom. ix. p. 157. Carré, *Experiences sur les tuyaux Capillaires* in the *Mem. Acad. Par.* 1705, p. 241. Daniel Bernoulli in the *Comment. Petropol.* 1727, p. 246. Mariotte *Traité du Mouvement des Eaux*, vol. ii. p. 105. Par. 1700. Cotes, *Hydrostatical Lectures*, sect. xi. Lond. 1738. Cigna, *Journal de Physique*, tom. iii. p. 109. Lord Charles Cavendish in the *Phil. Trans.* 1776, p. 382. Monge, *Mem. Acad. Par.* 1787, p. 506. Besile, *Journal de Physique*, vol. xxviii. p. 171; xxix. p. 287, 339; xxx. p. 125. Wilson, *Edinburgh Transactions*, vol. iv. p. 144. Venturi, *Memoires presentés a L'Institut*. tom. i. p. 125. Paris, 1805. MM. Hauy and Tremery in La Place's *Suppl.* au Diz. Liv. de la Mecanique Celeste. La Place, *Supplement a la Theorie de l'action Capillaire*, Par. 1807. Gay Lussac, *Id.* Biot's *Traité de Physique*, tom. i. chap. xxii. Paris, 1816.

CHAP. VI.

Description of Instruments, and Experiments for illustrating the doctrines of Hydrostatics.

1. *Description of the Mechanic or Hydrostatic Paradox.*

Hydrostatic paradox.

It appears from Cor. 2. of Prop. iv. p. 428, that the pressure exerted upon the bottoms of vessels filled with fluid, does not depend upon the quantity of fluid which they contain, but solely upon its altitude. This proposition has been called the mechanic or hydrostatic paradox, and the instrument for illustrating it has received the same name.

Plate CCCXVII. Fig. 1.

This instrument is shewn in Fig. 1. where AB is a box,

Plate CCCXVII. Fig. 1.

which contains about a pound of water, and *a b c d e* a glass tube, fixed to the end C of the beam of a balance, and the other end to a moveable bottom, by which the water in the box is supported, the bottom and wire being equal in weight to an empty scale suspended at the other extremity of the balance. If a pound weight is put into the empty scale, it will cause the bottom to rise a little, and the water will appear at the lower end of the tube *a*. The water will therefore press with a force of one pound upon the bottom. If another pound is put into the scale, the water will ascend to *b*, twice as high as the point *a*, above the bottom of the vessel. If a third, a fourth, and a fifth pound be put successively into the scale, the water will rise at each time to *c*, *d*, and *e*, the distances *a b*, *b c*, *c d*, *d e*, being equal to one another. This result will be obtained, however small be the bore of the glass tube; and since when the water is at *b*, *c*, *d*, *e*, the pressures upon the bottom are successively twice, thrice, four times and five times as great as when the water was contained within the box, it follows that the pressure upon the bottom of the vessel depends wholly on the height of the water in the glass tube, and not upon the quantity which it contains. If a long narrow tube, therefore, be fixed in the top of a cask, and if both the cask and the tube be filled with water; then though the tube be so small as not to hold a pound of the fluid, the pressure of the water in the tube will be in danger of bursting the cask in pieces, for the pressure is the same as if the cask was continued up in its full size to the height of the tube, and filled with water: (See Chap. I. Sect. 1. Prop. IV. Cor. 2.) It follows therefore, from this principle, that any quantity of water, however small, may be made to exert a force of any assignable magnitude, by increasing the height of the column, and diminishing the base on which it presses. This, however, has its limits; for when the tube becomes capillary, the attraction of the glass will support a great quantity of the included water, and will therefore diminish the pressure upon its base. The preceding machine should be so constructed, that the moveable bottom may have no friction against the inside of the box, and that no water may get between it and the box. The method of effecting this will be manifest from Fig. 2. where ABCD is a section of the box, and *a b c d* its lid, which is made very tight. The moveable bottom E, with a groove round its edges, is put into a bladder *f g*, which is tied close round it in the groove by a strong waxed thread. The upper part of the bladder is put over the top of the box, at *a* and *d*, all around, and is kept firm by the lid *a b c d*, so that if water be poured into the box through the aperture *l l* in its lid, it will be contained in the space *f* E *g h*, and the bottom may be raised by pulling the wire *i* fixed to it at the point E of the moveable bottom. See Ferguson's *Lectures*, vol. ii. p. 100. Edit. Edin. 1806.

Fig. 2.

2. *Description of the Hydrostatic Press.*

Description of the hydrostatic press.

This ingenious and powerful machine, which has been recently brought into notice by the late Mr Bramah, is founded on the doctrine contained in the corollary to the fundamental principle of the equilibrium of fluids, (see p. 427,) namely, that if any number of pistons are applied to apertures of different sizes in the sides of a vessel full of water, the forces with which the pistons are applied will be in equilibrio, if they are proportional to the apertures to which they are applied. Thus if a piston G (Fig. 1.) is applied to an aperture at G, having an area of two square inches, it will be in equilibrio with another piston applied to the whole aperture AB of 2000 square inches, if the force with which the piston G is applied, is to the force with which AB is applied as 2 to 2000, or as 1 to 1000. Hence it follows, that a force of one pound applied at G will raise 1000 pounds placed upon the piston AB. The same result will be obtained if the vessel has the form shewn in Fig. 11. the one piston being applied at *a b*, and the other at AB.

Plate CCCXIII. Fig. 1.

Plate CCCXIII. Fig. 11.

The hydrostatic press founded on this principle was first proposed as a new machine by Pascal in his *Traitez de L'Equilibre des Liqueurs, et de la Pesanteur, de la Masse de L'air*, Chap. II. Edit. 2d. Paris, 1664. He describes it as a new sort of machine for multiplying forces, (*Nouvelle sorte de machine pour multiplier les forces*,) and he considers it as a new mechanical power equal in value to the lever or the screw. Although Pascal speaks so highly of his new machine, it is not a little singular, that no attempt appears to have been made for more than a century and a half to apply it to the useful purposes of life. Mr Bramah had the very great merit, not only of re-inventing the machine, (for we believe he was not aware of its having been proposed by any other person,) but of pointing out its application to a great variety of useful purposes, such as working cranes, pulling up the roots of trees, packing goods of all kinds, &c. In our article Crane, (see Vol. VII. pp. 315, 316, &c.) we have given a full description of the hydrostatic press, as applied to a crane; and by studying that part of the article, our readers will have no difficulty in understanding the construction of the instrument.

Plate CCXV. Fig. 1.

The hydrostatic press is represented by the parts GHEFFL of Fig. 1. Plate CCXV. In the Figure, FF represents the wooden frame which supports the iron cylinder L. This cylinder communicates with a small copper pipe *g g h*, terminating in a common forcing-pump at *h*, which stands in an iron cistern H containing the water. The power is applied to the handle G of the pump, and the piston, pressing on the surface of the water in the pipe at *h*, communicates its force, through the intervention of the water, to the piston of the cylinder L, to the top of which the work to be performed is applied. See also our article Jack in this volume, page 599.

3. *Hydrostatic Bellows improved by Ferguson.*

Common hydrostatic bellows.

The common hydrostatic bellows consisted of a tube of glass or any other substance, about three feet high, communicating with a cylindrical vessel, whose sides were made of leather like a pair of bellows, while its upper and lower surfaces were formed of circular or oval boards about 15 inches in diameter. When water is poured into the tube, it flows into the bellows, and separates the boards a little. Heavy weights to the amount of 300 pounds, are then placed upon the upper board, and by pouring water into the tube till it reaches the top, the moveable board with all its load will be raised and kept in equilibrio by the column of fluid, although the fluid itself does not weigh more than a quarter of a pound. In order to shew the experiment with more effect, a man may place himself upon the upper board instead of the weights, and raise himself merely by pouring water into the small pipe.

Improved by Ferguson.

Plate CCCXVII. Figs 3, 4, 5.

The following very ingenious machine has been proposed by Mr Ferguson as a substitute for the common hydrostatical bellows: ABCD, Fig. 3. is an oblong square box, into one of whose sides is fixed the upright glass tube *a* I, which is bent into a right angle at the lower end, at *i*, Fig. 4. To this bent extremity is tied the neck of a large bladder K, which lies in the bottom of the box ABCD. Over this bladder is placed the moveable

PLATE CCCXVII. Figs. 3, 4, 5.

board L, Figs. 3. and 5. in which the upright wire M is fixed. Leaden weights N, N, with holes through their centre, to the amount of 16 pounds, are put upon this wire, and press upon the board L. The cross bar *p* is then put on, in order to keep the glass tube in an upright position; and afterwards the bent piece EFG, for keeping the weights N, N horizontal, and the wire M vertical. Four upright pins, about an inch long, are placed on the corners of the box, for the purpose of supporting the board L, and preventing it from pressing the sides of the bladder together. When the machine is thus fitted up, pour water into the tube I, till the bladder is filled up to the board L. Continue pouring in more water, and the upward pressure which it will excite in the bladder will raise the board with all its weights, even though the tube should be so small as to contain no more than an ounce of water. See Ferguson's *Lectures*, vol. ii. p. 104.

4. *Experiments for illustrating the quaquaversus pressure of Fluids, and the Effects produced at different Depths.*

Experiments for illustrating the quaquaversus pressure of fluids, and the effects produced at different depths.

PLATE CCCXVII. Fig. 6.

Exp. 1. If we take a common wine glass AB, and, holding it in a vertical direction, bring its mouth in contact with the surface of water in the vessel M, it will be seen, that a small quantity of water has entered the wine glass, and that the remainder of the glass is filled with air. By depressing the glass, or sinking it in the fluid, a greater quantity of water will enter it; the included air being condensed into a smaller space as the pressure of the superincumbent column of water is increased. By continuing to depress the glass, it will be seen that the pressure of the water increases with the depth, and by holding the mouth of the glass in different directions, as shewn at CD and EF, it will appear, that the water presses equally in every direction.

Exp. 2. If we insert into an empty vessel a number of tubes of glass bent into various angles, or if we hold them in the hand, and introduce into their lower orifices a quantity of mercury, so that the surface of the mercury may come to the very orifice of the shorter legs; then, if water is poured into the vessel, it will be seen, during the time of its filling, that the mercury is pressed gradually from its lower orifices towards the higher orifices, which are supposed to rise to a greater height than the surface of the water. Now, as the lower orifices of the glass tubes may be made to point in every possible direction, it follows, that the pressure of the superincumbent fluid is also propagated in every direction. When it is required that the lower orifice should point exactly downwards, in order to shew the upward pressure of fluids, a straight tube should be used, and the mercury introduced into it must be kept in by the application of the extremity of the finger, till the height of the water above the orifice is equal to 14 times the length of the column of mercury introduced. Upon removing the finger, and continuing to pour in water, the mercury will ascend in the tube. If the finger were removed before it had risen to a height 14 times greater than the length of the mercurial column, the mercury would have fallen out of the tube, as it is 14 times heavier than water, and therefore requires a column 14 times as long to keep it in equilibrio.

Exp. 3. The pressure of fluids at different depths may be very simply illustrated, by attaching a bag, made of leather, and filled with mercury to the extremity of a glass tube, so that the mercury may just enter the tube when the bag is held in air. By immersing the bag in water, the pressure of the fluid upon the bag will force up the mercury, and the height to which it rises will shew the magnitude of the pressure at different depths.

PLATE CCCXVII. Fig. 7.

Exp. 4. The propagation of pressure through fluids is also illustrated by the amusing experiment of the *Cartesian Devil,* as it has been called, after Descartes, by whom it was discovered. The figure of a man made of glass or enamel, is so constructed that it has the same specific gravity as water, and is therefore suspended in a mass of fluid. A bubble of air, (similar to the air in the glass of Exp. 1.) communicating with the water, is placed in some part of the figure, sometimes in a small globe, as shewn at *m*. At the bottom B of the vessel is a diaphragm of bladder, which can be pressed upwards by applying the finger to the extremity *e* of a lever *e o* moving round *o* as its centre of motion. The pressure applied to *a* is communicated through the water to the bubble of air, which is thus compressed: The specific gravity of the figure is therefore increased, and it sinks to the bottom. By removing this pressure, the figure again rises, so that it may be made to oscillate or dance in the vessel without any visible cause. Fishes made of glass are sometimes substituted in place of the human figure, and when a common jar is used for the experiment, the pressure is applied to the upper surface of it at A. The construction of the apparatus shewn in Fig. 6. is obviously the best, as the spectator does not observe the means which are employed to alter the specific gravity of the figure.

Exp. 5. The pressure of fluids at very great depths is finely illustrated by an experiment which has often been made at sea, of making an empty bottle well corked descend to a great depth. The pressure of the water drives in the cork, and the bottle when brought up is always filled with water. Mr Campbell, the respectable author of *Travels in the South of Africa*, tried this experiment on his voyage home from the Cape of Good Hope. He drove very tight into an empty bottle a cork, which was so large that half of it remained above the neck. A cord was then tied round the cork, and fastened to the neck of the bottle, and a coating of pitch was put over the whole. When it was let down to about the depth of 50 fathoms, the captain felt, by the additional weight, that it had instantaneously filled; and, upon drawing it up, the cork was found in the inside of the bottle, which was of course filled with water.

Another bottle was prepared in a similar manner; but, in order to secure the cork, a sail needle was passed through the cork, so as to rest on the mouth of the bottle, and the whole was covered over with pitch. When the bottle had descended 50 fathoms, the captain again felt that it had filled with water; but, upon bringing it up, the cork and needle were found in the same position, and no part of the pitch appeared to be broken, although the bottle was completely filled with water. The water had in this case obviously insinuated itself through the pores of the pitch and the cork, and not, as Mr Campbell imagines, through the pores of glass. The experiment of forcing mercury through wood by the common pressure of the atmosphere, takes away the apparent improbability of this explanation.—See Campbell's *Travels,* p. 507. Note. Lond. 1815.

5. *Experiment for illustrating the equality of the pressure of fluids in every direction.*

Experiments for illustrating the equality of the pressure of fluids in every direction.

If a soft or frangible substance is exposed to any force in one direction more than another, it will either lose its shape, or be broken to pieces; but if the force with which the body is pressed is applied to every part of the body, it will preserve its form if it is soft, and will not be broken if it is frangible. Hence it follows, that if any body is exposed to a pressure sufficiently powerful to change its shape or crush it to pieces, and if it preserve its form and its integrity under this pressure, we are entitled to infer that the pressure is equal in every direction.

Let a piece of very soft wax, of an irregular shape, and an egg, be placed in a bladder filled with water. Let the bladder be then laid in a brass box, and a cover of brass put upon the bladder, so as to be entirely supported by it. If a hundred or a hundred and fifty pounds weight be laid upon this cover, so as to press upon the bladder, this enormous force, though propagated through the fluid, and acting upon the soft wax and egg, will produce no effect. The egg will not be broken, nor will the wax change its figure.

6. *Apparatus for Illustrating the Doctrine of Specific Gravities.*

Apparatus for illustrating the doctrine of specific gravities.

In order to shew that when a solid body is immersed in a fluid, the loss of weight which it sustains is equal to the weight of the water which it displaces, or of a quantity of water of the same bulk with the body, the following very simple apparatus has been employed.

PLATE CCCXVII. Fig. 8.

A cylindrical or cubical body of any kind, either entirely solid, or made hollow and loaded within, so as to sink in the fluid, is exactly fitted to a hollow cylinder or cubical vessel, so that the solid contents of the hollow cylinder or cubical vessel is exactly equal to the solid contents of the cylindrical or cubical solid. The cylindrical or cubical vessel is then suspended to the hook of a hydrostatic balance, or any other balance, and the solid cylinder or cube is suspended to a hook in the bottom of the cylindrical or cubical vessel. Weights are now put into the opposite scale of the balance till an equilibrium is produced in air. Every thing remaining in this situation, the solid cylinder or cube is completely immersed under water, and consequently the equilibrium is destroyed; that is, the scale of the balance to which the apparatus is suspended will require to have added to it a weight equal to the loss of weight sustained by the solid, in order to restore this equilibrium. By filling with water, therefore, the cylindrical or cubical vessel, it will be found that the equilibrium is exactly restored. Hence it is obvious to the eye, that the loss of weight sustained by the solid is exactly equal to the weight of water displaced.

7. *To make a Body lighter than Water lie at the bottom of a Vessel filled with Water.*

To make a body lighter than water lie at the bottom of a vessel filled with water.

We have seen in Prop. IV. p. 430, that when a body has a less specific gravity than a fluid, it will float upon the surface of the fluid, as it is pressed upwards with a force greater than its own weight. If by any means, however, we can prevent the upward pressure from acting upon the lighter body, it is manifest that it must remain at the bottom of the vessel in the same manner as it would rest upon any other body in the open air, for the body is not only pressed down by its own weight but by the weight of the superincumbent fluid.

In order to shew how to prevent the upward pressure from acting upon the solid, let us take two pieces of wood planed perfectly flat and smooth, so that no water can get in between them when their smooth surfaces are put together. If one of the pieces of wood is cemented to the bottom of a glass vessel, so as to have its smooth side uppermost, and if the other piece is placed above it, and held in that situation till the vessel is filled with water, it will be found to lie as quietly and firmly as if it were a plate of lead or stone. If the edge of the upper plate, however, is raised in the slightest degree, so as to allow the water to insinuate itself between the plates, the wood will instantly spring to the surface.

This experiment is sometimes made in a different manner. A flat and smooth brass plate is fixed at the bottom of the vessel, and a large mass of cork has a thin smooth brass plate fixed to its bottom, so that the specific gravity of the cork and its brass base may be much less than that of water. The brass plate on which the cork rests is then placed on the fixed brass plate; and when water is poured into the vessel, the cork will remain at the bottom. The two brass plates should be oiled a little on their touching surfaces, and should be ground upon one another, but not very accurately, for in this case the force of cohesion would prevent their separation, independent of the weight of the superincumbent pressure of the fluid; as it is well known that one brass plate can lift another in the open air, even when it is two or three pounds weight. The experiment as made with the brass plates is therefore not so satisfactory as the one with pieces of wood, for the reason which we have now assigned; and though we are satisfied that the cork and the brass plate are together lighter than water, yet the result appears less striking, as we are always in the habit of seeing brass sink to the bottom.

A similar result may also be obtained by fixing a glass plate at the bottom of a glass vessel, using a plate of ivory instead of wood, and pouring mercury into the vessel in place of water.

8. *Experiment for illustrating the parabolic form of a fluid surface influenced by a centrifugal force.*

Experiment for illustrating the parabolic form of a fluid surface influenced by a centrifugal force.

PLATE CCCXIII. Fig 3.

In order to shew that a horizontal surface of water assumes a parabolic form when it is acted upon by a centrifugal force, along with the force of gravity, we have only to take a bucket containing water, whose surface *c d* is of course horizontal when the bucket is at rest. If by means of a rope R, however, fastened to the handle AB, we give the bucket a rotatory motion round a vertical line, the surface will lose its horizontal form, and the water becoming concave in the centre, will rise round the sides of the vessel, and have its surface of the form of a parabolic conoid, whose section *m n o* is a parabola. See Chap. I. Prop. 1. cor. p. 427.

9. *Description of Dr Hooke's Semicylindrical Counterpoise.*

Hooke's semicylindrical counterpoise.

PLATE CCCXVII. Fig. 9.

The principal object of this ingenious contrivance was to keep a vessel always full of water, or any other fluid, but as it is not only of use in hydrostatical experiments, but also illustrative of the principles of the equilibrium of fluids, we have thought it necessary to give a drawing and description of it in this place. In Fig. 9. ABG is a vessel of any form. Upon a horizontal axis C, a semicylinder or a hemisphere, whose section is DEF, is made to revolve, and the weight of the semicylinder is so adjusted that it is exactly equal to the weight of a portion of the fluid of half its magnitude. When the vessel is filled with water, the semicylinder is half immersed, and since it has half the specific gravity of the fluid, the semicylinder is in the same circumstance as if it were floating, and therefore exerts no pressure on the horizontal axis C. As the vessel is emptied either by evaporation, or by discharge from an orifice, the quantity of the semicylinder immersed will be diminished, and the equilibrium of consequence destroyed; and it will therefore move round the axis C till half of it is again immersed, and the equilibrium restored. In this way the semicylinder will always descend as the water runs out, and consequently the fluid must necessarily stand at the same height AB in the vessel.

Plate CCCXVII. Fig. 9.

10. *Experiments illustrative of the Pressure of the Superior Strata of Fluids upon the Inferior Strata.*

Experiments illustrative of the pressure of the superior strata of fluids upon the inferior strata.

Exp. 1. If we pour coloured water into a glass vessel, and put a tube of glass, with a bore exceeding $\frac{1}{10}$ of an inch, the coloured water will stand in the tube at the same height as it does in the vessel. Let oil of turpentine be now poured above the water, and its pressure upon the surface of the water will cause the coloured fluid to ascend in the tube, but always to a height less than that of the surface of the oil of turpentine; the column of the coloured fluid raised, being to the thickness of the mass of oil in the inverse ratio of their specific gravities. The same experiment may be made by substituting quicksilver in place of the coloured water, and water in place of the oil of turpentine.

Exp. 2. If a vessel contains any fluid, a heavier fluid may be introduced below the lighter one, without any admixture taking place, and their separating surface will be horizontal. If a vessel for example contains water, let a quantity of milk be drawn up into a glass tube by suction, and if the open end of the tube is placed at the bottom of the vessel, and the milk allowed to discharge itself gradually, it will occupy the lower part of the vessel.

11. *Description of the Hydreoles invented by M. Mannoury Dectot.*

Description of the hydreoles invented by M. Mannoury Dectot.

In Prop. I. of Chap. I. Sect. II. it has been demonstrated, that when two fluids are placed in the opposite branches of a bent glass tube or syphon, the altitudes above the point of junction will be in the inverse ratio of their specific gravities; that is, a fluid lighter than water will rise to a greater height in one of the branches than the water in the other.

M. Mannoury Dectot has employed this principle very ingeniously in raising water above its natural level, by mixing air with the water, so as to diminish its specific gravity, and thus cause it to rise to a considerable height in one of the branches of the syphon. In order to make an intimate mixture of water and air, he introduces the air in the form of minute bubbles, which lodge among the molecules of the water, and being kept separate from each other, they are retained by adhesion in such a manner that they are only disengaged slowly, and do not unite with each other and escape until the water which contains them has been raised to the proper height.

Hydreole by suction.

M. Mannoury Dectot has given two forms to this machine, one of which he calls the hydreole by suction, and the other the hydreole by pressure. In the hydreole by suction, the water passes through a mass of air, absorbs part of it, and becomes in some measure gaseous, and therefore it will rise to a greater height than the reservoir from which it flows.

Hydreole by pressure. Plate CCCXIII. Fig. 11.

In the hydreole by pressure, the air is driven by force through a number of small holes, so as to mix itself with the water in a number of minute bubbles. In order to form a proper idea of this machine, let us suppose that ABCD, Plate CCCXIII. Fig. 11. is a reservoir filled with water, and that the bent tube *a b c d* is joined to it at D. The water will obviously rise to the same level *a b*, AB in both vessels. Let us suppose, that a pair of bellows M is applied to an opening N in the tube, closed with a plate of iron, perforated with a great number of small holes, the air discharged from the bellows will enter the water in the form of very minute bubbles, which will be kept separate from each other by the mutual adhesion of the particles of water. The water above N will thus be rendered specifically lighter, and will therefore rise in the tube *a b c d*. Instead of using a pair of bellows, M. Mannoury Dectot obtains a current of air in the following manner. Between the opening N and the reservoir ABCD, he places a close vessel, communicating by one pipe with the reservoir, and by another with the opening at N. A column of water from the reservoir runs into the close chamber, compresses the included air, and this compressed air rushing through the other tube, enters through the holes in the aperture at N, and mixes itself with the water to be raised.

We have not been able to obtain any account of the preceding machine, but the very general one contained in the report of MM. Prony, Perier, and Carnot, which was approved of by the Institute of France, on the 28th December 1812. An account of M. Mannoury Dectot's new hydraulic machines, will be found in Part III. of this article on Hydraulic Machinery.

12. *Description of the Common Syphon.*

Description of the syphon. Plate CCCXVII. Fig. 10.

The syphon is a tube of glass or metal, bent in such a manner that one of its legs or branches is longer than the other. It is represented in Fig. 10. by ABCD. The shorter leg AB is immersed in the fluid in the vessel MNOP, and by applying the mouth to the orifice D, and sucking out the air in the syphon, the water ascends, and will continue to be discharged at D till the vessel is completely emptied.

Let us suppose that the syphon had legs of equal length, such as AB, BC, and that the water was drawn up by suction till it reached the extremity C; then it is obvious, that as the pressure of the air on the surface of water is equal to the pressure of the air at the extremity C, and as the columns AB, BC of the fluid are equal, there is no force which could enable the water to discharge itself at C. When the leg BC, however, is lengthened, so as to be equal to BD, then the water is discharged at D by the pressure of the additional column CD, and the velocity with which it is discharged will be in proportion to the difference between the legs of the syphon.

13. *Description of an Improved Syphon.*

Description of an improved syphon. Fig. 11.

The improved syphon is shewn in Fig. 11. where D is a stop-cock fixed at the extremity of its longer branch AB. A small bent tube ED lying along the outside of the same branch, communicates with the cavity of the branch AB, above the stop-cock. When the aperture C is placed in the fluid to be drawn off, the mouth of the stop-cock D is closed, and the air is drawn out of the longer branch by suction at E. Instead of a stop-cock at B, the finger may be applied till the air is sucked out at E.

14. *Description of a Syphon acting by Capillary Attraction.*

Description of a syphon acting by capillary attraction.

If a bunch of cotton or worsted threads, or any absorbing fibres, is placed with one extremity in a vessel of water, and with the other hanging over the edge of it, the fluid will rise among the threads by the force of capillary attraction, and the water will be discharged from the longer branch in successive drops. Mr Leslie has very ingeniously employed this syphon for keeping moist the bulb of his hygrometer.

15. *Explanation of intermitting or reciprocating Springs upon the principle of the Syphon.*

Explanation of intermitting or reciprocating springs upon the principle of the syphon.

A reciprocating spring, is a spring which alternately flows and ceases to flow. The name is also given to those springs which have a periodical swell, or which discharge a great quantity of water at one time, and a small quantity at another, after regular intervals. The first of these kinds of springs is easily accounted for, by supposing that the channel which carries off the water from a cavern has the form of a syphon. In this case, the water will only flow when it rises in the cavern to a height equal to that of the syphon, and the flow will stop till the cavern is again filled to the same height. The following explanation of the second kind of intermitting springs was suggested about a century ago to Dr Atwell of Oxford, by the phenomena of Laywell Spring at Brixam, near Torbay, in Devonshire. Let AA be a large cavern near the top of a hill, which derives its supply of water from rains or melted snow percolating through the chinks of the mountain, and let CC be the small channel which convey the waters of the cavern to the opening G in the hill, where they are discharged in the form of a small spring. From the cavern AA let there be a small channel D, which carries water into another B, and let the water of the second cavern be carried off by a bent channel E*e*F wider than D, and joining the first channel CC at *f*, before it issues from the mountain, the point of junction *f* being below the level of the bottom of both the caverns. As the cavern B fills with water, the fluid will ascend to the same height in the channel E*e*F, but it will not be discharged by this channel till the surface in B is on a level with *e*, the highest part of the channel. The water will then be carried off by the natural syphon E*e*FG, till the whole is discharged, and consequently there will be a great swell in the spring at G. This swell will now cease, as the channel D does not convey the water into B so fast as the syphon E*e*F carries it off; and it will again commence as soon as the water in B rises to a level with the summit *e*. Mr Ferguson has illustrated this operation by a simple machine, a description of which will be found in his *Lectures*, vol. ii. p. 106, 107.

Plate CCCXVII. Fig. 12.

16. *To construct a Vessel, from which the Water will escape when it reaches a certain height.*

To construct a vessel from which the water will escape when it reaches a certain height. Fig. 13.

This vessel, which is called Tantalus's cup, consists of a metallic vessel, ABCD, divided into two compartments by the partition EF. A glass tube H*h*, open at both ends, is inserted in the opening H, in the partition EF, the lower end being allowed to reach a little below EF. The tube H*h* must then be covered by a small glass receiver *a b c*, or a wide tube hermetically sealed above, a small aperture being left at the bottom of this tube to admit the water. This mechanism is generally covered by the figure of a man representing Tantalus, as shewn in the drawing. If water is now poured into the vessel, it will get admittance into the receiver or wide tube, and will always stand at the same height in this tube that it does in the vessel. The water will therefore be retained in the vessel as long as it does not enter the tube H*h*, but as soon as the water rises in the vessel to the same level as the point *h*, it will flow down the tube H*h*; which acting like a syphon, will discharge the whole fluid in the vessel. If water is poured slowly in with the intention of making it rise to the lips of Tantalus, it will never reach them provided the syphon carries off the water faster than it is poured in. In the lower compartment of the vessel, there ought to be a small air-hole near the top, to allow the air to escape when the water takes its place.

Plate CCCXVII. Fig. 13.

17. *To construct a vessel which retains water when it is upright, but discharges it when it is inclined.*

To construct a vessel which retains water when it is upright, but discharges it when it is inclined.

Let ABCD be the vessel divided as formerly into two compartments by the partition EF. Into this partition insert the longer branch *b c* of a syphon *a b c*, whose shorter branch *b a* reaches nearly to the bottom of the vessel. If water is now poured into the vessel till it stands a little below the lower side of the bent part of the syphon, it is obvious that no water will descend through the syphon, as it has not risen high enough through the shorter branch to enable it to pass through the bent portion. If the vessel, however, is inclined to one side, as it is in the act of drinking, the water will rise higher in the short branch *a b*, pass over the bent part of the syphon, descend in the longer branch, and carry off all the water into the lower compartment of the vessel. In order that this experiment may succeed, the sides of the vessel ought not to be symmetrical round the point *a* at the summit of the syphon; for in this case no inclination of the vessel, however great, will cause the water to flow over the point *a*. The syphon should therefore be placed towards one side of the vessel, and the vessel inclined to the same side.

Fig. 14.

A similar effect may be produced much more elegantly by using the double cup shewn in Fig. 15. where *a b c* represents the syphon. The person who tries to drink, must apply his lips to the side *b* of the syphon, otherwise the experiment will not succeed.

Fig. 15.

18. *To construct a machine in which all the water projected into a basin from a jet d'eau appears to be drank by a bird.*

To construct a machine in which all the water projected into a basin from a jet d'eau appears to be drank by a bird. Fig. 16.

This ingenious and elegant machine is shewn in Fig. 16. where ABCD is a vessel divided into three compartments by the partitions EF and GH. In the partition EF insert two tubes, one of which LM, forms a communication between the bottom of the compartment BG and the bottom of EC; while the other tube IK forms a communication between the upper part of EC and the upper part of HF. A third tube NO is fixed in the cover AB, extending from near the bottom of HF, and rising with a tapering bore to the point O, through the middle of the vessel SR, intended to receive the water which falls from the pipe NO. The figure of a bird with its bill immersed in the water in the basin SR, is placed on one side, and through its body passes a bent syphon QP, the lower branch of which goes into the compartment BG.

When the two upper compartments are nearly filled up to a little below K with water, through two apertures for that purpose, and when these apertures are shut, it is obvious that when the cock of the pipe LM is opened, the water will descend through LM, and occupying the compartment EC, will drive the air up through the pipe IK, and compress the air contained in the cavity HF. This condensed air pressing on the surface HK of the water, will raise it in the tube NO, and cause it to be projected upwards in a jet d'eau. The water from the jet, after being carried to a height due to the pressure which it experiences, will fall down into the vessel SR. But as the water escapes from the compartment BG, the air in that compartment will be rarefied, and will therefore not be sufficient to balance the pressure, if the exterior air upon the surface of the water is SR. This unbalanced pressure will therefore force the water up the syphon QP, through which all the water in the vessel SR will be conveyed into the cavity BG, as if it had been drank by the bird.

For farther information respecting the subjects treated of under this Chapter, the reader is referred to the following works: Pascal's *Traitez de l'Equilibre des Liqueurs*, &c. &c. Paris, 1664; S. Gravesende's *Physices Elementa Mathematica*, lib. iii. Leid. 1742; *Phil. Trans.* 1732, vol. xxxvii. p. 301; Desagulier's *Course of Experimental Philosophy*, vol. ii. lect. 7 and 8, Lond. 1763; Ferguson's *Lectures on Select Subjects in Mechanics, Hydrostatics, Hydraulics*, &c. vol. ii. Edin. 1806; Dr Thomas Young's *Course of Lectures on Natural Philosophy*, vol. i. Description of Plates; Leslie's *Short Account of Experiments and Instruments depending on the relations of Air to Heat and Moisture*, Edin. 1813; Campbell's *Travels in the South of Africa*; and Ozanam's *Mathematical Recreations*, edited by Montucla and Hutton. See also Part III. of this article on Hydraulic Machinery.

PART II. ON HYDRAULICS.

Definition.

HYDRAULICS, from *ὑδωρ water*, and *αυλος*, which sometimes signifies a *torrent*, is that branch of the science of hydrodynamics which treats of fluids considered as in motion. It therefore embraces the phenomena exhibited by water issuing from orifices in reservoirs, projected obliquely or perpendicularly in jet d'eaux, moving in pipes, canals, and rivers, oscillating in waves, or opposing a resistance to the progress of solid bodies.

CHAP. I.

ON THE MOTION OF FLUIDS ISSUING FROM RESERVOIRS BY VERTICAL OR HORIZONTAL ORIFICES.

General Principles.

General principles.

WHEN a vessel is filled with a homogeneous fluid, and is in equilibrium, all the particles of fluid which it contains are equally pressed in every direction. But if a small aperture is made in the bottom of the vessel, the particles which rested upon the part of the bottom which is removed being no longer supported, will descend by their own gravity. The particles immediately above them will also descend, and all the fluid in the vessel will descend in lines nearly vertical; and when they arrive within 3 or 4 inches of the orifice, they will gradually turn into a direction more or less oblique, and make directly for the orifice. The same thing happens when the orifice is made on the side of the vessel. The preceding results were obtained experimentally by M. Bossut, who employed a glass vessel kept constantly, and rendered the motion of the fluid particles visible, by throwing into the water minute substances specifically heavier than it; such as filings, and small fragments of pounded slate.

When the vessel was allowed to empty itself by an orifice in the bottom of the vessel, the surface of the fluid preserved its horizontality during its descent, and when it came to within 6 lines, or half an inch of the orifice, a funnel-shaped hollow or cavity appeared in the surface of the fluid. When the water issued from an orifice in the side of the vessel, the water also preserved its horizontality; and when the surface reached the upper edge of the orifice, the water inclined a little from the orifice, forming an approximation to a hollow.

General principles.

As the various particles of fluid which rush towards the orifice move in directions which converge to a point without the orifice, it is obvious that the column of fluid which issues from the vessel ought to have a smaller diameter than the orifice itself. This diminution in the diameter of the column was first observed by Sir Isaac Newton, and was called by him the *vena contracta*, or the contraction of the fluid vein. The distance from the orifice at which the greatest contraction takes place, is equal to the semidiameter of the orifice, and the area of the section of the vein at this place was to the area of the orifice as 10 to 14.14 according to Newton, or as 10 to 16 according to Bossut. When the orifice, instead of being a mere aperture in a thin plate, is a short cylindrical tube, Bossut found that the area of the section of the vena contracta was to that of the orifice as 10 to 12.3.

In proceeding to give a very short view of the theory of fluids issuing from orifices, we must warn the reader not to expect that strict coincidence between theory and practice which is to be found in many other branches of science. In optics and astronomy, and even in those parts of hydrostatics which we have already considered, the theoretical results scarcely differ at all from those which are obtained from accurate experiments; but in every branch of hydraulics the deductions of theory are so uncertain, that they are of no use whatever in any of the important purposes to which this science is applicable. It is only the general laws deduced from experiment that can be safely employed in the various operations of hydraulic architecture.

We shall therefore pass over very rapidly the theoretical part of the subject, and endeavour to lay before our readers a full account of the practical parts of hydraulics, availing ourselves of the invaluable labours of the Abbé Bossut.

Discharge of Fluids from Orifices.

Definitions.

Definitions.

1. A *vertical orifice* is an orifice placed in a vertical direction, so to allow the water to issue in a horizontal stream.

2. A *horizontal orifice* is an orifice placed in a horizontal direction, so as to allow the fluid to escape in a vertical direction.

3. An *ajutage* is a name given to any orifice, or cylinder, or cone from which water issues.

4. An *additional tube* is a tube of any form, inserted in a simple orifice made in the sides or bottom of a vessel.

5. A *head of water* is a term used to denote the height of the fluid above the orifice, or in general the height of a spring or source of water above the lowest point where it can be employed to exert a mechanical force, either by its impulse or by its weight.

6. If water issues with a velocity V, equal to that which a heavy body would acquire by falling through a height H, the velocity is said to be the velocity *due to the height H*, and the height is said to be *due to the velocity V*.

PROP. I.

If a fluid moves in an open canal, or through a tube, kept constantly full, whose diameter gradually varies, and if the fluid has the same velocity in every point of the same section, the velocities in different sections will be in the inverse ratio of the areas of the sections.

Since the canal and tube are always full, the same quantity of fluid must pass through every section in the same time. But as the quantity of fluid which passes through any section, whose area is A, is proportional to that area, and also to the velocity V with which it flows, it must be proportional to A and V jointly, or A × V. In like manner the quantity of fluid which runs through the area a of any other section in which v is the velocity, will be proportional to $a \times v$. Hence $V : v = a : A$.

SCHOLIUM.

The case stated in the proposition is one which is purely theoretical, and can never occur in practice. In every canal the velocity of the surface is always greatest, and in every tube the particles in its axis always move most rapidly.

PROP. II.

If a fluid is discharged from a vertical or horizontal orifice infinitely small, in a vessel where the fluid is kept constantly at the same height, the velocity with which the fluid issues, is equal to that which a heavy body would acquire by falling through a height equal to the height of the fluid above the orifice.

PLATE CCCXVIII. Fig. 1.

Let ABDC, Fig. 1. be a vessel in which the surface of the water always stands at AB, and let $m\,n$ be the very small orifice through which the fluid is discharged. Let us suppose the fluid divided by horizontal planes into an infinite number of laminæ, then since the area of the orifice $m\,n$ is infinitely small compared with the area of the laminæ, it will follow, from Prop. I. that the velocity with which the laminæ descend must be infinitely small. Now it is obvious that the lowest film of fluid $m\,n$ is pressed out by the weight of the column $m\,n\,p\,o$. (See Chap. I. Sect. I. Prop. IV.) Let M be the mass of the column of fluid $m\,n\,h\,g$, which is discharged at every instant by the pressure of $m\,n\,p\,o$, or by the force $m\,n \times m\,o$, and let m be the mass of a lesser column of fluid $m\,e\,f\,n$, which would have been discharged in the same time, solely by its own gravity, which may be represented by the line E m. Then if V be the velocity of the column $m\,g\,h\,n$, and u the velocity of the column $m\,e\,f\,n$, the quantity of motion of the column $m\,g\,h\,n$ will be $V \times M$, and the quantity of motion of the column $m\,e\,f\,n$ will be $u \times m$. But the moving forces are $m\,n \times m\,o$, and $m\,n \times E\,m$; and as they must be proportional to the quantities of motion which they produce, (see DYNAMICS, p. 286,) we have

$$m\,n \times m\,o : m\,n \times E\,m = V \times M : u \times m \text{ or}$$

$$V \times M : u \times m = m\,o : E\,m.$$

But the masses M, m discharged in the same time are as the area of the orifice multiplied by the velocity; that is, $M : m = m\,n \times V : m\,n \times u$, or $M : m = V : u$, and as magnitudes have the same ratio as their equimultiples have, (Euclid, V. 15,) we have

$M\,V : M\,u = V^2 : u^2$; but it has already been shewn that

$M\,V : M\,u = m\,o : E\,m$, hence

$V^2 : U^2 = m\,o : E\,m$.

Now if v is the velocity which a heavy body would acquire by falling through the height $m\,o$, we have, by DYNAMICS, p. 292, Case 4,

$$v^2 : u^2 = m\,o : m\,E, \text{ consequently}$$

$$V^2 : u^2 = v^2 : u^2,$$

and $V^2 = v^2$ and $V = v$, that is, the velocity V, with which the fluid issues from the orifice $m\,n$, under the pressure of the column $m\,n\,p\,o$, is equal to the velocity v, which a heavy body would acquire by falling through the height $m\,n$.

It is obvious, that the preceding reasoning is applicable to a vertical orifice, or to an orifice in any position, provided its depth is equal to $m\,n$, for the pressure of the fluid is the same in all directions.

Cor. 1. If the vessel ABDC, instead of being kept constantly full, is allowed to empty itself by the orifice $m\,n$, the velocity will always diminish; and when the surface has assumed a lower level GH, the velocity will be that which is due to $h\,m$.

Cor. 2. As the velocities of heavy bodies, descending by the force of gravity are as the square roots of the spaces or heights through which they fall, (see DYNAMICS, p. 292, Case 4,) the velocity of the issuing fluid will be as the square roots of the altitude of the surface of the fluid above the orifice. That is, if the water stands successively at the heights $o\,m$, $h\,m$, the velocities will be as $\sqrt{mo} : \sqrt{mh}$.

Cor. 3. As the quantities of fluid discharged are proportional to the velocities when the orifices remain the same, they will also be proportional by *Cor.* 2. to the square roots of the height of the fluid in the vessel.

Cor. 4. If the orifice is horizontal, but opening upwards, so as to discharge the fluid in a vertical direction, the water will rise in a jet to the same height as the surface of the fluid in the reservoir. As all heavy bodies acquire in falling a velocity which would carry them upward to the same height from which they fell, the same must be true of fluids. In practice, however, the resistance of the air, and the friction of the fluid upon the sides of the orifice, prevent this from being true.

Discharge of Fluids from Orifices.

Cor. 5. If the fluid, when it issues from the orifice should continue to move uniformly with the velocity with which it issues, it would describe a space equal to 2 mo, in the same time that a heavy body would fall through the height om.

In studying the preceding proposition, the reader must consider it as giving the velocity, not at the orifice itself, but at the *vena contracta*, where the velocity is greatest. Sir Isaac Newton having found that the velocity at the *vena contracta* was that which was due to the whole height of the fluid, and that the velocity at the *vena contracta* was to the velocity of the orifice as $\sqrt{2} : 1$, or as $1.414 : 1$, necessarily concluded that the velocity at the orifice is only that which is due to *half* the altitude of the fluid.

Prop. III.

If a cylindrical or prismatic vessel, of which the horizontal section is every where the same, is filled with fluid, and empties itself by an orifice, the velocity with which the surface descends, and also the velocity with which the water issues, is uniformly retarded.

Since the velocity of the surface of the fluid is to the velocity at the orifice, as the area of the orifice is to the area of the horizontal section of the vessel, or the area of the surface, the velocity of the surface must vary as the velocity at the orifice. But the velocity at the orifice varies as the square root of the height of the fluid in the vessel by Prop. II. Cor. 2.; consequently the velocity of the surface must also vary according to the height of the fluid, that is, with the space through which it descends. But as the velocity of heavy bodies projected upwards varies in this manner, the velocity of the fluid surface must be uniformly retarded in the same manner as heavy bodies.

Prop. IV.

If a fluid issues from a cylindrical or prismatic vessel, whose horizontal section is every where the same, and in which the fluid is always kept at the same height, the orifice will discharge twice the quantity contained in the vessel, in the same time that the vessel would have emptied itself.

As the surface of the fluid is uniformly retarded, and as its velocity becomes nothing at the bottom, the space which the descending surface would describe, with the first velocity, continued uniform during the time that the vessel takes to empty itself, is twice the space that the surface really describes in the time in which the vessel empties itself. In this time, therefore, the quantity of fluid discharged in the former case is twice that which is discharged in the latter case, as the quantity discharged when the vessel is kept constantly full, may be measured by what would be the descent of the surface, if it could descend with the velocity with which its descent commences.

The preceding demonstration is given by Mr Vince. M. Bossut deduces the proposition as a corollary from formulæ which express the quantity of water discharged under the circumstances stated in the proposition.

Prop. V.

To determine the quantity of water discharged by a small vertical or horizontal orifice, the time of discharge, and the height of the fluid in the vessel, when any two of these quantities are known.

Plate CCCXVIII. Fig. 1.

Let A represent the area of the small orifice mn; W the quantity of water discharged; T the time of discharge, H the height mo of fluid in the vessel, and $g =$ 16.087 feet, the space described by gravity in a second. Then since, by dynamics, the times are as the square roots of the spaces, we have $\sqrt{g} : \sqrt{H} = 1 \text{ second} : \sqrt{\frac{H}{g}}$, the time in which a heavy body would fall through the height H. But since the velocity is uniform, the space described will be double in the time that a heavy body would describe the height H, and therefore a column of fluid $= A \times 2H$ will be discharged in the time $\sqrt{\frac{H}{g}}$. Now, as the quantities of fluid discharged in different times are proportional to the times, we have $2AH : W = \sqrt{\frac{H}{g}} : t$. Hence,

$$W = \frac{2AHt}{\sqrt{\frac{H}{g}}} = \frac{2AHt \times \sqrt{g}}{\sqrt{H}}, \text{ and since } \frac{H}{\sqrt{H}} = \sqrt{} H,$$

$$\text{we have } W = 2At\sqrt{gH}$$

$$A = \frac{W}{2t\sqrt{gH}}$$

$$t = \frac{W}{2A\sqrt{gH}}$$

$$H = \frac{W^2}{4gt^2A^2}.$$

Cor. By means of these formulæ, we may determine the quantity of water W′ which is discharged in the same time T, from any other vessel in which A′ is the area of the orifice, and H the altitude of the fluid; for since t and g are constant, we shall have

$$W : W' = A\sqrt{H} : A'\sqrt{H'}.$$

Prop. VI.

To determine the time in which the surface of water in a vessel will descend through a given height, where the fluid is discharged through a small orifice in the bottom.

Plate CCCXVII. Fig. 2.

Let ABCD be the vessel, and let it be required to determine the time in which the surface of the fluid descends from AB to RS. Draw MN, $\mu\nu$ parallel and infinitely near to each other, then since $P\pi$ is infinitely small, we may consider the height πo as constant during the time that the lamina of fluid MN $\mu\nu$ flows through the orifice; and consequently its velocity is uniform. The time t, therefore, in which the height $P\pi$ is described, will, by Prop. IV. be $t = \frac{MN \times P\pi}{2A\sqrt{g}\sqrt{Pm}}$; for in the present case $W = MN \times P\pi$, and $H = Pm$. In a similar manner we may obtain the times t', t'' for all the other elementary laminæ into which the sum ABNM may be supposed to be divided, and therefore the sum of all these elementary terms, which may be obtained either by fluxions or by a geometrical construction, will be the time required in the proposition.

In order to find the time geometrically, draw EF equal and parallel to BC, and construct upon EF as an axis a parabola FTG, with a given parameter p. Prolong the lines AB, MN, $\mu\,\nu$, and RS, till they meet the parabola in G, c, d, and T. Construct a second curve XZY, so that each of the ordinates Ha, Kb, LZ, may be equal to the corresponding sections MN, $\mu\,\nu$, RS, divided by their corresponding ordinates in the parabola Hc, Kd, LT. Now, since $\mathrm{H}\,a = \frac{\mathrm{MN}}{\mathrm{H}\,c}$, and $\mathrm{MN} = \mathrm{H}\,a \times \mathrm{H}\,c$, and since by the property of the parabola, (See Conic Sections, Prop. XIII. p. 157.) $\mathrm{H}\,c^2 = \mathrm{HF} \times p$, and $\sqrt{\mathrm{HF}} = \sqrt{\mathrm{P}\,m} = \frac{\mathrm{H}\,c}{\sqrt{p}}$, we have, by substituting, in the above value of t, the preceding values of MN, and $\sqrt{\mathrm{P}\,m}$, $t = \frac{\mathrm{H}\,a \times \mathrm{H}\,c \times \mathrm{HK} \times \sqrt{p}}{2\mathrm{A} \times \sqrt{g} \times \mathrm{H}\,c}$, and dividing by $\sqrt{p}$ and Hc

$$t = \frac{\sqrt{p}}{2\mathrm{A}\sqrt{g}} \times \mathrm{HK} \times \mathrm{H}\,a,$$

which consists of the constant factor $\frac{\sqrt{p}}{2\mathrm{A}\sqrt{g}}$ multiplied into the variable curvilineal area H$a\,b$K. But as the same may be shewn for every other element of the time, it follows that the time of descent from AB to RS will be equal to $\frac{\sqrt{p}}{2\mathrm{A}\sqrt{g}} \times$ ELZX.

Cor. It follows from this proposition, that the times in which the surface AB will descend through the heights oP, $o\,s$, will be proportional to the corresponding areas EHaX, ELZX, and that the time of descent through any of these heights is to the time in which the vessel is completely emptied, as the corresponding area EHaX or ELZX, is to the whole area EFYX.

Prop. VII.

To determine the time in which the surface of water in a prismatic or cylindrical vessel will descend through a given height, viz. from AB to RS in Fig. 3.

This problem, as Bossut has remarked, may be very easily resolved by the method of fluxions; but we shall follow this excellent mathematician in the elementary demonstration which he has given of it. Let us suppose that a body, not heavy, ascends through the height $m\,o$, Fig. 3. and describes that space in the very same way as a heavy body would descend through the height $o\,m$. Then it is obvious that the different velocities of the ascending and descending body may be expressed by the ordinates of a parabola GTF. When the ascending body has arrived in π, it will describe the small space πP or KH, with a velocity represented by the ordinate Hc; but the time of describing $m\,o$ is $\sqrt{\frac{m\,o}{g}}$; and if the final velocity of the ascending body were continued uniform, the body would describe a space$=2\,m\,o$ in the time $\sqrt{\frac{m\,o}{g}}$. But in uniform motions, the spaces divided by the velocities are as the times of description. Hence $\frac{2\,m\,o}{\mathrm{EG}} : \frac{\mathrm{HK}}{\mathrm{H}\,c} = \sqrt{\frac{m\,o}{g}}$: Time HK, (or the time of describing GV.) Consequently

PLATE CCCXVIII. Fig. 3.

PLATE CCCXVIII.

$$\text{Time HK} = \frac{\mathrm{HK} \times \mathrm{EG}}{2\,\mathrm{H}\,c\sqrt{g} \times \sqrt{m\,o}},$$

and substituting for $\sqrt{m\,o}$ its value $\frac{\mathrm{EG}}{\sqrt{p}}$, p being the parameter of the parabola, we have

$$\text{Time HK} = \sqrt{\frac{p}{g}} \times \frac{\mathrm{HK}}{2\,\mathrm{H}\,c};$$

but by Prop. VI. the time in which the water descends through the same space Pπ, or HK, is

$$\frac{\sqrt{p}}{2\mathrm{A}\sqrt{g}} \times \mathrm{H}\,a \times \mathrm{HK} = \frac{\sqrt{p}}{2\mathrm{A}\sqrt{g}} \times \frac{\mathrm{MN}}{\mathrm{H}\,c}.$$

If we now substitute in place of Ha its equal $\frac{\mathrm{MN}}{\mathrm{H}\,c}$; and multiply the first of these expressions by MN, and the second by A, the products will be equal, or

$$\frac{\mathrm{MN}\,.\sqrt{p}.\mathrm{HK}}{2\sqrt{g}\,\mathrm{H}\,c} = \frac{\mathrm{MN}\,.\,\mathrm{A}\sqrt{p}\,.\,\mathrm{HK}}{2\mathrm{A}\sqrt{g}\,.\,\mathrm{H}\,c}.$$

Hence, by Euclid, (VI. 16.) the time of the body's ascending through $m\,o$, is to the time in which the surface descends through Pπ, as the area A of the orifice is to the area MN of the base of the cylindrical or prismatic vessel; and as the same is true of all the other elementary times which the ascending body and the descending surface employ in describing small equal spaces, it follows that the whole time in which the ascending body will describe the height $m\,o$, is to the time in which the vessel will be completely emptied, as the area A of the orifice is to the area of the base of the vessel. The time, therefore, in which the vessel will empty itself will be $\sqrt{\frac{m\,o}{g}} \times \frac{\mathrm{B}}{\mathrm{A}}$, B being the area of the base.

If RDSC is the vessel, then the time in which it will be entirely emptied will be $\sqrt{\frac{m\,s}{g}} \times \frac{\mathrm{B}}{\mathrm{A}}$, consequently the differences of these times, or the time in which the surface AB will descend into the position RS, will be

$$\text{Time } m\,s = \mathrm{B}\frac{(\sqrt{m\,o} - \sqrt{m\,s})}{\mathrm{A}\sqrt{g}}.$$

Prop. VIII.

To construct a clepsydra, or water clock, of a cylindrical form.

Fig. 3.

The equation in the preceding proposition enables us to do this in a very simple manner. Let us suppose that it is required to measure 12 hours, and that the height AD is divided into 144 equal parts; then the height of the surface of the water at the commencement of the time will be 144 parts. At the end of one hour the height will be 121; at the end of the second hour it will be 100, as in the following Table:

Hours to run	12	11	10	9	8	7	6	5	4	3	2	1	0
Hours from commencement	0	1	2	3	4	5	6	7	8	9	10	11	12
Height of the surface from the bottom	144	121	100	81	64	49	36	25	16	9	4	1	0
Length of each hour in parts		23	21	19	17	15	13	11	9	7	5	3	1

Discharge of Fluids from Orifices.

Since the velocity with which the surface AD descends is as the square roots of the altitudes, then, as the velocities are proportional to the times, the times in which these altitudes are described will also be as the square roots of the altitudes. Hence, since 12, 11, 10, &c. are the times in which the different heights are to be described, the heights should be as 12^2, 11^2, 10^2, or as 144, 121, 100, 81.

PLATE CCCXVIII. Fig. 3.

The exact time of describing each part of the altitude A is easily deduced from the formula. If the time is to be one hour, then we must proportion the area B of the base, and the height h of the vessel, to the area A of the orifice; so that 1 hour $= B\frac{(\sqrt{h}-\sqrt{\frac{121}{144}})}{A\sqrt{g}}$, or 1 hour $=\frac{B\sqrt{h}}{12\,A\sqrt{g}}$; from which any of the three quantities B, h, and A may be found, when two of them are given.

SCHOLIUM.

In practice, the 11 first divisions should only be employed, on account of the effect of the funnel-shaped cavity upon the regularity of the discharge. See p. 437, 506.

PROP. IX.

Fig. 3.

If a prismatic or cylindrical vessel ABCD is kept constantly full, it will discharge twice as much water as it contains in the time that it takes to empty itself completely.

It follows from Prop. VII. that the time in which it empties itself is $\frac{B\sqrt{h}}{A\sqrt{g}}$, h being equal to the height $m\,o$; and from Prop. V. that the quantity of fluid discharged in the same time, when the vessel is kept constantly full, is $\frac{B\sqrt{h}}{A\sqrt{g}}\times 2\,A\sqrt{g\,h}=2\,B\times h$; but this quantity is double of the prism ABCD, which is equal to $B\times h$.

SCHOLIUM.

In practice, the effect of the funnel-shaped cavity must be considered. See Chap. III. Sect. V. p. 506.

PROP. X.

If water is discharged from two prismatic or cylindrical vessels, the times in which their surfaces descend through similar heights, will be in the compound ratio of the areas of the bases, and the difference between the square roots of the height of each surface at the beginning and end of its motion directly, and inversely as the areas of the orifices.

Let the corresponding quantities in the two vessels be distinguished by accents, then, by Prop. VI.

$$\text{time } o\,s:\text{time } o's'=B\frac{(\sqrt{o\,m}-\sqrt{s\,m})}{A\sqrt{g}}:B'\frac{(\sqrt{o'm'}-\sqrt{s'm'})}{A'\sqrt{g}}$$

$$\text{or dividing by } \sqrt{g}, \text{ as } B\frac{(\sqrt{om}-\sqrt{sm})}{A}:B'\frac{(\sqrt{o'm'}-\sqrt{s'm'})}{A'}.$$

SCHOLIUM.

In practice, the effects of the contraction of the fluid vein must be considered, as in Chap. III. Sect. V, p. 306.

PROP. XI.

Discharge of Fluids from Orifices.

To determine the quantity of water which is discharged in a given time from a large rectangular orifice in the side of a vessel.

Hitherto we have supposed, that the orifice from which the water was discharged, when it issued from the side of a vessel, was so small, compared with the diameter of the vessel, that every part of the orifice might be considered as at the same depth below the surface. As this supposition, however, is inadmissible in the case of large orifices, we must now suppose a large orifice divided into an infinite number of small rectangles, (if the orifice is rectangular,) and regarding each of these as an orifice, all the points of which are equidistant from the fluid surface, we must determine the quantity of water discharged by means of the preceding propositions. The sum of all these elementary quantities will then be the total quantity of fluid discharged during the given time.

PLATE CCCXVIII. Fig. 4.

In order to shew the mode of doing this, by a geometrical construction, we shall take the case of a rectangular orifice as given by Bossut. Let LNOM be the given orifice in the vessel ABCD kept constantly full of water. Draw XZ, $x\,z$, infinitely near each other, and parallel to LM, so as to form the elementary rectangle XZ $z\,x$. Then if RI is the height, which may be considered as the distance of all the points of the small orifice from the surface AD, the quantity of water discharged in the time t will be $2XZ\times Ii\times t\sqrt{g}\times\sqrt{RI}$. In order to find the sum of all these elementary quantities, construct upon the axis RV the parabola RT, whose parameter is p, and produce KM, IZ, $i\,z$, VO to Y, S, s, and T. The small parabolic area IS $s\,i$ may be considered as a rectangle $=IS\times I\,i$. But $IS=\sqrt{RI}\times\sqrt{p}$; hence $IS\times I\,i=I\,i\times\sqrt{RI}\times\sqrt{p}$. Calling e this parabolic area, and q the elementary quantity of water which flows through the elementary orifice XZ $z\,x$, we shall have $e:q=I\,i\times\sqrt{RI}\times\sqrt{p}:2\,XZ\times t\sqrt{g}\times I\,i\times\sqrt{RI}$, which gives us

$$q=e\times\frac{2\,XZ\times t\sqrt{a}}{\sqrt{p}}.$$

If we can determine, therefore, the sums of all the e's or the parabolic surface KVTY, we shall easily determine the sum of the q's or the total quantity Q, which is discharged in the time t from the aperture LNOM.

Complete the rectangle RVTH, and draw SG, sg parallel to VR. Now the area RHT is composed of the elements SG, $s\,g$, which are proportional to the squares of the distances RG, Rg: (see CONIC SECTIONS, Sect. IV. Prop. XII. Cor.) Hence these elements increase as the sections of a pyramid, whose summit is R, and whose height is RH. Consequently the form of all the GS's which make up the area RHT, are equal to $\frac{1}{3}$ RH × HT; therefore the area RVT $=\frac{2}{3}$ VR × VT. The space KVTY, or the sum of the e's, is therefore $=\frac{2}{3}(RV\times VT-RK\times KY)$; but

$$q=e\times\frac{2\,XZ\times t\sqrt{g}}{\sqrt{p}}.$$

Hence we have

$$Q=\tfrac{2}{3}(RV\times VT-RK\times KY)\times\frac{2XZ\times t\sqrt{g}}{\sqrt{p}}.$$

If we substitute in this expression $\sqrt{VR}\times\sqrt{p}$ instead of VT; $\sqrt{RK}\times\sqrt{p}$ instead of KY; and if we call $VR=H$, and $RK=h$, and $XZ=b$, we have

$$Q=\frac{4\,b\,t\sqrt{g}(H\sqrt{H}-h\sqrt{h})}{3}.$$

In this expression, g is always $=16.087$.

Prop. XII.

To determine the horizontal distance to which water will be projected from orifices in the side of a vessel, and the nature of the curve which it will describe.

Plate CCCXVIII. Fig. 5.

Let ABCD, Fig. 5. be a vessel of water, which is discharged at O through the bent tube GEO, in the direction OP. If the water were influenced by no other force but that with which it is projected, it would move uniformly in the direction *m o* P, with a velocity equal to that which a heavy body would acquire in falling through the height QO. But as it is acted upon by gravity, as soon as it escapes from the orifice O it will obviously describe some curve line O *n p*. Make the elementary space $O\,m = m\,o$, and $OP = 2\,OQ$. Draw PM parallel to ON, and join QM. Let fall from the points *m*, *o*, P, the vertical lines *m n*, *o p*, PV, which will be parallel to OM, and complete the parallelograms O*mn*R, O *o p* S, OPVT. Let us now suppose, that in the time in which the water would have described the space O *m*, the force of gravity would have caused it to fall through the height OR; and that in the time in which it would have described the space O *o*, it would have descended through OS by the force of gravity alone. Now, since the fluid at O is solicited by two forces, one of which, viz. the force of projection, would carry it through the space O *m* in a certain time, while the other, viz. the force of gravity, would carry it through the space OR in the same time, the fluid will at the end of the given time be found at *n*. In like manner it may be shewn, that at the end of the time in which the water would have described O *o* uniformly, it will be found in the point *p*. But since O *m*, O *o* represent the times in which the water reaches the points *m*, *p* of its path, and since in these times the force of gravity has caused the water to fall through the spaces *m n*, *o p*, then as the spaces are proportional to the squares of the times, we have $m\,n, o\,p = O\,m^2 : O\,o^2$, that is on account of O *m n* R, O *o p* S, being parallelograms $OR : OS = R\,n^2 : S\,p^2$, which is the relation between the abscissæ and the ordinates of the Apollonian hyperbola. (See Conic Sections, Sect. IV. Prop. XII. Cor.)

It would be unnecessary to proceed any farther in explaining and demonstrating the geometrical construction which is usually given for finding the amplitude either of oblique or horizontal jets, as the construction and the demonstration of it are exactly the same as that which we have given in our article Gunnery, Vol. X. p. 572, &c. for the parabolic path of projectiles. The two classes of phenomena, and the mathematical laws by which they are regulated, are exactly the same.

Prop. XIII.

To determine the pressure exerted on the interior of conduit pipes by the water which they convey.

Plate CCCXVIII. Fig. 5. No. 2.

Let the fluid column, Plate CCCXVIII. Fig. 5. No. 2. be divided into an infinite number of equal and vertical laminæ GF *g f*. Then if we abstract friction, it is obvious that all the points of the same lamina have the same velocity, and that this velocity is the same in all the laminæ. If *q r* represent the section of the contracted vein at the orifice *p n*, the velocity of the laminæ is to the velocity in *q r*, as the area of the orifice *q r* is to the area of the section GF; for at every instant there passes out of *q r* a small prism of water equal to GF *g f*, and therefore these prisms have velocities reciprocally proportional to their bases. (See Prop. I. p. 488.) If we therefore call *h* the constant height of water in the reservoir, D the diameter of the tube, *d* that of the orifice *q r*, and if we consider that the velocity in *q r* is that due to the height *h*, and may be expressed by $\sqrt{h}$, then $D^2 : d^2 = \sqrt{h} : \frac{d^2\sqrt{h}}{D^2}$, the velocity of the water in the pipe. But as the velocity $\sqrt{h}$ is due to the height *h*, the velocity $\frac{d^2\sqrt{h}}{D^3}$ will be due to the altitude $\frac{d^4 h}{D^4}$. But since each particle of fluid that reaches the extremity PN of the pipe tends to move with the velocity $\sqrt{h}$, while it moves only with the velocity $\frac{d^2\sqrt{h}}{D^2}$, every point of P *p* or N *n* upon which it rests must be pressed with a force equal to the difference of the pressure due to the velocities $\sqrt{h}$, and $\frac{d^2\sqrt{h}}{D^2}$, that is, every part of the pipe will be pressed with a force equal to $h - \frac{d^2 h}{D^4}$.

Cor. 1. If an aperture very small in relation to each of the orifices PN, *p n* is made in the side of the pipe, the water will issue with a velocity due to the height $h - \frac{d^4 h}{D^4}$. This height will vanish when $d = D$, or when the whole aperture PN is opened.

See Bossut's *Traité D'Hydrodynamique*, Tom. II. chap. xi. p. 197, &c. from which the preceding proposition is taken.

Scholium.

In page 513, 514, of the present article, will be found a set of valuable experiments by Bossut, in which he has measured the quantity of water discharged by apertures in the side of the pipe. The agreement between the formula and the observed results, is very striking.*

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* In a series of very recent and interesting experiments on the discharge of liquids through small orifices, made by M. Hachette, of which some account will be found in the following Chapter, he has discovered that the quantity of fluid discharged by orifices varies by placing an obstacle at some distance from the orifice. Daniel Bernoulli made an experiment on this subject, and concluded from it, that an obstacle does not alter the quantity of fluid discharged. In his experiment, however, the time of the flow was too short for obtaining correct results.

M. Hachette employed a circular orifice, 20 millimetres in diameter, which discharged water from a large vessel into a vessel placed at a great distance from the orifice. The surface of the water in the vessel sank about six decimetres in 10′ 21″. The plane face of an obstacle was presented at different distances from the orifice, and the jet fell perpendicularly on this plane. The following were the results:

Distance of the Obstacle in Millimetres.

128	80	50	24	4

Corresponding Times in which the Surface of the Water sunk Six Decimetres.

10′ 21″	10′ 25″	10′ 26″	11′ 13″	15′ 54″

Hence it follows, that at the distance of 128 millimetres (5.039 inches), the obstacle produces no effect; but that, at the distance of four millimetres 0.157 of an inch, the time is increased rather more than one-half.

CHAP. II.

ON THE LATERAL COMMUNICATION OF MOTION IN FLUIDS.

This branch of hydrodynamics has been cultivated almost solely by M. Venturi, professor of natural philosophy at Modena, who published an account of his ingenious investigations in 1798. Sir Isaac Newton was acquainted with the fact that such a lateral communication took place, and has deduced from it the propagation of rotatory motion from the interior to the exterior strata of a whirlpool; but M. Venturi has the sole merit of explaining the different phenomena which it produces, and of applying it to the explanation of many curious phenomena. The following propositions contain a brief and general view of the subject.

PROP. I.

The motion of a fluid is communicated to the lateral parts which are at rest.

LATE
CCXVIII.
g. 5.
o. 3.

In order to establish this proposition by direct experiment, Venturi introduced the horizontal cylindrical pipe A *c* (Plate CCCXVIII. Fig. 5. No 3.) into a vessel DEFB, filled with water as high as DB. Opposite the aperture C, and at a little distance from it, is placed a small rectangular canal of tinned iron SMBR, open at the top SR, and having its inclined bottom MB resting on the edge B of the vessel. The breadth of this canal is 24 lines, the diameter of the tube AC is 14.5 lines, and the extremity A is inserted in a reservoir, of which the water is kept at a constant height. When the water of the reservoir is permitted to flow through AC, the current rises along the canal MB, and of course rushes out of the vessel in the current BV. In this way a current is created in the fluid in the vessel DEFB. This fluid is carried into the canal SR, and issues at B along with the water in the reservoir. In a few seconds, therefore, the water DD falls to MH. A similar effect will be obtained if we bring any light bodies near a stream of water issuing from a reservoir. These bodies will be carried along by the air which descends with the stream.

From these experiments, it follows that the lateral parts of a fluid are carried along with any stream that flows through the fluid, and consequently that the motion of the fluid is communicated to the lateral parts which are at rest.

SCHOLIUM.

Venturi has applied the principle in the proposition to explain the theory of the water blowing machine. He has also shewn that the eddies of the water in rivers are produced by motion communicated from the more rapid parts of the stream to the lateral parts which are more at rest; and has pointed out a method, which he has actually tried with success, of draining, by means of a fall of water without the help of machines, a piece of ground, even though the ground should lie on a lower level than the established current below the fall. See Prop. VI. and p. 564, 565, of this article.

PROP. II.

In descending cylindrical tubes, the upper extremities of which have the form of the contracted vein, the velocity of the effluent water is that which corresponds with the height of the fluid above the inferior extremity of the tube.

PLATE
CCCXVIII.
Fig. 6.

M. Venturi has established this proposition upon the principle of virtual ascension, combined with the pressure of the atmosphere, in the following manner. Let BLKO, Plate CCCXVIII. Fig. 6, be a conical tube, having the form of the vena contracta, and let the cylindrical tube LCQK have the same diameter as the contracted part LK. Now, the fluid stratum LK continuing to descend through the height LC, will tend to have its motion accelerated in the same manner as all other bodies falling by the force of gravity. Hence, when it passes from LK to LM, it tends to detach itself from the stratum which lies immediately above it; or, which is the same thing, it tends to produce a vacuum between LK and MN, and the same effect is produced through the whole length LC of the tube. The pressure of the atmosphere becomes active, as far as is necessary, to prevent the vacuum, and its action is the same, both at A, the surface of the fluid, and at C, the inferior extremity of the tube. The atmospherical pressure at A increases the velocity of the fluid which issues at CQ, while the atmospherical pressure at C destroys the sum of the accelerations which would be produced along LC, so that the fluid remains continuous in the tube.

Let T be taken to represent the time in which the continuous column of fluid LCQK passes through the tube LC, whatever be the velocity at L, and the successive acceleration from L to C. Then, if we suppose this column to return upwards from D to E, it will pass through the space DE, which is equal to LC in the same time T, and during this time it will lose all the acceleration which it acquired in its descent from L to C. The pressure of the column ED, continued during the time T, is therefore the force necessary to destroy the successive acceleration from L to C, and to prevent the fluid from losing its continuity in the tube LC. Hence it follows that the part of the pressure of the atmosphere which is exerted at CQ to destroy the sum of the accelerations along LC is equal to the pressure of a column ED of a fluid of the same nature as that of the reservoir from which the water flows. And since the same pressure must also be exerted upon the surface A of the reservoir, if we take FA = LC, the fluid at LK will issue with a velocity due to the height FL = AC, abstracting the retardation produced by the external inequalities of the tube LCQK.

SCHOLIUM.

The theory of Venturi has been recently controverted by M. Hachette, who supposes, that the principal cause of the increased expenditure by tubes is the adhesion of the fluid to the sides of the tubes arising from capillary attraction. The following account of Hachette's experiments, taken from M. Poisson's Report, will enable the reader to determine which of the two theories is the most plausible. We conceive, that new experiments are necessary to decide the question.

Exp. I. The fluid in motion was mercury, and the pipe was made of iron. When the mercury was perfectly pure, it had no affinity for the iron, and flowed out as it would have done from a small orifice equal to the diameter of the pipe. But when the mercury was covered with a pellicle, formed of an alloy of tin and other metals, this alloy covered the inside of the pipe, and the mercury then flowed with a full stream.

PLATE CCCXVIII.

Exp. II. The fluid next used was water, and the pipe was coated within with wax. The water flowed as if through a small orifice, without filling the tube. But whenever the water was made to moisten the wax, the pipe was instantly filled, owing to the wax being replaced by the first coat of water which covers it. Hence the reason why a disc of glass at last adheres to water with the same force whether it is covered or not with a coating of wax; for as soon as the wax is wetted, it is merely the action of water on water which determines the phenomena, as M. Laplace has explained in his *Theory of Capillary Action*.

Another important fact determined by M. Hachette is, that in a vacuum, or in air rarefied to a certain degree, the phenomena of pipes ceases to take place. Thus, if water is made to run in a full stream through a tube under the receiver of an air pump, then, upon rarifying the air in the receiver, the fluid vein was observed to detach itself from the sides of the pipe, when the internal pressure was reduced from 0.76 of a metre to 23 centimetres of mercury. By thus diminishing the internal pressure, the effect of the external pressure is increased, which is transmitted to the pipe by means of the fluid contained in the vessel, and to which is added the pressure of the fluid. But there is a point at which these two pressures are sufficiently powerful to detach the fluid vein from the sides of the pipe, in the same manner as a disc of glass or metal may be detached from the surface of a fluid to which it adheres by the application of a sufficient force. The phenomena, therefore, exhibited in a vacuum, or in rarified air, agrees perfectly with the explanation of M. Hachette, and does not prove, as might be supposed, that the phenomena of pipes are produced by the pressure of the air in which the fluid is discharged; an opinion which is inconsistent with the two preceding experiments, for in these experiments the action of the air was the same, and yet the phenomena were different, according to the nature of the fluid, and the matter of which the pipe was composed.

When the fluid vein has been detached by rarefying the air, M. Hachette observed, that the water does not again begin to flow in a full stream when the air is readmitted. This contraction of the vein, which took place in the rarefied air, continues to subsist though the pressure of the atmosphere is restored. Hence he concludes, that the adhesion of the water to the sides of the pipe takes place only at the commencement of the motion, before the fluid has acquired a sensible velocity in a direction which separates it from the sides. In order to verify this conjecture, M. Hachette made the following experiment:—The water flowed in a full stream through a pipe without the receiver of an air-pump. A small hole was made in this pipe very near the orifice. The external air then entered into the pipe, as ought to have happened according to the theory of D. Bernoulli. It interposed itself between the water and the sides of the pipe. The contraction of the vein takes place in the inside of the tube, and the water ceases to flow in a full stream. This being the case, the small hole was exactly shut. The adhesion of the water to the pipe was not again produced, and the flowing of the water continued as if the pipe had not existed, so that it might have been removed or replaced without any change in the flow of the water. This experiment succeeded equally well whatever was the direction of the jet; but care must be taken not to agitate the apparatus, for a very small lateral motion of the fluid causes it to adhere again to the moist sides of the pipe. It was probably from having neglected this precaution, that M. Venturi obtained a result apparently different from the preceding. See Thomson's *Annals of Philosophy*, July 1817, vol. x. p. 34.

PROP. III.

If water is discharged from a short tube of a conical form, the pressure of the atmosphere will increase the expenditure in the ratio of the exterior section of the tube to the section of the contracted vein, whatever be the position of the tube, provided that its internal figure be adapted throughout to the lateral communication of motion.

Having already shewn that the atmospherical pressure increases the expenditure through additional tubes whatever be their position, Venturi next proceeds to examine the mode of action by which the atmosphere produces this augmentation, and he begins with the case best adapted to favour the action of the atmosphere, which is that of conical diverging tubes.

PLATE CCCXVIII. Fig. 14.

Let AB, Plate CCCXVIII. Fig. 14, the extremity of the tube ABEPF, be applied to an orifice in a thin plate, and let the part ABCD have the form nearly of the contracted vein, which is found by experiment to make no perceptible alteration upon the expenditure by the simple orifice AB. The water which issues through CD is disposed to continue its course in a cylindrical form CGHD; but if the lateral parts CFGDFH continue, the cylindrical stream CGHD will communicate its motion to the lateral parts successively from part to part, as shewn in Prop. I. Hence, if the divergence of the sides CE, DF be such as is best adapted to the speedy and complete lateral communication of motion, all the water contained in the truncated conical tube CDEF will at last acquire the same velocity as that of the stream which continues to issue through CD. Upon this supposition, while the fluid stratum CDQR, preserving its velocity and thickness, would pass into RQTS, a vacuum would be formed in the solid zone R *m r* SQ *n o* T. Or if it should be supposed that the stratum CDQR, preserving its progressive velocity, should enlarge in RQTS; this cannot happen without its becoming thinner and detaching itself from the stratum which succeeds it, and by that means leaving a vacuum equal to the zone R *m r* SQ *n o* T. A similar effect would obviously take place throughout the whole of the tube CE, and if the quantity C *m* is supposed invariable, the sum of all these empty spaces will be equal to the solid zone VE *x* G *z* YFH.

From this reasoning it follows, that the lateral communication of motion produces the same effect in a conical tube, whether horizontal or vertical, as is produced by the action of gravity in a descending cylindrical tube, as described in Prop. II. In this case, also, a part of the pressure of the atmosphere is active on the reservoir, and at the outer extremity EF. If the action of the atmosphere upon the surface of water in the reservoir increases the velocity at the section CD, this velocity will likewise communicate itself to the whole fluid CDFE, and the tendency to a vacuum will take place as before; but since the atmospherical action is as powerful at EF, it will take away at EF all the velocity which it added at CD; so that being deducted from the same mass, and in the same time at EF, the fluid will not cease to be continuous in the pipe. It is found by computation, that this will happen when the velocity of CD is increased in the ratio of CD to EF^2.

Lateral Communication of Motion in Fluids.

By applying the general laws of motion to the lateral fluid filaments of the stream which issues through AB, it is found that they tend to describe a curve which commences within the reservoir, for example at A, and continues towards CSE. In order to determine the nature of this curve, it is necessary to know and to combine together, by calculation, the mutual convergency of the fluid filaments in AB, the law of the lateral communication of motion between the filaments themselves, and their divergent progression from C to E. These combinations and calculations are considered by Venturi as beyond the efforts of analysis. When the tube ABFE has a figure different from this natural curve, the experimental results will always differ more or less from those deduced from theory.

Prop. IV.

The quantity of fluid discharged through cylindrical tubes is less than through conical tubes which diverge from the commencement of the contracted vein, and have the same external diameter.

LATE CCXVIII. g. 11.

The general theory is the same for tubes both of a cylindrical and a conical form, but the loss of living force is greater in the cylinder, and the effect of the communication of motion in these tubes cannot approach its maximum as in the cone. Let the compound tube ACNM, Plate CCCXVIII. Fig. 11. have the part ACFD of the form of the *vena contracta*, and let the cylindrical part GINM have its diameter MN greater than DF. Hence it follows, from the reasoning in the preceding proposition, that the lateral communication of motion tends to produce a vacuum in the solid zone ROYSXQTZ. If the communication of motion in the tube were completely made, it would follow that the pressure of the atmosphere would increase the velocity of the contracted vein in the ratio of DF^2 to MN^2. The form, however, of the cylindrical tube, always destroys a considerable part of the effect; for the fluid filaments AD, in describing the curve DR, strike the sides of the tube GM at R with considerable force, and thus lose a part of their motion. Eddies or circular whirls are produced in the space DGR, as in a bason which receives water by a channel. These eddies are to a certain extent a failure in the effect, and retard the efflux of the water. A much less increase of the expenditure takes place in the cylindrical tube than corresponds to the ratio of DF^2 to MN^2.

The reader will be able to form a general notion of the effects of these internal shocks and eddies upon the efflux of a cylindrical tube, by attending to the experiments in Table XII. p. 503, of this article.

g. 12.

M. Venturi next considers, whether, in the internal part of the simple cylindric tube KLV, Fig. 12. there is the same augmentation of velocity, and the same contraction of the stream, as in the compound tube of Fig. 11. By reasoning according to the principles which he has established, he concludes, 1. That in the section KL of Fig. 12. there is the same increase of velocity as takes place in the section AC of Fig 11. (See Prop. II.) The fluid particles which pass through these sections have in both cases the same direction; for this direction can depend only on the impulse received within the reservoir, which is the same in both cases. In Fig. 12. the fluid particles, after having passed through the section KL, immediately begin to experience the effect of the lateral communication of motion, and therefore they must deviate laterally through the curve L *x z*, before they arrive at the place of contraction, which they assume at DF, Fig. 11. and which they likewise assume when the orifice is made in a thin plate. If we suppose a tube of glass *y* K, Fig. 12. to have one of its extremities applied at K, and the other opening into the reservoir, it will be seen that the pressure of the atmosphere which is exerted upon the coloured fluid T, (see p. 503. Table XII. exp. 7.) must act likewise upon the surface of the reservoir, and aid the pressure of the fluid in the reservoir in forcing the water into the tube *y* K, as it presses the coloured liquor into TS. In like manner, the pressure of the atmosphere must increase the impulse of all the fluid particles which arrive at KL, and consequently must increase the expenditure. As a part of the active force of the fluid must always be destroyed by the eddies in an additional cylindric tube, it follows that the effluent column can never have the velocity which is due to the real head, and which is observed nearly entire in orifices in a thin plate; and the diminution of velocity corresponds with the increase of the time beyond that indicated by the theory.

Lateral Communication of Motion in Fluids.

Plate CCCXVIII. Fig. 11.

Scholium.

The theory of the lateral communication of motion in fluids must apply in a similar manner to ascending and descending tubes, whenever the form admits of this lateral communication. In descending tubes, the increase of expenditure occasioned by this cause, must be added to that which is produced by the acceleration of gravity, and which has been estimated in Prop. II. But in ascending tubes, we must subtract this effect from that which is produced by gravity.

Prop. V.

By means of proper adjutages applied to a given cylindrical tube, it is possible to increase the expenditure of water through that tube in the proportion of 24 to 10, the head or the altitude of water in the reservoir remaining the same.

The truth contained in this proposition is deduced from the experiments which we have given in Table XII. p. 503 and 504 of this article, and the form of the adjutages is explained in p. 504, and represented in Plate CCCXVIII. Fig. 16.*

Fig. 16.

Scholium.

"At Rome," says Venturi, "the inhabitants purchased the right of conveying water from the public reservoirs into their houses." The law prohibits them from making the pipe of conveyance larger than the aperture granted them at the reservoir, as far as the distance of 50 feet. The legislature was therefore aware, that an additional pipe of greater diameter than the orifice would increase the expenditure; but it was not perceived that the law might be equally evaded by applying the conical frustum CD beyond the 50 feet. From the structure of this compound pipe, we learn, that it is not proper to make the flues of chimnies too

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* M. Clement, in some very recent experiments on the discharge of water through cylindrical and conical tubes, has succeeded in increasing the expenditure of water in a much greater ratio by changing the form of the compound tube used by Venturi. See Poisson's Report on M. Hachette's Memoir, Part III.

Fig. 16.

large in the apartments; but that it will be sufficient if they be enlarged at their upper terminations, according to the form CD, Fig. 16. This divergency of the upper part will carry off the smoke very well, even when it is not practicable to afford chimnies of sufficient length to the upper apartments. The same observation is applicable to chemical furnaces for strong fire."

Prop. VI.

The eddies of the water in currents and rivers are produced by motion, communicated from the more rapid parts of the stream to the lateral parts, which are more at rest.

Plate CCCXVIII. Fig. 5. No. 4.

"The water which moves in the channel MNH, Fig. 5. No. 4. meets the obstacle BA, which impedes its course, and causes it to rise and discharge itself in the direction AC, with an increased velocity. Suppose the water in BDCA to be dormant, the current AC communicates its motion to the lateral particles E, (Prop. 1.) and conveys them forward; the surface of the dormant water becomes depressed at E, and the most remote particles towards D are urged, according to the laws of the equilibrium of fluids, to fill the depression. The current AC continues to carry them off, and the space BDCA continues to be exhausted. The water of the current AC, by virtue of the same laws, is acted upon by a constant force which urges it towards the cavity E, while its natural course or projection carries it towards AC. Under the agency of these two forces, the water AC acquires a curve-lined motion in CD, and descends as it were through an inclined plane, becoming retrograde in DE, whence it would proceed to strike the obstacle BA, and the current AC, after which it would undergo several oscillations previous to acquiring a state of equilibrium and repose. But the current AC continues its lateral action; a second time it draws away the water through CD into E, and forces it to renew its motion through the curve CDE; in which manner the eddy continues without ceasing.

If the river should pass through a contraction of its bed at N, it will produce eddies at both sides, at P and at Q, similar to those we have considered at DC.

Suppose the stream of water, after having struck the bank GH, to be reflected into a new direction HS, the lateral communication of motion will excite eddies in the angle of reflection R.

When two currents of unequal velocity meet obliquely in the middle of the river, the most rapid current will produce eddies in that which is the least rapid.

Fig. 5. No 5.

Suppose a stream of water to flow over a bed of unequal depth. If the longitudinal section of the inequalities of the bottom exhibit a gentle slope, as at ABC, Fig. 5. No. 5. the superior water will impress its motion by lateral communication upon the inferior water which is near the bottom, beneath the line AC, and a current will take place through the whole depth of the section MB. The current, which is formed near the bottom at B, is turned out of its course by the slope BC, and proceeds to rise above the surface at Q, sometimes in the form of a curling wave, or vertical whirlpool. If the extremities of the hollow place form an abrupt angle, as DEFG, eddies will be produced even at the bottom, in the vertical direction at D, and sometimes also at G. These phenomena may be observed in an artificial channel with glass sides.

Every eddy destroys a part of the moving force of the current of the river. For the water which descends by a retrograde motion in the inclined plane CDE, Fig. 5. No. 4. cannot be restored in the direction of the current of the river but by a new impulse. It is as it were a ball, which is forced to rise on an inclined plane, whence it continually falls back again to receive new impulsions.

Plate CCCXVIII. Fig. 5. No. 4.

Hence we deduce, as a primary consequence, *that in a river, of which the course is permanent, and the sections of its bed unequal, the water continues more elevated than it would have done, if the whole river had been equally contracted to the dimensions of its smallest section.* The cause of this phenomenon is the same as that which retards the expenditure through the tube with enlarged parts. (Prop. 7. No. 4.) The water which descends from the elevation above the contracted part N into the bason PQ, Fig. 5. No. 4. loses nearly the whole of the velocity it acquired by descending from it; because the narrow part has a curved slope towards the lower part of the river, which directs the velocity of the stream in an horizontal direction. Guglielmini has well remarked, that a fall does not influence the velocity of the lower stream, because the eddies of the water in the bason PQ destroy the velocity produced by the fall. This velocity increases the depth, and enlarges the width of the channel at PQ. Eddies are formed on each side, at the bottom, and at the surface, both in the horizontal and vertical directions. It would be to no purpose to attempt to prevent this hollowing out and enlargement of the channel by such a fall by adopting the means of close walls, for the bason would then obtain its enlargement where these constructions might end.

If the channel have a number of successive contractions and dilatations MN, without cascade or dam, there will still be formed, at each dilatation, eddies which will diminish the velocity more than if the channel had an uniform section equal to that in M or N. It will therefore follow, that the surface of the water, after each dilatation, must rise, in order to recover the velocity it lost by the eddies. If we call the height to which the water must rise, above the elevation necessary to have overcome the retardations of a bed of uniform section, $= a$, and the number of equal and successive alternate dilatations and contractions be $= m$, the height of the rise in the stream thus alternately dilated beyond that of the same river uniformly contracted, will be $= am$. We here suppose the bottom of the river to be uniform. If this bottom be of such a nature to be attacked by the current, the contracted parts will be hollowed out, and the matter will be deposited in the enlarged parts.

The second consequence which we draw from the principle here established, respecting the loss of force caused by the eddies, is of considerable importance in the theory of rivers, and appears to have been neglected by those who have treated on this subject. The friction of the water along the wet banks, and over the bottom of rivers, is very far from being the only cause of the retardation of their course, which consequently requires a continued descent to maintain its velocity. One of the principal and most frequent causes of retardation in a river, is also produced by the eddies, which are incessantly formed in the dilatations of the bed, the cavities of the bottom, the inequalities of the banks, the flexures or windings of its course, the currents which cross each other, and the streams which strike each other with different velocities. A considerable part of the force of the current is thus employed to restore an equilibrium of motion, which that current itself does continually derange."

CHAP. III.

ACCOUNT OF EXPERIMENTS ON THE DISCHARGE OF WATER FROM VESSELS THROUGH SIMPLE ORIFICES AND ADDITIONAL TUBES.

SECT. I. *On the Vena Contracta.*

On the vena contracta.

IN the first Chapter of Hydraulics we have explained the cause of the contraction of the fluid vein, or *vena contracta*, and have stated in general the effect which this contraction produces upon the quantity of water discharged from vessels. The following are the measures of the contraction according to different authors; A being the area of the orifice, and *a* the area of the section of the contracted vein:

	A.	*a*.
Sir Isaac Newton, ...	141	100
Poleni, ...	140	100
Highest found by Bossut, . .	150	100
Mean of six experiments by Bossut,	150.6	100
Lowest found by Bossut, . .	151.5	100
Bernoulli, ...	156	100
Michelotti, ...	156	100
Du Buat, ...	150	100
Venturi, ...	158.5	100
Eytelwein, ...	156.2	100

The measures given by Bossut were taken by a pair of spherical compasses, with which he measured directly the diameter of the contracted vein, which he found to preserve the same diameter for some lines. The altitude of the water in the reservoir which Bossut used was 11 feet 8 inches. He measured the *vena contracta* also, when the water issued by vertical orifices placed 4 feet below the surface of the fluid, and he obtained the very same results.

The ratio of A to *a* is however by no means constant. It undergoes perceptible variations, by varying the form and position of the orifice; the thickness of the plate in which the orifice is made; the form of the vessel; and the velocity of the issuing fluid.

SECT. II. *On the quantity of Water discharged by Orifices of different Forms, from Vessels kept constantly full.*

Discharge from simple orifices.

IN order to determine the quantity of water discharged by orifices of different forms, M. Bossut employed very clear water, which was excellent for drinking. The experiments were made at Mezieres, in the beginning of September, in very fine weather, which is the only information from which we can conjecture the temperature of the water. The orifices were perforated in plates of copper half a line thick; the time was ascertained sometimes by a seconds watch, and at other times by a simple seconds pendulum; and the most exact measures were used in ascertaining the quantity of water discharged. The fundamental measure which he employed was a hollow cube of copper, having one of its sides exactly six inches within. It contained the eighth part of a cubic foot when it was entirely full, and on its four interior faces were traced four vertical scales for ascertaining the quantity of water which it contained when it was full. M. Bossut also used other two measures, one of which was a small barrel containing exactly a cubic foot, or eight times the contents of the cubical vessel; and the second was a barrel containing eight cubic feet. Each of these barrels had two small tubes rising from their upper end, through one of which the water was poured, and upon which was the mark to shew when it contained exactly the number of cubic feet. The second tube allowed the included air to escape as the water was poured in.

TABLE I. *Shewing the quantity of Water discharged in one Minute by Orifices differing in form and position.*

Constant Height of the Fluid above the centre of the Orifice.	Form and position of the Orifice.	Diameter of the Orifice.	No. of Cub. In. discharged in a Minute.
Ft. In. Lin.		Lines.	
11 8 10	Circular and Horizontal,	6	2311
	Circular and Horizontal,	12	9281
	Circular and Horizontal,	24	37203
	Rectangular and Horizontal, ...	12 by 3	2933
	Horizontal and Square,	12 side	11817
	Horizontal and Square,	24 side	47361
9 0 0	Vertical and Circular,	6	2018
	Vertical and Circular,	12	8135
4 0 0	Vertical and Circular,	6	1353
	Vertical and Circular,	12	5436
5 0 7	Vertical and Circular,	12	628

General results.

From these results we may conclude,

1. That the quantities of water discharged in equal times by the same orifice from the same head of water, are very nearly as the areas of the orifices; and,

2. That the quantities of water discharged in equal times by the same orifices under different heads of water, are nearly as the square roots of the corresponding heights of the water in the reservoir above the centres of the orifices.

If we call Q, *q* the quantities of water discharged in the same time from the two orifices A, A′ under the same height of water in the reservoir; *q* and Q′ the quantities of water discharged during the same time by the same aperture A, under the different heads of water *h*, *h′*, we have by the first of the above results, $Q : q = A : A'$; and by the second, $q : Q' = \sqrt{h} : \sqrt{h'}$; from which we obtain $q = \frac{A' \times Q}{A}$, and $q = \frac{Q' \sqrt{h}}{\sqrt{h'}}$; then since $\frac{A' \times Q}{A} = \frac{Q' \sqrt{h}}{\sqrt{h'}}$, we have by Euclid, B. V. $Q : Q' = A \sqrt{h} : A' \sqrt{h'}$, that is, in general.

3. The quantities of water discharged during the same time by different apertures under different heights of water in the reservoir, are to one another in the compound ratio of the areas of the apertures, and of the square roots of the heights in the reservoirs.

This general rule may be considered as sufficiently correct for ordinary purposes; but, in order to obtain a great degree of accuracy, Bossut recommends an attention to the three following rules.

1. Friction is the cause, that, of several similar orifices, the smallest discharges less water in proportion than those which are greater, under the same altitudes of water in the reservoir.

2. Of several orifices of equal surface, that which has the smallest perimeter ought, on account of the friction, to give more water than the rest, under the same altitude of water in the reservoir.

3. That, in consequence of a slight augmentation which the contraction of the fluid vein undergoes, in proportion as the height of fluid in the reservoir increases, the expence ought to be a little diminished.

In the following Table, given by the Abbé Bossut, he has compared the theoretical with the real discharges from an orifice one inch in diameter, and the different altitudes of the fluid in the reservoir. The real discharges in column 3d were not determined by direct experiment, but were ascertained with the precaution indicated in the three preceding rules, and may be considered to be as accurate as if they had been obtained from direct experiment. The fourth column was computed by M. Prony.*

Comparison of the theoretic with the real discharges.

TABLE II. *Comparison of the Theoretic with the Real discharges from an Orifice one inch in diameter.*

Constant height of the Water in the Reservoir above the centre of the Orifice.	Theoretical discharges through a circular Orifice one inch in diameter.	Real discharges in the same time through the same Orifice.	Ratio of the theoretical to the real discharges.
Paris Feet.	Cubic Inches.	Cubic Inches.	
1	4381	2722	1 to 0.62133
2	6196	3846	1 to 0.62073
3	7589	4710	1 to 0.62064
4	8763	5436	1 to 0.62034
5	9797	6075	1 to 0.62010
6	10732	6654	1 to 0.62000
7	11592	7183	1 to 0.61965
8	12392	7672	1 to 0.61911
9	13144	8135	1 to 0.61892
0	13855	8574	1 to 0.61883
1	14530	8990	1 to 0.61873
2	15180	9384	1 to 0.61819
13	15797	9764	1 to 0.61810
14	16393	10130	1 to 0.61795
15	16968	10472	1 to 0.61716
1	2	3	4

It appears from this Table, that the real as well as the theoretical discharges are nearly proportional to the square roots of the heights of the fluid in the reservoir. Thus for the heights 1 and 4, whose square roots are as 1 to 2 feet, the real discharges are 2722 and 5436, which are to one another as 1 to 1.997, very nearly as 1 to 2.

By means of the formula in the preceding page, we may easily apply the above Table to the determination of the quantities discharged under different altitudes of water in the reservoir, and from orifices of different sizes. Let it be required, for instance, to determine the quantity of water discharged from an orifice of 3 inches in diameter, under an altitude of 30 feet. Then, since the real quantities discharged are in the compound ratio of the orifices, and the square roots of the altitudes of the water, and since the theoretical discharge by an orifice 1 inch in diameter, under an altitude of 15 feet is 16968 cubical inches in a minute, we have $1\sqrt{15} : 9\sqrt{30} = 16968 : 215961$, the theoretical discharge. But since the theoretical is to the real discharge as 1 to .62, the above value being diminished in that ratio, gives 133309 cubic inches for the real quantity of water discharged by the orifice.

The following formulæ have been given by M. Prony, as deduced from the preceding experiments of Bossut, †

$$Q=0.61938\ AT\sqrt{2\,g}\ H,$$

A being the area of the orifice in square feet, H the altitude of the fluid in feet, T the time, g the force of gravity at the end of a second, and Q the quantity of water in cubic feet. As $\sqrt{2\,g}$ is a constant quantity, and is equal to 7.77125, we have

$$Q = 4.818\ AT\sqrt{H} \text{ for orifices of any form.}$$

If the orifices are circular, and if d represents their diameter, then

$$Q = 3.7842\ d^2\ T\sqrt{H}.$$

From the second of these equations we obtain

$$A = \frac{Q}{4.818\ T\sqrt{H}}$$

$$T = \frac{Q}{4.818\ A\sqrt{H}}$$

$$H = \frac{Q}{(4.818AT)^2}$$

These formulæ will be found to give very accurate results; but if we wish to obtain a still higher degree of accuracy, we must not use the mean co-efficient 0.6194, but the one in the Table which comes nearest to the circumstances of the case. Thus if the head of water happens to be small, such as 1 foot, then we must take the co-efficient 0.62133, and if it happens to be great, we must use the least co-efficient 0.61716.

To determine the velocity of the issuing fluid.

In order to determine the velocity with which the fluid is discharged, we must first obtain the theoretical velocity, which is $V=\sqrt{32.174}\sqrt{H}=8.016\sqrt{H}$ in English inches. That is, the velocity acquired by falling through any height H, is found by multiplying the square root of the height by 8.016. But as the real velocity of the issuing fluid is to its theoretical velocity as 0.6194 to 10, we have $4.965\sqrt{H}$ as the measure of the real velocity, or in round numbers $5\sqrt{H}$; that is the velocity in a second of time in English feet is five times the square root of the height of the fluid in the reservoir; or, if we prefer expressing these values in inches, then since 32.2 feet = 772 inches, and $\sqrt{772} = 27.78$, we have $V = 27.78\sqrt{H}$ for the theoretical velocity, and $V = 17.206\sqrt{H}$ for the velocity at a simple orifice.

In order, however, to obtain the velocity more accurately, we should deduce the co-efficient of $\sqrt{H}$, not from the medium co-efficient in the preceding Table, but from the co-efficient in the Table which approaches nearest to the circumstances of the experiment.

Michelotti's experiments.

The following Table contains a series of experiments by M. Michelotti, which were made on a most magnificent scale, and with the utmost accuracy. As they extend to apertures of three inches both square and circular, and to altitudes twice as great as those employed by Bossut, they form an excellent supplement to his experiments. We consider them indeed as much more valuable than those of Bossut, as the quantities of water discharged in each experiment were prodigiously greater than his. The reservoir employed was 20 feet high, and three feet square within, and had openings at different distances from the top. The water flowed into a cistern whose area was 289 square feet, and whose figure was uniform, and the quantity of it was ascertained in French feet, by measuring its height in the cistern.

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* See his *Architecture Hydraulique*, tom. 1. p. 369.

† The measures are in French feet, which are to English feet as 1066 is to 1000.

Discharge of Water from Orifices.

Table III. *Containing the Experiments of Michelotti on the quantities of Water discharged by different vertical orifices under different heads of Water.*

Head above the Centre of the orifice.				Size and nature of the orifice.	Time of running.	Cubic feet of water expended		
Feet.	Inch.	Lines.	Parts.		Minutes.	Feet.	In.	Lin.
6	7	4	3	Square, of 3 inches.	10	463	7	3
6	10	2	8		12	566	5	6
11	8	1	6		$8\frac{1}{2}$	516	9	5
11	9	9	10		10	612	1	5
21	8	3	6		5	415	5	3
21	8	7	0		6	499	2	8
6	7	6	0	Square, of 2 inches.	15	329	9	8
11	5	1	4		15	423	5	7
21	5	3	7		10	385	4	0
6	9	1	0	Square, of 1 inch.	30	158	6	7
11	10	8	1		24	163	9	6
21	6	1	0		60	562	11	4
6	8	4	0	Circular, of 3 inches diameter.	15	542	10	6
11	7	1	0		12	570	11	8
21	7	4	0		8	521	3	7
6	9	5	0	Circular, of 2 inches diameter.	30	488	8	3
11	8	8	0		29	589	6	5
21	10	10	0		20	575	5	10
6	10	6	0	Circular, of 1 inch diameter.	60	247	4	3
11	8	11	0		60	324	1	5
22	0	2	0		60	444	6	5

The preceding Table gives a co-efficient of 0.625, which is not very different from 0.619, the mean co-efficient obtained by Bossut.

Smeaton and Brindley's experiments.

The following experiments were made by Messrs Brindley and Smeaton. The water extended over a very large surface, and the heights above the orifice were measured from the surface to the tops of the orifices.

Height of the surface above the tops of the orifices in Feet.	Nature of the orifices.	Time of running.	Quantity of Water discharged in cubic feet.
1	1 in. square	9 min. 22 sec.	20
2	1 do.	6 40	20
3	1 do.	5 20	20
4	1 do.	4 44	20
5	1 do.	4 14	20
6	$\frac{1}{2}$ do.	17 33	20
The co-efficient deduced from these experiments is 0.63.			

Sect. III. *On the quantities of Water discharged through openings in Reservoirs when very large, and in reaching to the surface.*

Discharge through large openings.

The following experiments were made by Messrs Brindley and Smeaton on the quantities of water discharged by rectangular notches, through which the water flowed from a very extensive surface. The first column contains the width of the notches in inches: the second contains their depth; the third contains the quantity of water discharged; and the fourth the time in which that quantity was discharged.

Discharge of Water from large Openings.

Table IV. *Containing Messrs Brindley and Smeaton's Experiments on the Quantities of Water discharged by rectangular Notches.*

Width of the notches in inches.	Depth in inches.	Quantity of water in cubic feet.	Time of discharging.	
6	1	20	7 min.	16 sec.
6	$1\frac{3}{8}$	20	4	55
6	$2\frac{5}{16}$	20	2	19
6	$3\frac{1}{8}$	20	1	33
6	$6\frac{1}{2}$	20	0	30
6	5	20	0	46
6	$1\frac{1}{4}$	20	5	26
6	$1\frac{3}{8}$	20	3	55
6	$5\frac{1}{8}$	20	0	42

The experiments of Bossut were not extended to any of the cases included in the present Section; but we are fortunately in possession of some good experiments by Du Buat on the quantity of water discharged over weirs and bars, which are cases in which the orifice extends to the surface.

Du Buat's experiments. PLATE CCCXVIII. Figs. 7, 8.

A *weir* or jetty is represented in Figs. 7, and 8. of Plate CCCXVIII. Weirs are most commonly erected as in Fig. 4. where BCD is a weir of solid masonry or of timber, with a strong plank AB, called the waste board, over which the water flows. In this case, therefore, the depth of the orifice is measured by the depth of the upper edge of the plank AB below the level surface of the water in the river or reservoir. Du Buat made four accurate experiments on this subject, the result of which is given in the following Table, reduced to English inches, the length of the orifice being $18\frac{1}{3}$ inches.

Table V. *Containing Experiments by Du Buat on the quantity of Water discharged over Weirs.*

Depth of the orifice in English feet.	Discharge of water in cubic feet observed.	Discharge calculated by the formula.
1.778	506	524
3.199	1222	1218
4.665	2153	2155
6.753	3750	3771

M. Buat has given the following formula reduced to English inches, by which column 3d has been calculated, which shews its near agreement with observation. The formula, as altered by Dr Robison, is

$$D = l\sqrt{130.032\,H^3}, \text{ or}$$

$$D = 11.4172\,l\,H^{\frac{3}{2}},$$

where D is the quantity of water discharged in cubic feet, l the length of the wasteboard, and H its depth. That is, *multiply the square root of the cube of the depth of the upper edge of the wasteboard below the surface by* $11\frac{1}{2}$, *and by the length of the wasteboard, and the product will be the quantity discharged in English inches.*

In deducing the preceding formula, M. Du Buat has assumed that AF, Fig. 7. is one half of AL, and that the quantity by which we must divide the square of the mean velocity per second, to have the height of fall which is due to it, was 726. Dr Robison, however, had occasion to examine a numerous set of experiments, in which AF was always less than $\frac{1}{2}$ of AL, and was nearly $\frac{1}{3}$, and in which the quantity of water discharged was greater than what is given by Du Buat's formula.

It appeared indeed that AF depended on the form of the wasteboard, as might have been expected. When the board was very thin and had a considerable depth, AF was much greater than when the board was thick or narrow, and placed on the top of a broad damhead, as in Fig. 8.

Du Buat's general formula, viz.

$$D = \tfrac{2}{3} l \sqrt{2\,G} \left(1 - (\tfrac{1}{2})^{\frac{3}{2}}\right) H^{\frac{3}{2}}$$ may be accommodated to any ratio between AF and AL, in place of the ratio of $\frac{1}{2}$ adopted in the formula. Thus, if $AF = m \times AL$, m being a fractional co-efficient less than 1, the formula becomes

$$D = \tfrac{2}{3} l \sqrt{2\,G}\,(1 - m^{\frac{3}{2}})\,H^{\frac{3}{2}}$$

Dr Robison has calculated the following Table from Du Buat's formula, which is suited to English inches.

Table calculated for weirs, by Dr Robison.

Table VI. *Containing the quantity of Water discharged over a Weir.*

Depth of the upper edge of the wasteboard below the surface in English inches.	Cubic feet of water discharged in a minute by every inch of the wasteboard, according to Du Buat's formula.	Cubic feet of water discharged in a minute by every inch of the wasteboard, according to experiments made in Scotland.
1	0,403	0,428
2	1,140	1,211
3	2,095	2,226
4	3,225	3,427
5	4,507	4,789
6	5,925	6,295
7	7,466	7,933
8	9,122	9,692
9	10,884	11,564
10	12,748	13,535
11	14,707	15,632
12	16,758	17,805
13	18,895	20,076
14	21,117	22,437
15	23,419	24,883
16	25,800	27,413
17	28,258	30,024
18	30,786	32,710

We have added to this Table a third column containing the quantities of water discharged, as inferred from experiments made in this country, and examined by Dr Robison, who found that they in general gave a discharge $\frac{1}{18}$ greater than that which is deduced from Du Buat's formula. We would recommend it therefore to the engineer to employ the third column in his practice.

The preceding Tables and formula suppose that the water from which the discharge is made is perfectly stagnant; but if it should happen to reach the opening with any velocity, we have only to multiply the area of the section by the velocity of the stream.

When the quantity of water discharged over a weir is known, the depth of the edge of the wasteboard, or H, may be found from the following formula.

$$H = \left(\frac{D}{11.4172\,l}\right)^{\frac{2}{3}}$$

Experiments of Michelotti.

The experiments of Michelotti give $0.2703 \sqrt{H}$ for the number of cubical inches discharged in a second over a weir when the height H is one inch, and the real discharge to the theoretical discharge as 9536 to 1000. These numbers, however, suppose the length of the weir to be infinite, or to be so great that the contraction at its two ends produces no perceptible effect in diminishing the discharge. The formula, therefore, of Michelotti includes only the contractions produced by the upper edge of the wasteboard.

Experiments of M. Eytelwein.

In order to calculate the discharge of rectangular orifices reaching to the surface, M. Eytelwein represents the velocity, which varies as the square root of the height, by the ordinates of a parabola and the quantity of water discharged by the area of a parabola $\frac{2}{3}$ of that of the circumscribing rectangle. Hence the quantity of water discharged may be found by taking $\frac{2}{3}$ of the velocity due to the mean height, and allowing for the contraction of the vein. This mode of calculation M. Eytelwein has found to agree wonderfully with the experiments of Du Buat already given, as well as with several accurate experiments of his own.

M. Eytelwein takes the case of a lake, in which a rectangular opening is made without any lateral walls, three feet wide, and reaching two feet below the surface of the water. In this case, as appears from the following Table of co-efficients given by that engineer, the co-efficient for finding the velocity as corrected for contraction, is 5.1. Hence H being the height, we have $\frac{2}{3}\sqrt{H} \times 5.1$; and since $H = 2$ feet in the present instance, we have the corrected mean velocity $= 4.8$ feet; and as the area is $3 \times 2 = 6$, the quantity of water discharged in a second is 28.8 cubic feet. Putting C for the co-efficient corrected for contraction, W the width of the aperture, and H its depth below the surface, we have the general formula,

$$Q = \tfrac{2}{3} \sqrt{H} \times C \times \overline{H \times W}$$

for the quantity of water in cubic feet according to Eytelwein.

As the same co-efficient answers for a weir of considerable extent, we may deduce from the preceding formula the depth or breadth necessary for the discharge of a given quantity of water. Thus let it be required in a lake with a weir three feet broad, and in which the water stands five feet above the weir, to know how much the weir must be widened in order that the water may stand a foot lower, we have the velocity $= \frac{2}{3}\sqrt{5} \times 5.1$, and the quantity of water $= \frac{2}{3}\sqrt{5} \times 5.1 \times 3 \times 5$; but as it is required that the height H shall be reduced one foot, or from 5 to 4, we have the velocity suited to this $= \frac{2}{3}\sqrt{4} \times 5.1$, and consequently the section will be

$$\frac{\frac{2}{3}\sqrt{5} \times 5.1 \times 3 \times 5}{\frac{2}{3}\sqrt{4} \times 5.1} = \frac{\sqrt{5} \times 3 \times 5}{\sqrt{4}} = 7.5\sqrt{5},$$

and the height is 4, the breadth must be $\frac{7.5}{4}\sqrt{5} =$ 4.19 feet.

On the discharge from vertical orifices of considerable magnitude with a constant head of water.

Plate CCCXVIII. Fig. 9.

If the surface of water always stands at the same height AB in the vessel ABCD, Fig. 9. and if the lateral orifice, of considerable magnitude, is *m n o p*, then we have only to determine by the preceding methods the quantities of water discharged by the open orifices *r p o s*, *r m n s*, and the difference between these quantities will give the discharge for the orifice *mnop*. The same result may be obtained with nearly the same accuracy, by taking the velocity due to the centre of gravity of the orifice below AD, and correcting it by its proper co-efficient.

The following Table contains Eytelwein's co-efficients for different cases connected with those which belong to the present section. The whole velocity due to the height is 8.04, and the diminished velocity arising from contraction is shewn in the last column.

Eytelwein's Table of co-efficients.

TABLE VII. *Containing Eytelwein's Co-efficients for Orifices of different kinds.*

No.	Nature of the Orifices employed.	Ratio between the theoretical and real discharges.	Co-efficients for finding the velocities in Eng. Feet
1.	For the whole velocity due to the height	1 to 1.00	8.04
2.	For wide openings whose bottom is on a level with that of the reservoir	1 to 0.961	7.7
3.	For sluices with walls in a line with the orifice	1 to 0.961	7.7
4.	For bridges with pointed piers	1 to 0.961	7.7
5.	For narrow openings whose bottom is on a level with that of the reservoir	1 to 0.861	6.9
6.	For smaller openings in a sluice with side walls	1 to 0.861	6.9
7.	For abrupt projections and square piers of bridges	1 to 0 861	6.9
8.	For openings in sluices without side walls	1 to 0.635	5.1

SECT. IV. *On the Quantities of Water discharged from Vessels kept constantly full, by additional Tubes adapted to circular Orifices.*

Discharge
rom addi-
ional tubes.
PLATE
CCXVIII.
Fig. 6.

IT was observed, even by Julius Frontinus, that a short tube inserted into an orifice, produced a greater discharge of fluid than would have been obtained by a simple orifice of the same area.[*] Guglielmini noticed the same fact, and explained it by an augmentation in the weight of the atmosphere. He regarded the velocity at the end CQ, (Fig. 6.) of the tube BOQC, as that which is due to the whole height AC, upon the erroneous supposition that the pressure at C is the same in a state of motion as in a state of rest. Guglielmini did not consider the diminution of discharge arising from the friction of the same surface of the tube BOQC, nor the augmentation of discharge arising from the form of the tube, and, by a singular concurrence, these errors mutually compensated each other in his experiments.

M. Mariotte considers the water as issuing at CQ, with a velocity which is a mean proportional between the velocities due to the heights AB and AC. Daniel Bernoulli explained the increased expenditure from additional tubes, by the theory of the conservation of living forces; and Euler and d'Alembert[†] were of opinion, that the pressure of the atmosphere were concerned in the production of the effect. It was reserved, however, for Venturi, as we have already seen in the preceding chapter, to explain the phenomenon in the most satisfactory manner. Before we proceed to give an account of his experiments, we shall lay before our readers a full view of the experiments of M. Bossut.

ossut's ex-
eriments,
ig. 10.

M. Bossut inserted in the bottom CD (Fig. 10.) of the reservoir ABCD, a cylindrical tube *m n o p* made of copper, well polished within: it was two inches in diameter, and two inches long. Having stopped the aperture *m n* by means of a cork, and filled the reservoir with water to the height of 11 feet 8 inches 10 lines above *m n*, he found, upon removing the cork, that the water did not follow the sides of the tube, but that the vein was contracted as in a simple orifice, and could not be made to fill the tube without giving it a greater weight. He therefore took a cylinder *m n o p*, 1 inch in diameter, and 2 inches long, in which the water readily filled the tube. In repeating these experiments, however, he thought of stopping the discharge within the reservoir, instead of without, by means of a circular plate M, covered with felt, and placed at the end of a handle L. Upon withdrawing the plate M, he was surprised to find that the water sometimes followed the sides of the tube, and sometimes refused to follow them; and he was at last able to produce the effect at pleasure, even when the length of the tube was reduced from 2 inches to 1 inch and 6 lines. When the length of the tube was reduced to half an inch, he could never succeed in making the water touch its sides. Between the interval of half an inch and 1½ inches, it is not easy to observe what takes place with certainty.

Bossut's experiments.

The following Table shews the results which M. Bossut obtained.

TABLE VIII. *Containing the Quantities of Water discharged by Cylindrical Tubes one inch in diameter and of different lengths, whether the Tubes were inserted in the bottom or in the sides of the vessel.*

Constant altitude of the fluid above the superior base of the tube 11 feet 8 inches and 10 lines.		
Lengths of the Tubes expressed in lines.		Cubical inches discharged in a minute.
The tube filled with the issuing fluid	48	12274
	24	12188
	18	12168
The tube not filled with the issuing fluid . .	18	9282

These results clearly prove, that the expenditure increases with the length of the tube, and that the quantities of fluid discharged are nearly as the square roots

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[*] Sed et calicis positio habet momentum, si in rectum et ad libram collocatus est; modum servat; et ad cursum aquæ si oppositus devexusque, amplius rapit; ad latus autem pretereuntis aquæ conversus et supinus, nec ad haustum pronus; segniter exiguumque sumit. Julius Frontinus *De Aquæductibus Urbis Romæ*, lib. i. juxta fin.

[†] See D'Alembert *Traité de l'Equilibre et du mouvement des Fluides*, § 149.

Discharge of Water through additional Tubes.

of the altitudes of the fluid above the interior orifice of the vertical tube.

It follows also from the above measurement, that *when the height of the reservoir and the orifice are the same, the theoretical discharge, the discharge by an additional tube, and the discharge by a simple orifice*, are nearly as the numbers 16, 13, 10. Hence Bossut concludes that the effect of contraction is not wholly destroyed by the tube, as the difference between the theoretical and the real discharges is too great to be ascribed to friction.

The following Table contains the effects produced by tubes of different diameters, and under different altitudes of fluid in the reservoir.

TABLE IX. *Containing the Quantities of Water discharged by Cylindrical Tubes two inches long, with different Diameters and under different heads of Water.*

Constant altitude of the water above the orifice.		Diameter of the tube.	No. of cubic inches discharged in a minute.
Feet.	Inches.	Lines.	
3	10	6 } The tube not filled with the issuing fluid.	1689
		10	4703
		6	1293
		10	3598
2	0	6	1222
		10	3402
		6	935
		10	2603

General results.

From these results we may conclude,

1. That the discharges by different additional tubes under the same head of water, are nearly proportional to the areas of the orifices, or to the squares of the diameters of the orifices.

2. That the discharges by additional tubes of the same diameter under different heads of water are nearly proportional to the square roots of the heads of water.

It follows, from the two preceding corollaries, in general, that the discharges during the same time, by different additional tubes, and under different heads of water in the reservoir, are to one another nearly in the compound ratio of the squares of the diameters of the tubes, and the square roots of the heads of water.

M. Bossut has deduced from the above experiments the following Table, which contains a comparative view of the theoretical discharges from a tube one inch in diameter, with the real discharges by an additional tube of the same diameter, under different heads of water. The last column, containing the ratio between these two discharges, was computed by M. Prony.

TABLE X. *Comparison of the Theoretical with the Real Discharges from an additional Tube of a cylindrical form, one Inch in Diameter and two Inches long.*

Constant altitude of the Water in the Reservoir above the Centre of the Orifice.	Theoretical Discharges through a circular Orifice one Inch in Diameter.	Real Discharges in the same time by a cylindrical Tube *one* Inch in Diameter and *two* Inches long.	Ratio of the theoretical to the real Discharges.
Paris Feet.	Cubic Inches.	Cubic Inches.	
1	4381	3539	1 to 0.81781
2	6196	5002	1 to 0.80729
3	7589	6126	1 to 0.80724
4	8763	7070	1 to 0.80681
5	9797	7900	1 to 0.80638
6	10732	8654	1 to 0.80638
7	11592	9340	1 to 0.80573
8	12392	9975	1 to 0.80496
9	13144	10579	1 to 0.80485
10	13855	11151	1 to 0.80483
11	14530	11693	1 to 0.80477
12	15180	12205	1 to 0.80403
13	15797	12699	1 to 0.80390
14	16393	13177	1 to 0.80382
15	16968	13620	1 to 0.80270
1	2	3	4

Hence it follows, that the velocity in English inches will be $V = 22.47\sqrt{H}$ for additional tubes. See p. 498. col. 2.

M. Prony has given the following formulæ, as deduced from the preceding Table. The letters have the same values as in p. 498.

$Q = 0.81\,AT\sqrt{2gH}$; but since $2g$ is constant, and is $= 7.77125$, we have

$$Q = 4.9438\,d^2\,T\sqrt{H},$$

From which we obtain

$$d = \sqrt{\frac{Q}{4.9438\,T\sqrt{H}}},$$

$$T = \frac{Q}{4.9438\,d^2\sqrt{H}},$$

$$H = \frac{Q}{(4.9438\,d^2\,T)^2}.$$

On the discharge of water by conical tubes.

When the interior surface of the additional tube is of a conical form, the quantities of water discharged undergo considerable variations. M. Bossut made no experiments whatever with tubes of this kind, but the defect is fortunately supplied by those of the Marquis Poleni, which are published in his work *De Castellis per quæ derivantur Fluvium Aquæ.*

TABLE XI. *Containing the Experiments of the Marquis Poleni, on the Quantities of Water discharged by Conical Tubes of different Diameters.*

Head of Water.	Length of the Tube.	Nature of the Orifices employed.	Diameter of the Inner Orifice.	Diameter of the Outer Orifice.	Quantity discharged in a Minute in Cubic Feet, as calculated by Bossut.	Time in which 73035 Cubic Inches were discharged.
Constant height of the water in the reservoir, 256 lines, or 1 foot 9 inches and 4 lines. French.	Length of each tube 92 lines, or 7 inches 8 lines. French.	Orifice in a thin plate,	26 lines		15877	4′ 36″
		Cylindrical tube,	26		23434	3 7
		1st Conical tube,	33	26 lines	24758	2 57
		2d Conical tube,	42	26	24619	2 58
		3d Conical tube,	60	26	24345	3 0
		4th Conical tube,	118	26	23687	5 3

Discharge of Water through additional Tubes.

The discharge in the preceding Table, for a simple orifice, is less than that which is given by Bossut, which appears to arise from his having used a measure of the cubic inch of water, which errs in excess. From Poleni's results, we may conclude,

1. That the real discharges are always less with conical tubes than the theoretical discharges, which, in the present case, is 27425 cubical inches in a minute; and,

2. That in augmenting to a certain degree the diameter of the inner orifice of the conical tube, the quantity of water expended is also augmented; but that, when this enlargement is pushed too far, there is a tendency to produce an exterior contraction of the vein of fluid, and thus to make the circumstances of the case the same as in simple orifices, in which the discharges are the least possible.

Discharge of Water through additional Tubes.

When the conical tube is placed with its smallest orifice in the reservoir, it will yield more water than a cylindrical tube, the diameter of whose orifice is equal to the smallest orifice of the conical tube.

Experiments of M. Venturi on tubes of various forms.

The best experiments on additional tubes, have been made by M. Venturi, and fully described in his valuable work on the lateral communication of motion in fluids. We have thrown them, in an abridged state, into the following Table, and have computed the numbers in the last column.

TABLE XII. *Containing the Experiments of Venturi on additional Tubes of various forms.*

	Height of Water.	Nature and Dimensions of the Tubes and Orifices.	Time in which 4 Paris cubic feet were discharged.	Number of cubic inches discharged in a minute.
	Inches. 92.5	1. Circular orifice, 18 lines in diameter,	41″	10115
		2. Cylindrical tube, 18 lines in diameter, and 54 lines long,	31	13378
g. 11.		3. Compound tube, Fig. 11. in which AC = GI = MN = 18 lines; DF = 14.5; AB = 11; BG = 10; GM = 37; AM = 58; the conical portion having nearly the form of the contracted vein,	31	13378
g. 11.		4. Conical tube AC DF, Fig. 11. with the rest removed,	42	
		5. A cylindrical pipe, 18 lines in diameter, and 54 lines long, having 12 small holes made in its circumference, at the distance of 9 lines from its inner orifice,	41	10115
		No water passed through the holes, and the stream did not fill the tube. The same effect was produced when all the holes are open, as when any number of them is shut, provided *one* is open.		
		6. The same pipe, with all the holes shut with wet skin. The stream now filled the pipe,	31	13378
g. 12.		7. Cylindrical tube, Fig. 12. 18 lines in diameter, and 57 lines long. The glass tube QRS was joined to the additional tube, and immersed in a coloured liquid T. The coloured liquid rose to S, 24 inches above T, and the time in which 4 cubic feet was expended was	31	13378
g. 11.		8. The compound tube of No. 3, or Fig. 11. in the same circumstances as No. 7.	31	13378
	27.5	9. The tube, No. 6, with its apparatus, was applied so as to throw the water upwards. The liquor rose 20 inches,	34	12198
		10. Simple orifice, 18 lines in diameter,	45	9216
	40.0	11. Simple orifice, 18 lines in diameter,	38	10915
g. 13.		12. Horizontal tube, partly conical and partly cylindrical, like Fig. 13. diameter at A = 18 lines, AD = 31 inches,	48	8640
		13. Same tube, placed vertically,	48	8640
		14. Simple orifice, 11.2 lines in diameter,	98	4232
		15. Tube of No. 12. placed horizontally, had AC of the form of the contracted vein, and the diameter A, 11.2 lines in diameter,	130	3190
		16. Tube of No. 15, placed vertically,	129	3213
	AB&F 32.5	17. Vertical tube BOCQ, diameter 18, length BC, 3 inches,	41	10115
		18. Ditto, 18, 12	38	10915
		19. Ditto, 18, 24	35	11828
. 6.		20. Horizontal tube BOCQ, 18, 3 Fig. 6.	42.5	9758
		21. Ditto, 18, 12	45	9216
		22. Ditto, 18, 24	48	8640
. 14.		23. Compound tube, Fig. 14. where AB = EF = 18 lines, AC = 11; CO = 15.5; CG = 49	27.5	15080
		24. A tube, consisting of a cylindrical tube 3 inches long and 15.5 lines in diameter, interposed between the two conical tubes of the preceding experiment	28.5	14551
. 15.		25. The tube of Fig. 15, ABCD had the same form as before, but CDEF was 78 lines long and 23 lines in diameter. Three glass tubes were added, as in the Figure, and immersed in mercury. The mercury rose 53 lines in DX, 20.5 in NP, and .7 in OZ	25	16560
		26. The same tube with the portion PNFE cut off	31	13378

Discharge of Water through additional Tubes.

PLATE CCCXVIII. Fig. 15.

Height of Water.	Nature and Dimensions of the Tubes and Orifices.	Time in which 4 Paris cubic feet were discharged.	Number of cubic inches discharged in a minute.
Inches. 32.5	27. The tube, Fig. 15. 148 lines long, and 27 in diameter at EF; the rest as in the last experiment	21″	19748
	28. When the last tube is prolonged to any length beyond 148 lines	21	19748
	29. Same tube 204 lines long, by fixing a prominence within the tube at O, so as to make the fluid fill the tube	19	21830
	30. Horizontal tube, Fig. 15. being made more divergent, 117 lines long and 36 in diameter, the rest remaining as before. The stream did not fill the whole section	28	14811
	31. By cutting off successive portions of the pipe until CE was only 20 lines long, and the external diameter 18 lines, the time always was	28	14811
	32. When CE was 20 lines, and EF 20, the stream was detached from the sides of the tube, and the time was	42	9874
Height above lower extremity.			
41.5	33. The tube, Fig. 15. was applied in place of BCQO of Fig. C	22	18850
23.0	34. The same tube, Fig. 15. applied to form an ascending jet	30	13824
Above upper extremity.		Time in which one cubical foot of water was discharged	
31.7	35. Simple orifice, 4.5 lines in diameter from vertical jet	161	644
	36. Ditto with an additional cylindrical tube of the same diameter, and ten lines long	121	856
56.	37. The orifice of No. 35. with a vertical jet	123	843
	38. Ditto with an additional cylindrical tube of § 36.	91	1139

Conclusions from Venturi's experiments.

The preceding Table contains a general abstract of the numerous experiments of Venturi, which were made publicly in the Theatre of Natural Philosophy at Modena. The following are the conclusions which he has deduced from them.

1. If the part of the additional tube nearest the reservoir has the form of the contracted vein, the expenditure will be the same as if the tube were not contracted at all.

This proposition is deduced from experiments 1, 2, 3, 4.

2. The pressure of the atmosphere increases the expence of water through a simple cylindrical tube when compared with that which flows through a simple orifice, whatever be the direction of the tube.

This proposition is deduced from experiments 5, 6, 7, 8, 9, 10.

3. In descending cylindrical tubes, the upper ends of which have the form of the contracted vein, the quantity of water discharged is that which corresponds with the height of the fluid above the inferior extremity of the tube.

This proposition, which has been established theoretically in the preceding Chapter, is likewise deducible from experiments 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22.

4. In additional conical tubes, the pressure of the atmosphere increases the expenditure in the proportion of the area of the external section of the tube to the area of the section of the contracted vein, whatever be the position of the tube, provided that its internal figure is adapted throughout to the lateral communication of motion.

This proposition is established by experiments 23—33. These experiments also shew, that, by varying the divergence of the sides of the tube, the lateral communication of motion has a maximum and a minimum effect. The minimum is seen in experiment 32. The lateral communication of motion appears to cease to produce its effect when the angle of the sides of the tube exceeds 16°. Experiment 23d nearly determines the maximum effect when the same angle is about 30°.

5. The quantity of water discharged is less through cylindrical tubes than through conical tubes which diverge from the commencement of the contracted vein, and have the same exterior diameter.

This is established by experiments 35, 36, 37, 38.

6. By applying proper adjutages to a given cylindric tube, the expenditure of water through that tube may be increased in the ratio of 25 to 10, the head of water remaining the same.

PLATE CCCXVIII. Fig. 16.

In order to produce this singular effect, the inner extremity of the tube AD must be filled with a conical piece of the form of the contracted vein, which will increase the expenditure from the ratio of 12.1 to 10. At the other extremity of the pipe BC apply a truncated conical tube CD, of which the length must be nearly nine times the diameter at C, and its external diameter D must be 1.8 C. This additional tube will increase the expenditure in the ratio of 24 to 12.1, by experiment 27. Hence the expenditure will be increased by the two pieces in the ratio of 24 to 20.

Experiments on the Expenditure of Bent Tubes.

Venturi's experiment on bent tubes. Fig. 17.

In order to ascertain the effects of bent tubes, M. Venturi employed two tubes ABC, DEF, 15 inches long, and 14.5 lines in diameter. The portions A, D have the form of the *vena contracta*, and were applied to the orifice of a reservoir, which was 18 lines in diameter, and in which the water was 32.5 inches high. The elbows or flexures BC, EF were made in the plane of the horizon. The tubes were made of copper soldered with silver, and the curvature BC was produced by filling the tube with melted lead, in order that the tube might preserve its diameter during the act of bending. The elbow DEF was rectangular. A rectilineal tube of similar dimensions was also tried, and the following were the results.

Discharge of Water through additional Tubes.

	Four cubical feet were discharged in
Rectilineal tube	45″
Curved tube	50
Rectangular tube	70

Experiments of Du Buat on ent tubes.

The following results were obtained by Du Buat, respecting the effects produced by bent tubes 1 inch in diameter, and of different lengths.

	Number of Bendings.	Angle of the bending.	Velocity per second both in straight and bent tubes in inches.	Augmentation of the head of water which overcomes the resistance at the flexure.	Augmentation of the head calculated from the formula.
				Inches.	Inches.
Tube 1 inch in diameter and 117 inches in length.	3	36° 0	84.945	2.49	2.49
	2	36 0	84.945	1.5	1.66
	4	24 34	84.945	1.5	1.66
	3	24 34	84.945	1.12	.1.24
	1	36 0	84.945	0.75	0.83
	2	24 34	84.945	0.75	0.83
	1	24 34	84.945	0.37	0.41
	10	36 0	71.59	5.905	5.905
Tube 138 inches long.	4	36 0	58.808	1.64	1.59
Tube 117 inches long.	4	36 0	58.438	1.5	1.57
	2	36 0	58.438	0.75	0.78
	4	24 34	58.438	0.75	0.78
	1	36 0	58.438	0.37	0.39
Tube 138½ inches long.	4	36 0	29.33	0.41	0.396
Tube 737 inches long.	4	36 0	28.657	0.39	0.378

The last column of the preceding Table is computed from the formula $\frac{V^2 s^2 n}{m}$; V being the velocity, *s* the sine of the angle of the bending, *n* the number of bendings, and *m* a constant quantity, which is found to be nearly 300. Hence $\frac{V^2 s^2}{300}$ is the measure of the resistance.

PLATE CCCXVIII. Fig. 18.

M. Venturi employed a tube of the form shewn in Fig. 18. The orifice A has the form of the contracted vein, and the rest of the tube is interrupted by various enlargements of its diameter. The following are its dimensions.

	Lines.
Diameter at A	11.2
Diameter at B, C, F, G,	9
Diameter of the enlarged parts	24
Length of BC, FG, &c.	20
Length of CD, EF, GH,	13

The length of the enlarged parts was variable, being at one time 38, and another 76 lines, with the same effect in both.

By means of this tube, the following results were obtained under a pressure of 32.5 inches.

Number of enlarged parts.	Time in which four cubical feet of water were discharged.
0	109″
1	147
3	192
5	240

Venturi afterwards applied to the same orifice a tube having the same form and the same diameter as ABC, but cylindrical throughout, and without any enlargements. It was 36 inches long, and the time in which four cubic feet were expended was 148″.

Discharge of Water through additional Tubes.

"When the fluid passes from C," says Venturi, "to the middle of the enlarged part DE, part of the motion is directed from the direction CF towards the lateral parts of the enlargement. This part of the motion is consumed in eddies, or against the sides. Consequently there remains so much the less motion in the following branch FG. This is also the cause which destroys or weakens the pulse in the arteries beyond an aneurism.

"From this consideration we are justified in concluding, that if the internal roughness of a pipe diminishes the expenditure, the friction of the water against these asperities does not form any considerable part of the cause. A right lined tube may have its internal surface highly polished. Throughout its whole length it may every where possess a diameter greater than the orifice to which it is applied; but, nevertheless, the expenditure will be greatly retarded if the pipe should have enlarged parts or swellings. This is a very interesting circumstance, to which perhaps sufficient attention has not been paid in the construction of hydraulic machines. It is not enough that elbows and contractions are avoided; for it may happen, by an intermediate enlargement, that the whole advantage may be lost which may have been procured by the ingenious dispositions of the other parts of the machine."

Eytelwein's Experiments on additional Tubes.

Eytelwein's experiments.

The experiments of M. Eytelwein on additional tubes confirm the general results obtained by Venturi. The following are the leading results which he obtained:

	Ratio of the Discharges.	Co-efficients for the velocity.
Shortest tube that will cause the stream to adhere every where to its sides	.8125 to 1.0000	6.5
Short tubes, having their lengths from 2 to 4 times their diameters	.82	6.6
Conical tube approaching to the form of the *vena contracta*	.92	7.38
The same tube with its edges rounded off	.98	7.86
A tube projecting within the reservoir	.50	4.0

M. Eytelwein is of opinion, that Venturi's assertion that the discharge of a cylindric tube may be increased in the ratio of 24 to 10, is not generally correct, and that when the tube is very long, scarcely any additional expenditure is obtained by the addition of such a tube. From a great number of experiments which he made with different pipes, he infers that a compound conical pipe, such as that shewn in Fig. 16, may increase the discharge to 2½ as much as through a simple orifice, or as 24 to 10, as stated by Venturi, or to more than half as much more as would fill the whole section with the velocity due to the height; but that where a considerable length of pipe intervenes, the additional orifice appears to have little or no effect.

Exhaustion of Vessels.

Michelotti's experiments.

Michelotti made many experiments for determining the real form of the *vena contracta*. He constructed a great variety of ajutages resembling it, till he found one which gave the greatest discharge. This ajutage was formed by the revolution of a trochoid round the axis of the jet. The diameter of the outer orifice was 36, that of the inner orifice 46, and the length of the axis was 96. This ajutage gave .9831 to 1000 as the ratio of the real to the theoretical discharge. The following are Michelotti's results:

Theoretical discharge	1.0000
Trochoidal ajutage	9831
Tube 2 diameters long	8125
For a tube projecting into the reservoir, and flowing full	6814
For do. when the vein was contracted	5134

SECT. V. *Experiments on the Exhaustion of Vessels.*

On the exhaustion of vessels.

We have already seen, in stating the general principles of hydraulics, that a funnel-shaped cavity is formed in the surface of a fluid, when, in the course of its descent, it has nearly reached the orifice from which the fluid is discharged. This circumstance renders it impossible to determine the exact time in which a vessel is completely emptied. The superincumbent pressure of the head of water being removed by the formation of the funnel-shaped cavity above the orifice, the water is at last discharged in successive drops. M. Bossut therefore abandoned the idea of attempting to measure the time of emptying vessels, and confined his experiments to the determination of the time in which the upper surface of the fluid descends through a certain vertical height in prismatic vessels, in which the area of the horizontal section is constant. The following Table contains the results of his experiments.

TABLE XII. *Shewing the times in which Prismatic Vessels are partly exhausted.*

Altitude of the water in the reservoir 11.6666 Paris feet.

Constant area of a horizontal section of the vessel in square feet.

Diameter of the circular orifice.	Depression of the upper surface of the fluid.	Time in which the depression takes place, according to experiment.		Time of the depression of the surface by the formula.		Difference between the theory and the experiments.
Inches.	Feet.	Min.	Sec.	Min.	Sec.	Seconds.
1	4	7	25½	7	22.36	3.14
2	4	1	52	1	50.59	1.41
1	9	20	24½	20	16	8.50
2	9	5	6	5	4	2.00

The first column of the Table contains the diameter of the circular orifice; the second the depression of the upper surface of the fluid in feet; the third the time in which the surfaces descend through this height, according to experiment; the fourth contains the time as calculated from the formula in Chapter I. corrected by substituting 0.62 A instead of A, in order to make allowance for the effect of contraction. The numbers in column fourth always err in defect, probably from 0.62 being taken too great. If the orifices are vertical, the altitude of the fluid must be measured from their centre of gravity.

Exhaustion of Vessels.

Venturi's experiments.

A few experiments on the partial exhaustion of vessels were made by M. Venturi. An orifice, 4.5 lines in diameter, was made near the bottom of a cylindrical vessel 4.5 inches in diameter. The altitude of the water in the vessel was 8.3 inches above the centre of the orifice. The surface of the water was then depressed 7 inches in 27½ seconds. A cylindrical tube, of the same diameter as the orifice, and 11 lines in length, was applied to the same orifice. The vessel was filled to the same height as formerly, and its surface descended 7 inches in 21 seconds of time. These experiments were afterwards repeated under the receiver of an air pump, in which the mercurial gauge stood only at the height of 10 lines, and the surface of the fluid was depressed 7 inches, whether the water flowed through the simple orifice, or the cylindrical tube.

SECT. VI. *Experiments of Bossut on the discharge of Water into a submerged Vessel.*

On the discharge of water into a submerged vessel.

PLATE CCCXIX. Fig. 1.

In order to examine the discharge of water into submerged vessels, M. Bossut employed a vessel ABCD, Fig. 1. two feet in diameter, in which a white-iron cylinder VMNT, 1 foot high, and 20 lines in diameter, was immersed. This cylinder is supported on a tripod, so that it can be set in a vertical line, and is furnished with graduated scales for measuring the water which it receives. The orifice in the cylinder VMNT being shut, water is poured into the vessel till it reaches a certain height, and when the orifice is opened, the water rushes in and fills the cylinder. The following are the results of Bossut's experiments.

Depth of immersion or HM.	Diameter of the orifice.	Time in which the water rises to H on a level with the water in the vessel.	Calculated time.
11 inches	1 line	119 seconds.	155.97
11	3	15	17.33

The fourth column contains the time, as calculated from theory, which differs very considerably in the first experiment from the observed time. M. Bossut accounts for this, by saying, that at the first entrance of the water, a jet is formed which penetrates the plate of water in the cylinder VMNT, till it stands at a certain height, when the surface of the water becomes level. Now as this jet will continue longer with small than with large orifices, a greater quantity of water, in proportion, ought to be discharged. Bossut also made the following experiments.

Exp. 1. When the water entered the cylinder by an orifice one inch in diameter, it was necessary to immerse the cylinder 8 inches and 11 lines in the water of the vessel, in order that the water might raise itself to the upper margin VT of the vessel.

Exp. 2. The bottom MN being wholly removed, the cylinder required to be immersed 7 inches and 7 lines, in order that the water might rise to the upper margin VT.

Exp. 3. When a large plate of white-iron was put round MN, it was necessary to sink the cylinder 6 inches 11½ lines, in order that the water might rise to the upper margin VT.

SECT. VII. *Bossut's Experiments on the Motion of Water in a Vessel crossed with Diaphragms.*

Motion of water in a vessel with diaphragms.

The experiments of Bossut on this subject were made xhaustion f Vessels.

LATE CCXIX. gs. 2, 3.

with two vessels ABCD, DCBA, Fig. 2. and Fig. 3. whose internal diameter is 6 inches, and height 3 inches. The length of ED was one foot, and EA two feet. The diaphragm EF was pierced with an aperture G, 6 lines in diameter; covers DC, AB with different orifices, were placed successively on the cylinder, and the cylinders were inverted, as shewn in the two Figures. A narrow opening, 18 lines broad, was cut through the whole length of the cylinders, and covered up with glass, in order to see what was going on within, and near the diaphragm EF was perforated a small aperture *t*, which could be either opened to admit the air, or shut up with wax. The following results were then obtained.

ig. 2.

Exp. 1. The cylinder Fig. 2. being completely filled, and the hole *t* shut, orifices of 6, 12, and 21 lines were successively applied. In all these cases the water in the lower compartment abandoned the diaphragm when the height EH of the water was about 6 or 7 lines. At the instant of separation a whistling noise was heard, arising from the passage of the air from the upper to the under compartment.

ig. 3.

Exp. 2. By inverting the cylinder as in Fig. 3. and applying the same orifices, the very same effects were produced.

Exp. 3. The vessel having the position in Fig. 2. the hole *t* being now opened, and the orifice at M being 6 lines, the separation took place when EH was about 14 inches.

Exp. 4. When the diameter of the orifice at M was four lines, the separation took place when EH was six inches.

SECT. VIII. *Experiments on the ascent of Water in Jets d'eau, either vertically or obliquely.*

Experiments on Jets d'eau.

On jets d'eau.

THE custom which formerly prevailed of decorating pleasure grounds and public squares with jets d'eau, rendered the subject of the present Section much more interesting than it is at present. The phenomena of jets, however, are still of importance in a scientific point of view; and as the fashions of former times may again return, it would be inexcusable to omit altogether the consideration of this branch of Hydrodynamics.

According to the theory of vertical jets, which has already been explained under Chap. I. of Part II. they ought to rise to the same height as that of the surface of water in the reservoirs from which they flow. This, however, is not found to be the case in practice. The friction of the water on the sides of the tubes, the resistance of the air, and the obstruction of the descending drops, all conspire in diminishing the altitude to which water would otherwise be projected.

PLATE CCCXIX. Figs. 4, 5.

In the experiments made by Bossut, he employed a large reservoir ABCD, Fig. 4. and 5. to which he fitted horizontally two tubes BE of white iron, closed at the end E, and open at the end next the reservoir. Each of these was six feet long. The diameter of the first was 3 inches 8 lines, and that of the second from 9 to 10 lines, and on the upper surface of these tubes ajutages of different sizes were placed. Around the ends of each ajutage was soldered a tube of white iron, whose diameter was greater than that of the ajutage, in order to be able to stop the jet by means of cork, which goes into the white iron tubes. The following Table contains the results of the experiments.

TABLE XIII. *Shewing the Altitudes to which Jets rise through Ajutages of different forms, the Altitude of the Reservoir being Eleven Feet, reckoning from the upper surface of the horizontal Tubes OE, OE. Fig. 4. and 5.*

Diameter of the horizontal tubes CE, CE, each being 6 feet long.		Form of the Orifices.	References to Fig. 4. and 5.	Diameter of the Orifice.	Altitude of the Jet when rising vertically, reckoning from OF.			Altitude of the Jet when inclined a little to the vertical.			Description of the Jets.
Inch.	Lines.			Lines.	Feet.	Inch.	Lines.	Feet.	Inch.	Lines.	
3	8	Simple orifice,	F	2	10	0	10	10	4	6	The vertical jet very fine.
3	8	—	G	4	10	5	10	10	7	6	The vertical jet fine, and not much enlarged at the top.
3	8	—	H	8	10	6	6	10	8	0	All the jets occasionally rise to different heights. This is very perceptible in the present experiment. The vertical jet is much enlarged at top. The inclined one less so, and more beautiful.
3	8	Conical tube,	M	Length, 70 Lower diameter, 9 Upper diameter, 4	9	6	4	9	8	6	The vertical jet fine.
3	8	Cylindrical tube,	N	Length, 70 Diameter, 4	9	1	6	7	3	6	The vertical jet is very fine.
0	9½	Simple orifice,	M	2	9	11	0	—	—	—	The jet is here fine.
0	9½	—	L	4	9	7	10	—	—	—	The jet is much deformed, and very much enlarged at top.
0	9½	—	K	8	7	10	0	—	—	—	The column is much broken; and the successive jets are detached from each other.

General results.

In comparing the three first experiments, it appears that great jets rise higher than small ones. This arises from the greater mass of the large jets; for as both of them are projected with the same velocity, the large ones having a greater momentum, are more able to overcome the obstacles which are opposed to them. This, however, is true only of high jets. For when they do not exceed two or three feet in height, and when the ajutages are not below one line in diameter, small jets rise to the same height as large ones. This conclusion must also be limited to the case where the conduit pipe OE affords a sufficient supply of water; for it appears from the three last experiments, when the conduit tube OE is very narrow, that the small jets rise to a greater height than large ones. Hence there is obviously a certain ratio which must exist between the diameter of the horizontal tube and that of the ajutage, to produce a maximum height in the jet.

In order to find this ratio, Bossut has given the following method. Let D be the diameter of the tube, d that of the orifice, v the velocity of the water in the tube, and h the altitude of the fluid in the reservoir. Now $\sqrt{h}$ may be taken as the constant velocity at the ajutage. But by HYDRAULICS, Chap. I. Prop. 1. $\sqrt{h}:v=D^2:d^2$, and $v=\frac{d^2}{D}\sqrt{h}$. In like manner, in any other tube, in which D' d', h' and v' represent the same quantities as before, we have $v'=\frac{d'^2}{D'^2}\sqrt{h'}$. But upon the hypothesis, which is conformable to experiment, that two jets will each rise to the greatest possible height when the velocities of the water in the two conduit tubes are equal, we have $v=v'$ and $\frac{d^2}{D^2}\sqrt{h}=\frac{d'^2}{D'^2}\sqrt{h'}$; consequently, $D^2:D'^2=d^2\sqrt{h}:d'^2\sqrt{h'}$; that is, *the squares of the diameters of the horizontal tubes ought to be to each other in the compound ratio of the squares of the diameters of the ajutages, and the square roots of the heights of water in the reservoir.*

Hence, if we know from one direct experiment the diameter which a tube ought to have to supply a given ajutage under a given height of fluid in the reservoir, we may find the diameter of every other tube which is necessary to supply any other ajutage under a given height of fluid in the reservoir.

With this view, M. Bossut made the following experiments. He applied a tin tube one inch in diameter to a reservoir. The point of the tube, bent upwards in order to project the water vertically, was made of lead, and was a little more than an inch long, and to the extremity of it seven different orifices were successively applied. The following were the results.

TABLE XIV. *Containing the Experiments of Bossut on the Height of Jets with different Orifices.*

Diameter of the Ajutage.	Height of the Jet.		
Lines.	Feet.	inches.	lines.
1	3	1	6
2	3	1	8
3	3	2	0
4	3	1	7
5	3	1	5
6	3	0	4
7	2	10	6

From these results it follows, that for a height of water in the reservoir of 3 feet 2 inches and 11 lines, and a conduit tube which has a diameter of 1 inch, the diameter of the orifice should be about $3\frac{3}{4}$ lines. Now Mariotte found from experiment, that for a head of water of 52 feet, and an ajutage 6 lines in diameter, the diameter of the conduit tube should be 36 lines; whereas the preceding rule will give 38, agreeing very nearly with the experimental result.

It appears, from a comparison of the experiments of Bossut and Mariotte, that the *differences between the height of vertical jets and the height of the reservoir are nearly as the square of the heights of the jets themselves.* Hence, if we know this difference in once case, the difference in any other will be found by simple proportion. If the height of the reservoir of the second jet is given, and if it is required to determine the height of the jet, we must resolve a quadratic equation. Thus, let a be the height of the reservoir of the experimental jet, b the height of the same jet, c the height of the reservoir of the proposed jet, x the height of the proposed jet; then by the rule $a-b:c-x=b^2:x^2$, we obtain

$$x^2=\frac{b^2(c-x)}{a-b}, \text{ or } x=\frac{-b^2+b\sqrt{(4ac-4bc+b^2)}}{2(a-b)}$$

In order to facilitate the application of the preceding principles to practice, Bossut has computed the following Table:

TABLE XV. *Containing the Altitudes of Reservoirs, the Diameters of the Horizontal Tubes, &c. for Jets of different heights.*

Altitude of the jet.	Altitude of the reservoir.		Quantity of water discharged in a minute from an ajutage 6 lines in diameter.	Diameters of the horizontal tubes suited to the two preceding columns.
Paris Feet.	Feet.	Inch.	Paris Pints.	Lines.
5	5	1	32	21
10	10	4	45	26
15	15	9	56	28
20	21	4	65	31
25	27	1	73	33
30	33	0	81	34
35	39	1	88	36
40	45	4	95	37
45	51	9	101	38
50	58	4	108	39
55	65	1	114	40
60	72	0	120	41
65	79	1	125	42
70	86	4	131	43
75	93	9	136	44
80	101	4	142	45
85	109	1	147	46
90	117	0	152	47
95	125	1	158	48
100	133	4	163	49

The two first columns, containing the heights of the jets and the corresponding altitudes of the reservoirs, are taken from Mariotte. The heights of the jets and of the reservoirs not included in the Table, may be found from the preceding formula. The third column contains, in Paris pints, of which 36 form a cubic foot, the water discharged in a minute by an ajutage six lines in diameter; and the fourth column contains the diameter which ought to be given to the conduit tubes for an ajutage of six lines relatively to the altitudes in column 2. This column is computed on the hypothesis, that for an ajutage six lines in diameter, and an altitude of 16 feet of water in the reservoir, the conduit tube must be $28\frac{1}{2}$ lines in diameter, and upon

Experiments on Jets d'eau.

the principle that the squares of the diameters of the conduit tubes are as the squares of the diameters of the ajutages multiplied by the square roots of the altitude of water in the reservoir.

It appears from a comparison of columns 5th and 6th of Table XIII. that the jets never reach the height of the reservoir, and that a small inclination of the jet causes it to rise higher than when it is projected vertically, a fact which was long ago observed by Wolfius. (See *Elementa Matheseos Universæ*, tom. i. p. 802. schol. 4.) The diminution of the height of the jet has been very properly ascribed by Wolfius principally to the gravity of the falling waters, which obstruct the ascent of the water which is rising. When the velocity of the foremost particles of water is spent, the particles immediately behind strike against them, and lose their velocity, and in consequence of this constant collision between the ascending and descending particles, the jet continues at an altitude less than that of the reservoir. This consideration also affords a reason why the height of the jet is increased, by giving it a slight inclination; for the descending fluid falling a little to one side, no longer opposes the ascent of the rising fluid. In proof of the opinion that the diminution of the jet is produced by the gravity of the falling water, Wolfius states that he has found that mercury rises to a still less altitude than water.* This, however, is not owing to the greater specific gravity of mercury; for though the particles of mercury are heavier than those of water, yet the momentum with which they ascend is proportionally greater, and therefore there is the same ratio between the momentum and the resistance which opposes their ascent, as there is in the case of water.

Toricellius † seems to have been the first who observed, that when the water is first projected from the orifice it generally springs higher than the height at which it permanently settles, which no doubt arises from there being at first no descending fluid to retard its vertical ascent. Another phenomenon however, more remarkable, has been noticed by other authors. When the water first escapes from the orifice, it generally springs higher than the reservoir from which it flows, but the elevation is momentary, and the water speedily settles at a constant height. This fact has been ascribed to the elasticity of the air which follows the water in its passage through the orifice; but it is manifest that this would only diminish its specific gravity, as in the hydreoles of M. Mannoury Dectot, (see page 485,) and would never give an additional impulse to the ascending fluid. In order to explain this phenomenon, Bossut supposes the ajutage to be stopped, and that the air which follows the water accumulates near the orifice in a condensed state; as soon therefore as the orifice is opened, the elasticity of the included air causes it to escape with rapidity, and the water rushing into the space which it leaves, acquires by this short fall in the tube a certain velocity, which increases at the orifice in the ratio of the section of the orifice to the section of the tube.

n oblique ts.

In Chap. I. of HYDRAULICS, we have considered the theory of oblique jets. The following experiments were made by Bossut.

Experiments on Jets d'eau.

Height of the water above the orifice. Feet.	Diameter of the ajutage. Lines.	Height of the ajutage above a horizontal plane.			Amplitude of projection on a horizontal plane.		
		Ft.	in.	lin.	Ft.	in.	lin.
9	6	4	3	7	12	3	3
4	6	4	3	7	8	2	8

Hence it follows, that the real amplitudes, which are always less than those deduced from theory, are nearly as the square roots of the altitudes of the water in the reservoirs. In order to find the amplitude of any other jet, when the height of the water in the reservoir is 25 feet, we have $\sqrt{9}:\sqrt{25}=11$ feet 3 inches 3 lines : 18 feet 9 inches 5 lines.

Venturi's experiments on oblique jets.

The following experiments on oblique jets were made by M. Venturi and M. Michelotti.

Height of the water in the reservoir. Inches.	Nature of the orifice.	Height of the ajutage above a horizontal plane. Inches.	Amplitude of projection. Inches.
32.5	A simple orifice	54	81.5
32.5	Additional tube	54	69
	Plate CCCXVIII. Fig. 5.		
	A simple orifice	19.33	23.2
	Additional tube	19.33	20

PLATE CCCXVIII. Fig. 5.

M. Bossut took a tube, and having filled it with water, he allowed it to empty itself by orifices of different sizes. When no orifice was added, but when the tube was allowed to empty itself, the water did not issue with the greatest velocity when the tube was fullest, but when a certain quantity of the water had run out. In the case of small ajutages, the greatest velocity, and the greatest amplitude of projection, is always that which is due to the corresponding height of water in the reservoir; but, in very large orifices, this relation does not exist.

CHAP. IV.

ON THE MOTION OF WATER IN PIPES AND OPEN CANALS.

Motion of water in pipes and open canals.

THERE is perhaps no branch of science so highly important as that part of Hydrodynamics which relates to the conveyance of water in pipes and canals, and there is none in which theory affords the engineer so little assistance.

When it is required to supply a town with water, the first step of the engineer is to discover one or more springs situated above the level of that part of the town from which the water is to be distributed to private houses, and to the public fountains. The water discharged by the springs is then to be collected into one or more reservoirs, and conduit pipes of lead, or wood, or iron, are then to be laid to convey the water to the principal reservoirs in the town. The quantity of water which is necessary for the supply of the inhabitants having been previously ascertained, an additional allowance being made for the probable extension of the

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* "Ego quidem multum tribuo gravitati aquæ ascendentis, quia observavi quod argentum vivum ad minorem altitudinem elevatur quam aqua. Nimirum guttarum anteriorum motus si languescit, posteriores in eas incurrentes retardantur: id quod ipsismet oculis suis videre poterit, qui aquas salientes attentius contemplare voluerit. Atque inde est quod si lumen angulo quantolibet exiguo inclinetur, ut aqua saliens a perpendiculo non admodum declinare videatur, saltus altitudo statim major evadat." Wolfii *Elementa Matheseos Universæ*, tom. i. p. 802. Schol. 4.

† *De Motu Projectorum*, lib. iii. or his *Opera Geometrica*, p. 192.

town, the engineer has next to consider what diameter of pipe is necessary to convey the quantity of water required. The quantity of water discharged will obviously depend upon the diameter of the conduit pipe, and on the velocity with which the water issues from it. Hence, if we can find the velocity of the water, the diameter will be easily ascertained.

The experiments of which we have already given a full account, enable us to determine, with very great accuracy, the velocity with which water will issue from an orifice of any form, or from short cylindrical or conical tubes, either simple or compound; and hence we can easily ascertain the velocity with which the water will enter the pipe, or its *initial velocity;* but these experiments afford us no assistance in ascertaining the various obstructions which the water suffers in its passage, so as to determine the velocity with which it issues from a pipe of a given length and diameter.

In order to obtain practical rules relative to this interesting subject, many valuable and laborious experiments have been made. The most celebrated individuals who have devoted their attention to this branch of hydrodynamics, are Bossut, Du Buat, M. Prony, and M. Girard, by whose labours the art of conducting water has been brought to a very high degree of perfection. It shall therefore be our principal object in the present Chapter to give an account of the experiments of these eminent individuals.

SECT. I. *Account of the Experiments of Bossut and Couplet on the Motion of Water in Conduit Pipes and Open Canals.*

Experiments of Bossut.

THE experiments of Bossut were made upon an eminence near the springs by which the town of Mezieres is supplied with water. Two reservoirs were excavated, one of which furnishes water to the second, in which it stood at a constant height. The first of these reservoirs contained from 25 to 30 cubic toises of water, and the second was considerably less in magnitude, so as to contain only about six cubic toises of water when it stood at its greatest height, which was about 4½ feet. A horizontal tube of white iron, about eight or nine inches in diameter, communicated with the bottom of the small reservoir, and terminated in a cubical box of white iron, about one foot broad, and shut up on all sides. To one of the vertical faces of this box, were fitted perpendicularly two straight pipes of white iron, one of which had sixteen lines of interior diameter, and the other twenty-four lines. Various lengths of these pipes were employed, between 30 and 180 feet. At different distances, small holes were perforated, in order to facilitate the exit of the included air. These apertures were afterwards stopped up by a little wax. In this way, M. Bossut obtained the results contained in the following Table.

TABLE I. *Containing the Quantities of Water discharged by Conduit Pipes of different lengths and diameters, compared with the Quantities discharged from additional tubes inserted in the same Reservoir.*

Constant altitude of the water in the reservoir above the axis of the tube.	Length of the conduit Pipes.	Quantity of water discharged in a minute by an additional tube.	Quantity of water discharged by the conduit pipe in a minute.	Ratio between the quantities of water furnished by the tube and the pipe of 16 lines diameter.	Quantity of water discharged by an additional tube in a minute.	Quantity of water discharged by the conduit pipe in a minute.	Ratio between the quantities of water furnished by the tube and the pipe of 24 lines diameter.
		Tube and Pipe 16 lines diam.			Tube and Pipe 24 lines diam.		
Feet.	Feet.	Cubic Inches.	Cubic Inches.		Cubic Inches.	Cubic Inches.	
1	30	6330	2778	100 to 43.89	14243	7680	100 to 53.92
1	60	6330	1957	100 to 30.91	14243	5564	100 to 39.06
1	90	6330	1587	100 to 25.07	14243	4534	100 to 31 83
1	120	6330	1351	100 to 21.34	14243	3944	100 to 27.69
1	150	6330	1178	100 to 18.61	14243	3486	100 to 24.48
1	180	6330	1052	100 to 16.62	14243	3119	100 to 21.90
2	30	8939	4066	100 to 45.48	20112	11219	100 to 55.78
2	60	8939	2888	100 to 32.31	20112	8190	100 to 40.72
2	90	8939	2352	100 to 26.31	20112	6812	100 to 33.87
2	120	8939	2011	100 to 22.50	20112	5885	100 to 29.26
2	150	8939	1762	100 to 19.71	20112	5232	100 to 26.01
2	180	8939	1583	100 to 17.70	20112	4710	100 to 23.41
1	2	3	4	5	6	7	8

Explanation of the Table.

This Table contains two sets of experiments, one set on the relative quantities of water discharged by an additional tube 16 lines in diameter, and a pipe of various lengths of the same diameter; and another set on the relative quantities discharged by an additional tube 24 lines in diameter, and a pipe of various length and of the same diameter. The fifth and eighth columns contain the ratios of these discharges, which are also the ratios of the velocities with which the water issues from the additional tube and the extremities of the pipes.

Even at the short length of 30 feet, the velocity with which the water issues from the pipe is nearly one half of that with which it issues from the tube, and when the pipe is 180 feet long, and its diameter 16 lines, the ratio of the velocities is only 100 to 16.6, so that the water has lost 5-6ths of its initial velocity by its friction on the sides of the pipe.

It is obvious from a comparison of columns 5 and 8, that the diminution of the velocity is greatest in small pipes; a result which arises from the friction having a much greater effect on the fluid in the axis of the small tube, than on the fluid in the axis of the great one.

By comparing the six first experiments with the six last experiments, it will be seen that as the height of the fluid in the reservoir is increased, the diminution of discharge, and consequently of velocity, is also increased. This fact is analogous to what takes place in the friction of solid bodies, which in general increases with the velocity. Perhaps, however, it may yet be found, that when a very great velocity is given to the water, its velocity may be augmented, as Coulomb found it to be in some cases in solid bodies. From the above experiments, M. Bossut concludes in general, that the quantities of water discharged in equal times by a horizontal pipe under the same height of water in the reservoir, and for different lengths, *are to one another in the inverse ratio of the square roots of the lengths*, provided that these lengths are not very different from one another. Hence, when we know by experiment the quantity of water discharged for a given length of pipe, we may find the quantity discharged for any other length. Since the diminution of velocity is greatest when the head of water is small, we may conceive the head of water to be reduced to such a degree, that the velocity with which the water enters the pipe is not sufficiently powerful to overcome the resistances arising from the friction upon the pipe, and the mutual cohesion of the particles of water. In order to examine this point experimentally, M. Bossut employed a head of water only 16 lines, from which the water flowed into the two preceding pipes, when their length was a hundred and eighty feet. In this case the water was discharged in the form of a narrow fillet, and the drops succeeded each other almost as if they were insulated bodies. Hence it follows, that in order to have a perceptible and continuous discharge from conduit pipes, there should be a head of water of about 20 lines in 180 feet. If the current of water, however, is very large, such a great declivity as this will not be necessary.

General result.

n vertical nd inclin- d pipes.

As the preceding experiments relate only to pipes placed horizontally, M. Bossut proceeds to the consideration of vertical and inclined pipes. In the case of a vertical pipe, it is obvious that its motion will be accelerated during its descent through the tube, as appears in the experiment of Venturi already described. When the pipe is inclined, a similar acceleration takes place when the inclination is considerable; for if the angle of inclination were only 1 degree, the resistances which the fluid experiences would more than counterbalance the acceleration of gravity.

The following Table contains Bossut's experiments with a pipe, which formed the hypothenuse of a right angled triangle, the hypothenuse being to the altitude of the triangle as 2124 to 241. Its diameter was 16 lines.

TABLE II. *On the Quantity of Water discharged by inclined Pipes of different lengths.*

Head of water in inches.	Diameter of pipe.	Length of the pipe.	Number of cubic inches discharged in a minute.
10	16 lines.	59 feet.	5808
10	16	118	5801
10	16	177	5795

Now, an additional tube of the same diameter, and with the same head of water, would have discharged 5779 cubic inches in a minute, which is less than that which is discharged by the preceding pipes. By diminishing, however, the inclination of the above pipes, they would be brought to give the same discharge as the additional tube. This equality of discharge will take place when the inclination of the pipe is 6° 31′, or when the depression of the lower extremity of the pipe is one-eighth or one-ninth of its length. In this case the velocity, arising from the relative gravity of the water, is exactly counterbalanced by the resistance which the water experiences in the pipe.

On the Motion of Water in Bent Pipes.

In order to determine the effects of flexures or bendings in conduit pipes, M. Bossut made the following experiments. The pipes were perforated with small holes to facilitate the ascent of the air. At the end of each pipe was soldered a tube M, about two inches in diameter, which communicated with the smallest of the reservoirs already mentioned. This additional tube is furnished with a stopcock R, perforated with an aperture of more than 18 lines in diameter.

TABLE III. *Shewing the quantities of Water discharged by rectilineal and curvilineal leaden Pipes, 50 feet long, 1 inch in diameter, and 1 line thick.*

PLATE CCCXIX. Figs. 6, 7, 8.

Altitude of the Water in the Reservoir.		Form and Position of the Conduit Pipes. See Plate CCCXIX. Figs. 6, 7, 8.	Quantities of Water discharged in a Minute.
Feet.	Inch.		Cub. Inch.
0	4	The rectilineal tube MN, placed horizontally, Fig. 6. . .	576
1	0	The same tube similarly placed,	1050
0	4	The same tube, bent into the curvilineal form ABC, Fig. 7. each flexure lying flat on a horizontal plane, ABC being a horizontal section, ...	540
1	0	The same tube similarly placed,	1030
0	4	The same tube placed as in Fig. 8. where ABCD is a vertical section, the parts A, B, C, D, rising above a horizontal plane, and the parts *a*, *b*, *c*, lying upon it, ...	520
1	0	The same tube similarly placed,	1028

It appears from this Table, that a curvilineal pipe, in which the flexures lie horizontally, discharges less water than a rectilineal pipe of the same length, and that a still greater diminution takes place when the flexures are placed in a vertical plane. When there is a number of contrary flexures in a large pipe, the air sometimes lodges in the highest parts of the flexures, and greatly retards the motion of the water. This effect may be prevented by air holes, or by stop-cocks, which can be shut when the motion of the water is perfectly established.

As the pipes employed by M. Bossut were extremely short, he has endeavoured to supply this defect by combining them with the experiments made by M. Couplet at Versailles, with pipes, several of which were more than one mile, and one nearly three miles long. The results are shewn in the following Table.

TABLE IV. *Containing the results of the Experiments of Couplet and Bossut on Conduit Pipes differing in form, length, diameter, and in the materials of which they are composed,—under different Altitudes of water in the Reservoir.*

Altitude of the water in the reservoir.			Length of the conduit pipes.	Diameter of the conduit pipes.	Nature, Position, and Form of the Conduit Pipes.	Ratio between the quantities which would be discharged if the fluid experienced no resistance in the pipes, and the quantities actually discharged;—or the ratio between the initial and the final velocities of the fluid.
Feet.	inch.	lines.	Feet.	Lines		
0	4	0	50	12	Rectilineal and horizontal pipes made of lead	100 to 3.55
1	0	0	50	12	The same pipe similarly placed	100 to 3.18
0	4	0	50	12	The same pipe with several horizontal flexures	100 to 3.78
1	0	0	50	12	Same pipe	100 to 3.43
0	4	0	50	12	The same pipe with several vertical flexures	100 to 3.93
1	0	0	50	12	Same pipe	100 to 3.44
1	0	0	180	16	Rectilineal and horizontal pipe made of white iron	100 to 6.01
2	0	0	180	16	Same pipe	100 to 5.69
1	0	0	180	24	Rectilineal and horizontal pipe made of white iron	100 to 4.57
2	0	0	180	24	Same pipe	100 to 4.27
20	11	0	177	16	Rectilineal pipe made of white iron, and inclined so that its length is to the depression as 2124 is to 241	100 to 5.
13	4	8	118	16	Rectilineal pipe made of white iron, and inclined like the last	100 to 4.
6	8	4	159	16	Rectilineal pipe made of white iron, and inclined like the last	100 to 2.82
0	9	0	1782	48	Conduit pipe almost entirely of iron, with several flexures both horizontal and vertical	100 to 2.85
1	9	0	1782	48	Same pipe	100 to 26.53
2	7	0	1782	48	Same pipe	100 to 25.79
0	3	0	1710	72	Conduit pipe almost entirely of iron, with several flexures both horizontal and vertical	100 to 12.35
0	5	3	1710	72	Same pipe	100 to 11.37
0	5	7	7020	60	Conduit pipe, partly stone and partly lead, with several flexures both horizontal and vertical	100 to 23.10
0	11	4	7020	60	Same pipe	100 to 20.98
1	4	9	7020	60	Same pipe	100 to 19.49
1	9	1	7020	60	Same pipe	100 to 18.78
2	1	0	7020	60	Same pipe	100 to 18.40
12	1	3	3600	144	Conduit pipe made of iron, with flexures both horizontal and vertical	100 to 10.8
12	1	1	3600	216	Conduit pipe made of iron, with several flexures both horizontal and vertical	100 to 6.05
4	7	6	4740	216	Conduit pipe made of iron, with several flexures both horizontal and vertical	100 to 10.11
20	3	0	14040	144	Conduit pipe made of iron, with several flexures both horizontal and vertical	100 to 17.37

The application of the preceding Table is very simple. Let it be required, for example, to find the diameter of a pipe capable of discharging 40,000 cubic inches of water in a minute, at a point four feet below the level of the spring, and by a pipe 2400 feet long. Now, a short cylindrical tube, one inch in diameter, will furnish 7070 cubic inches in a minute, when the head of water is four feet. Hence, to find the diameter which will discharge 40,000 cubic inches, we have the analogy $\sqrt{70720} : \sqrt{40{,}000} = 12$ lines : 28.54 lines, the diameter required. But it appears from the preceding Table, that when the length of the pipe is about 2400 feet, it will discharge only about one-eighth of the water, or 5000 cubic inches. Hence, in order that it may discharge the whole 40,000 cubic inches, its diameter must be increased. This new diameter will be found thus, $\sqrt{5000} : \sqrt{40{,}000} = 28.54$ lines to 80.72, or 6 inches $8\frac{7}{10}$ lines, the diameter of the pipe which will discharge 40,000 cubic inches of water in a minute.

The following Table contains the remaining experiments made by M. Bossut.

TABLE V. *Containing Bossut's Experiments on the Quantities of Water discharged by different Pipes of various Lengths and with different Ajutages.*

Head of Water in Feet.		Length of Pipe.	Diameter of Pipe.	Size of Orifice.	Ratio of the Real to the Theoretical Discharges.	Ratio of the Height due to the Velocity to the Head of Water.	Cubic Inches of Water discharged in a Minute.
Feet.	In.	Feet.	Lines.	Lines.			
24	7	161	12	7¼	0.045	0.002	242
23	9	192	12	5¼	0.075	0.006	230
19	3	193	12	6½	0.068	0.005	222
19	9	188	12	6¼	0.061	0.004	237
19	10	146	12	2½ by 7	0.089	0.008	168
29	1	187	15	7½ by 5¼	0.105	0.011	588
8	0	1069	18	Two ajutages, each 6 lines	0.435	0.189	1686
24	7	278	15	3¼	0.396	0.157	458
32	7	314	15	Two ajutages having each 5 lines	0.227	0.052	1232
30	5	446	18	2 by 6¼	0.037	0.001	636
26	3	506	18	4	0.447	0.200	696
27	0	668	18	5½	0.301	0.091	900
30	0	812	18	11	0.048	0.002	600
10	5	194	12	5	0.377	0.139	576
10	11	462	12	5¼	0.332	0.109	576
10	0	420	15	7	0.163	0.028	483

The preceding experiments were made at Mezieres, on the 8th and 9th October 1779, upon the water discharged from the public and private fountains of that city.

Bossut's Experiments on the Pressure exerted upon Pipes by the Water which they convey.

ossut's experiments n the pressure exerted pon pipes y the wa- r which ey convey.

In Chap. I. of this part of hydraulics, we have already considered theoretically the amount of the pressure exerted upon conduit pipes by the included water. When a tube placed horizontally discharges water without any additional aperture, it is obvious that the weight of the included water is the principal force which it has to bear. But if the water is discharged through a small ajutage, the velocity of the water in the pipe is diminished, and hence there results a pressure against the sides. In order to measure this pressure, Bossut perforated the pipes at different lengths or distances from the reservoir with small apertures exactly perpendicular to the axis of the pipe, and considered the quantity of water discharged in a given time, as the exact measure of the lateral pressure which forced the fluid through the orifice. In this way he obtained the results in the three first columns of the following Table, which is suited to an orifice 3¼ lines in diameter.

TABLE VI. *Containing the Quantities of Water discharged by a Lateral Orifice, or the Pressures on the Sides of Pipes, according to Theory and Experiment.*

Altitude of the Water in the Reservoir.	Length of the Conduit Pipe.	Quantities of Water discharged in 1 Minute, according to Experiment.	Quantities of Water discharged in 1 Minute, computed from the Formula.
Feet.	Feet.	Cubic Inches.	Cubic Inches.
1	30	171	176
1	60	186	186
1	90	190	190
1	120	191	191
1	150	193	192
1	180	194	193
2	60	240	244
2	60	256	259
2	90	261	264
2	120	264	267
2	150	265	268
2	180	266	269

Motion of Water in Pipes and Canals.

The fourth column in the preceding Table is calculated from the formula $q = Q \times \frac{\surd(D^4 - d^4)}{D^2}$, which is thus obtained. We have already seen in Chap. I. of Part II. that the pressure of the fluid on the pipe is measured by $h - \frac{d^4 h}{D^4}$. Then, if Q is the quantity of water which would have been discharged in a given time under the head or pressure h, the quantity of water q discharged in the same time under the head or pressure $h - \frac{d^4 h}{D^4}$, will be thus found $Q : q = \surd h : \surd\left(h - \frac{d^4 h}{D^2}\right)$, and

$$q = Q \times \frac{\surd(D^4 - d^4)}{D^2}.$$

The agreement of the formula with the experiments is very striking. From this method of considering the subject, M. Bossut deduces a very simple method of determining the discharge from a long tube subject to friction from the expenditure of an orifice perforated in its sides. Let x denote the ratio of the expenditure of the proposed pipe having regard to friction, to the expenditure upon the supposition that there is no friction; or, which is the same thing, let $x = \frac{d^2}{D^2}$. By substituting x in place of $\frac{d^2}{D^2}$ in the preceding formula, we have $q = Q\surd(1 - x^2)$, and $x = \frac{\surd(Q^2 - q^2)}{Q}$. Let us now suppose that the tube has 2 inches diameter, that the Q head of water is 3 feet, that the lateral orifice is 6 lines, and that it discharges at the orifice 1000 cubic inches in a minute. This orifice, as appears from former experiments, would give 1178 cubic inches in a minute, if the extremity of the pipe were stopped, that is, $Q = 1178$ cubic inches, whilst q is only 1000 cubic inches. By putting these values in the equation $x = \frac{\surd(Q^2 - q^2)}{Q}$, we have $x = 0.5289$. But by Table II. p. 498, this additional tube would give 24504 cubic inches in a minute, abstracting the effects of friction; hence the effects of friction being included, it will discharge $0.5289 \times 24504 = 12952$ cubic inches in a minute. The preceding observations are also applicable to inclined tubes, whether straight or curved.

In the formation of pipes, it is necessary to give them a much greater thickness than that which is necessary to resist the pressure indicated by the preceding Table, for the pipes are exposed to several forces which are not taken into consideration. The following Table contains the thickness of leaden and iron pipes, which were used in France in the time of Bossut.

Motion of Water in Pipes and Canals.

Leaden Pipes.		Iron Pipes.	
Diameter in inches.	Thickness in lines.	Diameter in inches.	Thickness in lines.
1	2½	1	1
1½	3	2	3
2	4	4	4
3	5	6	5
4½	6	8	6
6	7	10	7
7	8	12	8

The thickness of pipes ought to increase with the head of water, and the strain should always be calculated from the whole height of the reservoir, and upon the supposition that the pipe is stopped at one end.

Bossut's Experiments on the Motion of Water in Canals.

Bossut's experiments on the motion of water in canals.

The experiments of Bossut on this subject were made upon an open canal, the bottom of which was on a level with the bottom of the reservoir from which the water flowed. The orifice by which the water issued into the canal from the reservoir had constantly a horizontal width of 5 inches, but the height of the orifice was made to vary by raising or depressing a slider, so as to obtain a rectangular opening of various heights. In order to measure the velocity of the water in the canal, Bossut tried various ways; but he ultimately preferred the method of finding it by observing the time which elapsed between the opening of the orifice, and the arrival of the water at different parts of the canal. The velocity thus found is obviously less than the velocity of the water when the current is perfectly established. But there is a constant ratio between these two velocities, in consequence of which the one may be safely inferred from the other. The canal was 105 feet long, and was divided into five equal parts, and also into three equal parts; so that each of the fifth parts was 21 feet, and each of the third parts 35 feet long. In order to ascertain the arrival of the water at these different parts of the canal, small wheels like those used by children were placed at each point of division; and the commencement of their motion, which indicated the arrival of the water at that point, was instantly perceived by the person who counted the oscillations of the pendulum. When the canal was horizontal, the following were the results.

TABLE VII. *Containing the Velocity of Water in different parts of a Rectangular Horizontal Canal 105 feet long, under different Altitudes of Fluid in the Reservoir.*

Altitude of the water in the reservoir.	*Ft. In.* 11 8	*Ft. In.* 7 8	*Ft. In.* 3 8	*Ft. In.* 11 8	*Ft. In.* 7 8	*Ft. In.* 3 8	Space run through by the water.
Vertical breadth of the orifice.	½ an inch.	½ an inch.	½ an inch.	1 inch.	1 inch.	1 inch.	*Feet.*
Time in which the number of feet in column 7th are run through by the water.	2″ 5— 10— 16— 23+	3″— 7 13— 20— 28+	3″+ 9 17+ 27+ 38+	2″ 4 7 11 16¼	2″+ 5 9 14 20	3″— 6+ 11+ 18+ 26	21 42 63 84 105

1

Motion of Water in Pipes and Canals.

In the preceding Table the signs + and — indicate that the number of seconds is either a little too small or a little too great.

It appears from the above Table, that the time successively employed by the water in running through spaces of 21 feet each, are as the numbers 2, 3—, 5, 6, 7+, which form nearly an increasing arithmetical progression, the difference of whose terms is nearly 1, so that the series may be continued, and the time determined in which the water will run through any number of feet. The two serieses of the times and spaces may also be continued for the other experiments in the Table, by means of the formula $t = 1'' \times \frac{4\,E}{5\sqrt{15\,H}}$, where E is the space described uniformly in the time t, with a velocity due to the height H. Bossut has calculated the times for the last line of the Table, or for the whole length of 105 feet. These times are,

Calculated by the formula,	6″.350,	7″.834,	11″.330,	6″.350,	7″.184,	11″.330
Observed,	23	28	38	16¼	20	26

from which it appears that the velocity of the water in the canal is very much retarded by the different resistances which it experiences; and that the retardation is less as the height of the orifice is increased.

Bossut's experiments on inclined canals.

The following experiments were made on the motion of water in inclined canals. The inclination of the canal is the depression of its lower extremity below a horizontal line which passes through its upper extremity.

TABLE VIII. *Containing the Velocity of Water in a Rectangular inclined Canal 105 Feet long, and under different Altitudes of Fluid in the Reservoir.*

ALTITUDE OF WATER IN THE RESERVOIR . .	*Ft. In.* 11 8	*Ft. In.* 7 8	*Ft. In.* 3 8	*Ft. In.* 11 8	*Ft. In.* 7 8	*Ft. In.* 3 8	Space run through by the water.
Inclination of the canal	*Ft. In.* 0 3	*Ft. In.* 0 3	*Ft. In.* 0 3	*Ft. In.* 0 6	*Ft. In* 0 6	*Ft. In.* 0 6	*Feet.*
	Time in which the number of feet in the last col. is run through by the water.						
Height of the orifice ½ an inch	4″ 11+ 22	4″+ 14+ 26	6″+ 18+ 34+	3″½ 11½ 21	4+ 14 25+	6 18— 31+	35 70 105
Inclination of the canal	*Ft. In.* 0 6	*Ft. In.* 0 6	*Ft. In.* 0 6	*Ft. In.* 1 0	*Ft. In.* 1 0	*Ft. In.* 1 0	
Height of the orifice 1 inch	3″ 8 15	4″— 9+ 19—	5″— 13— 23—	3″— 7½ 14	4″— 9 16	5— 12 21	35 70 105
Inclination of the canal	*Ft. In.* 2 0	*Ft. In.* 2 0	*Ft. In.* 2 0	*Ft. In.* 4 0	*Ft. In.* 4 0	*Ft. In.* 4 0	
Height of the orifice 1 inch	2″+ 7 13	4″— 9— 15—	4″ 10½ 17½	2″+ 6½ 12	3″+ 8 13	4+ 9+ 15+	35 70 105
Inclination of the canal	*Ft. In.* 6 0	*Ft. In.* 6 0	*Ft. In.* 6 0	*Ft. In.* 9 0	*Ft. In.* 9 0	*Ft. In.* 9 0	
Height of the orifice 1 inch	2″+ 6 10	3″ 7+ 12	4″ 9— 14—	2″+ 6— 9	3″+ 6½ 10	4″— 8— 12—	35 70 105
Inclination of the canal	*Feet.* 11	*Feet.* 11	*Feet.* 11	*Feet.* 11	*Feet.* 11	*Feet.* 11	
In the three first columns the height of the orifice was ½ an inch, and in the three last 1 inch.	*Half sec.* 2+ 7 12 17 21+	*Half sec.* 3+ 8+ 13+ 18+ 23+	*Half sec.* 4+ 10 16 22 28	*Half sec.* 2 5 9 13 17	*Half sec.* 3+ 7 11 15 19	*Half sec.* 3— 8 13 18— 22	21 42 63 84 105
Inclination of the canal	*Feet.* 11	*Feet.* 11	*Feet.* 11				
Height of the orifice 1½ inches	*Half sec.* 2 5 8+ 12 15+	*Half sec.* 3— 6 10— 13+ 17	*Halfse c.* 3+ 7 11+ 15 20				21 42 63 84 105

In the preceding experiments, Bossut only observed the velocity of the first portion of the water that issued from the reservoir. In order to compare this velocity with that of the current after it is completely established, he made the experiments in the following Table; the time in which the first portion of the water moved through the spaces in col. 6. was measured by means of the small wheels already mentioned; and the time in which the established current moved through the same spaces, was ascertained by placing gently upon the water four pieces of cork, which followed exactly the current. The first portion of the canal was always run through in less time than any of the other divisions, and the velocity did not become sensibly uniform till the declivity was about the 10th part of the length of the canal.

TABLE IX. *Containing a Comparison between the Velocity of the First Portion of Water, and that of the Established Current.*

	Vertical breadth of the Orifice 1 inch.		Vertical breadth of the Orifice 2 inches.		
Altitude of the water in the reservoir.	Time in which the space in col. 6. was run through by the 1st portion of water.	Time in which the space in col. 6. was run through by the established current.	Time in which the space in col. 6. was run through by the 1st portion of water.	Time in which the space in col. 6. was run through by the established current.	Space run through by the water.
Feet. Inch.	Seconds.	Seconds.	Seconds.	Seconds.	Feet.
4 0	10	8	8	7	100
	20+	17	17	$14\frac{1}{2}$	200
	31—	26	26	22	300
	42—	35	35—	29+	400
	$52\frac{1}{2}$	43+	43+	37—	500
	62+	52	52—	44+	600
2 0	11	10	9	8—	100
	23	20	19	16	200
	35	30	29	24	300
	46+	40	39	32	400
	58	49	49	40	500
	69	58	58	48	600
1 0	12+	12	15	13	100
	$25\frac{1}{2}$	23+	31	$26\frac{1}{2}$	200
	39	33	47	$39\frac{1}{2}$	300
0 6	11—	9	$13\frac{1}{2}$	$11\frac{1}{2}$	100
	22	18—	$26\frac{3}{4}$	23	200
	$32\frac{1}{2}$	27	$39\frac{1}{2}$	$33\frac{1}{2}$	300

It will be seen from these results, that the velocity of the first portion of water is always less than that of the established current, and that the one has to the other a ratio which is nearly constant. The difference between these two velocities is obviously owing to friction, and to the viscidity of the fluid. The velocity of the water in contact with the bottom of the canal is not only retarded by friction, but the weight of the superincumbent fluid; and the fluid must obviously have the greatest velocity at the surface at a point equidistant from the sides.

SECT. II. *Account of the Researches and Experiments of the Chevalier Du Buat.*

Account of Du Buat's researches.

IN the preceding investigations of Bossut, no attempt is made to deduce any very general principle or formula from which the quantity of water discharged by pipes and canals could be obtained in cases, which are not comprehended in the limits of his tables. His experiments, indeed, were neither sufficiently numerous nor varied to lay the foundation of any very general rule; and it is perhaps too much to expect that the same person should have the honour both of laying the foundation, and of bringing to perfection one of the most difficult branches of physico-mathematical science.

In the historical part of this article, we have given a full account of the origin of the labours of the Chevalier Du Buat, and have stated the general formula which he obtained for expressing in all cases the velocity of water, whether it is conveyed in a pipe or canal, or rolls in the beds of rivers. We shall now proceed to give as succinct and perspicuous a view as possible of the principal steps by which this formula was obtained, and shall then point out the method of applying the formula in practice, by means of copious Tables, which have never before been published.

Mode of expressing the slope of a pipe or canal.

Considering an inch as the unity of length, and a second as the unity of time, we may express the declivity of a canal by $\frac{1}{s}$, on the supposition that upon the length of the pipe or canal s there is a fall of 1 inch. But, in order to find the slope of a conduit pipe when the height of the reservoir and the place of discharge are known, we must subtract from the height of the reservoir, the height or head of water H due to the real velocity, which, in additional tubes, is $H = \frac{V^2}{505}$; for we have already seen in p. 502, col. 2, that $V = 22.47 \sqrt{H}$. Hence $H = \frac{V^2}{\overline{22.47}^2} = \frac{V^2}{505}$. The remainder which arises after this subtraction, must be considered as a declivity to be distributed over the whole length of the pipe.

Dn the re-
istances by
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ocity is ob-
ained.

In considering theoretically the change which the resistances will experience by an increase of velocity, it will appear that they will increase as the squares of the velocity; for while the impulses on all the little asperities are increased in the proportion of the velocity, the number of impelling particles is also increased in the same proportion. Du Buat therefore supposes the resistances equal to $\frac{V^2}{m}$, m being a constant quantity to be determined by experiment. Now, if g expresses the velocity acquired by a heavy body at the end of a second, $\frac{g}{s}$ will be the accelerating force relative to the slope $\frac{1}{s}$. But from the fundamental axiom, *that when a stream moves uniformly, the resistance is equal to the accelerating force*, we obtain $\frac{V^2}{m} = \frac{g}{s}$ and $V\sqrt{s} = \sqrt{mg}$, that is in the same pipe or canal, the product of the velocity by the reciprocal of the square root of the slope is a constant quantity; and the leading formula for all the uniform velocities is $V = \frac{\sqrt{mg}}{\sqrt{s}}$.

M. Du Buat now proceeds to examine the preceding equation experimentally, in order to ascertain if $V\sqrt{s}$ is actually a constant quantity. After comparing together the results of many accurate experiments, he finds that the values of $V\sqrt{s}$, though taken in the same pipe or canal, are not exactly equal, but that they increase a little in proportion as the velocities increase; and hence he concludes, *that the resistances are in a less ratio than the square of the velocities.* Hence the term $\sqrt{s}$ ought to be diminished. The fraction of the slope which Du Buat found to make $\sqrt{mg}$ a constant quantity, is $\sqrt{s} - \text{Log.}\ \sqrt{s + 1.6}$ in employing the hyperbolic logarithms. Let X represent this fraction; then we shall have $VX = \sqrt{mg}$ for the same pipe or canal.

It is manifest from theoretical considerations, as well as from direct experiment, that the resistances must have a relation to the magnitude of the section of the pipe or canal. As the resistances all arise from the friction of the water upon the sides of the tube or canal, it is obvious that they must be least in those pipes and canals in which the section has the greatest ratio to the perimeter in contact with the water; that is, the resistance of every particle of water will be in the direct ratio of the perimeter of the section, and inversely as the area of the section.

In cylindrical pipes, the section is the area of a circle; and the perimeter of the section is the circumference of the circle; and the quotient arising from dividing the one by the other, is always one-half of the radius; or one-half of the radius multiplied by the circumference, is always equal to the area of the section. In rectangular and irregular channels, there is still some line which, multiplied by the perimeter of the section, will give an area equal to the area of the section of the channel. This line, which may be called d, has been named the Mean radius by Du Buat, and the Hydraulic mean depth by Dr Robison.

Since the resistances increase as the ratio of the perimeter of the section, to the area of the section increaits increase to the quantity m must be proportional to d; and consequently $\sqrt{mg}$ must be proportional to $\sqrt{d}$ for different channels; and $\frac{\sqrt{mg}}{\sqrt{d}}$ should in every case be a constant quantity.

In examining, by experiment, if this was actually the case, Du Buat found, that $\sqrt{mg}$ was neither proportional to $\sqrt{d}$, nor to any power of d, but that it increased less and less in proportion as $\sqrt{d}$ increased. In very wide channels $\sqrt{mg}$ becomes sensibly proportional to $\sqrt{r}$, but in small channels the velocity diminishes much more than the values of $\sqrt{r}$. Du Buat ascribes this effect to the viscidity of the water, and he found, that his experiments were completely represented by diminishing $\sqrt{d}$ by one-tenth of an inch, that is, by using $\sqrt{d} - 0.1$ instead of $\sqrt{d}$; and hence $\frac{\sqrt{mg}}{\sqrt{d} - 0.1}$ is always a constant quantity, which Du Buat found, from many experiments, to be equal to 297.

Now, since $\frac{\sqrt{mg}}{\sqrt{d} - 0.1} = 297$, we have $m = \frac{\overline{297}^2}{g}$ $(\sqrt{d} - 0.1)^2 = \frac{88209}{362} (\sqrt{d} - 0.1)^2 = 243.7 (\sqrt{d} - 0.1)^2$ (or making $n = 243.7$) $= n (\sqrt{d} - 0.1)^2$. But the resistances were expressed by $\frac{V^2}{m}$, consequently they will now be expressed by $\frac{V^2}{n(\sqrt{d} - 0.1)^2}$.

We have also $\sqrt{mg} = \sqrt{ng} (\sqrt{d} - 0.1)$, and since $VX = \sqrt{mg}$, we obtain $V = \frac{\sqrt{ng} (\sqrt{d} - 0.1)}{X} = 297 \frac{(\sqrt{d} - 0.1)}{X}$, which is an expression of the velocity V for any channel, which, X being a variable quantity, M. Du Buat next proceeds to determine.

We do not think that our readers will be much instructed in following our author in his experimental determination of X. Upon the supposition that the value X must be sensibly proportional to $\sqrt{s}$ when s is great; that it must always be less than $\sqrt{s}$; that it must deviate, from the proportion of $\sqrt{s}$, so much the more that $\sqrt{s}$ is smaller; that it must not vanish when the velocity is infinite; and that it must agree with a series of experiments for every variety of channel and slope, M. Du Buat found, that these conditions would be fulfilled if we take $X = \sqrt{s} - \text{Hyp. Log.}\ \sqrt{s + 1.6}$. Hence $V = \frac{297 (\sqrt{d} - 0.1)}{\sqrt{s} - \text{Log.}\sqrt{s + 1.6}}$.

M. Buat next supposes, that there is a constant portion of the accelerating force employed in overcoming the viscidity, and producing the mutual separation of the adjacent filaments; and he expresses that part of the accelerating force by a part $\frac{1}{S}$ of that slope which constitutes the whole of it. If this were not employed in overcoming a resistance, it would produce a velocity which is really lost; so that, in reasoning upon this

Motion of Water in Pipes and Canals.

as we did upon the real velocity, its value will be $\frac{\sqrt{ng}\,(\sqrt{d}-0.1)}{\sqrt{S}-\text{Log.}\sqrt{S}}$, a quantity which must always be subtracted from the velocity already determined. Hence the value of V will be $\text{V}=\frac{\sqrt{ng}\,(\sqrt{d}-0.1)}{\sqrt{s}-\text{Log.}\sqrt{s+1.6}}-$

$$\frac{\sqrt{ng}\,(\sqrt{d}-0.1)}{\sqrt{S}-\text{Log.}\sqrt{S}}=(\sqrt{d}-0.1\left(\frac{\sqrt{ng}\,.}{\sqrt{s}-\text{Log.}\sqrt{s+1.6}}-\frac{\sqrt{ng}}{\sqrt{S}-\text{Log.}\sqrt{S}}\right).$$

But since the term $\frac{\sqrt{ng}}{\sqrt{S}-\text{Log.}\sqrt{S}}$ is composed of constant quantities, it may be expressed in a single number. The value of it was determined by many experiments to be 0.3 inches. By substituting, therefore, this value, we obtain

$$\text{V}=\frac{\sqrt{ng}\,(\sqrt{d}-0.1)}{\sqrt{s}-\text{Log.}\sqrt{s+1.6}}-0.3(\sqrt{s}-0.1),\text{ or in numbers,}$$

$$\text{V}=\frac{297\,(\sqrt{d}-0.1)}{\sqrt{s}-\text{Log.}\sqrt{s+1.6}}-0.3(\sqrt{d}-0.1)\text{ in Fr. measure,}$$

$$\text{V}=\frac{307\,(\sqrt{d}-0.1)}{\sqrt{s}-\text{Log.}\sqrt{s+1.6}}-0.3(\sqrt{d}-0.1)\text{inEng. measure.}$$

In these expressions the following are the values of the letters employed.

V represents the mean velocity in inches per second of any current moving in a channel of indefinite length, of which the sections of the declivity are constant.

d is the mean radius or hydraulic mean depth, or a quantity which, when multiplied by the perimeter of the section of the channel, gives an area equal to the area of the section. In circular pipes d is equal to half the radius.

n is an abstract and constant number, which is found by experiment to be equal to 243.7

g is the velocity in inches, acquired by a falling body at the end of a second of time, being always equal to 32.174.

s is the denominator of a fraction which expresses the slope of the channel, the numerator being supposed unity.

Log. denotes the hyperbolic logarithm of the quantity to which it is prefixed, and may be obtained by multiplying the common logarithm by 2.302581.

In order to shew the agreement of the preceding formula with experiment, M. Du Buat drew up the following Table, which contains the observed velocities as deduced from the experiments of Bossut, and from many new experiments made by Du Buat himself, and also the velocities calculated from the formula.

In the first set of experiments on pipes, col. 1. contains the number of the experiment; col. 2. the length of the pipe; col. 3. the height of the reservoir; col. 4. the values of s as deduced from col. 2. and 3; col. 5. the observed velocities; and col. 6. the computed velocities.

In the second set of experiments on canals and rivers, col. 2. shows the area of the section of the channel; col. 3. the perimeter of the channel in contact with the water; col. 4. the square roots of d, or the mean radius or hydraulic mean depth; col. 5. the denominator s of the slope; col. 6. the mean velocities observed; and col. 7. the mean velocities calculated.

Motion of Water in Pipes and Canals.

TABLE X. *Containing a Comparison of the Velocities calculated by Du Buat's Formula, with the Velocities observed in the Experiments of Couplet, Bossut, and Du Buat, on Pipes, Canals, and Rivers.*

SET I. EXPERIMENTS ON PIPES.

Experiments by the Chevalier DU BUAT.

Pipe $\frac{2}{3}$ of a Line in Diameter, placed Vertically, and $\sqrt{d}=0.117851$.

<table>
<tr><th>No.</th><th>Length of Pipe.</th><th>Height of Reservoir.</th><th>Values of s.</th><th>Observed Velocities.</th><th>Calculated Velocities.</th></tr>
<tr><td></td><td>Inches.</td><td>Inches.</td><td>Inches.</td><td>Inches.</td><td>Inches.</td></tr>
<tr><td>1</td><td>12</td><td>16.166</td><td>0.75636</td><td>11.704</td><td>12.006</td></tr>
<tr><td>2</td><td>12</td><td>13.125</td><td>0.9307</td><td>9.753</td><td>10.576</td></tr>
<tr><td colspan="6"><i>Pipe 1½ Line Diameter, placed Vertically, and</i> √d=0.176776 <i>Inch.</i></td></tr>
<tr><td>3</td><td>34.166</td><td>42.166</td><td>0.9062</td><td>45.468</td><td>46.210</td></tr>
<tr><td>4</td><td>Do.</td><td>38.333</td><td>0.9951</td><td>43.156</td><td>43.721</td></tr>
<tr><td>5</td><td>Do.</td><td>36.666</td><td>1.0396</td><td>42.385</td><td>42.612</td></tr>
<tr><td>6</td><td>Do.</td><td>35.333</td><td>1.07805</td><td>41.614</td><td>41.714</td></tr>
<tr><td colspan="6"><i>The same Pipe Horizontal.</i></td></tr>
<tr><td>7</td><td>34.166</td><td>14.583</td><td>2.5838</td><td>26.202</td><td>25.523</td></tr>
<tr><td>8</td><td>Do.</td><td>9.292</td><td>4.0367</td><td>21.064</td><td>19.882</td></tr>
<tr><td>9</td><td>Do.</td><td>5.292</td><td>7.03597</td><td>14.642</td><td>14.447</td></tr>
<tr><td>10</td><td>Do.</td><td>2.083</td><td>17.6378</td><td>7.320</td><td>2.351</td></tr>
<tr><td colspan="6"><i>Pipe 2 Lines Diameter, placed Vertically, and</i> √d=0.204124.</td></tr>
<tr><td>11</td><td>36.25</td><td>51.250</td><td>0 854509</td><td>67.373</td><td>64.945</td></tr>
<tr><td>12</td><td>Do.</td><td>45.250</td><td>0.963382</td><td>59.605</td><td>60.428</td></tr>
<tr><td>13</td><td>Do.</td><td>41.916</td><td>1.038080</td><td>57.220</td><td>57.838</td></tr>
<tr><td>14</td><td>Do.</td><td>38.750</td><td>1.120473</td><td>54.186</td><td>55.321</td></tr>
<tr><td colspan="6"><i>Same Pipe with a slope of</i> 1/1.3024.</td></tr>
<tr><td>15</td><td>36.25</td><td>33.500</td><td>1.291741</td><td>51.151</td><td>50.983</td></tr>
<tr><td colspan="6"><i>Same Pipe Horizontal.</i></td></tr>
<tr><td>16</td><td>36.25</td><td>15.292</td><td>2.79005</td><td>33.378</td><td>33.167</td></tr>
<tr><td>17</td><td>Do.</td><td>8.875</td><td>4.76076</td><td>25.430</td><td>24.553</td></tr>
<tr><td>18</td><td>Do.</td><td>5.292</td><td>7.89587</td><td>19.940</td><td>18.313</td></tr>
<tr><td>19</td><td>Do.</td><td>2.042</td><td>20.016366</td><td>10.620</td><td>10.492</td></tr>
</table>

Motion of Water in Pipes and Canals.

Motion of Water in Pipes and Canals.

Pipe 2$\frac{9}{10}$ Lines Diameter, placed Vertically, and $\sqrt{d}=0.245798$.

No.	Length of Pipe.	Height of Reservoir.	Values of a.	Observed Velocities.	Calculated Velocities.
	Inches.	Inches.	Inches.	Inches.	Inches.
20	36.25	53.250	0.952348	85.769	85.201
21	Do.	50.250	1.006424	82.471	82.461
22	Do.	48.333	1.044400	81.646	80.698
23	Do.	48.333	1.044400	79.948	
24	Do.	47.916	1.052952	81.027	80.318
25	Do.	44.750	1.124052	76.079	77.318
26	Do.	41.250	1.215688	73.811	73.904

Same Pipe with the Slope $\frac{1}{1.3024}$.

No.	Length of Pipe.	Height of Reservoir.	Values of a.	Observed Velocities.	Calculated Velocities.
27	36.25	37.500	1.332332	70.822	70.138

Same Pipe Horizontal.

No.	Length of Pipe.	Height of Reservoir.	Values of a.	Observed Velocities.	Calculated Velocities.
28	36.25	20.166	2.43034	51.956	50.140
29	Do.	9.083	5.26858	33.577	32.442
30	Do.	7.361	6.45035	28.658	28.801
31	Do.	5.000	9.35730	23.401	23.195
32	Do.	4.916	9.50972	22.989	22.974
33	Do.	4.833	9.66522	25.679	22.754
34	Do.	3.708	12.4624	19.587	19.550
35	Do.	2.713	16.3135	16.631	16.324
36	Do.	2.083	21.6639	14.295	14.003
37	Do.	1.625	27.5102	12.680	12.115
38	Do.	0.833	52.3427	7.577	8.215

Pipes sensibly Horizontal $\sqrt{d}=0.5$, or 1 Inch Diameter.

No.	Length of Pipe.	Height of Reservoir.	Values of a.	Observed Velocities.	Calculated Velocities.
39	117	36.000	5.65026	84.945	85.524
40	117	26.666	7.48002	71.301	72.617
41*	138.5	20.950	10.32149	58.808	60.034
42	117	18.000	10.78796	58.310	58.472
43*	138.5	6.000	33.19623	29.341	29.663
44*	737	23.700	63.66578	28.669	29.412
45	Do.	14.600	54.26340	21.856	22.056
46	Do.	13.700	57.77718	20.970	21.240
47	Do.	12.320	64.15725	19.991	19.950
48	Do.	8.96	87.86790	16.625	16.543
49*	Do.	8.96		16.284	
50*	Do.	7.780	101.0309	15.112	15.232
51*	Do.	5.930	132.1617	13.315	13.005
52*	Do.	4.20	186.0037	10.671	10.656
53*	Do.	4.20		10.441	
54*	138.5	0.700	257.8663	8.689	8.824
55*	737	0.500	1540.76	3.623	3.218
56	737	0.150	5113.42	1.589	1.647

Experiments of the Abbé Bossut.

Horizontal Pipe 1 *Inch Diameter $\sqrt{d}=0.5$.*

No.	Length of Pipe.	Height of Reservoir.	Values of s.	Observed Velocities.	Calculated Velocities.
	Inches.	Inches.	Inches.	Inches.	Inches.
57	600	12	54.5966	22.282	21.975
58	600	4	161.3120	12.223	11.756

Horizontal Pipe 1$\frac{1}{3}$ Inch Diameter $\sqrt{d}=0.57735$.

No.	Length of Pipe.	Height of Reservoir.	Values of s.	Observed Velocities.	Calculated Velocities.
59	360	24	19.0781	48.534	49.515
60	720	24	33.6166	34.473	35.130
61	360	12	37.0828	33.160	33.106
62	1080	24	48.35416	28.075	28.211
63	1440	24	64.1806	24.004	24.023
64	720	12	66.3020	23.360	23.345
65	1800	24	78.05318	21.032	21.182
66	2160	24	92.9474	18.896	19.096
67	1080	12	95.87567	18.943	18.749
68	1440	12	125.6007	16.128	15.991
69	1800	12	155.4015	14.066	14.119
70	2160	12	185.2487	12.560	12.750

Horizontal Pipe 2.01 Inch Diameter $\sqrt{d}=0.7089458$.

No.	Length of Pipe.	Height of Reservoir.	Values of s.	Observed Velocities.	Calculated Velocities.
71	360	24	21.47087	58.903	58.803
72	720	24	35.80824	43.	43.136
73	360	12	41.27586	40.322	39.587
74	1080	24	50.41193	35.765	35.096
75	1440	24	65.1448	30.896	30.096
76	720	12	70.14263	29.215	28.796
77	1800	24	79.84866	27.470	26.639
78	2160	24	94.79006	27.731	24.079
79	1080	12	99.1979	23.806	23.400
80	1440	12	129.0727	20.707	20.076
81	1800	12	158.75116	18.304	17.788
82	2160	12	188.5179	16.377	16.097

Couplet's *Experiments at Versailles.*

Pipe 5 Inches Diameter $\sqrt{d}=1.118034$.

No.	Length of Pipe.	Height of Reservoir.	Values of s.	Observed Velocities.	Calculated Velocities.
83	84.240	25	3378.26	5.323	5.287
84	Do.	24	3518.98	5.213	5.168
85	Do.	21.083	4005.66	4.806	4.887
86	Do.	16.750	5041.61	4.127	4.225
87	Do.	11.333	7450.42	3.154	3.388
88	Do.	5.583	15119.96	2.0107	2.254

Pipe 18 Inches Diameter $\sqrt{d}=2.12132$.

No.	Length of Pipe.	Height of Reservoir.	Values of s.	Observed Velocities.	Calculated Velocities.
89	43.200	146.083	304.9734	39.159	40.510

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* In the experiments marked with an asterisk, the pipe discharged itself into water. In all the other experiments it discharged itself in the air.

Motion of Water in Pipes and Canals.

SET. II. EXPERIMENTS WITH A WOODEN CANAL.

Trapezium Canal.

No.	Area of the Section of Canal.	Perimeter of Canal in contact with the Water.	Values of $\sqrt{d}$.	Values of *s*.	Mean Velocity observed	Mean Velocity calculated.
	Inches.	Inches.	Inches.	Inch.	Inches.	Inches.
90	18.84	13.06	1.20107	212	27.51	27.19
91	50.60	29.50	1.3096	212	28.92	29.88
92	83.43	26.	1.7913	412	27.14	28.55
93	27.20	15.31	1.33290	427	18.28	20.39
94	39.36	18.13	1.47342	427	20.30	22.71
95	50.44	20.37	1.57359	427	22.37	24.37
96	56.43	21.50	1.62007	427	23.54	25.14
97	98.74	28.25	1.86955	432	28.29	29.06
98	100.74	28.53	1.87910	432	28.52	29.23
99	119.58	31.06	1.96219	432	30.16	30.60
101	126.20	31.91	1.98868	432	31.58	31.03
100	130.71	32.47	1.00637	432	31.89	32.32
102	135.32	33.03	1.02407	432	32.32	31.61
103	20.83	13.62	1.23667	1728	8.94	8.58
104	34.37	17.	1.42188	1728	9.71	9.98
105	36.77	17.56	1.44708	1728	11.45	10.17
106	42.01	18.69	1.49924	1728	12.34	10.53

Rectangular Canal.

107	34.50	21.25	1.27418	458	20.24	18.66
108	86.25	27.25	1.77908	458	28.29	26.69
109	34.50	21.25	1.27418	929	13.56	11.53
110	35.22	21.33	1.28499	1412	9.20	10.01
111	51.75	23.25	1.49191	1412	12.10	11.76
112	76.19	26.08	1.70921	1412	14.17	13.59
113	105.78	29.17	1.90427	1412	15.55	15.24
114	69.	25.25	1.65308	9288	4.59	4.56
115	155.25	35.25	2.09868	9288	5.70	5.86

SET III. EXPERIMENTS ON THE CANAL OF JARD.

No.	Area of the Section of Canal.	Perimeter of Canal in contact with the Water.	Values of $\sqrt{d}$.	Values of *s*.	Velocity observed at Surface.	Velocity calculated.
116	16252	402	6.3583	8919	17.42	18.77
117	11905	366	5.7032	11520	12.17	14.52
118	10475	360	5.3942	15360	15.74	11.61
119	7858	340	4.8074	21827	9.61	8.38
200	7376	337	4.6784	27648	7.79	7.07
211	6125	324	4.3475	27648	7.27	6.55

Experiments on the River Hayne.

No.	Area of the Section of River.	Perimeter of River in contact with the Water.	Values of $\sqrt{d}$.	Values of *s*.	Velocity at Surface.	Velocity (mean) calculated.
122	31498	569	7.43974	6048	35.11	27.62
123	38838	601	8.03879	6413	31.77	28.76
124	30905	568	7.37632	32951	13.61	10.08
125	39639	604	8.10108	35723	15.96	10.53

Motion of Water in Pipes and Canals.

The slightest inspection of the preceding Table will show the reader how much the science of hydrodynamics is indebted to the labours of M. Buat. The coincidence of the calculated with the observed velocities is extremely striking.

New Tables for Facilitating the Application of Du Buat's Formula.

In order to facilitate the application of the formula in practice, Dr Robison in his dissertation on Waterworks, published in his *System of Mechanical Philosophy*, has computed two tables, one of which contains calculated values of the numerator of the fractional formula, or value of V, also the value of the negative quantity 0.3 ($\sqrt{d}$—0.1) corresponding to the different values of *d* from 0.1 to 100; while the other contains the value of the denominator of the formula for different values of *s* from 1.0 to 24000.

As these Tables were neither sufficiently correct, nor extensive, we have inserted the following tables, which were calculated with great care and trouble by Mr John Lourie of Glasgow, who has permitted us to publish them for the first time.

The column of natural numbers has been added in this Table, which will enable the engineer to calculate the velocity V without having recourse to logarithms. The logarithmic differences are likewise added.

Explanation of the Tables.

Explanation of the tables.

Table I. contains values of the denominator of the fractional formula. Col. 1. contains the values of *s* or the length of the pipe; and col. 2, 3, 4. the natural numbers, the hyperbolic logarithm, and the logarithmic difference from the denominator 307 ($\sqrt{d}$—0.1), all of which are computed from 1.0 to 2400.

Table II. which has not been calculated in any shape by Dr Robison, has been computed by Mr Lourie, and contains the values of the numerator 307 ($\sqrt{d}$—0.1), and the negative quantity 0.3 ($\sqrt{d}$—0.1) suited to conduit pipes of all diameters, from $\frac{1}{4}$ of an inch to 18 inches in diameter.

Table III. contains the values of the numerator of the fractional formula, and also the values of the negative quantity 0.3 ($\sqrt{d}$—0.1.) The first column contains the values of *d*, the mean radius or the hydraulic mean depth; col. 2 and 3. contain the natural numbers, and also the hyperbolic logarithms, and the logarithmic difference for the numerator 307 ($\sqrt{d}$—0.1); and col. 5. contains the values of the negative quantity 0.3 ($\sqrt{d}$—0.1), all of which are computed from 0.1 to 100.

Tables for facilitating the calculation from Du Buat's Formula.

Tables for facilitating the calculation from Du Buat's Formula.

TABLE I.

Containing Values of $\sqrt{s}-$Hyp. Log. $\sqrt{s+1.6}$, *the Denominator of the Fraction* $\frac{307(\sqrt{d}-0.1)}{\sqrt{s}-\text{Hyp. Log.}\sqrt{s+1.6}}$ *for every Value of the Slope s.*

Slope of the Pipe, or s.	$\sqrt{s}-$Hyp. Log $\sqrt{s+1.6}$		Log. Differ.	Slope of the Pipe, or s.	$\sqrt{s}-$Hyp. Log $\sqrt{s+1.6}$		Log. Differ.	Slope of the Pipe, or s.	$\sqrt{s}-$Hyp. Log $\sqrt{s+1.6}$		Log. Differ.
	Numbers.	Logarithms.			Numbers.	Logarithms.			Numbers.	Logarithms.	
1.0	0.52224	9.71787		6.0	1.43542	0.15698	422	20	2.93519	0.46772	1345
1.1	0.55218	9.74208	2421	6.1	1.44921	0.16113	415	21	3.02360	0.48052	1280
1.2	0.58063	9.76390	2182	6.2	1.46292	0.16522	409	22	3.10979	0.49273	1221
1.3	0.60782	9.78378	1988	6.3	1.47655	0.16925	403	23	3.19446	0.50440	1167
1.4	0.63391	9.80203	1825	6.4	1.49008	0.17321	396	24	3.27768	0.51557	1117
1.5	0.65904	9.81891	1688	6.5	1.50358	0.17713	392	25	3.35954	0.52628	1071
1.6	0.68334	9.83463	1572	6.6	1.51698	0.18098	385	26	3.44011	0.53657	1029
1.7	0.70688	9.84935	1472	6.7	1.53031	0.18478	380	27	3.51945	0.54647	990
1.8	0.72975	9.86318	1383	6.8	1.54356	0.18852	374	28	3.59762	0.55601	954
1.9	0.75202	9.87623	1305	6.9	1.55675	0.19222	370	29	3.67466	0.56522	921
2.0	0.77375	9.88860	1237	7.0	1.56987	0.19586	364	30	3.75064	0.57411	889
2.1	0.79497	9.90035	1175	7.1	1.58292	0.19946	360	31	3.82561	0.58270	859
2.2	0.81574	9.91155	1120	7.2	1.59591	0.20302	356	32	3.89959	0.59102	832
2.3	0.83609	9.92225	1070	7.3	1.60883	0.20651	349	33	3.97263	0.59908	806
2.4	0.85605	9.93250	1025	7.4	1.62168	0.20997	346	34	4.04478	0.60689	781
2.5	0.87565	9.94233	983	7.5	1.63448	0.21338	341	35	4.11606	0.61448	759
2.6	0.89491	9.95178	945	7.6	1.64721	0.21675	337	36	4.18650	0.62185	737
2.7	0.91386	9.96088	910	7.7	1.65988	0.22008	333	37	4.25614	0.62902	717
2.8	0.93252	9.96966	878	7.8	1.67250	0.22336	328	38	4.32500	0.63599	697
2.9	0.95090	9.97813	847	7.9	1.68505	0.22661	325	39	4.39311	0.64277	678
3.0	0.96902	9.98633	820	8.0	1.69755	0.22982	321	40	4.46050	0.64938	661
3.1	0.98690	9.99427	794	8.1	1.70999	0.23299	317	41	4.52720	0.65583	645
3.2	1.00455	0.00197	770	8.2	1.72237	0.23613	314	42	4.59321	0.66212	629
3.3	1.02197	0.00944	747	8.3	1.73470	0.23923	310	43	4.65857	0.66825	613
3.4	1.03919	0.01669	725	8.4	1.74699	0.24229	306	44	4.72330	0.67424	599
3.5	1.05621	0.02375	706	8.5	1.75921	0.24532	303	45	4.78740	0.68010	586
3.6	1.07304	0.03061	686	8.6	1.77139	0.24831	299	46	4.85091	0.68582	572
3.7	1.08968	0.03730	669	8.7	1.78353	0.25128	297	47	4.91384	0.69142	560
3.8	1.10616	0.04382	652	8.8	1.79558	0.25420	292	48	4.97621	0.69690	548
3.9	1.12247	0.05017	635	8.9	1.80760	0.25710	290	49	5.03802	0.70226	536
4.0	1.13862	0.05638	621	9.0	1.81957	0.25997	287	50	5.09931	0.70751	525
4.1	1.15461	0.06244	606	9.1	1.83150	0.26281	284	51	5.16007	0.71266	515
4.2	1.17046	0.06836	592	9.2	1.84338	0.26561	280	52	5.22033	0.71770	504
4.3	1.18617	0.07415	579	9.3	1.85521	0.26839	278	53	5.28009	0.72264	494
4.4	1.20174	0.07981	566	9.4	1.86699	0.27114	275	54	5.33938	0.72749	485
4.5	1.21718	0.08535	554	9.5	1.87873	0.27387	273	55	5.39820	0.73225	467
4.6	1.23249	0.09078	543	9.6	1.89043	0.27656	269	56	5.45655	0.73692	467
4.7	1.24767	0.09610	532	9.7	1.90208	0.27923	267	57	5.51145	0.74150	458
4.8	1.26274	0.10131	521	9.8	1.91369	0.28187	264	58	5.57194	0.74601	451
4.9	1.27769	0.10643	512	9.9	1.92525	0.28449	262	59	5.62900	0.75043	442
5.0	1.29253	0.11144	501	10.0	1.93677	0.28708	259	60	5.68564	0.75478	435
5.1	1.30726	0.11636	492	11.0	2.04978	0.31171	2463	61	5.74187	0.75905	427
5.2	1.32190	0.12120	484	12.0	2.15907	0.33427	2256	62	5.79970	0.76326	421
5.3	1.33641	0.12594	474	13.0	2.26504	0.35508	2081	63	5.85315	0.76739	413
5.4	1.35084	0.13060	466	14.0	2.36802	0.37439	1931	64	5.90821	0.77146	407
5.5	1.36516	0.13518	458	15.0	2.46828	0.39239	1800	65	5.96290	0.77546	400
5.6	1.37939	0.13960	451	16.0	2.56605	0.40927	1688	66	6.01723	0.77940	394
5.7	1.39353	0.14412	443	17.0	2.66152	0.42513	1586	67	6.07120	0.78327	387
5.8	1.40758	0.14847	435	18.0	2.75188	0.44010	1497	68	6.12483	0.78709	382
5.9	1.42154	0.15276	429	19.0	2.84625	0.45427	1417	69	6.17811	0.79086	377

Tables for facilitating the calculation from Du Buat's Formula.

TABLE I. *continued.—Values of* $\sqrt{s}$—Hyp. Log. $\sqrt{s+1.6}$, *the Denominator of the Fraction* $\frac{307(\sqrt{d}-0.1)}{\sqrt{s}-\text{Hyp.Log.}\sqrt{s+1.6}}$ *for every Value of the Slope s.*

Tables for facilitating the calculation from Du Buat's Formula.

Slope of the Pipe, or s.	$\sqrt{s}$—Hyp.Log $\sqrt{s+1.6}$		Log. Differ.	Slope of the Pipe, or s.	$\sqrt{s}$—Hyp.Log $\sqrt{s+1.6}$		Log. Differ.	Slope of the Pipe, or s.	$\sqrt{s}$—Hyp.Log. $\sqrt{s+1.6}$		Log. Differ.
	Numbers.	Logarithms			Numbers.	Logarithms.			Numbers.	Logarithms.	
70	6.23105	0.79456	370	410	17.23843	1.23650	599	1200	31.09531	1.49269	2046
71	6 28367	0.79821	365	420	17.47187	1.24234	584	1300	32.46984	1.51148	1879
72	6.33596	0.80181	360	430	17.70269	1.24804	570	1400	33.79388	1.52884	1736
73	6.38794	0.80536	355	440	17.93097	1.25360	556	1500	35.07269	1.54497	1613
74	6.43963	0.80886	350	450	18.15680	1.25904	544	1600	36.31062	1.56003	1506
75	6.49096	0.81231	345	460	18.38026	1.26435	531	1700	37.51139	1.57416	1413
76	6.65420	0.81571	340	470	18.60142	1.26955	520	1800	38.67820	1.58747	1331
77	6.59270	0.81907	336	480	18.82034	1.27463	508	1900	39.81376	1.60004	1257
78	6.64325	0.82238	331	490	19.03711	1.27960	497	2000	40.92165	1.61195	1191
79	6.69345	0.82565	327	500	19.25178	1.28447	487	2100	42.00052	1.62325	1130
80	6.74336	0.82888	323	510	19.46441	1.28924	477	2200	43.05569	1.63403	1078
81	6.79294	0.83206	318	520	19.67506	1.29392	468	2300	44.08763	1.64432	1029
82	6.84327	0.83521	315	530	19.88378	1.29850	458	2400	45.09784	1.65416	984
83	6.89147	0.83831	310	540	20.09064	1.30299	449	2500	46.08761	1.66358	942
84	6.94031	0.84138	307	550	20.29567	1.30740	441	2600	47.05826	1.67264	906
85	6.98889	0.84441	303	560	20.49892	1.31173	433	2700	48.01072	1.68134	870
86	7.03723	0.84740	299	570	20.70045	1.31598	425	2800	48.94605	1.68972	838
87	7.08531	0.85036	296	580	20.90030	1.32015	417	2900	49.86514	1.69780	808
88	7.13315	0.85328	292	590	21.09858	1.32425	410	3000	50.76880	1.70560	780
89	7.18075	0.85617	289	600	21.29510	1.32828	403	3100	51.65781	1.71313	753
90	7.22812	0.85903	286	610	21.49014	1.33224	396	3200	52.53284	1.72043	730
91	7.27525	0.86185	282	620	21.68365	1.33613	389	3300	53.39454	1.72750	707
92	7.32215	0 86464	279	630	21.87567	1.33996	383	3400	54.24352	1.73435	685
93	7.36882	0.86740	276	640	22.06634	1.34373	377	3500	55.08031	1.74100	665
94	7.41527	0.87013	273	650	22.25538	1.34743	370	3600	55.90543	1.74745	645
95	7.46150	0.87283	270	660	22.44313	1.35108	365	3700	56.71937	1.75373	628
96	7.50752	0.87550	267	670	22.62953	1.35467	359	3800	57.52267	1.75984	611
97	7.55332	0.87814	264	680	22.81459	1.35821	354	3900	58.31540	1.76578	594
98	7.59891	0.88075	261	690	22.99835	1.36170	349	4000	59.09832	1.77157	579
99	7.64430	0.88334	259	700	23.18083	1.36513	343	4100	59.87168	1.77722	565
100	7.68948	0.88590	256	710	23.36207	1.36851	338	4200	60.63580	1.78273	551
110	8.13063	0.91012	2422	720	23.54208	1.37184	333	4300	61.39103	1.78810	537
120	8.55408	0.93217	2205	730	23.72089	1.37513	329	4400	62.13754	1.79335	525
130	8.96187	0.95240	2023	740	23.89854	1.37837	324	4500	62.87595	1.79848	513
140	9.35566	0.97107	1867	750	24.07502	1.38157	320	4600	63.60622	1.80350	502
150	9.73683	0.98842	1735	760	24.25038	1.38472	315	4700	64.32872	1.80840	490
160	10.10655	1.00460	1618	770	24.42464	1.38783	311	4800	65.04368	1.81320	480
170	10.46582	1.01977	1517	780	24.59781	1.39090	307	4900	65.75134	1.81790	470
180	10.81550	1.03405	1428	790	24.76991	1.39392	302	5000	66.45192	1.82251	461
190	11.15634	1.04752	1347	800	24.94097	1.39691	299	5100	67.14563	1.82702	451
200	11.48899	1.06028	1276	810	25.11099	1.39986	295	5200	67.83267	1.83144	442
210	11.81403	1.07240	1212	820	25.28001	1.40278	292	5300	68.51323	1.83577	433
220	12.13196	1.08393	1153	830	25.44804	1.40565	287	5400	69.18747	1.84003	426
230	12.44324	1.09493	1100	840	25.61510	1.40849	284	5500	69.85560	1.84420	417
240	12.74829	1.10545	1052	850	25.78120	1.41130	281	5600	70.51773	1.84830	410
250	13.04747	1.11553	1008	860	25.94636	1.41408	278	5700	71.17412	1.85232	402
260	13.34111	1.12519	966	870	26.11060	1.41682	274	5800	71.82479	1.85627	395
270	13.62951	1.13448	929	880	26.27392	1.41952	270	5900	72.46996	1.86016	389
280	13.91296	1.14342	894	890	26.43636	1.42220	268	6000	73.10978	1.86398	382
290	14.19169	1.15203	861	900	26.59791	1.42485	265	6100	73.74434	1.86773	375
300	14.46596	1.16035	832	910	26.75859	1.42746	261	6200	74.37381	1.87142	369
310	14 73596	1.16838	803	920	26.91845	1.43005	259	6300	74.99826	1.87505	363
320	15.00189	1.17615	777	930	27.07745	1.43261	256	6400	75.61785	1.87862	357
330	15 26394	1.18367	752	940	27.23563	1.43514	253	6500	76.23267	1.88214	352
340	15.52227	1.19096	729	950	27.39301	1.43764	250	6600	76.84286	1.88560	346
350	15.77704	1.19803	707	960	27.54957	1.44011	247	6700	77.44847	1.88901	341
360	16.02840	1.20489	686	970	27.70535	1.44256	245	6800	78.04966	1.89237	336
370	16.27647	1.21156	667	980	27 86036	1.44499	243	6900	78.64650	1.89568	331
380	16.52146	1.21805	649	990	28.01460	1.44738	236	7000	79.23905	1.89894	326
390	16.76330	1.22436	631	1000	28.16180	1.44976	238	7100	79.82746	1.90215	321
400	17.00227	1.23051	615	1100	29.66399	1.47223	2247	7200	80.41179	1.90532	317

Tables for facilitating the calculation from Du Buat's Formula.

Tables for facilitating the calculation from Du Buat's Formula.

TABLE I. *continued.—Values of* $\sqrt{s}$—Hyp.Log. $\sqrt{s+1.6}$ *the Denominator of the Fraction* $\frac{307(\sqrt{d}-0.1)}{\sqrt{s}-\text{Hyp. Log. }\sqrt{s+1.6}}$ *for every Value of the Slope s.*

Slope of the Pipe, or s.	$\sqrt{s}$—Hyp.Log.$\sqrt{s+1.6}$		Log. Differ.	Slope of the Pipe, or s.	$\sqrt{s}$—Hyp. Log. $\sqrt{+1.6}$		Log. Differ.	Slope of the Pipe, or s.	$\sqrt{s}$—Hyp.Log.$\sqrt{s+1.6}$		Log. Differ.
	Numbers.	Logarithms.			Numbers.	Logarithms.			Numbers.	Logarithms.	
7300	80.99213	1.90844	312	8700	88.73817	1.94811	261	11000	100.22798	2.00099	2147
7400	81.56887	1.91152	308	8800	89.26698	1.95069	258	12000	104.84811	2.02056	1957
7500	82.14112	1.91456	304	8900	89.79281	1.95324	255	13000	109.28109	2.03854	1798
7600	82.70992	1.91756	300	9000	90.31576	1.95576	252	14000	113.54812	2.05518	1664
7700	83.27505	1.92051	295	9100	90.83582	1.95826	250	15000	117.66652	2.07065	1547
7800	83.83658	1.92343	292	9200	91.35306	1.96072	246	16000	121.65088	2.08511	1446
7900	84.39455	1.92631	288	9300	91.86753	1.96316	244	17000	125.51374	2.09869	1358
8000	84.94902	1.92916	285	9400	92.37930	1.96557	241	18000	129.26496	2.11148	1279
8100	85.50009	1.93197	281	9500	92.88831	1.96796	239	19000	132.91434	2.12357	1209
8200	86.04784	1.93474	277	9600	93.39476	1.97032	236	20000	136.46956	2.13504	1147
8300	86.59226	1.93748	274	9700	93.89858	1.97266	234	21000	139.93758	2.14593	1089
8400	87.13343	1.94018	270	9800	94.39982	1.97497	231	22000	143.32475	2.15632	1039
8500	87.67144	1.94286	268	9900	94.89852	1.97726	229	23000	146.63584	2.16624	992
8600	88.20645	1.94550	264	10000	95.39473	1.97952	226	24000	149.87637	2.17573	949

TABLE II.

Values of the Numerator $307(\sqrt{d}-0.1)$ *for every Value of the Hydraulic Mean Depth d, calculated for Pipes, from* ¼ *of an inch to 18 Inches Diameter ; also the Value of the Factor* $0.3(\sqrt{d}-0.1)$.

Diameters.	Mean Radius, or Hydraulic mean depth or values of d.	$307(\sqrt{d}-0.1)$			0.3 × $\sqrt{d}-0.1$	Diameters.	Mean Radius, or Hydraulic mean depth or values of d.	$307(\sqrt{d}-0.1)$			0.3 × $\sqrt{d}-0.1$
		Numbers.	Logarithms.	Log. Differ.				Numbers.	Logarithms	Log. Differ.	
0¼	0.0625	46.050	1.66323		0.045	9¼	2.3125	436.152	2.63964	637	0.426
0½	0.125	77.841	1.89121	22798	0.076	9½	2.375	442.419	2.64583	619	0.432
0¾	0.1875	102.235	2.00960	11839	0.100	9¾	2.4375	448.604	2.65186	603	0.438
1	0.25	122.800	2.08920	7960	0.120	10	2.5	454.710	2.65773	587	0.444
1¼	0.3125	140.918	2.14897	5977	0.138	10¼	2.5625	460.740	2.66346	573	0.450
1½	0.375	157.298	2.19672	4775	0.154	10½	2.625	466.697	2.66903	557	0.456
1¾	0.4375	172.361	2.23644	3972	0.168	10¾	2.6875	472.583	2.67448	545	0.462
2	0.5	186.382	2.27040	3396	0.182	11	2.75	478.402	2.67979	531	0.467
2¼	0.5625	199.550	2.30005	2965	0.195	11¼	2.8125	484.155	2.68498	519	0 473
2½	0.625	212.005	2.32635	2630	0.207	11½	2.875	489.844	2.69006	508	0.479
2¾	0.6875	223.851	2.34996	2361	0.219	11¾	2.9375	495.471	2.69502	496	0.484
3	0.75	235.170	2.37138	2142	0.230	12	3.	501.040	2.69987	485	0.490
3¼	0.8125	246.026	2.39098	1960	0.240	12¼	3.0625	506.550	2.70462	475	0.495
3½	0.875	256.472	2.40904	1806	0.251	12½	3.125	512.004	2.70927	465	0.500
3¾	0 9375	266.551	2.42578	1674	0.260	12¾	3.1875	517.405	2.71383	456	0.506
4	1.	276.300	2.44138	1560	0.270	13	3.25	522.752	2.71830	447	0.511
4¼	1.0625	285.748	2.45598	1460	0.279	13¼	3.3125	528.049	2.72267	437	0.516
4½	1.125	294.923	2.46971	1373	0.288	13½	3.375	533.295	2.72697	430	0.521
4¾	1.1875	303.846	2.48265	1294	0.297	13¾	3.4375	538.493	2.73118	421	0.526
5	1.25	312.536	2.49490	1225	0.305	14	3.5	543.644	2.73531	413	0.531
5¼	1.3125	321.013	2.50652	1162	0.314	14¼	3.5625	548.750	2.73937	406	0.536
5½	1.375	329.289	2.51758	1106	0.322	14½	3.625	553.811	2.74336	399	0.541
5¾	1.4375	337.380	2.52812	1054	0.330	14¾	3.6875	558.828	2·74728	392	0.546
6	1.5	345.297	2.53819	1007	0.337	15	3.75	563.803	2.75113	385	0.551
6¼	1.5625	353.050	2.54784	965	0.345	15¼	3.8125	568.737	2.75491	378	0.556
6½	1.625	360.650	2.55709	925	0.352	15½	3.875	573.630	2.75863	372	0.561
6¾	1.6875	368.105	2.56597	888	0.360	15¾	3.9375	578.484	2.76229	366	0.565
7	1.75	375.423	2.57452	855	0.367	16	4.	583.300	2.76589	360	0.570
7¼	1.8125	382.611	2.58276	824	0.374	16¼	4.0625	588.078	2.76948	354	0.575
7½	1.875	389.677	2.59070	794	0.381	16½	4.125	592.820	2.77292	349	0.579
7¾	1.9375	396.626	2.59838	768	0.388	16¾	4.1875	597.526	2.77636	344	0.584
8	2.	403.464	2.60580	742	0.394	17	4.25	602.197	2.77974	338	0.588
8¼	2.0625	410.195	2.61299	719	0.401	17¼	4.3125	606.833	2.78307	333	0.593
8½	2.125	416.826	2.61995	696	0.407	17½	4.375	611.437	2.78645	328	0.597
8¾	2.1875	423.359	2.62671	676	0.414	17¾	4.4375	616.007	2.78958	323	0.602
9	2.25	429.800	2.63327	656	0.420	18	4.5	620.545	2.79277	319	0.606

Tables for facilitating the calculation from Du Buat's Formula.

TABLE III.

Values of the Numerator $307(\sqrt{d}-0.1)$ *for every value of the Hydraulic Mean Depth* $\dot{d}$; *also the values of the Factor* $0.3(\sqrt{d}-0.1)$.

Mean Radius, or Hydraulic mean depth or values of *d*.	$307(\sqrt{d}-0.1)$			$0.3 \times \sqrt{d}-0.1$	Mean Radius, or Hydraulic mean depth or values of *d*.	$307(\sqrt{d}-0.1)$			$0.3 \times \sqrt{d}-0.1$
	Numbers.	Logarithms.	Log. Differ.			Numbers.	Logarithms.	Log. Differ.	
0.1	66.382	1.82205		0.065	5.5	689.279	2.83839	416	0.674
0.2	106.595	2.02774	20569	0.104	5.6	695.795	2.84248	409	0.680
0.3	137.451	2.13815	11041	0.134	5.7	702.253	2.84649	401	0.686
0.4	163.464	2.21342	7527	0.160	5.8	708.654	2.85043	394	0.692
0.5	186.382	2.27040	5698	0.182	5.9	715.000	2.85431	388	0.699
0.6	207.101	2.31618	4578	0.202	6.0	721.293	2.85811	380	0.705
0.7	226.155	2.35441	3823	0.221	6.1	727.534	2.86185	374	0.711
0.8	243.889	2.38719	3278	0.238	6.2	733.724	2.86553	368	0.717
0.9	260.458	2.41588	2869	0.255	6.3	739.864	2.86915	362	0.723
1.0	276.300	2.44138	2550	0.270	6.4	745.955	2.87271	356	0.729
1.1	291.285	2.46432	2294	0.285	6.5	752.000	2.87622	351	0.735
1.2	305.602	2.48516	2084	0.299	6.6	757.997	2.87967	345	0.741
1.3	319.334	2.50425	1909	0.312	6.7	763.950	2.88306	339	0.747
1.4	332.548	2.52185	1760	0.325	6.8	769.858	2.88641	335	0.752
1.5	345.297	2.53819	1634	0.337	6.9	775.723	2.88971	330	0.758
1.6	357.628	2.55343	1524	0.349	7.0	781.545	2.89295	324	0.764
1.7	369.579	2.56771	1428	0.361	7.1	787.327	2.89615	320	0.769
1.8	381.184	2.58113	1342	0.372	7.2	793.068	2.89931	316	0.775
1.9	392.470	2.59381	1268	0.384	7.3	798.768	2.90242	311	0.781
2.0	403.464	2.60580	1199	0.394	7.4	804.430	2 90549	307	0.786
2.1	414.185	2.61719	1139	0.405	7.5	810.054	2.90851	302	0.792
2.2	424.655	2.62804	1085	0.415	7.6	815.641	2.91150	299	0.797
2.3	434.888	2.63838	1034	0.425	7.7	821.190	2.91444	294	0.802
2.4	444.902	2.64826	988	0.435	7.8	826.704	2.91735	291	0.808
2.5	454.710	2.65773	947	0.444	7.9	832.183	2.92022	287	0.813
2.6	464.323	2.66681	908	0.454	8.0	837.627	2.92305	283	0.819
2.7	473.753	2.67555	874	0.463	8.1	843.037	2.92585	280	0.824
2.8	483.003	2.68395	840	0.472	8.2	848.414	2.92861	276	0.829
2.9	492.102	2.69205	810	0.481	8.3	853.758	2.93133	272	0.834
3.0	501.040	2.69987	782	0.490	8.4	859.070	2.93403	270	0.839
3.1	509.829	2.70743	756	0.498	8.5	864.351	2.93669	266	0.845
3.2	518.478	2.71473	730	0.507	8.6	869.601	2.93932	263	0.850
3.3	526.993	2.72180	707	0.515	8.7	874.820	2.94192	260	0.855
3.4	535.380	2.72866	686	0.523	8.8	880.009	2.94449	257	0.860
3.5	543.644	2.73531	665	0.531	8.9	885.169	2.94703	254	0.865
3.6	551.792	2.74177	646	0.539	9.0	890.300	2.94954	251	0.870
3.7	559.826	2.74805	628	0.547	9.1	895.403	2.95202	248	0.875
3.8	567.753	2.75416	611	0.555	9.2	900.477	2.95447	245	0.880
3.9	575.576	2.76010	594	0.562	9.3	905.424	2.95690	243	0.885
4.0	583.300	2.76589	579	0.570	9.4	910.544	2.95930	240	0.890
4.1	590.928	2.77153	564	0.577	9.5	915.537	2.96168	238	0.895
4.2	598.463	2.77704	551	0.585	9.6	920.505	2.96408	235	0.900
4.3	605.909	2.78241	537	0.592	9.7	925.446	2.96635	232	0.904
4.4	613.269	2.78765	524	0.599	9.8	930.362	2.96865	230	0.909
4.5	620.545	2.79277	512	0.606	9.9	935.253	2.97093	228	0.914
4.6	627.742	2.79778	501	0.613	10.0	940.119	2.97318	225	0.919
4.7	634.860	2.80268	490	0.620					
4.8	641.903	2.80747	479	0.627	11	987.504	2.99454	2136	0.965
4.9	648.873	2.81216	469	0.634	12	1032.779	3.01401	1947	1.009
5.0	655.773	2.81675	459	0.641	13	1076.204	3.03189	1788	1.051
5.1	662.604	2.82125	450	0.647	14	1117.989	3.04844	1655	1.092
5.2	669.368	2.82566	441	0.654	15	1158.306	3.06382	1538	1.131
5.3	676.067	2.82999	433	0.661	16	1197.300	3.07820	1438	1.170
5.4	682.704	2.83423	424	0.667	17	1235.093	3.09170	1350	1.207

Tables for facilitating the calculation from Du Buat's Formula.

TABLE III. *Continued.*

Values of the Numerator 307 $(\sqrt{d}-0.1)$ *for every Value of the Hydraulic Mean Depth* d *; also the Value of the Factor* $0.3(\sqrt{d}-0.1)$.

Mean Radius, or Hydraulic mean depth or values of d.	$307(\sqrt{d}-0.1)$			$0.3 \times \sqrt{d}-0.1$	Mean Radius, or Hydraulic mean depth or values of d.	$307(\sqrt{d}-0.1)$.			$0.3 \times \sqrt{d}-0.1$
	Numbers.	Logarithms.	Log. Differ.			Numbers.	Logarithms.	Log. Differ.	
18	1271.791	3.10442	1272	1.243	60	2347.312	3.37057	370	2.294
19	1307.482	3.11644	1202	1.278	61	2367.046	3.37421	364	2.313
20	1342.246	3.12783	1139	1.312	62	2386.621	3.37778	357	2.332
21	1376.150	3.13866	1083	1.345	63	2406.037	3.38130	352	2.351
22	1409.258	3.14899	1033	1.377	64	2425.300	3.38477	347	2.370
23	1441.620	3.15885	986	1.409	65	2444.413	3.38817	340	2.389
24	1473.286	3.16829	944	1.440	66	2463.380	3.39153	336	2.407
25	1504.300	3.17733	904	1.470	67	2482.203	3.39484	331	2.426
26	1534.699	3.18602	869	1.500	68	2500.887	3.39809	325	2.444
27	1564.519	3.19438	836	1.529	69	2519.434	3.40130	321	2.462
28	1593.791	3.20243	805	1.557	70	2537.846	3.40446	316	2.480
29	1622.546	3.21020	777	1.586	71	2556.128	3.40758	312	2.498
30	1650.808	3.21770	750	1.613	72	2574.282	3.41066	308	2.516
31	1678.604	3.22496	726	1.640	73	2592.310	3.41369	303	2.533
32	1705.954	2.23197	701	1.667	74	2610.224	3.41668	299	2.551
33	1732.881	3.23877	680	1.693	75	2627.998	3.41962	294	2.568
34	1759.402	3.24536	659	1.719	76	2645.664	3.42253	291	2.585
35	1785.536	3.25177	641	1.745	77	2663.214	3.42541	288	2.602
36	1811.300	3.25799	622	1.770	78	2680.651	3.42824	283	2.619
37	1836.708	3.26404	605	1.795	79	2697.976	3.43104	280	2.636
38	1861.775	3.26993	589	1.819	80	2715.191	3.43380	276	2.653
39	1886.514	3.27566	573	1.843	81	2732.300	3.43653	273	2.670
40	1910.938	3.28125	559	1.867	82	2749.304	3.43922	269	2.687
41	1935.059	3.28669	544	1.891	83	2766.204	3.44188	266	2.703
42	1958.887	3.29201	532	1.914	84	2783.002	3.44451	263	2.720
43	1982.434	3.29720	519	1.937	85	2799.700	3.44711	260	2.736
44	2005.708	3.30227	507	1.960	86	2816.301	3.44968	257	2.752
45	2028.719	3.30722	495	1.982	87	2832.906	3.45223	255	2.768
46	2051.475	3.31207	485	2.005	88	2849.215	3.45473	250	2.784
47	2073.986	3.31681	474	2.027	89	2865.532	3.45721	248	2.800
48	2096.258	3.32144	463	2.048	90	2881.758	3.45966	245	2.816
49	2118.300	3.32599	455	2.070	91	2897.893	3.46208	242	2.832
50	2140.118	3.33044	445	2.091	92	2913.940	3.46448	240	2.847
51	2161.718	3.33480	436	2.112	93	2929.900	3.46685	237	2.863
52	2183.109	3.33908	428	2.133	94	2945.776	3.46920	235	2.879
53	2304.204	3.34328	420	2.154	95	2961.565	3.47152	232	2.894
54	2225.280	3.34738	410	2.175	96	2977.274	3.47382	230	9.909
55	2246.073	3.35142	404	2.195	97	2992.900	3.47609	227	2.925
56	2266.678	3.35539	397	2.215	98	3008.445	3.47834	225	2.940
57	2287.100	3.35928	389	2.235	99	3023.912	3.48057	223	2.955
58	2307.343	3.36311	383	2.255	100	3039.300	3.48277	220	2.970
59	2327.411	3.36687	376	2.274					

Method of using the preceding Tables.

Method of Using the preceding Tables.

Example I. Water is brought into Edinburgh by several pipes, one of which is 5 inches in diameter. This pipe is 14,367 * feet long, and the reservoir at Comiston is 44 feet higher than the reservoir on the Castle-hill into which the water is delivered. It is required to know how many Scots pints the pipe should deliver in a minute.

1. In this case we have $d = \frac{5}{4} = 1.25$ inches.

2. We have $s = \frac{14,367}{44} = 326.36$.

Now, by entering Table III. with 1.25 as the value of *d*, and Table I. with 326 as the value of *s*, we obtain

2.49490 as the logarithm for the *numerator*, and
1.18065 as the logarithm corresponding to 326.36.
the difference of which logarithms is
1.31425 the logarithm of 20.618, or the value of

$$\frac{307(\sqrt{d}-01)}{\sqrt{s}-\text{Hyp. Log. }\sqrt{s+1.6}}$$

In order to find the value of the negative quantity 0.3 $(\sqrt{d}-0.1)$ enter Table III. col. 1. with 1.25, and in col. 5. will be found, by taking proportional parts, 0.305; hence we have the velocity V=20.618—0.305=20.313, the velocity of the water in inches per second.

The whole of the preceding operation may be saved by Table II.; for, by entering col. 1. of this Table with 5 inches as the diameter of the pipe, we obtain at once 2.49490, and 0.305 as the values of the numerator and the negative quantity. In order to obtain the number of Scotch pints per minute, each of which contains 103.4 cubic inches, we must multiply the velocity by 60″, and this product by 5^2 or 25, and then by 0.7854, the area of a circle whose diameter is 1, and then divide by 103.4. Thus,

Log. of 20.313	1.3077741
Log. of 60″	1.7781513
Log. of 5^2 or 25	1.3979400
Log. of 0.7854	9.8950909
From	4.3789563
Subtract Log. of 103.4	2.0145205
Remains Log. of 231.44	2.3644358

Scots pints, which should be delivered by the pipe.

Now, the pipe, when in its best order, yielded 250 pints in a minute, as we have learned from a MS. note of Dr Robison.

Since the logarithm of 60, of .7854, and of 103.4 is constant, we may take 1.7781513 + 9.8950909 — 2.0145205 = 9.6587217, and the operation will stand thus:

Log. of 20.313	1.3077741
Log. of 5^2	1.3979400
Log. for reducing to Scotch pints	9.6587217
Log. of 231.44 as before.	2.3644358

Hence we have the following Rule: Add together the logarithm of the velocity in inches per second, as found by the formula, the logarithm of the square of the diameter of the pipe, and the constant logarithm 9.6587213, and the sum is the logarithm of the Scotch pints discharged in a minute.

The facts in the preceding example respecting the supply of Edinburgh with water were taken from Dr Robison's article on Waterworks already quoted. We are informed, however, by James Jardine, Esq. civil engineer, that the facts are wholly erroneous, and we have been indebted to the kindness of this gentleman for the following state of the Edinburgh water pipes, to which we shall apply the formula of Du Buat.

Example II. An excellent cast leaden pipe was laid from the fountain head at Comiston to the reservoir on the Castlehill of Edinburgh in the year 1720. The interior diameter of the pipe was 4½ inches, the fountainhead was 51 feet above the point of delivery, and the length of the pipe was 14,930 feet. Its maximum discharge during the years 1738, 1739, 1740, 1741, and 1742, was 11⅓ cubic feet, or 189.4 Scotch pints per minute.

In this example we have $d = \frac{4\frac{1}{2}}{4} = 1.125$

$$s = \frac{14930}{51} = 292.745$$

Log. of numerator		2.46971
Log. of denominator		1.15431
Log. of	20.673	1.31540
Subtract negative quantity	.288	
Remains	20.385 the velocity per second.	

Hence

Log. of 20.385	1.3093107
Log. of $\overline{4\frac{1}{2}}^2$ or 20.25	1.3064250
Log. for reducing to Scotch pints . .	9.6587217
Log. of 188.13 Scotch pints	2.2744574

A result which agrees in a very wonderful manner with 189.4, the quantity actually delivered by the pipe.

Example III. A flanch cast iron pipe is laid from Swanston cistern to the reservoir on the Castlehill, Edinburgh. Its diameter is seven inches; the cistern at Swanston is 222 feet higher than the point of delivery, the length of the pipe is 21,350 feet, and in its best state it delivers 3½ cubic feet, or 593.3 Scotch pints in a minute.

In this case we have $d = \frac{7}{4} = 1.75$

$$s = \frac{21350}{222} = 96.17.$$

Log. of numerator		2.57452
Log. of denominator		0.87595
Log. of	49.964	1.69857
Subtract negative quantity	.367	
Remains	49.597 the velocity per second.	
Log. of	49.597 . .	1.695447
Log. of	7^2 or 49 . .	1.690196
Log. for reducing to Scotch pints . .		9.658721
Log. of 1107.5		3.044364

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* Dr Robison, who applied his tables to this example, makes the length of the pipe 14,637 by mistake, and has corrected it to 14,367 in his MS. notes.

lotion of Water in Pipes and Canals.

Hence the discharge is 1107.5 Scotch pints, which differs so widely from 593.3, the quantity actually delivered, that there must have been some unknown obstruction in the pipe.

The cast iron main, five inches in diameter, which is laid from Comiston to Edinburgh, was always very defective in its delivery. Though its length is only 13,519 feet, and the height of the fountain above the point of delivery 88 feet yet it yields only ten cubic feet, or 167.7 Scotch pints per minute.

EXAMPLE IV. Mr Watt found, from very careful measurements, that a canal in his neighbourhood, which was 18 feet wide at the surface, 7 feet wide at the bottom, 4 feet deep, and had a declivity of 4 inches in a mile, moved with a velocity of 17 inches per second at the surface, 14 inches in the middle, and 10 at the bottom; the mean velocity being 13.3.

Now, since the sloping side of a canal corresponding to 4 feet deep, and $\frac{18-7}{2} = 5\frac{1}{2}$ of projection, is 6.8 feet, we have for the perimeter of the section in contact with the water, $6.8 + 7 + 6.8 = 20.6$. The area of the section will therefore be $4 \times \frac{18+7}{2} = 50$ square feet. Hence $d = \frac{50}{20.6} = 2.4272$, or 29.126. The logarithm corresponding to this in Table III. is 3.21117, and the value of the negative quantity in col. 5. is 1.589.

Now, since the slope is 4 inches, or $\frac{1}{3}$ of a foot in a mile, we have $s = 15840$, and the corresponding logarithm in the table 2.08280. Hence,

From	3.21117
Subtract	2.08280

And there remains 1.12837 = Log. of 13.439 inches	
Subtract the negative quantity	1.589
And there remains	11.850 inches,

the velocity of the canal per second required, which differs considerably from 13.33, the mean velocity observed by Mr Watt.

In the two first examples, the reader will observe, that the formula errs in defect. Dr Robison considers it as most correct in small canals where it is most needed, such as in mill courses and other derivations for working machinery. From several comparisons with direct observation, he proposes to substitute in place of the expression Hyp. Log. $\sqrt{s+1.6}$ the expression $2\frac{1}{4}$ Com. Log. $\sqrt{s+1.6}$, which he considers both as more simple and more accurate.

ges up- u Bu- rmula sed by g.

Instead of the part of the numerator Hyp. Log, $\sqrt{s+1.6}$, Dr Young proposes to substitute $0.85\, s^{\frac{11}{500}}$, which is nearly the same for moderate velocities. He proposes also $V = 307\,(\sqrt{d} - 1)\left(\frac{1}{\sqrt{s}} + \frac{1.6}{s^{.88}} - .001\right)$ and since $s^{0.875}$ may be substituted without much inaccuracy in place of $s^{0.88}$, the term $\frac{1.6}{s^{0.88}}$ will become $\frac{1.6 s^{\frac{1}{8}}}{l}$, which may be determined without logarithms. Hence the whole formula will become

$$V = 153(\sqrt{d} - 0.2).\sqrt{\left(\frac{h}{l + 45\,d}\right)} + 1.6\left(\frac{h}{l + 45d}\right)^{\frac{7}{8}} - .001$$

l being the length of the pipe, h the height of the whole head of water, and d the diameter of the pipe. In this formula $s = \frac{l + 45d}{h}$. The formula may be applied to rivers, by taking $\frac{1}{s}$ as the sine of their inclination.

Motion of Water in Pipes and Canals.

M. Langsdorf has proposed to substitute 482 in place of the number 478 used by Du Buat in his formula $V^2 = \sqrt{478\, h}$ in French inches, which gives $V = \sqrt{509\, h}$ in English inches.

Changes proposed by Langsdorf.

When the pipe is bent in one or more places, the effect of the bending may be found by adding into one sum σ the squares of the sines thus,

$$s = \frac{l}{h - \left(\frac{V^2}{509} + \frac{V^2 \sigma}{3000}\right)}$$

Or more simply,

$$V = \sqrt{\left(\frac{509\, d\, h}{d + \frac{1}{23}\, l + 0.16\, d\, \sigma}\right)},$$

which is Langsdorf's formula reduced to English measure.

Formulæ proposed by M. Eytelwein.

M. Eytelwein conceives the head of water to be divided into two parts, one of which is employed in producing velocity, while the other is employed in overcoming the resistances to which it is exposed. He considers the height employed in overcoming the resistances to be directly as the length of the pipe, and as the circumference of the section, or as the diameter of the pipe, and inversely as the area of the section, or as the square of the diameter; that is, on the whole, inversely as the diameter. This height too, must, like the resistance arising from friction, vary as the square of the velocity. Hence if f denote the height due to the friction, δ the diameter of the pipe, and a a constant quantity, we shall have

$$f = V^2 \frac{a\, l}{\delta}, \text{ and } V^2 = \frac{f \delta}{a\, l}.$$

But the height employed in overcoming the friction, corresponds to the difference between the actual velocity and the actual height, that is $f = h - \frac{V^2}{b^2}$ where b is the co-efficient for finding the velocity from the height. Hence we have

$$V^2 = \frac{b^2 \delta\, h - \delta\, V^2}{a\, b^2\, l} \text{ and } V = \sqrt{\frac{b^2 \delta\, h}{a\, b^2\, l + \delta}}.$$

Now Buat found b to be 6.6, and $a\, b^2$ was found to be 0.0211, particularly when the velocity is between 6 and 24 inches per second. Hence we have

$$V^2 = \frac{43.6\, \delta\, h}{0.0211 l + \delta}, \text{ or } V = 45.5 \sqrt{\left(\frac{\delta\, h}{l + .47 \delta}\right)}.$$

Or, what is considered more accurate,

$$V = 50 \sqrt{\left(\frac{\delta\, h}{l + 50 \delta}\right)}.$$

Application of Eytelwein's formula.

If the pipe is bent, the velocity thus found must be diminished by taking the product of its square, multiplied by the sum of the sines of the several angles of flexure, and then by 0.0038. This will give the degree of pressure employed in overcoming the resistance occasioned by the angles; and subtracting this height from the height corresponding to the velocity, we may thence find the corrected velocity.

In applying this formula to *Example 2.* in p. 526, relative to the $4\frac{1}{2}$ inch pipe, which supplies Edinburgh with water, we have $h = 51$ feet, $\delta = 0.375$ of a foot,

=14930, hence we shall obtain 1.7136 for the velocity in feet per second, or 20.5632 for the velocity in inches, which, by the rule already explained, gives 189.77 Scotch pints per minute.

Quantity of water delivered by the pipe, ...	189.4 Scotch pints per minute.
Ditto determined by Eytelwein's formula, . . .	189.77
Ditto by Du Buat's formula.	188.13

From which it appears, that in this case Eytelwein's formula is the most correct of the two, the error being only 0.37, while in Du Buat's it is 1.27 Scotch pints. The accuracy of both the formulæ is very remarkable.

Eytelwein's rule for canals and rivers.

In order to obtain a rule for determining the velocity of water in canals and rivers, M. Eytelwein considers the friction as nearly proportional to the square of the velocity, not because a number of particles proportional to the velocity is torn asunder in a time proportionally short, but because, when a body is moving in lines of a given curvature, the deflecting forces are as the squares of the velocities; for it is obvious, that the particles of water which touch the sides and bottom of the canal must be deflected, in consequence of the elevations and depressions on the surface upon which they slide nearly into the same curvilineal path, whatever be the velocity with which they move. We may therefore consider the friction as nearly proportional to the square of the velocity, and as nearly the same at all depths. It will, however, vary according to the surface of the fluid which is in contact with the solid, in proportion to the whole quantity of fluid; that is, the friction for a given quantity of water will be directly as the surface of the bottom and sides of a canal, or as the perimeter of the section in contact with the water; or supposing the whole quantity of water to be spread upon a horizontal plane equal to the bottom and sides, the friction will be inversely as the height at which the water would stand, which is the mean radius, or hydraulic mean depth.

But in a river flowing uniformly, and neither accelerated nor retarded by gravity, the whole weight of the water must be employed in overcoming this friction; and if the inclination of the plane varies, the relative weight, or the force that urges the particles along the inclined plane, will vary as the height of the plane when its length is given, or as the fall in any given distance. Hence it follows, that the friction, which is equal to the relative weight, must vary as the fall; and the velocity, which is as the square root of the friction, must be as the square root of the fall; and supposing the hydraulic mean depth to increase or diminish while the inclination remains the same, the friction would be diminished or increased in the same ratio, and therefore, in order to preserve its equality with the relative weight, it must be proportionally increased or diminished, by increasing the square of the velocity, in the ratio of the hydraulic mean depth, or the velocity in the ratio of its square root. We may expect, therefore, that the velocities will be conjointly as the square root of the hydraulic mean depth, and of the fall in a given distance, or as a mean proportional between these two lines. If we take two English miles for a given length, we must find a mean proportional between the hydraulic mean depth, and the fall in two English miles; and having ascertained the relation which this bears to the velocity in a particular case, we may easily determine it in all other cases. According to M. Eytelwein's formula, this mean proportional is $\frac{11}{10}$ of the velocity, or 0.91 times the velocity in a second. Making d the hydraulic mean depth in inches, f the fall in two English miles in inches, $\sqrt{fd}$ being the mean proportional, we have

$$V = 0.91\sqrt{fd}$$

In applying this formula to Example II. in p. 526, relative to the velocity in a canal as measured by Mr Watt, we have $d = 29.126$ and $f = 8$ inches.

Hence $V = 0.91\sqrt{8 \times 29.126} = 0.91 \times 15.264 = 13.890$, a result which agrees very nearly with the mean velocity as ascertained by Mr Watt.

The preceding formula is applicable only to a canal, or to a straight river flowing through an equable channel. M. Eytelwein has shewn that the velocity is in general a little greater, when the bottom is horizontal than when it is parallel to the surface, and that the velocity in curved channels is always greater on the convex than on the concave side. It is not easy to give a rule for the decrease of the velocity from the surface to the bottom of a stream of water, as it is sometimes found to be a maximum below the surface.

The following are the velocities in the Arno and the Rhine:

Arno.		Rhine.	
Depth in feet.	Velocity in inches per second.	Depth in feet.	Velocity in inches per second.
2	39½	1	58
4	38½	5	56
8	37	10	52
16	33½	15	43
17	31		

M. Eytelwein considers that an approximate value of the mean velocity may be obtained by deducting $\frac{1}{130}$ for every foot of the whole depth.

Sect. III. *Account of the Investigations of M. Prony, respecting the velocity of Water in Conduit Pipes and open Canals.*

Investigations of Chezy, G rard, and Prony.

In our history of Hydrodynamics, we have already given a general view of the labours of Chezy, Girard, and Prony, in the composition of formulæ for determining the velocity of water in conduit pipes and open canals. As the formulæ obtained by these eminent engineers have all the same character, both from their extreme simplicity, and from their containing only algebraical quantities, we have thought it proper to give an account of them in the same Section. In doing this, we shall adopt the notation of M. Prony, and retain the coefficients as he has given them in French metres.

The following are the symbols which he employs:

$\lambda =$ the length of the pipe or canal.

$\zeta =$ the difference of level between the two extremities of the pipe.

$\omega =$ the area of the section of the pipe or canal.

$\chi =$ the perimeter of the section in contact with the water.

$g =$ the accelerating force of gravity, or 32.174.

$D =$ the diameter of the tube.

$R = \frac{\omega}{\chi} =$ the mean radius, or the hydraulic mean depth.

$I =$ the sine of the inclination of the pipe or canal.

$U =$ the mean velocity in the section ω.

$V =$ the velocity of the surface } In open canals, &c.

$W =$ the velocity at the bottom }

According to this notation, the formula of Du Buat, in English inches, is

$$U = \frac{\sqrt{307\,g}\left(\sqrt{\frac{\omega}{\chi}} - 0.1\right)}{\sqrt{\frac{\lambda}{\zeta}} - \text{Hyp. Log.}\sqrt{\frac{\lambda}{\zeta} + 1.6}} - 0.3\left(\sqrt{\frac{\omega}{\chi}} - 0.1\right)$$

Or when reduced to French metres,

$$U = \left(\frac{\sqrt{243.79}}{\sqrt{\frac{\lambda}{\zeta}} - \text{Hyp.Log.}\sqrt{\frac{\lambda}{\zeta} + 1.6}} - 0.049359\right)$$

$$\left(\sqrt{\frac{\omega}{\chi}} - 0.016453\right)$$

Formula of Chezy.

About eleven years before the publication of the second edition of Du Buat's work, M. Chezy obtained an expression of the velocity much more simple than the preceding. He assimilates the resistance of the sides of the pipe or canal to known resistances, which follow the law of the square of the velocity; and he supposes that the ratio of $\chi U^2 : \frac{\zeta \omega}{\lambda}$ is constant for all currents of the same fluid. Upon this hypothesis, it is sufficient to determine, by experiment, the values of U, χ, ζ and λ for any known current of water, and to deduce from it the general value of U in terms of χ, ζ and λ belonging to any other current. The formula of Chezy, deduced from these principles, is

$$U = \sqrt{\frac{g\,\omega\,\zeta}{\beta\,\lambda\,\chi}}.$$

A single experiment only is necessary for determining β, which is an abstract number, or $\frac{g}{\beta}$, which is a linear quantity.

Formula of Girard.

The fine researches of Coulomb respecting the resistance of fluids, were first applied by M. Girard to the discovery of a correct formula for expressing the velocity of water. He proposed to adopt for the value of the resistance, the product of a constant quantity, by the sum of the first and second powers of the velocity; and having determined this constant quantity after 12 experiments of Chezy and Du Buat, he obtained a formula, which, as we shall presently see, represents the experimental velocities as accurately as the more complicated one of Du Buat. He expresses the resistance due to the cohesion by $R'\chi U$; R' being a quantity to be obtained from experiment; and supposing that the adhesion to the *paroi mouillée*, or the film which adheres to the sides of the pipe, of the asperities which are there disseminated, is the same as that which retains the fluid molecules to one another, he makes the resistance due to these asperities equal to $R'\chi U^2$, so that the sum of the two resistances is $R'\chi(U + U^2)$, which leads to the formula $\frac{g\,\omega\,\zeta}{\lambda\,\chi} = R'(U + U^2)$.

M. Girard assigns, from the experiments of Du Buat, 0.0012181 as the value of R, and his formula becomes $U = -0.5 + \sqrt{\left(0.25 + 8052{,}54\,\frac{\omega\zeta}{\lambda\chi}\right)}$ or making $\frac{\zeta}{\lambda} = \frac{1}{b} = I$, and $\frac{\omega}{\chi} = R$, the formula becomes $U = -0.5 + \sqrt{(0.25 + 8052.54\,RI)}$.

In order to obtain a formula for the mean velocity of fluids, M. Prony found, that an expression of the mean velocity, deduced from the theory of fluids, and composed of terms relative to gravity, to the dimensions or figure of the pipe or canal, ought to be equal to a certain function of this mean velocity; and in determining this function, he observed, that in all the hypotheses respecting the unknown function of the velocity to which the resistance is proportional that makes the motion uniform, it may always be developed in a series, arranged according to the whole powers of the mean velocity, or the variable quantity. That is,

$$\frac{g\,\omega\,\zeta}{\lambda\,\chi} = c + \alpha U + \beta U^2 + \gamma U^3, \text{ \&c.}$$

in which c is a function independent of U, and which, along with the co-efficients α, β, γ, &c. must be determined by experiment.

The first term c of this series, is related on the one hand to the inclination which the canal or tube ought to have, in order that the motion may be ready to commence; and on the other hand, to the form and dimensions which must be given to the transverse section, in order that the whole fluid which is contained in the canal or pipe may adhere to it. The determination of this first term depends on very delicate experiments, which have not been made; but it is quite certain that, from its extreme smallness, it may be safely neglected.

The second term αU is naturally related to very small velocities; and as it is known from good experiments, that the first and second powers of the velocity satisfy all the phenomena included within certain limits, it is requisite first to examine if these limits contain the greatest velocities, which are necessary to be considered in practice. M. Prony therefore takes the equation

$$\frac{g\,\omega\,\zeta}{\lambda\,\chi} = \alpha U + \beta U^2,$$

and he then endeavours to determine the values of the constant quantities α and β, which may be conformable with the best experiments which have been made on the motion of water in canals.

In the execution of this task, M. Prony has availed himself of the fine methods for the correction of anomalies, which M. La Place has applied in his *Mecanique Celeste*,* for determining the figure of the earth. La Place has given no fewer than three of these methods, the last of which Prony considers as the best.

If we have obtained, for example, a series of experimental values of any variable quantity, these values may be connected together by a law, by applying small corrections to each of the experimental results. The equation which expresses this law, may be put under the form

$$Z = \alpha + \beta X,$$

where Z and X are functions of one or more variable quantities, of which we have a certain number of values either directly observed, or calculated from observations. It is then required to assign to the unknown constant quantities α and β such values, that the phenomena may be represented in the best possible manner by the preceding equation.

The explanation of these methods does not belong to the present article; but in some part of our work, probably under the article PHYSICS, we shall lay them befor our readers.

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* See *Mecanique Celeste*, Part I. Lib. iii. Sect. 39, and 40.

If we divide by U both sides of the equation, $\frac{g\omega\zeta}{\lambda\chi}=\alpha\,U+\beta\,U^2$, we obtain $\frac{g\omega\zeta}{\lambda\chi U}=\alpha+\beta\,U$, and putting $\frac{g\omega\zeta}{\lambda\chi U}=y$, we have an equation of the first order $y=\alpha+\beta\,U$, in which all the quantities are linear except β, which is an abstract number.

By calculating as many values of y corresponding to the determined values of U, as we have experiments on the velocity observed in canals, where ζ, λ, ω, and χ have been measured, and by finding α and β by the methods already mentioned, we obtain an expression of the velocity.

M. Prony has applied these methods to the twelve experiments, from which Girard deduced the value of the co-efficient R in his formula, chiefly with the view of comparing the results obtained by Du Buat's formula, Girard's formula, and his own formula. Two of these twelve experiments were made by M. Chezy upon the Rigole of Courpalet, and upon the Seine. The other ten are taken from Du Buat's work, and are those which Girard employed. From these experiments, Prony finds $\alpha=0.00093$, and $\beta=0.00266$. Hence we obtain

$$\frac{g\omega\zeta}{\lambda\chi}=0.00093\,U+0.00266\,U^2,$$

which, when reduced, gives

$$U=-0{,}174812+\sqrt{\left(0.0305592+\frac{3687{,}52\,\omega\zeta}{\lambda\chi}\right)}$$

The particulars of the twelve experiments are given in the following Table, in columns 1, 2, 3, 4, 5, 6. Column 7 is calculated from Du Buat's formula already given, column 8 from Girard's, and column 9 from the preceding formula of Prony's. The four experiments marked with an asterisk are rejected as anomalous.

TABLE I.

Containing the mean Velocities of Currents of Water deduced from eight Experiments, compared with the Velocities as calculated by the Formulæ of Du Buat, Girard, and Prony.

No. of Experiment.	Names of the Currents.	1	2	3	4	5	6	7	8	7
		Velocities observed, directly deduced from Ob ervation.		Total length of the Current or values of λ	Total declivity on the length λ, or values of ζ	Area of the Section of the Current, or values of ω	Perimeter of the Section, or values of χ	Mean Velocities calculated, or values of U.		
		Superficial Velocity.	Mean Velocity.					By the Formula of Du Buat.	By the Formula of Girard.	By the Formula of Prony.
1	Rigole of Courpalet.	0,142659	0,094051	31379,5	1,11438	0,674492	2,33863	0,130759	0,076449	0,086587
2	Canal of Jard.	0,196799	0,137345	467,769	0,016355	4,4883	8,77066	0,177309	0,131695	0,135891
3		0,210875	0,148857	467,769	0,016919	5,4050	9,12257	0,191385	0,071647	0,156218
4		0,260143	0,189760	467,769	0,021430	5,7582	9,20378	0,226847	0,1934	0,194314
5*		0,329414	0,248518	467,769	0,040605	8,72377	9,9076	0,393055	0,429232	0,384124
6	River Hayne.	0,368423	0,282091	359,272	0,010896	22,6466	15,3757	0,272865	0,280515	0,267086
7	Canal of Jard.	0,426081	0,332219	467,769	0,030454	7,6759	9,74518	0,314282	0,428938	0,293862
8	River Hayne.	0,432036	0,337349	359,272	0,010061	29,0468	16,3503	0,285046	0,317697	0,287803
9*	Canal of Jard.	0,461532	0,372087	467,769	0,052448	11,9092	10,8821	0,508103	0,661130	0,520199
10*	River Seine.	0,785029	0,652790	2592,22	0,297770	284,9	103,299	0,824497	1,17367	0,92010
11*	River Hayne.	0,860012	0,720968	359,272	0,056012	28,4598	16,269	0,778532	1,0541	0,843152
12		0,950426	0,803563	359,272	0,059396	23,0812	15,4082	0,747672	0,994162	0,796834

In the preceding Table, the mean velocities in column 2 were not directly observed, but were deduced from the superficial velocities by a formula of Du Buat, viz.

$$U=(\sqrt{V}-0.08227)^2+0.0067675.$$

In this formula, which is reduced to metres, U is the mean velocity, and V the superficial velocity. Girard also calculated his mean velocities by an equivalent formula.

The relative accuracies of the three formulæ will be seen from the following Table of differences.

	Absolute differences between the calculated and observed mean velocity.	
	Positive difference.	Negative difference.
Formula of Du Buat	0.0338	0.0391
Formula of Girard	0.0238	0.0970
Formula of Prony	0.0198	0.0060

In Du Buat's formula, the errors are between $\frac{8}{100}$ and $\frac{19}{100}$ of the observed results; in Girard's they are between $\frac{16}{100}$ and $\frac{18}{100}$; and in Prony's between $\frac{7}{100}$ and $\frac{4}{100}$. The great superiority of Prony's formula is therefore manifest.

As the preceding formula of Prony was drawn only from a few observations, for the purpose of comparing it with the other formula, he has deduced more correct values of α and β from 31 experiments, including the eight experiments of Du Buat in Table I. The 23 new experiments were performed with very great accuracy upon artificial canals, and have the advantage of giving the mean velocity from direct observation.

These experiments, which are contained in Table II. give the following values of α and β, viz.

$\alpha=0.000436$, $\beta=0.003034$, from which we obtain

$$U=-0.0718523+\sqrt{\left(0{,}00516275+\frac{3232.96\,\omega\zeta}{\lambda\chi}\right)}.$$

Or more simply,

$U=-0.07+\sqrt{\left(0.005+\frac{3233\,\omega\zeta}{\lambda\chi}\right)}$, which will be sufficiently exact. With the first of these formulæ, the numbers in column 8 of Table II. were calculated.

Motion of Water in Pipes and Canals.

Motion of Water in Pipes and Canals.

TABLE II.

Containing the Velocities of Water in Canals, as observed in thirty-one Experiments, compared with the Velocities calculated by Prony's Formula.

1	2	3	4	5	6	7	8
Number of Experiment.	Perimeters of the Sections, or values of χ	Areas of the Sections, or values of ω	Inclination of the Canal, or values of $\frac{\zeta}{\lambda}$	Values of the Functions $\frac{g\,\omega\,\zeta}{\lambda\,\chi\,U}$	Mean Velocities, or values of U		Velocities, or values of U calculated.
					By direct Experiment.	Deduced from the superficial Velocity.	
	Metres.	Metres.	Metres.	Metres.	Metres.	Metres.	Metres.
1	2,33863	0,674492	0,00003551	0,0008623		0,116509	0,123793
2	0,683516	0,050562	0,0001077	0,0006287	0,124251		0,103964
3	0,954216	0,0113764	*Id.*	0,0008160	0,154299		0,144161
4	8,77066	4,4883	0,00003496	0,0010922		0,160679	0,179161
5	9,12257	5,4050	0,00003617	0,0012213		0,172109	0,200992
6	9,20378	5,7582	0,00004581	0,0013239		0,212361	0,240924
7	0,368693	0,0152639	0,0005787	0,00097107	0,242005		0,215583
8	0,577402	0,0258071	0,0007082	0,0012481	0,248773		0,256018
9	0,460189	0,0251857	0,0005787	0,0011819	0,262849		0,256107
10	15,3757	22,6466	0,00003033	0,0014567		0,300783	0,314896
11	0,629377	0,0379215	0,0007082	0,0012779	0,327546		0,306459
12	0,505937	0,0307842	0,0005787	0,0010339	033,4013		0,273113
13	9,74518	7.6759	0,00006510	0,0014458		0,347893	0.341608
14	16,3503	29,0468	0,00002800	0,0013832		0,352792	0,33558
15	0.575237	0,025281	0,0010764	0,0012641	0,367069		0,325775
16	0,705984	0,0558285	0,0007082	0,0014321	0,383581		0,359686
17	0,789630	0,0753154	*Id.*	0,0015741	0,420938		0,400958
18	0,414442	0,0199317	0,0023419	0,0022326	0,494839		0,535840
19	0,575237	0,025281	0.0021834	0,0017179	0,547896		0,489747
20	0,490778	0,0288423	0,0023419	0,0024567	0,549520		0,599057
21	0,551415	0,0369616	*Id.*	0,0025427	0,605555		0,644159
22	0,582004	0,0413509	*Id.*	0,0025612	0,637227		0,665101
23	0,703819	0,061196	0,0024272	0,0028149	0,734678		0,756869
24	0,353534	0,0138056	0.0047170	0,0024262	0,744694		0,703180
25	0,737656	0,0632025	0,0021834	0,0023961	0,765809		0,709152
26	0,772306	0,0738205	0,0023148	0,0028111	0,772035		0,776964
27	15,4028	23,0812	0,00016532	0,0031313		0,776043	0,825972
28	0,798563	0,0370788	0,004717	0,0027442	0,782863		0,772683
29	0,840793	0,0876261	0,0023148	0,0028984	0,816430		0,814208
30	0,878961	0,095782	*Id.*	0,0028662	0,863261		0,834059
31	0,894121	0,0991601	*Id.*	0,0028604	0,880315		0,841999

In comparing the calculated with the observed results in the preceding Table, it appears that the absolute positive differences are 0.0272, and the absolute negative differences 0.0260, which shews that the anomalies have been divided with great equality, and that the calculated results hold a just medium between those which were observed. The preceding formula may therefore be adopted in practice with much confidence.

Motion of water in conduit pipes.

M. Prony next proceeds to the investigation of a formula for the motion of water in conduit pipes. In this case we have $\frac{\omega}{\chi} = \frac{1}{4}$ D, D being the diameter of the tube; and if Z is the difference of level between the surface of water in the superior reservoir, and that of the water in the lower basin, or the height of the head of water, the equation will be

$$\frac{\frac{1}{4} g\,ZD}{\lambda} = \alpha U + \beta U^2.$$

In order to find α and β, M. Prony selected fifty-one of the best experiments made by Couplet, Bossut, and Du Buat, and by the application of the methods of correction, he obtained

$$\alpha = 0.00017,\ \beta = 0{,}003416.$$

From which we obtain

$$\frac{\frac{1}{4} g\,ZD}{\lambda} = 0.00017\,U + 0{,}003416\,U^2,$$

which, after reduction, gives

$$U = -0{,}0248829 + \surd\left(0.000619159 + \frac{717{,}857\,DZ}{\lambda}\right).$$

By means of this formula, the numbers in column 8 of the following Table have been calculated, which agree most surprisingly with the observed results. This agreement is the more remarkable, as the experiments were made by different observers, and with different apparatus, and upon pipes whose lengths varied from 11½ feet to 7020, and their diameters from 1 inch to 18 inches.

The differences between the calculated and observed results amount only to $\frac{1}{26}$ or $\frac{1}{27}$.

The preceding formula should always be used in its present state when the velocities are very small; but when the velocities are considerable, we may in ordinary cases use the following very simple formula,

$$U = 26.79\sqrt{\frac{DZ}{\lambda}}.$$

From which it appears that the velocity is directly in the compound ratio of the square roots of the diameter of the pipe and the head of water, and inversely as the square roots of the length of the pipe; a result which agrees with that which the Abbé Bossut obtained from his experiments; that is, for any given head of water and diameter of pipe, the velocity in a horizontal pipe is inversely as the square root of the length of the pipe. See page 511, col. 1.

In Table IV. we have given the observed measures in French inches, for the sake of those who may wish to compare them with the other experiments of Du Buat or Bossut.

TABLE III.

Comparison of Prony's Formula, with the Results of Fifty-one Experiments by different Observers.

No. of Experiments.	Names of Observers.	Head of water above the lower end of the Pipe.	Diameter of the Pipe.	Length of the Pipe.	Values of $\frac{g\,DZ.}{4\lambda\,U}$	Velocities, or values of U.	
						Observed velocities.	Calculated velocities.
		Metres.	Metres.	Metres.	Metres.	Metres.	Metres.
1	Du Buat.	0,0040605	0,0270699	19,9506	0,00031409	0,0430142	0,04275
2	Couplet.	0,151132	0,135350	2280,37	0,00040412	0,0544296	0,059132
3	Couplet.	0,306784	*Id.*	*Id.*	0,00052299	0,0853786	0,092124
4	Du Buat.	0,013535	0,0270699	19,9506	0,00045929	0,0980744	0,092602
5	Couplet.	0,453422	0,135350	2280,37	0,00059072	0,111718	0,126321
6	*Id.*	0,570716	*Id.*	*Id.*	0,00063849	0,130098	0,133029
7	*Id.*	0,649678	*Id.*	*Id.*	0,00167009	0,141116	0,143345
8	*Id.*	0,676749	*Id.*	*Id.*	0,00168358	0,144093	0,146739
9	Du Buat.	0,0189489	0,0270699	3,74919	0,00142651	0,235211	0,289495
10	*Id.*	0,113694	*Id.*	*Id.*	0,00133843	0,282637	0,308824
11	*Id.*	*Id.*	*Id.*	*Id.*	0,00130958	0,288863	*Id.*
12	Bossut.	0,1082800	*Id.*	16,2419	0,00133748	0,330876	0,335905
13	*Id.*	0,324839	0,0360933	58,47108	0,00144598	0,340053	0,355330
14	Du Buat.	0,160525	0,0270699	19.9506	0,00148184	0,360437	0,371316
15	Bossut.	0,324839	0,0360933	48,7258	0,00154965	0,380766	0,391471
16	Du Buat.	0,210604	0,0270699	19,9506	0,00171296	0,409081	0,428717
17	Bossut.	0,324839	0,0360933	38,98072	0,00168746	0,436584	0,440183
18	Du Buat.	0,242547	0,0270699	19,9506	0,0018308	0,440807	0,461806
19	Bossut.	0,324839	0,0544106	58,47108	0,00167204	0,443325	0,441608
20	Du Buat.	0,242547	0,0270699	19,9506	0,0017932	0,450038	0,461806
21	Bossut.	0,324839	0,0544106	48,7258	0,00179521	0,495488	0,486011
22	*Id.*	0,649678	0,0360933	58,47108	0,00192257	0,511514	0,512245
23	*Id.*	0,324839	*Id.*	29,2355	0,00191780	0,512786	*Id.*
24	Du Buat.	0,333502	0,0270699	19,9506	0,00205052	0,541155	0,545006
25	Bossut.	0,324839	0,0544106	38,98072	0,001981315	0,560537	0,545851
26	Du Buat.	0,370858	0,0270699	19,9506	0,00217375	0,567657	0,576653
27	Bossut.	0,649678	0,0360933	48,7258	0,00207278	0,569335	0,563405
28	Du Buat.	0,395221	0,0270699	19,9506	0,00222265	0,591641	0,596064
29	Bossut.	0,324839	*Id.*	16,2419	0,00220106	0,603173	0,599029
30	*Id.*	*Id.*	0,0360933	19,49036	0,00233276	0,632354	0,632726
31	*Id.*	*Id.*	0,0544106	29,2355	0,002300502	0,644427	0,634365
32	*Id.*	0,649678	0,0360933	38,98072	0,00226756	0,649787	0,632347
33	*Id.*	*Id.*	0,0544106	58,47108	0,00221446	0,669467	0,634366
34	*Id.*	*Id.*	*Id.*	48,7258	0,00239239	0,743612	0,697201
35	*Id.*	*Id.*	0,0360933	29,2355	0,00258798	0,759989	0,734322
36	Du Buat.	0,641558	0,0270699	19,9506	0,0027506	0,776068	0,766011
37	Bossut.	0,324839	0,0544106	19,49036	0,0028119	0,790849	0,782336
38	Du Buat.	0,162419	0,0270699	3,74919	0,0036206	0,794259	0,892970
39	Bossut.	0,649678	0,0544106	38,98072	0,0026558	0,836353	0,781872
40	*Id.*	0,324339	0,0360933	9,74518	0,0032867	0,897639	0,904784
41	*Id.*	0,649678	*Id.*	19,49036	0,0031615	0,933183	*Id.*
42	*Id.*	*Id.*	0,0544106	29,2355	0,0030625	0,968157	0,907103
43	Couplet.	3,92739	0,487259	1169,42	0,0037855	1,06003	1,059247
44	Bossut.	0,324839	0,0544106	9,74518	0,0040737	1,09151	1,116427
45	*Id.*	0,649678	*Id.*	19,49034	0,0038209	1,16401	*Id.*
46	*Id.*	*Id.*	0,0360933	9,74518	0,0044911	1,31381	1,289627
47	Du Buat.	0,487259	0,0270699	3,16718	0,0064699	1,57845	1,704337
48	*Id.*	0,567116	*Id.*	3,74919	0,0063075	1,59193	1,689767
49	Bossut.	0,649678	0,0544106	9,74518	0,0055786	1,5945	1,588977
50	Du Buat.	0,721864	0,0270699	3,16718	0,0078386	1,93011	2,079787
51	*Id.*	0,974518	*Id.*	*Id.*	0,0088825	2,29946	2,420487

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TABLE IV.

Containing the observed Measures in TABLE III. *in French Inches.*

No. of Experiment.	Names of Authors.	Head of Water above the lower end.	Diameter of the Pipe.	Length of the Pipe.		Observed Velocities or values of U.
		Inches.	Inches.	Inches.	Feet.	Inches.
1	Du Buat.	0,15	1	737	61,417	1,589
2	Couplet.	5,583	5	84240	7020	2,0107
3	Couplet.	11,333	*Id.*	*Id.*	*Id.*	3,154
4	Du Buat.	0,5	1	737	61,417	3,623
5	Couplet.	16,75	5	84240	7020	4,127
6	*Id.*	21,083	*Id.*	*Id.*	*Id.*	4,806
7	*Id.*	24	*Id.*	*Id.*	*Id.*	5,213
8	*Id.*	25	*Id.*	*Id.*	*Id.*	5,323
9	Du Buat.	0,7	1	138,5	11,542	8,689
10	*Id.*	4,2	*Id.*	*Id.*	*Id.*	10,441
11	*Id.*	*Id.*	*Id.*	*Id.*	*Id.*	10,671
12	Bossut.	4	*Id.*	600	50	12,223
13	*Id.*	12	1,3333	2160	180	12,562
14	Du Buat.	5,93	1	737	61,417	13,315
15	Bossut.	12	1,3333	1800	150	14,066
16	Du Buat.	7,78	1	737	61,417	15,112
17	Bossut.	12	1,3333	1440	120	16,128
18	Du Buat.	8,96	1	737	61,417	16,284
19	Bossut.	12	2,01	2160	180	16,377
20	Du Buat.	8,96	1	737	61,417	16,625
21	Bossut.	12	2,01	1800	150	18,304
22	*Id.*	24	1,3333	2160	180	18,896
23	*Id.*	12	*Id.*	1080	90	18,943
24	Du Buat.	12,32	1	737	61,417	19,991
25	Bossut.	12	2,01	1440	120	20,707
26	Du Buat.	13,7	1	737	61,417	20,97
27	Bossut.	24	1,3333	1800	150	21,032
28	Du Buat.	14,6	1	737	61,417	21,856
29	Bossut.	12	*Id.*	600	50	22,282
30	*Id.*	*Id.*	1,3333	720	60	23,360
31	*Id.*	*Id.*	2,01	1080	90	23,806
32	*Id.*	24	1,3333	1440	120	24,004
33	*Id.*	*Id.*	2,01	2160	180	24,731
34	*Id.*	*Id.*	*Id.*	1800	150	27,470
35	*Id.*	*Id.*	1,333	1080	90	28,075
36	Du Buat.	23,7	1	737	61,417	28,669
37	Bossut.	12	2,01	720	60	29,215
38	Du Buat.	6	1	138,5	11,542	29,341
39	Bossut.	24	2,01	1440	120	30,896
40	*Id.*	12	1,333	360	30	33,160
41	*Id.*	24	*Id.*	720	60	34,473
42	*Id.*	*Id.*	2,01	1080	90	35,765
43	Couplet.	145,083	18	43200	3600	39,159
44	Bossut.	12	2,01	360	30	40,322
45	*Id.*	24	*Id.*	720	60	43,
46	*Id.*	*Id.*	1,333	360	50	48,534
47	Du Buat.	18	1	117	9,75	58,310
48	*Id.*	20,95	*Id.*	138,5	11,542	58,808
49	Bossut.	24	2,01	360	30	58,903
50	Du Buat.	26,666	1	117	9,75	71,301
51	*Id.*	36	*Id.*	*Id.*	*Id.*	84,945

M. Prony next proceeds to investigate a single formula which will serve both for canals and pipes. The resulting formula is

$$U = -0.0469734 + \sqrt{}\,(0.0022065 + 3041.47G).$$

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When this formula is applied to canals, we must take

$$G = RI\,;\ I = \frac{\zeta}{\lambda}\,;\ \text{and } R = \frac{\omega}{\chi}.$$

When it is to be applied to pipes, we must take

$$G = \tfrac{1}{4}\,DJ,\ D = \text{diameter of pipe, and } J = \frac{H' + \zeta - H''}{\lambda},$$

when the pipe discharges itself in water, or $J = \frac{H' + \zeta}{\lambda}$, when the pipe discharges itself in air; as in this case, $H'' = 0$, H' being the height of the head of water above the superior orifice of the pipe, and H'' the height of the head of water above the lower orifice of the pipe.

The formula in English feet is,

$$U = -0.1541131 + \sqrt{}(0,023751 + 32806.6\,G.)$$

On the Relation between the Superficial Velocity and the Mean Velocity.

Relation between the superficial and mean velocities.

The formula give by Du Buat for deducing the mean from the superficial velocity was, when reduced to the metre,

$$U = (\sqrt{V} - 0.08227)^2 + 0.0067675,$$

which is deduced from the equation

$$U = (\sqrt{V} - \sqrt{\tfrac{1}{4}\,W})^2 + \tfrac{1}{4}\,W,$$

where W is a constant velocity $= 0.0270699 = 1$ inch of the old measure, and $\sqrt{W} = 0.16453$.

Although this formula is sufficiently simple, and harmonizes with many of Du Buat's experiments, it is nevertheless incompatible with observation, as it makes the mean velocity U have a finite value, when the superficial velocity V is nothing. Now, as Prony has observed, every formula which does not make both these velocities vanish at the same time, is evidently erroneous; and, as it follows from the examination of the experiments, that the ratio between these velocities approaches to equality as they increase, so that at one limit we have $V = 0$, $U = 0$, and at another limit $V = \infty$, $U = \infty$; and $V = U$.

In order to obtain a formula which should satisfy these conditions, and at the same time be simple, and suited to the nature of the phenomena, M. Prony gives it the form

$$U = \frac{V\,(V + a)}{V + b},$$

which may be put under the form,

$\frac{V}{V - U} = \frac{b}{b - a} + \frac{V}{b - a}$, and making $\frac{b}{b - a} = \alpha$, and $\frac{1}{b - a} = \beta$, and using the values of V and U, given in col. 2. and 3. of the following Table, he obtained by the methods already mentioned.

$\alpha = 4.036$; $\beta = 1.280$, from which we have
$a = 2.37187$; $b = 3.15312$, and

$$U = \frac{V\,(V + 2.37187)}{V + 3.15312},$$

a formula which is not only more commodious, and more easily calculated, but also more conformable with experiments than that of Du Buat. This formula may be put under the form

$$U = V - 0.78125 + \frac{2.46338}{V + 3.15312},$$

from which we obtain,

$$V = \tfrac{1}{2}\,(U - 2.37187 + \sqrt{(U - 2.37187)^2 + 3.15312\,U})$$

The numbers in column 5 of the following Table have been computed from the formula

$$U = 0{,}816458\ V,$$

which gives a precision of between $\frac{1}{25}$ and $\frac{1}{18}$, and is a simplification of the preceding formula.

TABLE V.

Containing the observed mean Velocities of Water, compared with those deduced from the superficial Velocities by the Formulæ of Du Buat and Prony.

1.	2.	3.	4.	5.	6.	7.
Number of Experiments.	Velocities.				Values of $\frac{V}{V-U}$	Mean Velocities deduced by Prony's best Formula.
	Observed.		Calculated			
	Velocities of the surface, or values of V.	Mean velocities, or values of U.	By Du Buat's Formula.	By Prony's Formula.		
1	0,1638	0,1242	0,11124	0,13374	4,1363	0,12522
2	0,2954	0,2421	0,21951	0,24118	5,5422	0,22848
3	0,3118	0,2487	0,23346	0,25457	4,9414	0,24151
4	0,4331	0,3275	0,33837	0,35361	4,1014	0,33876
5	0,4640	0,3836	0,32526	0,37884	5,7711	0,36379
6	0,5197	0,4210	0,41462	0,42431	5,2654	0,40916
7	0,6186	0,4949	0,50273	0,50506	5,0008	0,49047
8	0,6719	0,5479	0,55057	0,54857	5,4185	0,53467
9	0,7797	0,7447	0,64795	0,63660	22,2770	0,61060
10	0,8121	0,6055	0,67737	0,66305	3,9308	0,65210
11	0,8473	0,6372	0,70939	0,69179	4,0328	0,68184
12	0,9280	0,7720	0,78304	0,75767	5,9488	0,75036
13	0,9745	0,7658	0,82562	0,79564	4,6694	0,79006
14	1,0257	0,8633	0,87246	0,83744	6,3158	0,83395
15	1,1461	1,0893	0,99346	0,93574	20,1780	0,93784
16	1,2994	1,0555	1,12538	1,0609	5,3264	1,0714
17	1,2994	1,1099	1,12538	1,0609	6,8569	1,0714

The agreement of the numbers in column 7, with those in column 3, is very striking; and it is remarkable that the numbers in column 5, calculated from Prony's simple formula, viz. $U = 0{,}816458\ V$, are more accordant with experiment than those in column 4, computed from Du Buat's formula. This formula may be reduced to

$$U = 0.82\ V, \text{ or even } U = 0.8\ V,$$

from which it follows that the mean velocity is four-fifths of the superficial velocity.

Formula for finding the quantities of water discharged.

In order to introduce into the equation which expresses the velocity, the value of the volume of water which flows through any section in a given time, Prony calls Q the volume of water, and $3.1416 = \pi$; and hence $U = \frac{4\,Q}{\pi\,D^2}$, and these being introduced into the equation $\frac{1}{4}\,g\,j\,D = \alpha U + \beta U^2$ where $\alpha = 0.00017$, and $\beta = 0.003416$, gives

$$\alpha + \frac{4\beta Q}{\pi D^2} = \frac{\pi g j D^5}{16\,Q},$$ which making $\frac{16\,\alpha}{\pi\,g} = \alpha'$, and $\frac{64\beta}{\pi^2 g} = \beta'$ gives

$$j\,D^5 - \alpha'\,Q\,D^2 - \beta'\,Q^2 = 0, \text{ or since}$$

$$\alpha' = 0.000088268 \text{ and } \beta'\ 0.002258305, \text{ we have}$$

$$j\,D^5 - 0.000088268\ Q\,D^2 - 0.00225830\ Q^2 = 0,$$

which expresses the relation between the diameter of a pipe, the quantity of water which it discharges in a second, when its length, its declivity, and the heads of water above its upper and lower orifices are known.

In this equation $j = \frac{H + \zeta - H'}{\lambda}$.

In order to facilitate the application of this formula, Prony has computed the following Table, which gives the relations between D, Q and j, as deduced from the above equation.

TABLE VI. *Containing the Declivity of the Pipe and its Diameter for different Quantities of Water discharged in a Second.*

Diameter of the Pipe in hundred parts of a Metre.	Quantities of Water discharged in a Second in ten thousand parts of a Cubic Metre.				
	Q = 0,0001	Q = 0,0002	Q = 0,0003	Q = 0,0004	Q = 0,0005
	Values of *j*.	Values of *j*.	Values of *j*.	Values of *j*.	Values of *j*.
0,01	0,2346568	0,9209736	2,0589504	3.6485872	5,6898840
0,02	0,0081604	0,0304354	0,0668247	0,1173284	0,1819463
0,03	0,0012563	0,0043712	0,0093445	0,0161763	0,0248665
0,04	0,0003585	0,0011580	0,0023986	0,0040803	0,0062031
0,05	0,0001429	0,0004303	0,0008622	0,0014387	0,0021597
0,06	0,0000699	0,0001979	0,0003840	0,0006281	0,0009304
0,07	0,0000392	0,0001052	0,0001981	0,0003179	0,0004645
0,08	0,0000241	0,0000620	0,0001137	0,0001792	0,0002585
0,09	0,0000159	0,0000395	0,0000707	0,0001097	0,0001562
0,10	0,0000111	0,0000267	0,0000468	0,0000714	0,0001006

Diameter of the Pipe in 10th parts of a Metre.	Quantities of Water discharged in a Second in thousand parts of a Cubic Metre.				
	Q = 0,001	Q = 0,002	Q = 0,003	Q = 0,004	Q = 0,005
0,10	0,0031410	0,0107986	0,0229728	0,0396636	0,0608709
0,11	0,0020654	0,0069353	0,0146096	0,0250884	0,0383716
0,12	0,0014184	0,0046519	0,0097005	0,0165642	0,0252431
0,13	0,0010100	0,0032364	0,0066793	0,0113387	0,0172145
0,14	0,0007416	0,0023230	0,0047441	0,0080051	0,0121058
0,15	0,0005589	0,0017126	0,0034611	0,0058044	0,0087424
0,16	0,0004309	0,0012925	0,0025848	0,0043079	0,0064617
0,17	0,0003387	0,0009955	0,0019705	0,0032636	0,0048748
0,18	0,0002709	0,0007808	0,0015297	0,0025176	0,0037446
0,19	0,0002199	0,0006222	0,0012069	0,0019740	0,0029236
0,20	0,0001809	0,0005030	0,0009662	0,0015705	0,0023160
0,21	0,0001506	0,0004118	0,0007836	0,0012660	0,0018589
0,22	0,0001267	0,0003411	0,0006431	0,0010327	0,0015100
0,23	0,0001076	0,0002864	0,0005334	0,0008516	0,0012399
0,24	0,0000922	0,0002411	0,0004468	0,0007092	0,0010233
0,25	0,0000796	0,0002055	0,0003776	0,0005960	0,0008606
0,26	0,0000692	0,0001765	0,0003217	0,0005050	0,0007263
0,27	0,0000606	0.0001526	0,0002762	0,0004312	0,0006177
0,28	0,0000533	0,0001329	0,0002387	0,0003708	0,0005291
0,29	0,0000472	0,0001164	0,0002077	0,0003209	0,0004562
0,30	0,0000420	0,0001026	0,0001817	0,0002795	0,0003958
0,31	0,0000375	0,0000908	0,0001599	0,0002447	0,0003453
0,32	0,0000337	0,0000808	0,0001414	0,0002154	0,0003029
0,33	0,0000303	0,0000722	0,0001256	0,0001906	0,0002671
0,34	0,0000274	0,0000648	0,0001121	0,0001694	0,0002366
0,35	0,0000249	0,0000584	0,0001005	0,0001511	0,0002104
0,36	0,0000227	0,0000528	0,0000904	0,0001354	0,0001880
0,37	0,0000207	0,0000479	0,0000816	0,0001218	0,0001685
0,38	0,0000189	0,0000436	0,0000739	0,0001099	0,0001517
0,39	0,0000174	0,0000398	0,0000672	0,0000996	0,0001370
0,40	0,0000160	0,0000364	0,0000612	0,0000905	0,0001241
0,41	0,0000148	0,0000334	0,0000560	0,0000824	0,0001128
0,42	0,0000136	0,0000307	0,0000513	0,0000753	0,0001028
0,43	0,0000126	0,0000283	0,0000471	0,0000690	0,0000939
0,44	0,0000117	0,0000262	0,0000434	0,0000634	0,0000860
0,45	0,0000109	0,0000243	0,0000401	0,0000583	0,0000790
0,46	0,0000102	0,0000225	0,0000371	0,0000538	0,0000728
0,47	0,0000095	0,0000209	0,0000344	0,0000498	0,0000671
0,48	0,0000089	0,0000195	0,0000319	0,0000461	0,0000621
0,94	0,0000083	0,0000182	0,0000297	0,0000428	0,0000575
0,50	0,0000078	0,0000170	0,0000277	0,0000398	0,0000534

TABLE VI. *Continued.—Containing the Declivity of the Pipe and its Diameter for different quantities of Water discharged in a Second.*

Diameter of the Pipe in hundred parts of a Metre.	Quantities of Water discharged in a Second in ten thousand parts of a Cubic Metre.				
	Q = 0,0006	Q = 0,0007	Q = 0,0008	Q = 0,0009	Q = 0,0010
	Values of *j*.	Values of *j*.	Values of *j*.	Values of *j*.	Values of *j*.
0,01	8,1828408	11,1274576	14,5237344	18,3716732	22,6712700
0,02	0,2606785	0,3535250	0,4604858	0,5815609	0,7167502
0,03	0,0354151	0,0478221	0,0620876	0,0782115	0,0961938
0,04	0,0087669	0,0117718	0,0152178	0,0191049	0,0234331
0,05	0,0030252	0,0040352	0,0051897	0,0064888	0,0079324
0,06	0,0012908	0,0017092	0,0021857	0,0027203	0,0033131
0,07	0,0006380	0,0008384	0,0010656	0,0013197	0,0016006
0,08	0,0003515	0,0004583	0,0005789	0,0007132	0,0008614
0,09	0,0002103	0,0002720	0,0005414	0,0004184	0,0005030
0,10	0,0001343	0,0001725	0,0002151	0,0002623	0,0003141

Diameter of the Pipe in 10th parts of a Metre.	Quantities of Water discharged in a Second in thousand parts of a Cubic Metre.				
	Q = 0,006	Q = 0,007	Q = 0,008	Q = 0,009	Q = 0,010
0,10	0,0865949	0,1168355	0,1515927	0,1908665	0,2346569
0,11	0,0544593	0,0733515	0,0950481	0,1195492	0,1468547
0,12	0,0357371	0,0480462	0,0621704	0,0781097	0,0958642
0,13	0,0243067	0,0326154	0,0421406	0,0528822	0,0648402
0,14	0,0170464	0,0228267	0,0294468	0,0369067	0,0452064
0,15	0,0122752	0,0164028	0,0211252	0,0264424	0,0323543
0,16	0,0090463	0,0120616	0,0155076	0,0193844	0,0236919
0,17	0,0068041	0,0090516	0,0116172	0,0145009	0,0177028
0,18	0,0052106	0,0069157	0,0088597	0,0110428	0,0134650
0,19	0,0040555	0,0053698	0,0069666	0,0086458	0,0105074
0,20	0,0032026	0,0042303	0,0053992	0,0067092	0,0081604
0,21	0,0025625	0,0033767	0,0043014	0,0053367	0,0064826
0,22	0,0020749	0,0027274	0,0034676	0,0042954	0,0052109
0,23	0,0016984	0,0022271	0,0028259	0,0034950	0,0042342
0,24	0,0014041	0,0018367	0,0023259	0,0028719	0,0034747
0,25	0,0011715	0,0015286	0,0019319	0,0023816	0,0028774
0,26	0,0009856	0,0012829	0,0016182	0,0019916	0,0024029
0,27	0,0008357	0,0010851	0,0013660	0,0016784	0,0020223
0,28	0,0007136	0,0009244	0,0011615	0,0014247	0,0017143
0,29	0,0006135	0,0007928	0,0009942	0,0012175	0,0014629
0,30	0,0005307	0,0006842	0,0008563	0,0010470	0,0012563
0,31	0,0004617	0,0005939	0,0007419	0,0009056	0,0010851
0,32	0,0004039	0,0005183	0,0006462	0,0007876	0,0009424
0,33	0,0003551	0,0004547	0,0005658	0,0006885	0,0008227
0,34	0,0003137	0,0004008	0,0004978	0,0006047	0,0007216
0,35	0,0002783	0,0003548	0,0004399	0,0005335	0,0006358
0,36	0,0002480	0,0003154	0,0003904	0,0004728	0,0005627
0,37	0,0002218	0,0002816	0,0003478	0,0004206	0,0004999
0,38	0,0001991	0,0002523	0,0003111	0,0003756	0,0004459
0,39	0,0001794	0,0002268	0,0002792	0,0003367	0,0003991
0,40	0,0001621	0,0002046	0,0002515	0,0003028	0,0003585
0,41	0,0001470	0,0001852	0,0002272	0,0002731	0,0003230
0,42	0,0001337	0,0001681	0,0002059	0,0002472	0,0002919
0,43	0,0001219	0,0001530	0,0001871	0,0002243	0,0002646
0,44	0,0001115	0,0001396	0,0001705	0,0002042	0,0002406
0,45	0,0001022	0,0001278	0,0001558	0,0001863	0,0002193
0,46	0,0000939	0,0001172	0,0001427	0,0001704	0,0002003
0,47	0,0000865	0,0001078	0,0001310	0,0001563	0,0001835
0,48	0,0000798	0,0000993	0,0001206	0,0001436	0,0001685
0,49	0,0000738	0,0000917	0,0001112	0,0001323	0,0001550
0,50	0,0000684	0,0000848	0,0001027	0,0001221	0,0001429

Method of using the Table.

In order to shew the method of using this Table, let us take the case of the $4\frac{1}{2}$ inch pipe which conveys water to Edinburgh. In this case, (see p. 526, Example II.) we have

Reduced to Metres.*

$H = 51$ feet 15.54

$D = 0.375$ 0.1143

$l = 14930$ 4550.4

$j = \frac{15.54}{4550.4} =$ 0.0034151

Since the value of $D = 0.1143$ is in tenth parts of a metre, we must enter the lower part of Table VI. in column 1, and by taking proportional parts, it will be found that the value of Q corresponding to D, and to the value of $j = 0.0034151$ is 0.005104 parts of a cubic metre, which being multiplied by 61023.5, the number of English cubic inches in a cubic metre, gives 311.46 cubic inches discharged in a second. By multiplying this by 60″, and dividing the product by 103.4, the number of cubic inches in a Scotch pint, we obtain 180.7, as the number of Scotch pints that the preceding pipe ought to discharge in a minute, according to Prony's Table.

The following comparison of the results of the different formulæ will be interesting to the reader.

	Scotch Pints.
Quantity of water actually discharged by the pipe	189.4
Do. by Eytelwein's formula	189.77
Do. by Girard's formula	188.26
Do. by Du Buat's formula	188.13
Do. by Prony's simple formula . . .	192.32
Do. by Prony's Table	180.7

This comparison is by no means favourable to Prony's formulæ.

Sect. IV. *Account of the Experiments of Du Buat and Girard, on the effect of Heat upon the Motion of Water in narrow Pipes.*

The effect of heat in promoting fluidity known to the ancients.

The effect of heat in augmenting the fluidity of water, seems to have been noticed at a very early period. Plutarch informs us, that the clepsydræ, or water clocks, went faster in summer than in winter, which he seems to ascribe to an increase of fluidity. *Ελάττονα γαρ ἡ ψυχροτης το ὑδωρ ποιει βαρυ και σωματωδες, ως εστιν εν ταις κλεψυδραις καταμαθειν, βραδιον γαρ ελκουσι χειμωνος ἡ θερους. Quest. Natural.*

Du Buat's experiments.

M. Du Buat made a series of experiments on the effect of heat upon the velocity of different fluids discharged from small tubes; but these effects were not very striking, as he employed tubes of too great a diameter. The results which he obtained are shewn in the following Table.

TABLE *Containing Du Buat's Experiments on the Motion of different Fluids, at different degrees of temperature in Tubes of Glass.*

Diameter and length of the Pipe.	Names of the Fluids.	Degrees of Heat above the freezing point.	Head of Water above the head of the tube.	Height of the expense in a minute expressed in inches.	Velocity in a second in inches.
Horizontal tube 2.9 lines, or 0.24166 of an inch in diameter, and 36.25 inches long	Rain water	3	2.0833	5.2777	13.057
	Salt water	3	2.0833	5.1666	12.7823
	Salt water	11	2.0833	5.2222	12.9197
	Salt water	10 to 11	4.9166	9.25	22.8845
	Alcohol .	12	5.0000	7.5833	18.7611
	Mercury .	10 to 12	0.8124	3.75	9.2775
	Mercury .	10 to 12	0.9166	4.0833	10.1021
	Mercury .	10 to 12	2.1944	6.6111	16.3558
Horizontal tube 2 lines, or 0.16666 of an inch in diameter, and 36.25 inches long	Rain water	55	8.875	5.2777	27.455
	Rain water	30	15.2916	6.9166	35.980
	Rain water	36	15.2916	7.0833	36.847
	Rain water	56	15.2916	7.2013	37.461
	Alcohol .	12	5.292	2.50	13.005
	Alcohol .	12	5.875	3.8338	19.941
	Mercury .	10 to 12	1.125	1.75	9.103
	Mercury .	10 to 12	2.7082	3.00	15.606
	Mercury .	10 to 12	5.1666	4.25	22.108
	Mercury .	10 to 12	0.0555	0.0000	0.000
Horizontal tube $1\frac{1}{2}$ line in diameter and 34 16666 inches long	Alcohol .	12	9.292	1.125	10.402

From these results Du Buat concludes, that water moves less rapidly as it approaches to congelation, and that it runs more rapidly as its temperature increases; that salt water runs more slowly than rain water at the same temperature; that spirit of wine runs perceptibly less rapidly than water, on account of its viscosity, or its great adhesion to the sides of the tube; and that mercury which, when it is very pure,

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* English feet are reduced to metres by dividing them by 3.281.

is not attracted by the glass, flows more rapidly than water.

These experiments are, however, very far from satisfactory; and it was reserved to M. Girard to ascertain the precise influence of temperature on the motion of water in capillary tubes. The experiments of this eminent engineer were made with tubes of copper accurately calibred, and whose lengths could be varied at pleasure. The first series of tubes had a diameter of 2.96 millimetres, and each tube was two decimetres long, having at each of its ends a brass virrel, one of which had a male, and the other a female screw, so that the tubes could be all put together, so as to form different lengths, from 20 to 222 centimetres. The second series of tubes was formed in a similar manner, and each tube had a diameter of only 1.83 millimetres. The experiments were made in the manner which we have already described in our History of Hydrodynamics.

In applying to these experiments the general formula

$$\frac{g\,\omega\,\zeta}{\lambda\,\chi\,U}=\alpha+\beta\,U \text{ or } \frac{g\,D\,H}{4\,\lambda\,U}=\alpha+\beta\,U$$

which expresses the condition of a linear and uniform motion, M. Girard has obtained the following results:

1. That whatever be the head of water, provided the capillary tube is of a sufficient length; the term $\beta\,U$, proportional to the square of the velocity, disappears from the general formula, so that it becomes $\frac{g\,D\,H}{4\,\lambda\,U}=\alpha$ which expresses the conditions of the uniformity of the simplest linear motion.

2. That in every case where the conditions of the motion are expressed by this formula, the variations in the temperature of the water have a very great influence on the velocity with which it flows in the tube, so that if the head of water, and the length and diameter of the pipe remain the same, the velocity which is expressed by 10 at 0° of the centigrade thermometer is expressed by 42 at 85° of that thermometer.

3. That in every case where the formula $\frac{g\,DH}{4\,\lambda\,U}=\alpha$ does not satisfy observation, that is, when the length of the tube is below a certain limit, the variations of temperature have but a slight influence on the velocity with which the water is discharged; so that if this velocity by a pipe 55 millimetres long, and at 5^0 of temperature, is represented by 10, it will be represented by 12 at 87 degrees, every other circumstance in the experiments being the same.

4. That at equal temperatures the expression $\frac{g\,DH}{4\,\lambda\,U}=\alpha$ decreases with the diameter of the tube employed.

5. That the influence of temperature upon the velocities follows the same law in capillary tubes of an unequal diameter, that is, that the successive differences of the expression $\frac{g\,DH}{4\,\lambda\,U}=\alpha$ becomes as much less for equal differences of temperature as the temperature is raised.

6. That this law shews itself with more regularity, as the observations are made upon tubes of a smaller diameter, or, which is the same thing, that the linearity of the motion is more perfect.

7. That the values of the formula $\frac{g\,DH}{4\,\lambda\,U}=a$, calculated in the same circumstances for two tubes of unequal diameters, differ more from one another as the temperature becomes lower, and that these values appear to have a tendency to become identical in proportion as the temperature increases; so that if their difference is represented by 6 at 0° of temperature, it is represented only by 1 when the temperature approaches to 80^0.

8. And lastly, that the temperature which exercises so great an influence on the phenomena of the uniform discharge of water by capillary tubes, has scarcely any influence in ordinary conduit pipes, whose diameters exceed the limits of capillarity.

An account of the preceding experiments was laid before the Institute of France on the 28th Nov. 1814, and on the 16th January and 13th February 1815. The remaining part of the paper was laid before the same learned body on the 13th January 1817, and contained various experiments on the discharge of different fluids through capillary tubes. In some future article, we expect to have it in our power to lay before our readers, a fuller view of the very interesting results which M. Girard has obtained.

Sect. V. *Account of Mr Smeaton's Experiments on the Friction of Water in Pipes.*

Mr Smeaton seems to have made a number of valuable experiments on the discharge of water through openings, and from conduit pipes; but no particular account of these has been left among his papers. We have been favoured, however, by Mr Farey, with two Tables containing the results of Mr Smeaton's experiments, which were found among his MSS. and have never before been published. Although the last of the Tables relates to the subject of a preceding Section, we shall make no apology for inserting it in this place, as it was not in our possession when that part of the volume was printed.

The following Table, computed by Mr Smeaton from his own experiments, shews the head of water which is necessary to overcome the friction, &c. in horizontal pipes 100 feet long, and to produce the velocity contained in the two first columns of the Table. Hence, if a certain supply of water is required from a given pipe, the Table shews us the different heads or heights of the reservoir, by which the velocity necessary to afford this supply will be produced. By comparing this Table with the formula of Du Buat, it will be seen that Mr Smeaton makes the effects of friction considerably greater than that formula, the velocities given by the Table being less than those given by the formula.

TABLE I.

Computed by Mr Smeaton, for shewing the Friction of Water in Horizontal Pipes. The Bore of the Pipe being given, and the Velocity of the Water therein, the Height of Head, or Column necessary to overcome the Friction and produce that Velocity, is shewn by this Table for 100 Feet in length.

			Bore of the Pipes.																					
Velocities per Second.			½ Inch.		¾ Inch.		1 Inch.		1¼ Inch.		1½ Inch.		1¾ Inch.		2 Inch.		2¼ Inch.		2½ Inch.		3 Inch.		3½ Inch.	
Ft.	In.	Inch.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
0	1	1	0	0.2	0	0.16	0	0.12	0	0.1	0	0.08	0	0.07	0	0.06	0	0.06	0	0.05	0	0.04	0	0.04
0	2	2	0	0 7	0	0.5	0	0.4	0	0.3	0	0.25	0	0.2	0	0.2	0	0.17	0	0.15	0	0.12	0	0.10
0	3	3	0	1.2	0	0.8	0	0.6	0	0.5	0	0 4	0	0 4	0	0.3	0	0.3	0	0.25	0	0.2	0	0.18
0	4	4	0	2 0	0	1.3	0	1.0	0	0.8	0	0.7	0	0.6	0	0.5	0	0.4	0	0.4	0	0.3	0	0.3
0	5	5	0	3.2	0	2.1	0	1.6	0	1.3	0	1.1	0	0.9	0	0.8	0	0.7	0	0.6	0	0.5	0	0.5
0	6	6	0	4.5	0	3.0	0	2.2	0	1.8	0	1.5	0	1.3	0	1.1	0	1.0	0	0.9	0	0.7	0	0.6
0	7	7	0	6.0	0	4.0	0	3.0	0	2.4	0	2.0	0	1.7	0	1.5	0	1.3	0	1.2	0	1.0	0	0.8
0	8	8	0	8.0	0	5.3	0	4.0	0	3.2	0	2.7	0	2.3	0	2.0	0	1.8	0	1.6	0	1.3	0	1.1
0	9	9	0	9.5	0	6.3	0	4.7	0	3.8	0	3.2	0	2.7	0	2.4	0	2.1	0	1.9	0	1.5	0	1.4
0	10	10	0	11.7	0	7.8	0	5.9	0	4.7	0	3 9	0	3.4	0	2.9	0	2.6	0	2.3	0	1.9	0	1.7
0	11	11	1	2.2	0	9.5	0	7.1	0	5.7	0	4.7	0	4.1	0	3.6	0	3.2	0	2.8	0	2.4	0	2.0
1	0	12	1	4.7	0	11.1	0	8.4	0	6.7	0	5 6	0	4.8	0	4 2	0	3.7	0	3.3	0	2.8	0	2.4
1	1	13	1	7.5	1	1.0	0	9.7	0	7.8	0	6.5	0	5.6	0	4.9	0	4.3	0	3.9	0	3.2	0	2.8
1	2	14	1	10.2	1	2.8	0	11.1	0	8.9	0	7.4	0	6.4	0	5.6	0	4.9	0	4.4	0	3.7	0	3.2
1	3	15	2	1.0	1	4.6	1	0.5	0	10.0	0	8.3	0	7.1	0	6 2	0	5.5	0	5.0	0	4.2	0	3.6
1	4	16	2	4 5	1	7.0	1	2.2	0	11.4	0	9.5	0	8.1	0	7.1	0	6.3	0	5.7	0	4.7	0	4.1
1	5	17	2	7.5	1	9.0	1	3.7	1	0.6	0	10 5	0	9.0	0	7.9	0	7.0	0	6.3	0	5.2	0	4.5
1	6	18	2	11.0	1	11.3	1	5.5	1	2 0	0	11.7	0	10.0	0	8.7	0	7.8	0	7.0	0	5.0	0	5.0
1	7	19	3	2.5	2	1 6	1	7.2	1	3.4	1	0.8	0	11.0	0	9 6	0	8.6	0	7.7	0	6.4	0	5.5
1	8	20	3	6 0	2	4.0	1	9 0	1	4.8	1	2.0	1	0.0	0	10.5	0	9.3	0	8.4	0	7.0	0	6.0
1	9	21	3	9.7	2	6.5	1	10.9	1	6.3	1	3.3	1	1.1	0	11.4	0	10.2	0	9.1	0	7.6	0	6.5
1	10	22	4	1.5	2	9.0	2	0.7	1	7.8	1	4.5	1	2.1	1	0.4	0	11.0	0	9.9	0	8.2	0	7.1
1	11	23	4	5.7	2	11.8	2	2.9	1	9.5	1	5.9	1	3.4	1	1.4	0	11.9	0	10.7	0	9.0	0	7.7
2	0	24	4	9.7	3	2.5	2	4.9	1	11.1	1	7.2	1	4.5	1	2.4	1	0.8	0	11.5	0	9.6	0	8.2
2	2	26	5	6.5	3	8.3	2	9.2	2	2 6	1	10.1	1	7.0	1	4.6	1	2.8	1	1.3	0	11.1	0	9.5
2	4	28	6	3.7	4	2.5	3	1.9	2	6.3	2	1.2	1	9.6	1	6.9	1	4.8	1	3.1	1	0.6	0	10.8
2	6	30	7	1.7	4	9.2	3	6.9	2	10.3	2	4.6	2	0.5	1	9.4	1	7.0	1	5.1	1	2.3	1	0.2
2	8	32	8	0.5	5	4 3	4	0.2	3	2.6	2	8.1	2	3.6	2	0.1	1	9.4	1	7.3	1	4.1	1	1.8
2	10	34	9	0.5	6	0.3	4	6 2	3	7.4	3	0.1	2	7.0	2	3.1	2	0.1	1	9.7	1	6.1	1	3.5
3	0	36	10	1.0	6	8.6	5	0.5	4	0.4	3	4.3	2	10.6	2	6.2	2	2.9	2	0.2	1	8.2	1	5.3
3	2	38	11	2.5	7	5.6	5	7.2	4	5.8	3	8.8	3	2.2	2	9.6	2	5.9	2	2.9	1	10.4	1	7.2
3	4	40	12	5 0	8	3.3	6	2.5	4	11.6	4	1.7	3	6.6	3	0.2	2	9.1	2	5.8	2	0.8	1	9.3
3	6	42	13	8.0	9	1.3	6	10.0	5	5.6	4	6.7	3	10.9	3	5.0	3	0.4	2	8.8	2	3.3	1	11.4
3	8	44	15	0.0	10	0.0	7	6.0	6	0.0	5	0.0	4	3.4	3	9.0	3	4.0	3	0.0	2	6.0	2	1.7
3	10	46	16	4.5	10	11.0	8	2.2	6	6 6	5	5.5	4	8.1	4	1.1	3	7.7	3	3.3	2	8.7	2	4.1
4	0	48	17	10.0	11	10.6	8	11.0	7	1.6	5	11.3	5	1.1	4	5.5	3	11.6	3	6.8	2	11.7	2	6.6
4	3	51	20	1.2	13	4.8	10	0.6	8	0.5	6	8.4	5	8.9	5	0.3	4	5.6	4	0.2	3	4.2	2	10.5
4	6	54	22	6.7	15	0.5	11	3.4	9	0.3	7	6.2	6	5.4	5	7.7	5	0.1	4	6.1	3	9.1	3	2.7
4	9	57	25	1.5	16	9.0	12	6.7	10	0.6	8	4.5	7	2.1	6	3.4	5	7.0	5	0.3	4	2.2	3	7.1
5	0	60	28	0.2	18	8.1	14	0.0	11	2.5	9	4.1	8	0.1	7	0.0	6	2.7	5	7.2	4	8.0	4	0.0
			1		2		3		4		5		6		7		8		9		10		11	

N. B. Find the velocity of the water per second in feet and inches in the first column, or in inches in the second; and underneath the diameter of the bore in inches, (disposed in the uppermost row,) you will find the perpendicular height of a column of water in feet and inches, and 10th necessary to overcome the friction of that pipe of 100 feet in length, to obtain the given velocity.

TABLE I.—Continued.

Computed by Mr Smeaton, for shewing the Friction of Water in Horizontal Pipes. The Bore of the Pipe being given, and the Velocity of the Water therein, the Height of Head, or Column necessary to overcome the Friction and produce that Velocity, is shewn by this Table for 100 *Feet in length.*

Bore of the Pipes.

Velocities per Second.			4 Inch.		4½ Inch.		5 Inch.		6 Inch.		7 Inch.		8 Inch.		9 Inch.		10 Inch.		11 Inch.		12 Inch.	
Ft.	In.	Inch.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
0	1	1	0	0.03	0	0.03	0	0.02	0	0.02	0	0.02	0	0.01	0	0.01	0	0.01	0	0.01	0	0.01
0	2	2	0	0.09	0	0.08	0	0.07	0	0.06	0	0.05	0	0.05	0	0.04	0	0.04	0	0.03	0	0.03
0	3	3	0	0.15	0	0.14	0	0.12	0	0.10	0	0.09	0	0.08	0	0.07	0	0.06	0	0.05	0	0.05
0	4	4	0	0.25	0	0.2	0	0.2	0	0.17	0	0.14	0	0.12	0	0.11	0	0.10	0	0.09	0	0.08
0	5	5	0	0.4	0	0.4	0	0.3	0	0.3	0	0.2	0	0.2	0	0.18	0	0.16	0	0.15	0	0.14
0	6	6	0	0.6	0	0.5	0	0.4	0	0.4	0	0.3	0	0.3	0	0.25	0	0.2	0	0.20	0	0.19
0	7	7	0	0.8	0	0.7	0	0.6	0	0.5	0	0.4	0	0.4	0	0.3	0	0.3	0	0.27	0	0.25
0	8	8	0	1.0	0	0.9	0	0.8	0	0.7	0	0.6	0	0.5	0	0.4	0	0.4	0	0.36	0	0.3
0	9	9	0	1.2	0	1.1	0	0.9	0	0.8	0	0.7	0	0.6	0	0.5	0	0.5	0	0.4	0	0.4
0	10	10	0	1.5	0	1.3	0	1.2	0	1.0	0	0.8	0	0.7	0	0.6	0	0.6	0	0.5	0	0.5
0	11	11	0	1.8	0	1.6	0	1.4	0	1.2	0	1.0	0	0.9	0	0.8	0	0.7	0	0.6	0	0.6
1	0	12	0	2.1	0	1.9	0	1.7	0	1.4	0	1.2	0	1.0	0	0.9	0	0.8	0	0.8	0	0.7
1	1	13	0	2.4	0	2.2	0	1.9	0	1.6	0	1.4	0	1.2	0	1.1	0	1.0	0	0.9	0	0.8
1	2	14	0	2.8	0	2.5	0	2.2	0	1.9	0	1.6	0	1.4	0	1.2	0	1.1	0	1.0	0	0.9
1	3	15	0	3.1	0	2.8	0	2.5	0	2.1	0	1.8	0	1.6	0	1.4	0	1.2	0	1.1	0	1.0
1	4	16	0	3.6	0	3.2	0	2.8	0	2.4	0	2.0	0	1.8	0	1.6	0	1.4	0	1.3	0	1.2
1	5	17	0	4.0	0	3.5	0	3.1	0	2.6	0	2.2	0	2.0	0	1.7	0	1.6	0	1.4	0	1.3
1	6	18	0	4.4	0	3.9	0	3.5	0	2.9	0	2.5	0	2.2	0	1.9	0	1.7	0	1.6	0	1.5
1	7	19	0	4.8	0	4.3	0	3.8	0	3.2	0	2.7	0	2.4	0	2.1	0	1.9	0	1.7	0	1.6
1	8	20	0	5.2	0	4.7	0	4.2	0	3.5	0	3.0	0	2.6	0	2.3	0	2.1	0	1.9	0	1.8
1	9	21	0	5.7	0	5.1	0	4.6	0	3.8	0	3.3	0	2.9	0	2.5	0	2.3	0	2.1	0	1.9
1	10	22	0	6.2	0	5.5	0	4.9	0	4.1	0	3.5	0	3.1	0	2.7	0	2.5	0	2.2	0	2.1
1	11	23	0	6.7	0	6.0	0	5.4	0	4.5	0	3.8	0	3.4	0	3.0	0	2.7	0	2.4	0	2.2
2	0	24	0	7.2	0	6.4	0	5.8	0	4.8	0	4.1	0	3.6	0	3.2	0	2.9	0	2.6	0	2.4
2	2	26	0	8.3	0	7.4	0	6.6	0	5.5	0	4.7	0	4.2	0	3.7	0	3.3	0	2.9	0	2.8
2	4	28	0	9.5	0	8.4	0	7.6	0	6.8	0	5.4	0	4.7	0	4.2	0	3.8	0	3.4	0	3.2
2	6	30	0	10.7	0	9.5	0	8.6	0	7.1	0	6.1	0	5.4	0	4.8	0	4.3	0	3.9	0	3.6
2	8	32	1	0.1	0	10.7	0	9.6	0	8.0	0	6.9	0	6.0	0	5.4	0	4.8	0	4.4	0	4.0
2	10	34	1	1.6	1	0.1	0	10.8	0	9.0	0	7.7	0	6.8	0	6.0	0	5.4	0	4.9	0	4.5
3	0	36	1	3.1	1	1.4	1	0.1	0	10.1	0	8.6	0	7.6	0	6.7	0	6.0	0	5.5	0	5.0
3	2	38	1	4.8	1	3.0	1	1.4	0	11.2	0	9.6	0	8.4	0	7.5	0	6.7	0	6.1	0	5.6
3	4	40	1	6.6	1	4.6	1	2.9	1	0.4	0	10.6	0	9.3	0	8.3	0	7.4	0	6.8	0	6.2
3	6	42	1	8.5	1	6.2	1	4.4	1	1.7	0	11.7	0	10.2	0	9.1	0	8.2	0	7.5	0	6.8
3	8	44	1	10.5	1	8.0	1	6.0	1	3.0	1	0.9	0	11.2	0	10.0	0	9.0	0	8.2	0	7.5
3	10	46	2	0.6	1	9.8	1	7.6	1	4.4	1	2.0	1	0.3	0	10.9	0	9.8	0	9.0	0	8.2
4	0	48	2	2.7	1	11.8	1	9.4	1	5.8	1	3.3	1	1.4	0	11.9	0	10.7	0	9.7	0	8.9
4	3	51	2	6.1	2	2.8	2	0.1	1	8.1	1	5.2	1	3.1	1	1.4	1	0.0	0	11.0	0	10.1
4	6	54	2	9.8	2	6.1	2	3.1	1	10.6	1	7.3	1	4.9	1	3.0	1	1.5	1	0.3	0	11.3
4	9	57	3	1.7	2	9.5	2	6.1	2	1.1	1	9.5	1	6.9	1	4.7	1	3.1	1	1.7	1	0.6
5	0	60	3	6.0	3	1.4	2	9.6	2	4.0	2	0.0	1	9.0	1	6.7	1	4.8	1	3.3	1	2.0
			12		13		14		15		16		17		18		19		20		21	

N. B. Find the velocity of the water per second in feet and inches in the first column, or in inches in the second; and underneath, the diameter of the bore in inches (disposed in the uppermost row) you will find the perpendicular height of a column of water in feet and inches and 10th necessary to overcome the friction of that pipe for 100 feet in length, to obtain the given velocity.

The second Table, which is copied from the original one used by Mr Smeaton, shews the expence of water through a rectangular notch, or over a waste-board of different widths and depths. The term thickness of water employed by Mr Smeaton, is the same as the depth of the lower edge of the waste-board below the level surfaces of the water in the river or reservoir. The water gauge is nothing more than the rectangular orifice or notch through which the water issues.

TABLE II.

For finding the Expence of Water by the Water Gauge, having an Aperture of 1, 2, 3, 6, 12, *or* 18 *Inches in width, at any given thickness of Water running through the same.*

Thickness of Water.	Mean Velocity per Minute.	Difference.	Expence per Minute.	Difference.
		1 Inch Gauge.		
Inches	Feet.		Cubic Feet.	
¼	46.29	—	0.05	—
		19.2		.09
½	65.46	—	0.14	—
		14.7		.11
¾	80.16	—	0.25	—
		12.4		.12
1	92.58	—	0.37	—
		2 Inch Gauge.		
¼	46.29	—	0.11	—
		19.2		.18
½	65.46	—	0.29	—
		14.7		.24
¾	80.16	—	0.53	—
		12.4		.28
1	92.58	—	0.81	—
		10.9		.30
1¼	103.50	—	1.11	—
		9.9		.31
1½	113.40	—	1.42	—
		9.1		.34
1¾	122.47	—	1.76	—
		8.4		.36
2	130.92	—	2.12	—
		3 Inch Gauge.		
¼	46.29	—	0.16	—
		7.2		.08
⅓	53.46	—	0.24	—
		12.0		.20
½	65.46	—	0.44	—
		10.1		.23
⅔	75.60	—	0.67	—
		4.6		.13
¾	80.16	—	0.80	—
		12.4		.43
1	92.58	—	1.23	—
		20.8		1.00
1½	113.40	—	2.23	—
		17.5		1.14
2	130.2	—	3.37	—
		15.5		1.20
2½	146.40	—	4.57	—
		13.9		1.27
3	160.32	—	5.84	—

Thickness of Water.	Mean Velocity per Minute.	Difference.	Expence per Minute.	Difference.
		6 Inch Gauge.		
Inches.	Feet.		Cubic Feet.	
½	65.46	—	.91	—
		27.1		1.58
1	92.58	—	2.49	—
		20.8		2.06
1½	113.40	—	4.55	—
		17.5		2.42
2	130.92	—	6.97	—
		15.5		2.71
2½	146.40	—	9.68	—
		13.9		2.94
3	160.32	—	12.62	—
		12.9		3.17
3½	173.21	—	15.79	—
		11.9		3.31
4	185.16	—	19.10	—
		11.2		3.40
4½	196.40	—	22.50	—
		10.6		3.38
5	207.00	—	25.88	—
		10.1		3.71
5½	217.14	—	29.59	—
		9.7		3.51
6	226.80	—	33.10	—
		12 Inch Gauge.		
1	92.58	—	5.14	—
		38.3		8.96
2	130.92	—	14.10	—
		29.4		11.63
3	160.32	—	25.73	—
		24.8		13.71
4	185.16	—	39.44	—
		21.8		15.32
5	207.00	—	54.76	—
		19.8		16.64
6	226.80	—	71.40	—
		18.1		17.90
7	244.94	—	89.30	—
		16.9		18.76
8	261.84	—	108.06	—
		15.9		19.24
9	277.73	—	127.30	—
		15.0		19.07
10	292.74	—	146.37	—
		14.3		20.43
11	307.05	—	166.80	—
		13.7		20.30
12	320.70	—	187.10	—

18 *Inch Gauge.*

Thickness of Water.	Mean Velocity per Minute.	Difference.	Expence per Minute.	Difference.
Inches.	Feet.		Cubic Feet.	
1	92.58	—	7.71	—
		38.3		13.43
2	130.92	—	21.14	—
		29.4		17.69
3	160.32	—	38.83	—
		24.8		20.60
4	185.16	—	59.43	—
		21.8		23.23
5	207.00	—	82.66	—
		19.8		26.01
6	226.80	—	108.67	—
		18.1		27.41
7	244.94	—	136.08	—
		16.9		28.78
8	261.84	—	164.86	—
		15.9		31.86
9	277.73	—	196.72	—
		15.0		31.98
10	292.74	—	228.70	—
		14.3		32.66
11	307.05	—	261.36	—
		13.6		36.44
12	320.70	—	297.80	—
		25.7		65.93
14	346.41	—	363.73	—
		23.9		75.17
16	370.32	—	438.90	—
		22.5		76.64
18	392.79	—	515.54	—

Comparison of the Table with Du Buat's formula.

It will be seen from a comparison of this Table with Du Buat's formula in p. 500, that there is a considerable agreement between them. For great depths of the wasteboard, Du Buat's formula gives a much greater discharge than Smeaton's Table. At small depths of the wasteboard, Du Buat's formula gives results less than those of Smeaton's Table, while for intermediate depths the results approach very near each other. The 18 inch gauge, for example, with a depth of 18 inches, discharges, according to Smeaton, 515.54 cubic feet in a minute; whereas, according to Buat, it should discharge 554.15 cubic feet. The same gauge, at a depth of only one foot, discharges 7.71 cubic feet; whereas, according to Du Buat, it should discharge only 7.254 cubic feet. The same notch, with a depth of 8 inches, discharges 164.86 cubic feet; and, according to Du Buat, it should discharge 164.20 cubic feet, which is very nearly the same result.

CHAP. V.

ON THE PERCUSSION AND RESISTANCE OF FLUIDS.

On the resistance of fluids.

As the laws of the resistance of fluids can be determined only from experiment, we shall not occupy our pages with theoretical discussions, which are of no practical utility. It will be necessary, however, to make the reader acquainted with the ordinary theory of the resistance of fluids, which may be comprehended in a few propositions.

SECT. I. *On the Theory of the Resistance of Fluids.*

If a body is moved through a fluid medium, it experiences an obstruction in its motion, which is called the resistance of the fluid; but if the fluid is in motion, and strikes the body at rest; the force sustained by the body is called the percussion of the fluid. The force exerted upon the body is obviously the same in both these cases; and the percussion and the resistance of fluids follow the same laws. The ordinary theory which we are about to explain, may be used without much risk of error in all cases where the angles of impulse is not below 60°, which is the case in wheels moved by the force of water.

PROP. I.

If a fluid, whose particles have all the same velocity, strikes a plane surface, the resistance will be as the product of the squares of the velocity of the fluid, the density of the fluid, and the area of the plane.

The resistance must obviously be equal to the force with which each particle strikes the plane, multiplied by the number of particles which strike it in a given time. But the force of each particle is as its velocity, and the number of particles which strike the plane in any given time, must also be as the velocity. Hence the resistance will be as the square of the velocity. It is obvious also that the resistance will be proportional to the density of the fluid, as the number of particles which strike the plane in the same time must be proportional to the density; the number of particles which strike the plane must likewise increase with the area of the plane; and therefore the whole resistance must be proportional to the square of the velocity of the fluid, the density of the fluid, and the area of the surface of the plane.

PROP. II.

If a fluid in motion strikes a plane surface at rest, inclined to the direction in which the fluid moves, the resistance perpendicular to the plane is proportional to the square of the sine of the angle of inclination.

PLATE CCCXIX. Fig. 9.

Let AB be the plane surface, inclined at an angle ABC to the direction DE, or CB of the motion of the fluid. Draw AC perpendicular to DE. Then it is obvious that the number of particles which strike against the surface AB is proportional to AC, for none of those which are beyond A and C can have any effect upon the plane. Likewise, if we take EF to represent the velocity of the fluid, and resolve this velocity into the two velocities FG, perpendicular to the surface of the plane, and GE parallel to the same surface, it is manifest that the part GE has no effect in acting against the plane. Hence the part of the force which acts perpendicular to the plane is FG, or the sine of the angle GEF = ABC, the inclination of the plane. That is the force which acts perpendicular to the plane is proportional to sin. ABC; and the number of particles which strike the plane is also proportional to sin. ABC, consequently the resistance must be proportional to sin. ABC × sin. ABC = sin.^{2} ABC, or the square of the sine of the angle of inclination.

COR. The resistance which the plane experiences in the direction of its motion, is proportional to the cube of the sine of the angle of inclination. For as the resistance in a direction FG, perpendicular to the plane, is proportional to the square of the sine of the angle of inclination, it must itself vary as the sine of the angle when reduced to the direction DE; that is, the whole resistance must vary as $\sin.^{2} ABC \times \sin. ABC = \sin.^{3} ABC$, or the cube of the sine of the angle of inclination.

Scholium.

Absolute measure of the resistance.

The two preceding propositions enable us to compare together the resistances experienced by plane surfaces moving in a fluid with different velocities, and at different angles of inclination. It is necessary, however, to know the absolute measure of the resistance for perpendicular impulses, in order that we may determine the absolute measures in all other cases. It follows from the experiments of Bossut, that the resistance experienced by a plane surface, which strikes directly and perpendicularly an indefinite fluid, is sensibly equal to the weight of a column of the fluid, which has for its base the area of the plane surface, and for its altitude the height due to the velocity of the surface, that is, if R is the resistance, A the area of the resisted surface, s the specific gravity of the fluid, and h the height due to the velocity, we have $R = sA^{2}h$.

If the fluid is not of indefinite extent, but is merely a vein which strikes a plain surface at rest, the absolute measure of the resistance is quite different, being equal to a little less than the weight of a column of fluid whose base is the area of the surface, and whose height is double the height which is due to the velocity of the issuing vein, or $R = sA^{\prime}2h$. This measure of the resistance was first determined accurately by G. W. Krafft. Duhamel had made experiments on the same subject in 1669, and several other philosophers followed in the same path; but the result which they obtained was, that the height of the column was equal only to that which was due to the velocity. Krafft employed a rectangular lever, against the vertical arm of which the water issuing from an additional tube impinged, while the weights requisite to balance that force were placed in a scale placed on the horizontal arm. In this way he obtained the results which we have already given in p. 415. See *Comment. Petropol.* 1736, vol. viii. p. 253.

M. Bossut has given an account of similar experiments in the 2d edition of his Hydrodynamics, vol. ii. p. 293. from which it follows that the resistance is a little less than the weight of a column whose height is double that which belongs to the velocity. In Bossut's experiments the water issued vertically from the bottom of a reservoir, upon one of the arms of a horizontal balance; and he observed that the resistance was always less when the flat arm of the balance touched the orifice, than when there were some interval between them.[*]

These two simple propositions constitute the whole of the ordinary theory of the resistance of fluids. They are founded upon two suppositions, neither of which are correct. 1. That after any particle of fluid strikes the plane, it is supposed to be annihilated, or to produce no farther effect; and, 2. That the part of the force which in oblique impulses is parallel to the surface of the plane, has no influence whatever upon the resistance which the plane experiences from the perpendicular part of the force. The first of these suppositions is obviously incorrect, for as the particles are not annihilated after impulse, they must some how or other get out of the way of the particles which succeed them, which can only be done by acting upon them, and consequently affecting their velocity. The second supposition appears also to be incorrect, for Mr Vince found that the part of the force which is parallel to the plane is not entirely lost.

By proceeding upon the principle laid down in the preceding proposition, it is easy to determine the resistance experienced by globes, cones, cylinders, and in short bodies of any form. Such determinations, however, are of no use, as they differ too widely from the experimental results to be capable of any practical application.

For a general account of D'Alembert's theory of the resistance of fluids, we must refer our readers to the historical part of this article, where a short notice of Don George Juan's theory is also given. The explanation of this last theory, however, belongs more properly to Mechanics, as it is a deduction from that author's physico-mathematical theory of percussion.

Sect. II. *Account of Experiments on the Resistance of Fluids.*

1. *Account of Bossut's Experiments.*

Account of Bossut's experiments.

In our History of Hydrodynamics, we have already given a general account of the experiments made by Bossut, D'Alembert, and Condorcet, in the years 1775, and by Bossut alone in 1778, on the resistance of fluids. The following were the leading results which they obtained.

Resistances in an indefinite fluid.

1. That the resistances of the same body of any figure which divides a fluid with different velocities, are sensibly proportional to the squares of these velocities.

2. That the direct and perpendicular resistances of plane surfaces, are sensibly proportional for the same velocity to the area of the surface.

3. That the resistances which arise from oblique impulses are not in the ratio of the squares of the sines of the angles of incidence; but that, when the angles of incidence are between 50° and 90°, the ordinary theory may be employed as an approximation, by observing that it always gives resistances a little less than experiment, and as much less as the angle differs from 90°.

4. That the absolute measure of the direct and perpendicular resistance of a plane surface in an indefinite fluid, is the weight of a column of the fluid, which has for its base the area of the surface, and for its altitude the height due to the velocity.

The resistance is much greater, and nearly double, in a mill course, which conveys the water to the floatboards of an undershot wheel.

5. That the tenacity of the water is a force which may be regarded as infinitely small, in relation to that which a body experiences in striking the water, particularly when the velocity is considerable.

Resistances in a narrow canal.

The next set of experiments by Bossut were made on the resistances experienced in narrow canals. Dr Franklin had ascertained, by a rude experiment, when he was travelling in Holland, that barges experienced

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[*] The experiments of the Chevalier Borda gave a different result. He employed a cube, which floated upon the stagnant water of a large basin, and he found that the height due to the resistance did not much exceed that which was due to the velocity. See *Mem. Acad. Par.* 1763, 1767.

Resistances in a narrow canal.

a greater resistance when the waters of the canal were low; but no precise measure of this increase of resistance, nor any explanation of its cause, were given till Bossut published his experiments. The following were the general results which he obtained.

1. That in narrow canals the resistances are proportional to the squares of the velocities, following the same law as in a fluid of indefinite extent.

2. That the resistances in narrow canals, and canals which have little depth, is greater than in fluids of indefinite extent.

The cause of this is obvious. When the velocity of the body is considerable, the fluid which that body pushes before it has not liberty to expand itself on every side, but forms a current more or less rapid as the velocity of the body is more or less great. If the body entirely filled the canal, it would push all the water before it like the piston of a pump; but as, in narrow canals, there is always some room for the water to run both below the boat and at its sides, a part of the fluid escapes in this way, while another part is driven back; and in this way a variety of contrary currents are formed, by which the resistance is increased. This augmentation of resistance is produced, not only by the heaping up of the fluid on its anterior part, but also by the want of hydrostatical support behind.

The preceding results furnish an excellent lesson to the engineer, in so far as they point out the advantage of making all canals of navigation as wide and deep as is consistent with a proper economy.

On the resistances of prows of different forms.

In 1778, M. Bossut undertook, in conjunction with Condorcet, a series of experiments, the object of which was to determine the law according to which the resistance varied in an indefinite fluid like the sea, by varying the angle of the prow of a vessel from a straight line, or 180°, to an angle of 12°. These experiments were made in the great reservoir, now destroyed, which formerly existed on the north side of the Boulevards of Paris. This reservoir was 200 long, 100 wide, and $8\frac{1}{2}$ deep. The form of the apparatus employed is shewn in Plate CCCXIX. Fig. 10. where MQNOP is the small vessel. The prow, MQN, had various angles, from 180° to 12°. The vessel was drawn along by a cord C attached to its centre of gravity, which passing below a pulley on the same level with *c*, rises nearly in a vertical line, and passing again over a pulley descends and is attached to the weights, by the descent of which the motion of the vessel is produced. A rope QR stretching across the whole length of the reservoir, serves to regulate the motion of the vessel. The vessel was then brought, by another rope fixed at *o*, to one end of the reservoir, and the time in which it described 96 feet uniformly by different weights suspended to the end of the rope, was carefully measured by an excellent seconds watch. Each experiment was repeated five times, and the mean of these times was adopted as the true measure. The general results of these experiments are given in the following Table, and compared with those given by the ordinary theory. The Table contains the resistances for fifteen different kinds of prows. The base MN Fig. 10. remains always the same, while the angle MQN of the prow, formed into an isosceles triangle, is made variable.

PLATE CCCXIX. Fig. 10.

Comparative Table of the Resistances experienced by 15 Angular Prows, as deduced by Bossut from his Experiments.

Angles of the Prow, or values of MQN = x.	Calculated Resistances according to the common theory, or values of Cos.² x.	Observed Resistances.	Difference between the observed and calculated Resistances.
180°	10000	10000	0
168	9893	9890	3
156	9578	9568	10
144	9084	9045	39
132	8446	8346	100
120	7710	7500	210
108	6925	6545	380
96	6148	5523	625
84	5433	4478	955
72	4800	3455	1345
60	4404	2500	1904
48	4240	1654	2586
36	4142	955	3187
24	4063	432	3631
12	3999	109	3890

The results in column third, as given by the ordinary theory, are calculated by the formula $1000 \text{ Cos.}^2 x$, x being the angle of the prow. In order to obtain a formula which will express the law of the experimental resistances, Bossut observes, that when the angle x undergoes a variation of 12⁰, each of the angles at the base of the isosceles prow will vary 6°. Calling this variation q, Bossut finds that the experimental resistance may be expressed by the formula

$$10000 \times \text{Cos.}^2 x + 3153 \left(\frac{x}{q}\right)^{3.25}.$$

This formula, however, though it answers well for prows with large angles, yet when the angle is small, it errs considerably in excess. In a prow of 12°, for example, the term $3.153 \left(\frac{x}{q}\right)^{5.25}$ becomes 4766 instead of 3631.

2. *Account of Du Buat's Experiments.*

Du Buat experime on the in pulse of a vein of flu

The attention of Du Buat was first directed to the determination of the resistance experienced by an immoveable surface, when struck by an insulated vein of fluid, whose area is either greater than, or equal to, the area of the surface. In order to measure this resistance, he balanced it by a column of fluid, the height of which measured the height due to the impulse. A tube of glass, about $1\frac{1}{2}$ lines of interior diameter, was bent into a right angle at its lower extremity. Into this bent part were fitted different surfaces for receiving the impulse of the fluid vein, which was to be balanced by the weight of column which ascended in the tube.

The result of these experiments was, that the height due to the impulse is the same as the height due to the velocity of the vein; whereas Bossut made it equal to the height due to twice the velocity. Du Buat accounts for this difference with great success. The vertical vein of fluid in Bossut's experiments, enlarged itself in striking the surface upon the balance; and the fluid filaments took a horizontal direction, after they had given the shock to the surface. The resistance, therefore, measured by Bossut was not merely the impulse of a vein whose diameter was that of the orifice, but also the additional pressure of a ring of fluid of a certain extent, around the circular base of the vein in contact with the resisted surface.

On the resistance of a body fixed in a current of water.

M. Du Buat next proceeds to ascertain the amount of the resistance, when an immoveable surface is placed in a current of indefinite extent. The instrument which he used for this purpose was a box of white iron, presenting a surface of one square foot. It had a thickness of nearly four lines, and was shut on all sides except a small opening in its posterior surface, into which was soldered the horizontal branch of a rectangular tin tube 16 lines in diameter, which received a float that indicated the height to which the water rose within the tube. By means of a bar of iron of about 10 feet long, which could be attached to the back of the box, the box could be fixed at any distance below the surface of the current. Five holes, each about a line in diameter, were perforated in the anterior side of the tin box. The first was in the middle, the second equidistant, in a horizontal line, from the middle and the edge, and the third in the same horizontal line, but only 10 lines distant from the edge; the fourth was quite close to the edge; and the fifth in the lower angle of the square. When the box was fixed, and the current of water was allowed to enter one or more of these holes, the fluid rose in the rectangular tin tube to a height due to the pressure of the current. In this way Du Buat made several experiments, which gave very singular results. The pressure was not only found to diminish from the centre of the surface to the edge or margin, but it became nothing at a certain distance from the centre, and afterwards negative at the margin. That is, when the water entered through the central hole, it rose to a certain height in the tin tube above the level of the stream. This height diminished when the water entered at a hole nearer the margin, the height became nothing at a certain distance, and still nearer the margin the fluid was actually depressed in the tin tube below the surface of the current. Du Buat explains this remarkable fact by saying, that the real pressure against any part of the surface is only the difference of the pressure against that part considered separately from the rest of the surface, and the height due to the variable velocity with which the water moves along the surface which is struck; that is, the water in escaping along the surface always diminishes the real pressure of the current; but towards the edges it becomes more powerful than the real current, and therefore that part is less pressed than if the fluid were immoveable, and will therefore sink in the tin tube.

In order to ascertain the mean pressure upon the whole surface, Du Buat shut up the holes already mentioned, and perforated the same surface with 625 holes, disposed symmetrically, with 25 on each side. By exposing this surface to the current, it appeared that the height of the water in the tube was 25⅓ lines, when the mean velocity was 36 inches per second, which is due to a height of 21⅓ lines. Hence the height due to the mean resistance is equal to 1.186 times the height due to the velocity.

On the diminution of pressure behind a resisted body.

By a similar contrivance Du Buat measured the diminution of pressure, or the *non-pressure* as he calls it, experienced by the posterior part of a body fixed in a current. He found, *1st*, That the diminution of pressure increased considerably by lengthening the body; *2d*, That it increased a little from the circumference of the body to its centre; and, *3dly*, That the diminution of pressure is proportional to the area of the surface that is submerged.

On the resistance to bodies moving in stagnant water.

It had hitherto been supposed by all authors, that the resistance experienced by a surface at rest from a fluid in motion, was exactly equal to the resistance of the same surface when it moved in stagnant water, with a velocity equal to that of the current. M. Du Buat resolved to examine this point experimentally, and from a variety of experiments made on the river Hayne, between Mons and Condé, he concluded, *1st*, That the phenomena are by no means the same when the body is at rest as when it is in motion. *2d*, That in the latter case, the pressure does not diminish so sensibly from the centre to the circumference, and instead of a negative pressure towards the sides, that the pressure is then so great, as to be measured by the third of the height due to the velocity, which shews that the water runs along the anterior surface with less velocity, or with more uniformity. *3d*, That the pressures diminish in a less ratio than the square of the velocity, when the velocities are less than three or four feet per second. *4th*, That the mean pressures are measured by the exact height due to the velocity, instead of 1.186 times the height, as before: And, *5thly*, That the diminution of pressure diminishes little from the centre to the circumference in the same order as the pressures.

Resistance to globes oscillating in fluids.

The next object of M. Du Buat is to determine the quantity of fluid which globes and plane surfaces drag along with them, when oscillating in a fluid. The globes were of wood, lead and glass. They oscillated in a vessel 51 inches long, 17 inches wide, and 14 inches deep: They were entirely immersed about three inches below the surface, and the wire which suspended them was as delicate as their weight would permit. The general result of these experiments is, that a globe oscillating in water drags along with it, both before and behind, a portion of fluid whose volume exceeds a little its own volume, or nearly $\frac{585}{1000}$ of its own volume.

Similar experiments were made with various plane surfaces of white iron, cylinders oscillating in the plane of their axes, quadrangular prisms oscillating in the plane of their axes, triangular prisms oscillating in the plane of their axes, cubes oscillating directly, cubes oscillating by the common section of two of their bounding planes, cubes oscillating by a solid angle, quadrangular prisms oscillating by the common section of two oblique faces, cylinders oscillating in the direction of their diameters, and cones, pyramids and mixed bodies oscillating in the plane of their axes; but our limits will not permit us to give any account of these experiments, which will be found in Part III. sect. 1. chap. viii. of Du Buat's *Principes D'Hydraulique*, tom. ii.

Resistance of vessels in narrow canals.

The attention of Du Buat is next directed to the important subject of the resistance opposed to vessels in narrow canals. From a comparison of several experiments, he has deduced the following formula:

$$R = \frac{K}{\frac{C}{b} + 2} \quad \text{or } R = \frac{8.46}{\frac{C}{b} + 2},$$

in which C is the area of the section of the canal, b the area of the section of the vessel, and R the resistance; the resistance in a fluid of indefinite extent being = 1.

In order to compare this formula with experiments, Du Buat employed five kinds of prismatic boats, several feet in length, and terminated both before and behind by a plane surface. The boat

Resistance of Fluids.

Resistance of vessels in narrow canals.

No. 1, had the immersed part = a rectangle of 1 foot of base upon 1 foot of height.

No. 2, had 2 feet of base upon 1 foot of height immersed.

No. 4, and 5, had 19 inches 8 lines upon 12 inches 5½ lines immersed, and differed only in their lengths.

No. 6, had its section like the great section of a vessel, and the area of the part immersed was 190 square inches.

The following Table shews the results of the experiment:

TABLE *Shewing the Resistance of Boats in Narrow Canals.*

Numbers of the Boats.	Ratio of the Sections or Values of $\frac{C}{b}$	Observed Resistances, or Values of R.	Resistances calculated by the Formula.
Canal 28½ Inches Wide, and 15 Inches 2 Lines Deep.			
1	3.00	1.66	1.69
2	1.50	2.50	2.41
4 & 5	1.76	2.25	2.25
6	2.275	1.94	1.97
Canal 40 Inches Wide, and 15 Inches 2 Lines Deep.			
1	4.212	1.33	1.36
2	2.106	2.11	2.05
4 & 5	2.476	1.90	1.89
6	3.192	1.62	1.62

From these experiments Du Buat has concluded, that a canal cannot be considered as of indefinite width, unless its width is 4.46, or 4½ times that of the vessel; or what is the same thing, that when this is the ratio between the width of the vessel and the canal, the vessel experiences the same resistance as if it moved in the open sea. In order to confirm this result, the following experiments were made, in which $\frac{c}{b}$ and R in the last column are calculated by reducing the canal to 4½ times that of the vessel.

Numbers of the Boats.	Ratio of the Sections or Values of $\frac{C}{b}$	Observed Resistances, or Values of R.	Resistances calculated by the Formula.
Canal 75 Inches Wide, and 15½ Deep.			
1	5.81	1.053	1.08
2	4.036	1.384	1.40
Canal of Indefinite Width, and 15 Inches 4 Lines Deep.			
2	5.75	1.125	1.09
5	5.53	1.143	1.12
Canal of Indefinite Width, and 27 Inches 3 Lines Deep.			
2	4.46	1.1	1.00

Resistance of Fluids.

Resistance of vessels in narrow canals.

The law of oblique resistances does not appear to be the same in a narrow canal as in a fluid of indefinite extent, and an angular prow added to a prismatic vessel produces a less diminution of the resistance as the canal becomes more narrow. M. Du Buat expresses the resistance of an angular prow in a narrow canal by the following formula:

$$r = R - \frac{\left(R - \frac{R}{q}\right)\left(\frac{C}{b} - 1\right)}{5.46}, \text{ in which}$$

R is the resistance of a plane prow in a narrow canal.

r the resistance of an angular prow of the same base.

q the ratio between the resistances of these two prows in an indefinite fluid; and

$\frac{C}{b}$ the ratio of the section as formerly.

When the boat No. 2. had an angular prow of 45°, and moved in a canal 28½ inches wide, and 15½ deep, the resistance was 4.42; whereas, the formula gives $r = 4.444$.

When the same boat had an angular prow of 14° 3′, the resistance was = 3.2; whereas, the formula gives $r = 3.25$.

When these experiments were repeated in a canal shut at both ends, the resistance of boat No. 1. was sensibly the same as when it was open; but when No. 2. was used, the resistance was considerably augmented. The effects in this case become very complicated, particularly for a canal which is short. When the sluices in canals are three or four miles distant, the part of the canal may be considered as of indefinite length, and if approaching one of its extremities, the boats ought to experience more resistance from this cause, yet the heaping up and the driving back of the water obliges the boats to rise, and thus allows the fluid to escape more easily behind.

3. *Account of the Experiments of Vince on the Resistance of Fluids.*

Account of Vince's experiments.

The experiments of Mr Vince on the resistance of fluids, were published in 1798, in the *Transactions of the Royal Society of London.* They were made with bodies moving at a considerable depth below the surface of water, and the resistance was measured both when the body moved in the fluid, and when the body was struck by the fluid in motion. The results of his experiments on the resistance of a plane surface moving in a fluid, are given in the following Table

Resistance when the plane moves in the fluid.

TABLE *shewing the Resistance of a Plane Surface moving in a Fluid with a Velocity of 0.66 of a Foot in a Second, and inclined at different Angles to the Line of its Motion.*

Inclination of the Plane to the Line of its Motion.	Resistances Observed.	Resistances calculated from Theory.	Power of the Sine of the Inclination to which the resistance is proportional.
Degrees.	Ounces Troy.	Ounces Troy.	Experiments.
10	0.0112	0.0012	1.73
20	0.0364	0.0098	1.73
30	0.0769	0.0290	1.54
40	0.1174	0.0616	1.54
50	0.1552	0.1043	1.51
60	0.1902	0.1476	1.38
70	0.2125	0.1926	1.42
80	0.2237	0.2217	2.41
90	0.2321	0.2321	
1	2	3	4

In the preceding Table, column 1st contains the angles of inclination at which the plane surface struck the fluid. Column 2d shews the resistance by experiment in the direction of their motion in Troy ounces. Column 3d shews the resistance by theory, the perpendicular resistance being supposed the same as that which is deduced from experiment. Column 4th contains the exponent of the power of the sine of the angle to which the resistance is proportional. This column was computed in the following manner: Calling s the sine of the inclination, and r the corresponding resistance; then, if r is proportional to the mth power of s, or to s^m, we have sin. 90°, or 1^m

$$s^m = 0.2321 : r \text{ and } s^m = \frac{r}{0.2321}; \text{ and, consequently,}$$

$$m = \frac{\text{Log. } r - \text{Log. } 0.2321}{\text{Log. } s}.$$

According to theory, the resistance in the direction of the motion of the plane should vary as the cube of the sine (Prop. II. Cor. p. 542); but it appears from the Table, that it varies in a much less ratio, but not as any constant power, or as any function of the sine and cosine. The actual resistance, therefore, must always exceed the theoretical resistance, which Mr Vince attributes partly to the part of the force parallel to the plane being neglected in the theory, but which appears to be really a part of the force which acts upon the plane.

Resistance when the plane is struck by the fluid.

When the plane surface was struck by the fluid in motion, Mr Vince obtained the results contained in the following Table.

Table *shewing the Resistance of a Plane Surface struck by a Fluid in Motion, and inclined at different Angles to the line of its Motion.*

Inclination of the Plane to the Sine of its Motion.	Resistances observed.			Resistances calculated from Theory.		
Degrees.	Oz.	Dwts.	Grs.	Oz.	Dwts.	Grs.
90	1	17	12	1	17	12
80	1	17	0	1	16	22
70	1	15	12	1	15	6
60	1	12	12	1	12	11
50	1	18	10	1	18	17
40	1	4	10	1	4	2
30	0	18	18	0	18	18
20	0	12	12	0	12	19
10	0	6	4	0	6	12

The coincidence between the experimental and the theoretical results is very surprising, the difference being nothing more than might have been expected from the ordinary inaccuracy of experiments. It follows, therefore, from Mr Vince's experiments, that when the fluid is in motion, the resistance varies as the sine of the angle of the plane's inclination.

The difference between the resistances in the two cases confirm the results obtained by Du Buat, and prove, that the resistance when the plane moves is to the resistance when the fluid moves as 5 to 6, a result which Mr Vince ascribes to the action of the fluid behind the body when in motion.

4. *Account of Coulomb's Experiments on the Resistance of Fluids in Slow Motions.*

Account of Coulomb's experiments on the resistance of fluids.

Notwithstanding the great value of the experiments of Bossut and Du Buat, yet none of these authors succeeded in determining the true law of the resistance of fluids. This honour was reserved for the late M. Coulomb, who first entertained the happy idea of ascertaining the laws of the resistance of fluids in slow motions, by the oscillation of horizontal discs in consequence of the torsion, or the twisting and untwisting of the wire by which they were suspended. In the present Section we shall endeavour to lay before our readers as distinct an account as possible of the investigations of this celebrated philosopher.

When a body in motion strikes a fluid at rest, it experiences two kinds of resistance. One of these arises from the cohesion of the fluid particles, which are separated from each other by the moving body; and as the number of molecules thus separated is proportional to the velocity of the body, this part of the resistance depending upon the cohesion, will likewise be proportional to the simple velocity.

The other part of the resistance arises from the inertia of the fluid particles, which being struck by the body, acquire a degree of velocity proportional to the velocity of the body; but as the number of these parts is proportional to the velocity, there ought to arise a resistance proportional to the square of the velocity. Hence the theory seems to inform us, that the *resistance of fluids should be represented by the sum of two quantities, one of which is proportional to the simple velocity, and the other to the square of the velocity.* This theoretical result was completely verified by Coulomb's experiments.

In order to submit these views to the test of experience, the ordinary methods of measuring the resistance of fluids are of no avail. When the moving body has a velocity about eight or nine inches per second, the resistance is always proportional to the square of the velocity; but when the velocity does not exceed four-tenths of an inch per second, the part proportional to the simple velocity becomes sensible; but as the velocity is extremely small, the resistance is also very small, and therefore the ordinary means cannot be used either in measuring the resistance, or in separating the parts due to the different terms of the formula. Coulomb therefore found it necessary, 1. To employ a measure, by which he could determine with great exactness very small forces. And, 2. To have it in his power to give to the moving body a degree of velocity so small, that the part of the resistance proportional to the square of the velocity might be compared with the other terms of the function which represent the resistance; or to be able to make the part of the resistance proportional to the square of the velocity so small compared with the other terms, that it might be safely neglected.

Apparatus employed by Coulomb. Plate CCCXIX. Fig. 11.

These objects were completely gained, by employing the apparatus represented in Plate CCCXIX. Fig. 11. where ABC is a stand, having a horizontal arm BC, to which is fixed the small circle ef, perforated in the centre for the purpose of admitting the cylindrical pin ba. Into a slit in the extremity of this pin is fastened, by means of a screw, the brass wire ag, whose force of torsion is to be compared with the resistance of the fluid; and its lower extremity is fixed in the same way into a cylinder of copper gd, whose diameter is about four-tenths of an inch. The cylinder gd is perpendicular to the disc DS, whose circumference is divided into 480 equal parts. When this horizontal disc is at rest, which happens when the torsion of the brass wire is nothing, the index RS is placed upon

Account of Coulomb's experiments on the resistance of fluids.

the point 0, the zero of the circular scale. The small rule R *m* may be elevated or depressed at pleasure round its axis *n*; and the stand GH which supports it may be brought into any position round the horizontal disc. The lower extremity of the cylinder *g d* is immersed about two inches in the vessel of water MNOP, and to the extremity *d* is attached the discs, or the bodies, whose resistance is to be determined when they oscillate in the fluid by the torsion of the brass wire.

In order to produce these oscillations, the disc DS, supported by both hands, must be turned gently round to a certain distance from the index, without deranging the vertical position of the suspended wire. The disc being then left to itself, the force of torsion causes it to oscillate, and the successive diminution of these oscillations is carefully observed. A simple formula gives in weights the force of torsion that produces the oscillations; and another formula well known to geometers, determines (by an approximation sufficiently accurate in practice) by means of the successive diminution of the oscillations, compared with their amplitude, what is the law of the resistance, relative to the velocity which produces these diminutions.

The method employed by Coulomb in reducing his experiments, is nearly the same as that by which Newton and others determined the resistance of fluids from the successive diminution of the oscillations of a pendulum vibrating in a fluid; but Coulomb's apparatus is not liable to any of the objections which attach to the use of the pendulum. It would be impossible, without a previous explanation of the principles of torsion, and a discussion too long and minute for the limits of our work, to make our readers acquainted with the various steps of Coulomb's investigation. All that we can pretend to do, is to give an account of the different physical results which he obtained.

General results.

Having attached to the lower extremity of the cylinder *g d* a circular white iron plate, about 6.677 inches in diameter, he found that when its oscillations were so slow, that the part of the resistance proportional to the square of the velocity was greatly inferior to the other part, the resistance which diminished the oscillations of the horizontal plate was uniformly proportional to the simple velocity, and that the other part produced no sensible effect upon the motion of the disc. He likewise found, in conformity with theory, that the momenta of resistance in different circular plates oscillating in a fluid, are as the fourth power of the diameters of these circles, when the resistance is proportional to the simple velocity; and that when a circle, 6.677 inches in diameter, oscillated with the velocity of 5.512 inches per second in its circumference, the momentum of resistance which the fluid opposed to its circular motion, was equal to $\frac{1}{10}$ of a gramme, multiplied by a lever 143 millimetres long, or 1.544 English Troy grains, at the end of a line 5.63 English inches long. Hence it follows, that the resistance of the two circular surfaces of the disc, is equal to a weight of 0.587 grammes.

If the plane or disc had only a velocity of ten millimetres, or one centimetre, the resistance would be only 0.042 grammes. In like manner it follows, that the resistance experienced by a surface of one square metre, moving with a velocity of one centimetre per second, is 0.703 grammes.

In order to determine comparatively with water the cohesion of different fluids, he filled a large vessel with clarified oil, such as is used in commerce for the lamps called *Quinquet;* and he found its temperature to be 16° of Reaumur's scale, which he marked, because the cohesion of oil varies with the temperature, though this variation is not sensible in water by small changes of temperature. By causing discs of different diameters to oscillate in the oil, he found that the momenta of resistance for two circles, moving round their centre in the plane of their superficies, varies as the fourth power of the diameter, a result which is also conformable with theory. The agreement of these results, Coulomb considers as leaving no doubt respecting the certainty of the term proportional to the velocity in the resistance of fluids.

Ratio of the cohesion of oil and water.

From these experiments, Coulomb likewise concluded that the difficulty which the same disc moving with the same degree of velocity experienced in separating the particles of oil, was to the difficulty which it experienced in separating the particles of water as 17.5 to 1, which will therefore express the ratio between the mutual cohesion of the particles of oil, and the mutual cohesion of the particles of water.

On the effect produced by the nature of the surface.

The next object of our author was to determine two important points. 1*st*, If the resistance of a body was influenced by the nature of its surface; and, 2*d*, if it was influenced by the pressure of the superincumbent fluid. In order to settle the first of these points, he covered the surface of a circle of white iron with a film of tallow, and wiped it slightly away, that the thickness of the plate might not be sensibly increased. He then caused this circle to oscillate as before; and he observed that the successive diminution of the oscillations was exactly the same as before the application of the tallow. Upon the coat of tallow he next scattered, by means of a sieve, a quantity of sand, which adhered to the surface; and he found that the resistance to the oscillations of the plate was not sensibly increased. Hence he concludes, that the part of the resistance proportional to the simple velocity arises from the mutual cohesion of the fluid particles, and not from the adhesion of these particles to the surface of the body. Whatever, indeed, was the nature of the surface, there was an infinite number of inequalities where the fluid particles were permanently lodged.

On the effect produced by pressure.

In order to determine the second point, M. Coulomb caused the bodies to oscillate at two different depths; one at a depth of .787 inches, and another at a depth of 19.6855 inches, and he found no difference in the resistances; but as the surface of the water supported the whole weight of the atmosphere, it was scarcely to be expected that a pressure of 19 inches of fluid would produce a very sensible increase of resistance. In order to decide the question, therefore, M. Coulomb employed another method.

Having placed a vessel full of water under the receiver of an air-pump, the receiver being furnished with a rod and collar of leather at its top, he fixed to the hook at the end of the rod a harpsichord wire numbered 7 in commerce, and suspended to it a cylinder of copper like *g d*, Fig. 11. which plunged in the water of the vessel, and under this cylinder he fixed a circular plane, whose diameter was 101 millimetres (3.975 English inches). When the oscillations were finished, and consequently the force of torsion nothing, the zero of torsion was marked by the aid of an index fixed to the cylinder. The rod was then made to turn quickly round through a complete circle, which gave to the wire a complete circle of torsion, and the successive ccount of oulomb's xperiments n the re- istance of luids.

diminution of the oscillations were carefully observed. The diminution for a complete circle of torsion was found to be nearly a fourth part of the circle for the first oscillation; but always the same, whether the experiment was made in a vacuum or in the atmosphere. A small pallet, 50 millimetres long (1.969 English inches), and 10 millimetres broad (0.3937 English inches), which struck the water perpendicular to its plane, furnished a similar result. We may therefore conclude, that when a submerged body moves in a fluid, the pressure which it sustains, measured by the altitude of the superior fluid, does not perceptibly increase the resistance; and consequently that the part of this resistance proportional to the simple velocity, can in no respect be compared with the friction of solid bodies, which is always proportional to the pressure.

These experiments were twice repeated in the cabinet of the Institute, in the presence of M. Charles and M. Lassuze.

n the re- istance of ylinders.

The attention of M. Coulomb was next directed to the determination of the resistance experienced by cylinders that moved very slowly, and perpendicular to their axes. When a cylinder, however small be its diameter, moves perpendicularly to its axis, the fluid particles which it strikes partake necessarily of its motion, and therefore it is not possible in the reduction of the experiments, to neglect the part of the resistance which is proportional to the square of the velocity. Hence he was obliged to perform the experiments in such a manner that both parts of the resistance might be computed. The three cylinders, which were successively subjected to trial, had a length of 9.803 inches. The cylinders were fixed by their middle under the cylinder *g d*, so that they formed two horizontal radii, the length of each of which was $\frac{9.803}{2} = 4.9015$ inches. The diameters of the cylinders were determined from their weight. After making the necessary experiments with cylinders whose diameters were 0.87 millimetres, 11.2 millimetres, and 21.1 millimetres, he found, from a comparison of the results, that the part of the resistance proportional to the simple velocity, which we shall call *r*, is not in different cylinders in the same ratio as the circumference of these cylinders, the ratio of their circumferences being as 24 to 1, while the values of *r* were as 3 to 1. In order to explain this result, Coulomb supposes that the particles which immediately touch the cylinder, take the same velocity as the cylinder; that the particles a little farther distant take a smaller velocity; and that at the distance of about one-tenth of an inch, the velocity ceases entirely. Hence it is at this last point that the cohesion ceases to have an influence on the resistance. Upon these suppositions, which Coulomb thinks require confirmation, he proposes to augment, by a constant quantity, the circumferences of all the cylinders, before comparing them with their resistance. This constant quantity to be added to the circumferences, he found to be 9.66 millimetres, or nearly an addition of three millimetres to their diameter; which shews that the portion of the fluid molecules detached from one another by the moving cylinder extends nearly to a distance of 1.5 millimetres from their circumferences.

In comparing the part of the resistance proportional to the square of the velocity, which we shall call R, with the diameters of the cylinders, it will be seen that these quantities in small cylinders are much greater than they ought to be in relation to their diameters, but in a much less ratio than in the preceding case. The augmentation of the circumferences is in this case only 1.77 millimetres, which is scarcely one-fifth of the former augmentation. Coulomb explains this difference from the theory in the following manner. All the fluid particles, when they are detached from one another, oppose the same resistance, whatever be the velocity which they take; so that as the quantity *r* depends only on the cohesion, the resistance due to their cohesion will extend only to the point where the velocity of the molecules of the fluid is nothing. In the comparison of the quantities R, all the particles are supposed to take a velocity equal to that of the cylinder; but as it is only the molecules in immediate contact with the cylinder that take this velocity, it follows that the augmentation of the diameter in determining the value of R, which answers the square of the velocity, should be less than in determining *r*, which is due to the cohesion. Besides, as Coulomb observes, these different degrees of lateral velocity, from the point of contact with the cylinder, where the velocity is equal to that of the cylinder, to the point where the cohesion renders the velocity nothing, ought to follow laws which new observations may soon determine, and which may throw great light upon this interesting branch of physics.

Account of Coulomb's experiments on the resistance of fluids.

On the resistance of cylinders.

In determining by experiment the part of the momentum of resistance proportional to the velocity in two cylinders of the same diameter but of different lengths, Coulomb found that the momentum of resistance was proportional to the cubes of their diameters. The same result is obtained from theory; for supposing each cylinder to be divided into the same number of parts, the length of each part will be proportional to the total length. The velocity of the corresponding parts will be as the same lengths, and also as the distance of these parts from the centre of rotation. The theory likewise indicates that the part of the momentum of resistance depending on the square of the velocity, in two cylinders of the same diameter, but of different lengths, is proportional to the fourth power of the length of the cylinder.

Real resistance of a given cylinder.

Coulomb now proceeds to determine the real resistance due to the simple velocity which a cylinder experiences while oscillating parallel to itself, and perpendicular to its axis. When the cylinder 9.803 inches long, and 0.04409 inches in circumference, was made to oscillate with a velocity of 5.512 inches per second, the part of the resistance *r* was equal to 58 milligrammes, or .8932 troy grains; and when the velocity was 0.3937 inches per second, the resistance was 0.00414 grammes, or 0.637 troy grains. Hence we may conclude, that the resistance of a cylinder of the same diameter, but of a metre in length, or 39.37 inches, will be about 17 milligrammes.

The preceding experiments were repeated in the same oil which was formerly used, and at the same temperature; and he found as formerly that the cohesion of oil was to that of water as 17 to 1. He considers oil as preferable to water for determining *r*; for in the case of small velocities, the part R disappears almost entirely.

In these experiments Coulomb observed an effect which he could not have anticipated. Although the cohesion of the oil is 17 times greater than that of water, yet the augmentation of the diameters of the cylinders, which it was necessary to apply, was only 3 millimetres, the same as for water. He observed also another curious fact, which is more easily understood, viz.

that the part of the resistance R is almost the same in oil as in water; for since this part arises merely from the inertia of the particles, it ought in different fluids to be proportional to their density.

Coulomb intended, in a second memoir, to determine numerically the value of the part of the resistance proportional to the square of the velocity; and to ascertain the resistance of globes, of pallets, of convex and concave surfaces; and also the difference between the resistance of a floating body and one entirely submerged; in consequence of his having found, that in slow motions the submerged body suffered a much less degree of resistance. We have to regret, however, that Coulomb did not live to complete these valuable researches. He died on the 3d August 1806, in the 70th year of his age; and left behind him the reputation of being one of the most able and original natural philosophers of the age in which he lived.

5. *Account of the Experiments of the Society for the Advancement of Naval Architecture.*

Experiments of the Society of Naval Architecture.

We regret that our limits will only permit us to lay before our readers some of the results of these excellent experiments.

The following experiments were made with a surface of 40 square feet, moving in its own direction with different velocities.

Velocities in Nautical Miles per hour.	Friction in Pounds.
1	0.563
2	1.992
4	6.642
6	12.839
8	19.856

When the same body had prows differently inclined, the following results were obtained.

Inclination of the Prows.	Friction.
9° 44′ 10″	30.67
14 28 40	35.34
19 28 15	41.71
30 0 0	51.44
90 0 0	148.25

The Society likewise found, that the direct resistance varied in a ratio a little greater than that of the square of the velocity, being proportional to $V^{2.108}$. A body which has the form of a fish, appeared to move with the least resistance; and soaked planks suffered a greater resistance than those which were not soaked.

6. *Comparison of the Results of different Formulæ and Experiments.*

Dr Thomas Young has drawn up the following valuable Table, containing a comparison of different formulæ with the experiments of Eytelwein, Bossut, and those of the Society for the advancement of Naval Architecture. In these formulæ, a is the angle of inclination, and R the resistance.

Formula A deduced by Dr Young, is $R = \cos.^2 a + \frac{1}{10} \text{tang.}\, a$.

Formula B deduced by Dr Young from theory is $R = \frac{1}{10} + \frac{4}{100} \text{tang.}\, a + 288 \cos.^2 a : 360 + a^{\circ}$.

Formula C deduced by Dr Young from experiments, is $R = \cos.^2 a + .0000004217\, a^{3.18}$ in which the last term is a little less than the millionth of the cube of the angle of incidence expressed in degrees.

Eytelwein's formula is $\cos.^2 a + \frac{4}{10}$ versed sin. a.

Compar of the re sults of ferent fo mulæ a experi ments.

Table *containing Dr Thomas Young's Comparison of different Formulæ and Experiments.*

Angles of Inclination or values of *a*.	Cos. ^{2} *a*.	Tang. *a*.	Formula A.	Formula B.	Formula C.	Eytelwein's Formula.	Bossut's Experiments.	Experiments of the Society for Naval Architecture.
0	1.0000	.000	1.0000	1.0000	1.0000	1.0000	1.0000	
6	.9890	.105	.9995	.9824	.9891	.9910	.9893	
12	.9568	.912	.9780	.9492	.9580	.9656	.9578	
18	.9045	.325	.9370	.9022	.9086	.9241	.9084	
24	.8346	.445	.8791	.8438	.8449	.8690	.8446	
30	.7500	.577	.8077	.7769	.7710	.8036	.7710	
36	.6544	.726	.7270	.7049	.6919	.7308	.6925	
42	.5523	.900	.6423	.6317	.6135	.6551	.6148	
48	.4478	1.111	.5589	.5606	.5414	.5802	.5433	
54	.3455	1.376	.4831	.4985	.4816	.5103	.4800	
60	.2500	1.732	.4232	.4407	.4403	.4500	.4404	.347
66	.1654	2.346	.4000	.3924	.4231	.4026	.4240	
72	.0955	3.078	.4033	.3869	.4344	.3719	.4142	.269
78	.0432	4.705	.5137	.4166	.4816	.3600	.4063	.222
84	.0109	9.514	(.9623)	.5875	.5658	.3693	.3999	

We have purposely omitted giving any account of the experiments of Hutton, Schober, and Colonel Beaufoy, on the resistance of air, as they do not belong to the present article.

CHAP. VI.

On the Oscillation of Fluids, and the Undulation of Waves.

Prop. I.

Oscillation of fluids.

The oscillations of a fluid in a syphon are isochronous, and are performed in the same time as those of a pendulum, whose length is equal to half the length of the oscillating columns.

On the c cillation fluids. Plate CCCXI Fig. 12.

Let MNOP, Plate CCCXIX. Fig. 12. be a syphon, consisting of two vertical branches MN, OP, connected together by a horizontal branch NO, and having the same internal diameter throughout its whole length. If water is poured into the syphon till it stands at AB in one leg, it will stand at CD in the other, ABCD being a horizontal line. Let a piston be now introduced at P, Oscillation of Fluids.

so as to cause the water to descend through the space Cg, it will of course rise in the other branch to the height ef, so that $Ae = Cg$. Upon withdrawing the piston, the elevated fluid in MN will descend in order to recover its level; the fluid in PO will also rise above its natural level, and again descending, a series of oscillations will be performed by the fluid similar to those of a pendulum, the surface AB vibrating between ef and $\iota\phi$, and the surface CD between gh and $\gamma\chi$. On account of the friction of the water, however, against the sides of the tube, the height $C\gamma$ will not be so great as Ae; and consequently, from the same cause, the oscillations will gradually diminish like those of a pendulum, till the water resume its state of equilibrium.

Plate CCCXIX. Fig. 12.

It is obvious from the Figure, that the force which produces the oscillations is the weight of the column of fluid $ef\phi\iota$, or twice the column $ABfe$, which is to the whole weight of the fluid column as $2\,Ae$ to ANOD, or as Ae to the length of a pendulum EF, Fig. 13. which describes arcs FI equal to Ae, or to one half of the oscillating column. Consequently since the length of the oscillating column ANOD is a constant quantity, the force which produces the oscillations is proportional to the space described by the water, and therefore the oscillations are isochronous.

Fig. 13.

Since the force by which the pendulum is made to describe the small arch FI is to the weight of the pendulum as FI is to FE, or as $Ae : EF$; and since the force which makes the water oscillate is to the weight of the whole water in the same ratio, the oscillations of the pendulum and of the fluid being produced by the same forces, must be performed in equal times.

Cor. The oscillations of a column of fluid will be proportional to the square roots of the length of the column of fluid. For as this is true of the pendulum, it must be true also of the oscillating fluid, which follows the same laws. See **Mechanics**.

Those who wish to study farther the subject of the oscillation of fluids, are referred to the *Principia* of Sir Isaac Newton, lib. ii. Prop. 45, 46. and to Bossut's *Traité Theorique et Experimental d'Hydrodynamique*, tom. i. chap. ix. p. 403. edit. 1796, where they will find a general method of determining the oscillations of water in a syphon of any form, with an application of the method to a cylindrical syphon, and to a rectilineal syphon composed of three tubes, two vertical, and one horizontal. The subject is also treated in Bernoulli's *Works*, tom. iii. p. 125, and in Hutton's *Mathematical Tracts*, vol. iii. p. 350.

Prop. II.

Undulation of Waves.

The undulations of waves are performed in the same time as the vibrations of a pendulum, whose length is equal to AC or BD, Fig. 14. the breadth of the wave, or the distance between two adjoining eminences or depressions.

Plate CCCXIX. Fig. 14.

Let ABCDE represent the section of two waves. It is obvious that the eminences A, C must descend, by the force of gravity, or a force equal to the weight of the elevated portion, and that the undulations are performed like the oscillations of water in a syphon, the highest parts AC becoming the lowest, while the lowest BD become the highest. Hence, if we take a pendulum, whose length is equal to half the distance between A and C, or B and D, the parts A, C will descend so as to be the lowest in the time of one oscillation of the pendulum, and in the time of another oscillation they will become the highest parts; that is, the pendulum will make two vibrations in the time of one undulation, or the time that one of the summits C has described a space comprehended between two adjacent summits. And as a pendulum, whose length is four times that of the preceding, oscillates once in the same time that it oscillated twice, it follows that the waves perform their oscillations in the same time as a pendulum, whose length is equal to AC or BD, the breadth of a wave. Hence a wave $3\frac{1}{18}$ feet broad, will have a velocity of $3\frac{1}{18}$ feet in a second; and a wave 18 inches broad will have a velocity of 26.538 inches per second.

The preceding doctrine of the oscillation of waves was first published by Sir Isaac Newton, in lib. ii. prob. 44. of the *Principia*. As the motion of waves, however, is partly circular, Sir Isaac considered his theory as only an approximation. M. La Place, in the *Memoirs of the Academy of Sciences* for 1776, has applied to this subject, particularly to rectilineal waves, the general laws of the motion of fluids, and obtained some interesting results, of which we have given a general account in our History of **Hydrodynamics**. La Grange has treated the subject in a general manner in the *Berlin Memoirs* for 1786, and M. Poisson and M. Cauchy have more recently written upon the same subject. The reader will find a general account of their labours in the History of **Hydrodynamics**, p. 418, 423. The same subject has likewise been treated by Dr Thomas Young, with his usual ability, in his *Lectures on Natural Philosophy*, vol. ii. p. 63.

Part III. ON HYDRAULIC MACHINERY.

Hydraulic Machinery.

The term **Hydraulic Machinery**, is, in strict propriety of language, applicable only to those machines which are driven by the force of water, whether it descends by its own weight, or acts by its impulsive power when in motion, or exerts a force in virtue of its re-action. It has, however, been applied in a more extended sense, so as to include various machines, by which water is raised or projected. The application of wind, and the force of animals, as the moving power of machinery, will be fully discussed under **Mechanics**, and the important application of steam will be considered at great length under the separate article of **Steam** *Engine*. As pumps and fire engines are pneumatical machines, they will be described under the articles **Pneumatics** and **Pump**.

CHAP: I.

On Water Wheels.

Water Wheels.

The usual method of employing water as the moving power of machinery, is to apply it to the circumference of wheels, from the axis or axletree of which the power is conveyed to the other parts of the machine. When the water is introduced into buckets placed round the circumference of a wheel moving in a vertical plane, so as to put the wheel in motion merely by its weight in the buckets, the wheel is called an *overshot wheel*, from the water being introduced over or near the summit of the wheel. When the water, after having acquired a considerable velocity by its descent along an inclined plane, is made to strike plane surfaces, or float-boards, arranged round the wheel's circumference, so as to put the wheel in motion merely by its impulsive force, it is called an *undershot wheel*, from the water being introduced at or near the under part of its circumference. When the water is introduced neither at the upper nor the lower point of the wheel, but at a point between them, so as to fall upon float boards fixed in the wheel's circumference, and to act both by its weight and by its impulse, it is called a *breast wheel*. When the water is made to issue from an aperture in the circumference of a wheel in the direction of the tangent, the wheel is said to be driven by the re-action or counter-pressure of the water. We shall now proceed to consider, in separate Sections, the best mode of constructing water wheels of these four different forms.

SECT. I. *On the Construction of Overshot Wheels.*

Overshot wheels.

PLATE CCCXIX. Fig. 15.

AN overshot wheel of the common kind, is represented in Plate CCCXIX. Fig. 15, where ABCD is the rim of the wheel, having a number of buckets *a*, *b*, *c*, *d*, arranged round its circumference. When the wheel is in a state of rest upon its axis O, and water is introduced into the bucket *c* from the horizontal mill course or canal EF, the weight of the water in the bucket, acting at the end of a lever equal to *m* O, puts the wheel in motion in the direction *c d*. When the subsequent bucket *b* comes into the position *c*, it is also filled with water, and so on with all the rest. When the bucket *c* reaches the situation of *d*, its mechanical effect to turn the wheel is increased, being now equal to the weight of water acting at the end of a lever *n* O, equal to the distance of its centre of gravity *d* from a vertical line passing through the axis O, so that the mechanical effect of the water in the bucket increases all the way to B, and of course diminishes while the buckets are moving from B to C.

The buckets, however, between B and C, have not the same power upon the wheel as those between A and B; for the water begins to fall out of the buckets before they approach to B, and are almost completely empty when they reach the point H. The construction of the buckets, therefore, as shewn in the Figure, is very improper, as it not only allows the water to escape before it has reached the point B, where its mechanical effect is a maximum; but also to escape completely, long before they have reached the lowest point C of the wheel. The power, therefore, of an overshot wheel must depend principally upon the form which is given to the buckets, which should always be fullest when they are at the point B, and should retain the water as long as possible. If the buckets were to consist of a single partition in the direction of the radii of the wheel, all the water would escape from the buckets before they passed the point B on a level with the axis O.

Fig. 16.

The form of a bucket, which has been regarded as the best, is represented in Fig. 16, by the line DCBAGIKL, where it is represented as composed of three partitions, viz. AB and GI, called the *start* or *shoulder*, which lies in the direction of the radius; BC and IK, called the *arm*, and inclined at an obtuse angle to the radius; and CD, KL, called the *wrest*, and inclined at an angle less than 180° to the arm BC or IK. The depth AG of each bucket is about $1\frac{1}{3}$ of GH; AB is $\frac{1}{2}$ of AM; and the angle ABC is such, that BC and GI prolonged would pass through the same point H. It ends, however, in C; so that FC is $\frac{5}{6}$ths of GH; and CD is placed so, that HD is nearly $\frac{1}{7}$th of HM. Hence it follows, that the arc FABC is nearly equal to DABC; so that the quantity of water FABC will still continue in the bucket when AD is a horizontal line, which happens when AB forms an angle of about 35° with a vertical line. The preceding construction of the buckets is obviously too complicated, and very little additional power is gained by the angle BCD. Hence the general practice is to continue BC to H, and AB is generally only $\frac{1}{3}$d of GH.

PLATE CCCXIX. Fig. 16.

New form of the buckets.

Such is the general view of the construction of buckets, which is given by Dr Robison; but we cannot agree with him in thinking that this form is the best. It must be obvious, upon the slightest consideration, that the power of the wheel would be a maximum, if the whole of its semi-circumference were loaded with water. This effect would be produced, if the buckets had the shape shewn in Fig. 17, where ABC is the form of the bucket, AB being in the direction of the radius, and BC part of the circumference of the wheel, and nearly equal to AD. This construction is, however, impracticable, as the aperture EC is not large enough either for the admission or the escape of the water, and when the last portion of the water flows out along BC, it would strike against the bottom DE of the bucket immediately above it. We must therefore consider what modification this form should receive, in order to give a free passage to the water at EC. This may be effected, by making BC (Fig. 18.) a little larger than BE, and diminishing AB, so as to make the angle ABC a little greater than 90°. In this way an aperture *d*E will be obtained, of sufficient magnitude both for the introduction and the discharge of the fluid; and the last portion of water will no longer strike against the bottom D *d* of the upper bucket. When the water is properly introduced by the methods afterwards to be described, this construction will be found to give great additional power to the wheel. Hence we see the reason why the inclination of DC, in Fig. 16, is advantageous, as it is an approximation to the preceding construction.

Fig. 17.

Fig. 18.

Double buckets contrived by Mr Burns. Fig. 19.

The late Mr Robert Burns of Cartside in Renfrewshire, a most ingenious millwright and mechanic, proposed what appeared to be a very great improvement upon the form of the buckets in overshot wheels. It consisted in using a double bucket, as shewn in Fig. 19, where LM is a partition almost concentric with the rim, and placed so as to make the inner and outer portions of the bucket hold equal quantities of water. When these buckets are filled $\frac{1}{3}$d, they retain the whole water at 18° from the bottom of the arch, and they retain $\frac{1}{2}$ of the water at 11°. Another great advantage of this construction is, that when there is little water to drive the wheel, it may be directed, by a slight adjustment of the spout, into the outer bucket, so as to make up, by the additional length of lever, for the small quantity of water which is in use. These advantages, however, are found in practice to be counterbalanced by disadvantages which cannot be got the better of. The water is found never to fill the inner buckets, and on this account we believe Mr Burns did not put the construction in practice.

It has in general been assumed by writers on water

On the ratio between the diameter of overshot wheels and the height of the fall.

wheels, that the diameter of overshot wheels should always be less than the height of the fall of water by which it is to be put in motion, and various ratios have been assigned between the height of the fall and the diameter of the wheel. The Chevalier de Borda has shewn, that overshot wheels will produce a maximum effect when their diameter is equal to the greatest height of the fall, but that a slight diminution of the wheel's diameter produces only a very small diminution of the maximum effect. If the height of the fall, for example, is 12 feet, and if the diameter of the wheel is made only 11 feet, the effect is diminished only $\frac{1}{12}$. This theoretical result has been confirmed by the admirable experiments of Mr Smeaton, who found, "*that the higher the wheel is in proportion to the whole descent, the greater will be the effect*;" because, as he remarks, "it depends less upon the impulse of the head, and more upon the gravity of the water in the buckets; and if we consider how obliquely the water issuing from the head must strike the buckets, we shall not be at a loss to account for the little advantage that arises from the impulse thereof, and shall immediately see of how little consequence this impulse is to the effect of an overshot wheel."

If the diameter of the wheel were equal to the whole height of the fall, the water would be laid in the buckets without having acquired any velocity; so that a portion of the power of the wheel would be spent in dragging this inert mass into motion, and also by the impulse of the buckets against the water, which will dash a part of it over the wheel. Hence it is necessary that the difference between the head of water and the diameter of the wheel should be such, that the water may acquire in its descent through that space a velocity a little greater than that of the circumference of the wheel. In this view of the subject, the water should fall through a height of 2½ or 3 inches per second, in order to acquire the velocity of the wheel; and therefore the diameter of the wheel should be only 3 inches less than the height of the fall.

The determination of the diameter of an overshot wheel, as given by Borda, Smeaton, Robison, and other authors, is founded upon the assumption, that it never should exceed the height of the fall. Let us suppose that we have a fall of 12 feet, and that the wheel should have a diameter of 11 feet according to Borda, then it appears to us, that a great advantage will be derived from making the wheel 15 feet. Now it is obvious, that the advantage of using the 15 feet wheel is, that we apply the water where it will act most perpendicularly to the line OD, Fig. 15. or the radius of the wheel, whereas the disadvantage of such a wheel is, that it begins to lose its water much sooner than the small one. We differ in opinion from Robison when he says, that the loss of power in the latter case exceeds what is gained in the former case; but we shall admit that it is so, and still maintain the superiority of the 15 feet wheel. When the wheel has a diameter less than the height of the fall, any augmentation of the quantity of water discharged by the mill course is of no use in increasing the effect of the wheel. The issuing water indeed acquires a velocity greater than it usually has, but this additional velocity is injurious to the motion of the wheel instead of being of any advantage. In the case of a 15 feet fall, however, when the water rises 1 or 2 feet above its usual level, we have it in our power, by a particular form of the delivering sluice, which will afterwards be described, (see p. 555,) to introduce this water upon the wheel 1 or 2 feet higher up the wheel, so that we are actually enabled to increase the height of the fall by this quantity.

Advantage of making the diameter of the wheel greater than the height of the fall.

On the proper velocity of overshot wheels.

Deparcieux's experiments.

From a series of experiments on overshot wheels, by M. Deparcieux, and published in 1754, he has concluded, that most work is performed by an overshot wheel when it moves slowly, and that the more we retard its motion by increasing the work to be performed, the greater will be the performance of the wheel. These experiments were made with a wheel 20 inches in diameter, and having 48 buckets. Cylinders of different diameters were placed upon the axle, and the effect of the wheel under different velocities was measured by the height to which it raised a weight suspended to a rope, which was wound round the different cylinders; and the general result was, that the slower the wheel turns, the greater is the effect, or the height to which the weight is raised.

In opposition to these results, the Chevalier D'Arcy maintained, that there is a certain velocity when the effect is a maximum; and he has shewn, from a comparison of Deparcieux's experiments with his own formulæ, that the wheel never moved with such a small velocity as would have given the maximum effect, and that if he had increased the diameter of his cylinders, he would have found that there was a velocity when the maximum effect began to diminish.

The experiments of Smeaton afford an excellent confirmation of the preceding reasoning. The wheel which he used was 25 inches in diameter. The depth of the buckets or of the shrouding, was 2 inches, and the number of buckets 36. When it made about 20 turns in a minute, the effect was nearly the greatest. When the number of turns was 30, the effect was diminished $\frac{1}{12}$th part. When the number was 40, the diminution was $\frac{1}{4}$th; when the number was less than 18½ its motion was irregular; and when it was loaded so as not to be able to make 18 turns, the wheel was overpowered by its load.

Abstract of Smeaton's experiments.

"It is an advantage in practice," says Mr Smeaton, "that the velocity of the wheel should not be diminished farther than what will procure some solid advantage in point of power; because, *cæteris paribus*, as the motion is slower the buckets must be made larger; and the wheel being more loaded with water, the stress upon every part of the work will be increased in proportion. The best velocity for practice, therefore, will be such, as when the wheel here used made about 30 turns in a minute; that is, when the velocity of the circumference is a little more than three feet in a second.

"Experience confirms, that this velocity of three feet in a second is applicable to the highest overshot wheels as well as the lowest; and all other parts of the work being properly adapted thereto, will produce very nearly the greatest effect possible; however, this also is certain from experience, that high wheels may deviate farther from this rule before they will lose their power by a given aliquot part of the whole, than low ones can be admitted to do; for a wheel of 24 feet high may move at the rate of six feet per second without losing any considerable part of its power; and, on the other hand, I have seen a wheel of 33 feet high, that has moved very steadily and well with a velocity but little exceeding two feet."

Bossut's experiments.

The experiments of the Abbé Bossut afford the same results. He used a wheel three feet in diameter. The height of the buckets was three inches, their width five inches, and their number 48; and the canal which conveyed the water furnished uniformly 1194 cubic inches in a minute. When the wheel was unloaded, it made $40\frac{1}{4}$ turns in a minute. The following Table, for which we have computed the fourth column, contains the results which he obtained.

Number of pounds raised.	Number of seconds in which the load was raised.	Number of revolutions performed by the wheel.	Effect of the wheel, or the product of the number of turns multiplied by the load.
11	60″	$11\frac{46}{48}$	$131\frac{32}{48}$
12	60	$11\frac{11}{48}$	$134\frac{36}{48}$
13	60	$10\frac{35}{48}$	$136\frac{37}{48}$
14	60	$9\frac{40}{48}$	$137\frac{32}{48}$
15	60	$9\frac{10}{48}$	$138\frac{6}{48}$
16	60	$8\frac{31}{48}$	$138\frac{16}{48}$
17	60	$8\frac{9}{48}$	$139\frac{9}{48}$
18	60	$7\frac{32}{48}$	138
19	The wheel turned very slowly.		
20	The wheel stopped, though first put in motion by the hand to make it catch the water.		

From this Table it appears, that the effect is a maximum when the number of turns is $8\frac{9}{48}$, or when the velocity of the circumference is 1 foot 4 inches per second. The effect diminished by diminishing the velocity, and the wheel was at last overpowered by its load, as in Smeaton's experiments, which ought always to happen when the resistance or load is equal to the effect of all the buckets when acting upon a semicircumference of the wheel with their respective quantities of water.

On the effect of overshot wheels.

In comparing the relative effects of water wheels, the Chevalier de Borda maintains, that an overshot wheel will raise through the height of the fall a quantity of water equal to that by which it is driven; while Albert Euler affirms that the effect is greatly inferior to this. The experiments of Mr Smeaton shew, that when the heads and quantities of water are least, the ratio between the power and the effect at the maximum is nearly as 4 : 3; but when the heads and quantities of water were greater, it is as 4 : 2; and by a medium of the whole, it is as 3 : 2. When the powers of the water, computed for the height of the wheel only, are compared with the effects, they observe a more constant ratio, the variation being only between the ratio of 10 : 8.1 and 10 : 8.5. Hence the ratio of the power, computed upon the height of the wheel only, is to the effect, at a maximum, as 10 : 8, or as 5 : 4 nearly; and the effects, as well as the powers, are as the quantities of water and perpendicular heights multiplied together respectively.

The form of the delivering sluice, and the method of introducing the water into the buckets, will be best explained in the description of different overshot wheels.

Smeaton's Overshot Wheel.

Smeaton's overshot wheel. PLATE CCCXX. Fig. 1 & 2.

The overshot wheel, as constructed by Mr Smeaton for the upper paper mill of Thornton, is shewn in Plate CCCXX. Fig. 1, where the diameter of the wheel is as nearly as possible equal to the height of the fall; and another wheel, which he considered as of an improved form, is represented in Fig. 2. where the diameter of the wheel exceeds the height of the fall. In both these Figures AB is the wheel, and MN the extremity of the mill course, where the water is delivered into the buckets. A vertical lever *a b c* turning round *b* as a centre, gives motion to the horizontal arm *c d*, and causes one of the shuttles *e f* to advance or recede; in consequence of which, the aperture on the right hand of *f* may be either increased or diminished, for the purpose of regulating the supply of water which the wheel may require. The iron bolt *g* goes through the bottom of the trough between the two shuttles, and is intended to prevent the bottom from sinking by the weight of the water. From the form of the aperture at *f*, it will be seen that the water will glide easily into the buckets without any waste. In both these machines, the water is turned back on the near half of the wheel; the consequence of which is, that the resistance of the lower water is removed, as it runs off in the same direction with the motion of the wheel. The wheel in Fig. 1. is made to fit its sweep and the sides of the conduit as if it were a breast wheel, so that the water does not get out of the buckets till it reaches the lowest point.

Improved Overshot Wheel.

Improved overshot wheel. Fig. 3.

An excellent overshot wheel, which we understand is used in Yorkshire, is represented in Fig. 3. It differs from the wheel in Fig. 2. in the construction of the extremity of the mill course, and in the mode of delivering the water upon the wheel. A pinion *d*, turned with a handle, works in the teeth of a rack *c a*, having a roller *a*, whose breadth is equal to that of the mill course, fixed at its extremity. Upon this roller is fixed a large piece of leather, which, after wrapping round part of the cylindrical circumference, extends downwards to *b*, where it is fixed, as seen in the Figure, between two plates of iron or wood held together by screws. This leather forms the shuttle in the following manner. When the water stands so low in the mill course MN, that none of it runs over the roller so as to fall into the buckets, the pinion *d* is made to move from right to left, so as to cause the rack *c a* and roller *a* to descend. The leather shuttle is thus wound up upon the roller, and the water is allowed to pass over the surface *a*, and to fall into the buckets through the apertures made of iron bars, as shewn in the Figure. When the water, on the contrary, rises in the mill course, so that too much of it flows over the roller, the rack is made to move in the opposite direction, so as to diminish the supply. In this construction of the regulator, we see at once the advantages of having the diameter of the wheel AB greater than the height of the fall; for we are at liberty to take advantage of the additional head which is gained by any increase in the quantity of water which is conveyed to the wheel.

Description of Mr Burns' Overshot Wheel without a Shaft.

Burns' overshot wheel without a shaft. PLATE CCCXX. Fig. 4 & 5.

This very ingenious machine was invented and erected by the late Mr Burns, whose mechanical ingenuity we have already had occasion to admire. It is represented in two different sections, in Figs. 4 and 5, and forms a large hollow cylinder by its buckets and sole, without having any shaft or axle tree.

This wheel is $12\frac{1}{2}$ feet diameter, and 7 feet broad over all, and has 28 buckets. The gudgeon is 6 inches diameter, by 9 inches long. The flaunch is $1\frac{1}{4}$ inch thick at the extreme points. The arms are of redwood fir, 6 inches square; one piece making two arms in length, where they cross one another at the wheel's centre, $1\frac{1}{2}$ inch of the wood remaining in each, connecting the two opposite arms as one piece. The wheel was made, by first fitting the gudgeon into a large

Fig. 4.

piece of hard wood, with the flaunch parallel to the horizon, and in that position the arms and rings were trained and bound fast to it. All the grooves for starts or raisers, and buckets, were cut out before it was removed; first one piece was bolted to the flaunch at *a a*, and so of the others, leaving the distant openings for the cross bars that reach between each arm and its opposite arm. These bars, or pieces, were only 4 inches square, and were of good beech wood, turned round in the body. They were 10 inches square at each end, in which was fitted a strong nut for a bolt, 1¼ inch thick, to go through *b*, and connect the two sides together.

After the arms were trained and fixed right upon the gudgeons, the innermost ring was completed; the tenons were trained on the arms first, and the rings, 4½ inches thick and 8 inches deep, put on by keys driven into the mortice. The remaining tenons were then reduced from 1¼ to 1 inch thick, and the outermost ring, only 3 inches thick by 6 inches deep, was firmly wedged thereon, and bound fast at the other ends by three strong wooden pins, as at O C; to the lower ring, the outside of the uppermost and undermost rings are flush, all the additional thickness of the lower ring projecting inside the buckets.

Some difficulty was found in laying the water properly into the buckets of this wheel, owing to the narrowness of the mouths of the buckets, by the high start or raiser, which was remedied by adopting the following plan.

The openings in the bottom of the troughing should be of iron, and so distant from each other that the water from them is thrown into two separate buckets. The iron curved parts should also be moveable, to adjust the openings to the quantity of water necessary for the wheel. Unless the head of water is 12 or 14 inches above these openings, it will be difficult to give it the proper direction into the buckets, especially if the openings are pretty wide for them; for then it deviates the more down from the line of direction, and tends to retard the wheel, by striking on the outside of the bucket.

The openings from which the buckets are filled, ought to be 10 inches less in length than the buckets, *i. e.* 5 inches at each side, otherwise the water is apt to jerk over on each side of the wheel, as the edge of the bucket passes by.

The mode of making and finishing the wheel at Cartside requires very little workmanship, compared to the usual method; and any good joiner will do it as well as a mill-wright. The joiner finished Cartside wheel in six or seven weeks. The construction will be better understood from the following reference to the figures.

Fig. 4. Represents three distinct transverse views. The part marked A, supposes a part of the shrouding in section shewing the pins; the part marked B, is a section of the wheel through any part of the buckets, and shewing three of the ties, 1, 2, 3, in section. Part C shews the manner in which the exterior ends of the wheel are finished, also the gudgeons, flaunch, &c.

Fig 5. Is a longitudinal section of the wheel through one of the arms, shewing the projection of the shrouding—the manner in which the arms of the wheel are connected together—and likewise the manner in which the ties are connected to the gudgeon.

Description of a Double Overshot Wheel with a Chain of Buckets.

Double overshot wheel with a chain of buckets.

When there is a very small supply of water falling from a very great head, the overshot wheel which it is necessary to employ is so large and expensive, and so apt to be injured from its unwieldy size, that few persons would be disposed to erect one. We have seen at Coalbrook Dale a very excellent overshot wheel, of about fifty feet in diameter, which went remarkably well; and we understand that there are in Wales some wheels of nearly double this diameter. In circumstances like this, the double overshot wheel, with a chain of buckets, is a most invaluable machine, not merely from the small price at which it can be erected, but from the great power which it possesses. A machine of this kind seems to have been first erected by M. Francini in 1668, in the garden of the king of France's old library. This machine of Francini's was driven by waste water, and raised water from a natural spring, by means of another chain of buckets fixed upon the same wheel.

M. Costar substituted a similar machine in place of the overshot wheel; and more recently Mr Gladstanes, an ingenious millwright at Castle Douglas, without knowing that he had been anticipated in the invention, erected several in Galloway for the purpose of giving motion to threshing mills.

Plate CCCXX. Fig. 6.

The double overshot wheel is represented in Plate CCCXX. Fig. 6, where A and B are two rag wheels, as they are called, and CDEF a series of buckets fixed to an endless chain, whose links fall into notches in the circumference of the rag wheels. The water issuing from the mill course at MN, is introduced into the buckets on the side C. The descent of the loaded buckets on the side C puts the wheels A and B in motion, and the power is conveyed from the shaft of the wheel A to turn any kind of machinery. When the buckets reach F, they allow the water to escape, and ascending empty on the side E, they again return to the spout MN, to be filled as before. In this machine, the buckets have in every part of their path the same mechanical effect to turn the wheels, and they will not allow the water to escape till they have reached almost the lowest part of the fall.

This species of wheel possesses another advantage, which can be obtained from no other, namely, that by raising the wheel B, and taking out two or three of the buckets, it may be made to work when there is such a quantity of back-water as would otherwise prevent it from moving.

Dr Robison, in his Dissertation on Water Works, published in the second volume of his *System of Mechanical Philosophy*, has described a machine of this kind, in which plugs, or horizontal floatboards, are fixed to a chain. On the side C these plugs pass through a tube, a little greater in diameter than that of the floats, and the water acting by its pressure upon these floats, as it does in the case of a breast wheel, gives motion to the wheels A and B.

The double overshot wheel is the best and the most economical which can be adopted for a small supply of water falling from a great height; but it is liable to get out of order, unless the chain which carries the bucket is made with great care and nicety.

Reference to authors on overshot wheels.

For farther information on overshot wheels, the reader is referred to Belidor's *Architecture Hydraulique*, vol. ii. p. 254. Desagulier's *Course of Experimental Philosophy*, edit. 3d, vol. ii. p. 455. Deparcieux, *Mem. Acad. Par.* 1754, p. 603, 671. Smeaton *On Mills*, p. 33. Albert Euler, *Comment. Soc. Gotting.* 1754. Kæstner, *Hydrodynamique*. Lambert, *Mem. Acad. Berl.* 1755. Borda, *Mem. Acad. Par.* 1767, p. 286. Bossut, *Traité* *d'Hydrodynamique*, edit. 1796, tom. i. chap. xvii. p. 538; and tom. ii. chap. xviii. p. 425. Fenwick's *Four Essays on Practical Mechanics.* Robison, *System of Mechanical Philosophy*, vol. ii; and Ferguson's *Lectures on Mechanics*, &c. vol. ii, Appendix.

Sect. II. *On Undershot Water Wheels.*

Undershot wheels. PLATE CCCXX. Fig. 7.

An undershot water wheel is a wheel with a number of floatboards, or plane surfaces arranged round its circumference for the purpose of receiving the impulse of the water, which is conveyed to the under part of the wheel from an inclined canal. A wheel of this kind of the ordinary construction, is shewn in Plate CCCXX. Fig. 7. where AB is the wheel with 24 floatboards, *c d* a floatboard receiving the impulse of the water, which moves with great velocity in consequence of having fallen from a considerable height down the inclined mill course MN. The principal points to be attended to in the construction of undershot wheels, are the construction of the mill course, the number, form, and position of the floatboards, and the velocity of the wheel in relation to that of the water when the effect is a maximum. The following rules for the construction of mill courses are given in the Appendix to Ferguson's *Lectures*, vol. ii.

Construction of the mill-course, Fig. 8.

"As it is of the highest importance to have the height of the fall as great as possible, the bottom of the canal, or dam, which conducts the water from the river, should have a very small declivity; for the height of the water-fall will diminish in proportion as the declivity of the canal is increased. On this account, it will be sufficient to make AB slope about one inch in 200 yards, taking care to make the declivity about half an inch for the first 48 yards, in order that the water may have a velocity sufficient to prevent it from flowing back into the river. The inclination of the fall, represented by the angle GCR, should be 25° 50′; or CR, the radius, should be to GR, the tangent of this angle, as 100 to 48, or as 25 to 12; and since the surface of the water S*b* is bent from *a b* into *a c*, before it is precipitated down the fall, it will be necessary to incurvate the upper part BCD of the course into BD, that the water at the bottom may move parallel to the water at the top of the stream. For this purpose, take the points B, D, about 12 inches distant from C, and raise the perpendiculars BE, DE: the point of intersection E will be the centre from which the arch BD is to be described; the radius being about $10\frac{1}{6}$ inches. Now, in order that the water may act more advantageously upon the floatboards of the wheel WW, it must assume a horizontal direction HK, with the same velocity which it would have acquired when it came to the point G: But, in falling from C to G, the water will dash upon the horizontal part HG, and thus lose a great part of its velocity; it will be proper, therefore, to make it move along FH an arch of a circle, to which DF and KH are tangents in the points F and H. For this purpose make GF and GH each equal to three feet, and raise the perpendiculars HI, FI, which will intersect one another in the point I distant about 4 feet 9 inches and $\frac{4}{10}$ths from the points F, and H, and the centre of the arch FH will be determined. The distance HK, through which the water runs before it acts upon the wheel, should not be less than two or three feet, in order that the different portions of the fluid may have obtained a horizontal direction: and if HK be much larger, the velocity of the stream would be diminished by its friction on the bottom of the course. That no water may escape between the bottom of the course KH and the extremities of the floatboards, KL should be about three inches, and the extremity *o* of the floatboard *n o* should be beneath the line HKX, sufficient room being left between *o* and M for the play of the wheel, or KLM may be formed into the arch of a circle KM concentric with the wheel. The line LMV, called by M. Fabre, the course of impulsion (*le coursier d'impulsion*) should be prolonged, so as to support the water as long as it can act upon the floatboards, and should be about 9 inches distant from OP, a horizontal line passing through O, the lowest point of the fall; for if OL were much less than 9 inches, the water having spent the greater part of its force in impelling the floatboards, would accumulate below the wheel and retard its motion. For the same reason, another course, which is called by M. Fabre, the course of discharge (*le coursier de decharge*) should be connected with LMV by the curve VN, to preserve the remaining velocity of the water, which would otherwise be destroyed by falling perpendicularly from V to N. The course of discharge is represented by VZ, sloping from the point O. It should be about 16 yards long, having an inch of declivity in every two yards. The canal which reconducts the water from the course of discharge to the river, should slope about 4 inches in the first 200 yards, 3 inches in the second 200 yards, decreasing gradually till it terminates in the river. But if the river to which the water is conveyed, should, when swollen by the rains, force the water back upon the wheel, the canal must have a greater declivity, in order to prevent this from taking place. Hence it will be evident, that very accurate levelling is necessary for the proper formation of the mill course."

Construction of the mill-course. PLATE CCCXX. Fig. 8.

The general ideas contained in the preceding constructions appear to have been first suggested by Du Buat, and afterwards fully explained by M. Fabre in his *Traité sur les Machines Hydrauliques.*

The diameters of undershot wheels must in general be accommodated to the nature of the machinery which they are to put in motion. If a great velocity is necessary, the wheel should for this purpose be made of a less diameter than would otherwise be advisable; but if a great velocity is not required, the diameter of the wheel ought to be considerable.

Number of floatboards.

M. Pitot, one of the earliest writers who attended to this subject, recommended that the number of floatboards should be equal to 360° divided by the arch of the circle plunged in the canal, and that their depth should be equal to the versed sine of that arch. The slightest consideration, however, is sufficient to convince us that the number of floatboards obtained by this rule is greatly too small. M. Du Petit Vandin, and afterwards M. Fabre, have, on the other hand, maintained, that the greatest possible number of floatboards should be used, provided the wheel is not too much loaded by them.

Smeaton's experiment on the number of float boards.

In Mr Smeaton's model, by which his experiments were performed, the diameter of the wheel was 24 inches, and the number of floatboards 24. When the number was reduced to 12, a diminution in the effect was produced on account of a greater quantity of water escaping between the floats and the floor; "but a circular sweep being adapted thereto of such a length that one float entered the curve before the preceding one quitted it, the effect came so near to the former, as not to give hopes of advancing it, by increasing the number of floats beyond 24 in this particular wheel."

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The experiments of Bossut were made with a wheel, whose exterior diameter was 3 feet 1 inch 10 lines. It was used successively with 48, 24, and 12 floatboards directed to the centre. They were exactly 5 inches wide, and from 4 to 5 inches high. The edges and the extremities of the floatboards were distant about half a line from the bottom and sides of the inclined canal in which the wheel was placed, and the arch plunged in the water was 24° 54′. When this wheel was tried, it made 33½ turns in a minute, when it had 48 floatboards, and when the weight raised was 12 pounds. When 24 floatboards were put on, it made only 29 turns in a minute, the weight raised being the same; and when 12 floatboards were used, it made no more than 25½ turns in a minute. The velocity of the water in the canal, which had a declivity of 10½ feet in 50, was 300 feet in 33 seconds. Hence Bossut concludes, that the wheel ought to have at least 48 floatboards, whereas wheels 20 feet in diameter, and with only 25° or 30° of the circumference immersed, have generally only 40.

When wheels are moved by a river, they ought to have a different number of floatboards. In order to find the number, M. Bossut used a different wheel, in which the floatboards were so placed that he could set them at any inclination to the radius, and employ any number of them at pleasure. The exterior diameter was 8 feet, the width of the floatboards 5 inches, and their height 6 inches. This wheel was made to move in a current from 12 to 13 feet wide, and in a depth of water of from 7 to 8 inches. The floatboards were plunged four inches in the water, so that the circumstances were the same as in an open river. When 24 floatboards were used, a load of 40 pounds was raised with a velocity of $15\frac{34}{48}$ turns in 40 seconds; whereas when 12 floatboards were used, the velocity with which the same load was raised was only $13\frac{14}{48}$ turns in the same time. When 48 floatboards were put on, 24 pounds were raised, with a velocity of $27\frac{12}{48}$ turns in a minute; and 24 floatboards raised the weight with a velocity of $27\frac{7}{48}$, the difference being perfectly trifling. Hence 24 floatboards at least should be used in cases of this kind. A smaller number would be sufficient, if a greater arch of the wheel were plunged in the stream. In practice, it was the general custom to use only 8 or 10 floatboards, and sometimes fewer, on wheels placed in rivers; but the number ought to have been from 12 to 18.

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oards.

From theoretical considerations, M. Pitot has shewn, that floatboards should always be a continuation of the radius; but this rule is found to be quite incorrect in practice. The advantages arising from inclining the floatboards, were first pointed out in 1753 by Deparcieux, who shews, that the water will thus heap up upon them, and act by its weight as well as by its impulse. This opinion has been amply confirmed by the experiments of Bossut with the wheel already mentioned, moving in a canal where the velocity of the water was 300 feet in 27 seconds. When the floatboards were a continuation of the radius, a weight of 34 pounds was raised with a velocity of $20\frac{16}{48}$ turns in 40 seconds. When their inclination was 8°, the same load was raised with a velocity of $19\frac{30}{48}$ in 40 seconds. When the inclination was 12°, the velocity was $19\frac{40}{48}$ in 40″; and when the inclination was 16°, the velocity was $20\frac{14}{48}$ turns in 40 seconds, nearly the same, but still a little less than when the floatboards were a continuation of the radius. Hence it follows, that a wheel placed upon canals which have little declivity, and in which the water is at liberty to escape easily after the impulse, the floatboards ought to be a continuation of the radius.

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periments.

Undershot Wheels.

The same wheel being placed in the current already mentioned, viz. from 12 to 13 feet wide, and from 7 to 8 inches deep, floatboards which were a continuation of the radius, raised 40 pounds with a velocity of $13\frac{17}{48}$ turns in 40 seconds. With those inclined 15°, the number of turns in the same time was $14\frac{22}{48}$; with those inclined 30°, the number was $14\frac{22}{48}$; and with those inclined 37°, the number was $14\frac{15}{48}$. Hence it follows, that the most advantageous obliquity is, in this case, about 15 or 30 degrees. The difference of effect, however, appears to be very trifling, particularly beyond 15°. M. Fabre is of opinion, that when the velocity of the stream is 11 feet per second or greater, the inclination should never be less than 30°; that, as the velocity diminishes, the number of floatboards should diminish in proportion; and that when the velocity is 4 feet or under, the floatboards should be a continuation of the radius. The experiment of inclining the floatboards a little in the opposite direction, has not been tried by any of the authors whom we have quoted, but we think it worth trying, as it might increase the effect, by allowing the water to escape more readily from below the floatboards.

On the proper velocity of undershot wheels.

In order to determine the ratio between the velocity of the wheel and that of the water which drives it, Parent and Pitot considered only the action of the fluid upon one floatboard, and consequently they made the force of impulsion proportional to the square of the relative velocity, or to the square of the difference between the velocity of the stream and that of the floatboard. Desaguliers, Maclaurin, Lambert, Atwood, Du Buat, and Dr Robison, have gone upon the same principle, and have therefore fallen into the same error, of making the velocity of the wheel ⅓ of the velocity of the current when the effect is a maximum. The Chevalier de Borda, whose valuable Memoirs have been too much overlooked by later writers, has however, corrected this errror. He has shewn, that the supposition is perfectly correct when the water impels a single floatboard; for as the number of particles which strike the floatboard in a given time, and also the momentum of these, are each as the relative velocity of the floatboards, the momentum must be as the square of the relative velocity, that is, $M \doteqdot R^2$, M being the momentum, and R the relative velocity. But as the water acts on more than one floatboard at once, the number acted upon in a given time will be as the velocity of the wheel, or inversely as the relative velocity; for if we increase the relative velocity, the velocity of the water remaining the same, we must diminish the velocity of the wheel. Consequently, we shall have $M \doteqdot \frac{R^2}{R}$ or $M \doteqdot R$; that is, the momentum of the water acting upon the wheel, varies as the relative velocity.

Now, let V be the velocity of the stream, F the force with which it would strike the floatboard at rest, and v the velocity of the wheel. Then the relative velocity will be $V - v$; and since the velocity of the water will be to its momentum, or the force with which it would strike the floatboard at rest, as the relative velocity is to the real force which the water exerts against the moving floatboards, we shall have $V : V - v = F : F \times \frac{\overline{V-v}}{V} = \frac{F}{V} \times \overline{V-v}$. But the effect of the wheel is measured by the product of the momentum of the water and the velocity of the wheel, consequently the effect of the undershot wheel will be

$$v \times \overline{\frac{F}{V} \times V - v} = \frac{F}{V} \times V - v^2.$$

Now this effect is to be a maximum, and therefore its differential must be equal to 0, that is, v being the variable quantity, $V\,dv - 2\,v\,dv = 0$, or $2\,v\,dv = V\,dv$. Dividing by dv, we have $2\,v = V$, and $v = \frac{V}{2}$, that is, the velocity of the wheel will be *one-half* the velocity of the fluid when the effect is a maximum.

Smeaton's experiments.

This has been amply confirmed by the experiments of Mr Smeaton. "The velocity of the stream (says he, p. 77,) varies at the maximum between one-third and one-half that of the water; but in all the cases in which most work is performed in proportion to the water expended, and which approach the nearest to the circumstances of great works, when properly executed, the maximum lies much nearer to *one-half* than *one-third*, one half seeming to be the true maximum, if nothing were lost by the resistance of the air, the scattering of the water carried up by the wheel, &c. all which tend to diminish the effect more at what would be the maximum if these did not take place than they do when the motion is a little slower." Smeaton considers 5 to 2 as the best general proportion.

Bossut's experiments.

A result, nearly similar to this, was deduced from the experiments of Bossut. He employed a wheel whose diameter was three feet. The number of floatboards was at one time 48, and at another 24, their width being five inches, and their depth six. The experiments with the wheel, when it had 48 floatboards, were made in the inclined canal, in which the velocity was 300 feet in 27 seconds. The experiments with the wheel, when it had 24 floatboards, were made in a canal, contained between two vertical walls, 12 or 13 feet distant. The depth of the water was about seven or eight inches, and its mean velocity about 2740 inches in 40 seconds. The floatboards of the wheel were immersed about four inches in the stream.

Time in which the weight is raised.	Weight raised.	Number of turns made by the wheel.	Weight raised.	Number of turns made by the wheel.
Seconds.	48 Floatboards.		24 Floatboards.	
	Pounds.	Pounds.	Pounds.	Pounds.
40	$30\frac{1}{2}$	$22\frac{12}{48}$	30	$17\frac{22}{46}$
40	31	$22\frac{4}{48}$	35	$16\frac{25}{48}$
40	$31\frac{1}{2}$	$21\frac{42}{48}$	40	$15\frac{28}{48}$
40	32	$21\frac{32}{48}$	45	$14\frac{31}{48}$
40	$32\frac{1}{2}$	$21\frac{20}{48}$	50	$13\frac{34}{48}$
40	33	$21\frac{8}{48}$	55	$12\frac{37}{48}$
40	$33\frac{1}{2}$	$20\frac{44}{48}$	56	$12\frac{28}{48}$
40	34	$20\frac{32}{48}$	57	$12\frac{19}{48}$
40	$34\frac{1}{2}$	$20\frac{21}{48}$	58	$12\frac{10}{48}$
40	35	$19\frac{44}{48}$	59	$12\frac{1}{48}$
40	$35\frac{1}{2}$	$19\frac{15}{48}$	60	$11\frac{40}{48}$
40	36	$18\frac{28}{48}$	61	$11\frac{30}{48}$
40			62	$11\frac{19}{48}$
			63	$11\frac{7}{48}$
			64	$10\frac{41}{48}$
			65	$10\frac{25}{48}$
			66	$10\frac{5}{48}$

As the effect of the machine is measured by the product of the load raised, and the time employed, it will appear, by multiplying the second and third columns, that the effect was a maximum when the load was $34\frac{1}{2}$ pounds, the wheel performing $20\frac{21}{48}$ revolutions in 40 seconds. By comparing the velocity of the centre of impression computed from the diameter of the wheel, and the number of turns which it makes in 40 seconds, with the velocity of the current, it will be found that the velocity of the wheel, when its effect is the greatest possible, is nearly two-fifths that of the stream; the very same ratio which Smeaton has given. From the two last columns of the Table, where the effect is a maximum when the load is 60 pounds, the same conclusion may be deduced.

Smeaton's results.

The following are the other results which Mr Smeaton deduced from his experiments. He found, that in undershot wheels, the power employed to turn the wheel is to the effect produced as 3 to 1; and that the load which the wheel will carry at its maximum, is to the load which will totally stop it as 3 to 4. The same experiments inform us, that the impulse of the water on the wheel, in the case of a maximum, is more than double of what is assigned by theory, that is, instead of four-sevenths of the column, it is nearly equal to the whole column. In order to account for this, Mr Smeaton observes, that the wheel was not, in this case, placed in an open river, where the natural current, after it had communicated its impulse to the float, has room on all sides to escape, as the theory supposes; but in a conduit or race, to which the float being adapted, the water could not otherwise escape than by moving along with the wheel. He likewise remarks, that when a wheel works in this manner, the water, as soon as it meets the float, receives a sudden check, and rises up against it like a wave against a fixed object; insomuch, that when the sheet of water is not a quarter of an inch thick before it meets the float, yet this sheet will act upon the whole surface of a float, whose height is three inches. Were the float, therefore, no higher than the thickness of the sheet of water, as the theory supposes, a great part of the force would be lost by the water dashing over it. Mr Smeaton likewise deduced, from his experiments, the following maxims.

Smeaton's maxims.

1. That the virtual or effective head being the same, the effect will be nearly as the quantity of water expended.
2. That the expense of water being the same, the effect will be nearly as the height of the virtual or effective head.
3. That the quantity of water expended being the same, the effect is nearly as the square of the velocity.
4. That the aperture being the same, the effect will be nearly as the cube of the velocity of the water.

Undershot Wheel moving at Right Angles to the Stream.

Undershot wheel at right angles to the stream.

Undershot wheels have sometimes been constructed like windmills, having large inclined floatboards, and being driven in a plane perpendicular to the direction of the current. Albert Euler, who has examined theoretically this species of water wheel, concludes that the effect will be twice as great as in common undershot wheels, and that in order to produce this effect, the velocity of the wheel, computed from the centre of impression, should be to the velocity of the water as radius is to thrice the sine of the inclination of the floatboards to the plane of the wheel. When the inclination is 60°, the ratio will be as 5 to 13 nearly, and when it is 30°, it will be nearly as 2 to 3. In this kind of wheel, a considerable advantage may also be gained by inclining the floatboards to the radius. In this case, Horizontal Water Wheels.

the area of the floatboards ought to be much greater than the section of the current, and before one floatboard leaves the current, the other ought to have fairly entered it. This construction may be employed with advantage in deep rivers that have but a small velocity.

Besant's Undershot Wheel.

Besant's undershot wheel.

This wheel, invented by Mr Besant of Brompton, is constructed in the form of a hollow drum, to resist the admission of water; but its principal peculiarity consists in the arrangement of the floatboards in pairs on the periphery of the wheel. Each floatboard is set obliquely to the plane of the wheel's motion, and the corresponding floatboard is inclined at the same angle, but in an opposite direction, the plane of the wheel bisecting the angle formed by the two floatboards. The acute angle which the one floatboard forms with its corresponding one is open at the vertex; but one of the floatboards extends beyond the other. By this construction, the resistance from the tail water is diminished; but so far as we know, the machine has never come into use. See Ferguson's *Lectures*, vol. ii.

Horizontal Water Wheels.

Horizontal water wheels with perpendicular float-boards.

Horizontal water wheels differ in no respect from common undershot wheels except in the circumstance of their extremities being placed vertically. The mill course is constructed nearly in the same manner for both. The principal object of this form of the water wheel is to save machinery, by placing the mill-stone directly on the vertical shaft of the wheel. The water wheel must therefore move with a very great velocity, so as to enable the mill-stones to perform their work. The water is turned into a horizontal direction before it strikes the floatboards, which may be either vertical or inclined to the radius, as in undershot wheels.

PLATE CCCXX. Fig. 9.

Horizontal wheels are often constructed so that the floatboards have a very great inclination to the radius. In this case, the water is not turned into a horizontal direction, but is made to strike the floatboards perpendicularly, as in Fig. 9. where AB is the wheel, MN the mill-course discharging its contents perpendicularly upon the floatboard C, which ought to have a surface more than twice the area of the section of the stream. In this construction, the maximum effect will be produced when the velocity of the floatboards is not less than $\frac{5.67 \sqrt{h}}{2 \text{ sin. } a}$, where *h* is the height of the fall, and *a* the angle which the direction of the fall makes with a vertical line. But since this quantity increases as the sine of *a* decreases, we may diminish the angle *a*, and thus increase the velocity of the floatboards, to suit the nature of the work to be performed, without lessening the maximum effect, which cannot be done in vertical wheels where a determinate velocity is necessary to produce the greatest possible effect. See Ferguson's *Lectures*, vol. ii. Appendix.

With curvilineal floatboards. Figs 10, 11.

In the southern departments of France, the floatboards are made of a curvilineal form, so as to present a concave surface to the stream. This construction is shewn in Figs. 10, 11, where AB is the wheel, CD the vertical shaft, and *m*, *n* the concave floatboards. The Chevalier Borda remarks, that in theory a double effect is produced when the floatboards have this form; but that the advantage is not so great in practice, from the difficulty of making the fluid enter and leave the course in a proper manner. They appear, however, to be decidedly superior to those in which the floatboards are plane, as the water acts by its weight as well as by its impulsive force. The ratio of the effects in the two cases, with five or six feet of fall, is nearly as 3 to 2. An advantage may be gained by dividing the current, and throwing it in separate portions upon different floatboards. See Leopold's *Theatrum Mach. General.*

Leslie's horizontal wheel. Figs. 12, 13.

A different kind of horizontal wheel, invented by Mr Robert Leslie, which works by the tide upon the principle of a smoke jack, is shewn in Figs. 12, 13. This machine, which is shewn in a vertical section in Fig. 12, and in a horizontal section in Fig. 13, consists of a circular box or drum *op*, widened at top into another circular drum AB, two parts of which, GO and EF, are made to open and shut, as shewn by the dotted lines. When the tide moves in the direction OE, the part GO shuts into the position GH, and admits the water upon the wheel; but when the tide returns, GH assumes the position GO, and EF shuts into the dotted position E*f*, and admits the water to the wheel. The axis EF, Fig. 12, stands vertically, and has the vanes *m*, *n* fitted upon it like those of a smoke jack. The water enters at O, and at F *f* when the tide returns, descends in the direction of the arrows, acts by its impulse and its weight on the oblique vanes *m*, *n*, and, after turning the wheel about its vertical axis EF, escapes at the aperture P, or P′ when the tide returns.

Wheels with Spiral Floatboards.

Wheels with spiral floatboards.

IN some of the southern provinces of France a conical horizontal wheel with spiral floatboards is frequently used. It has the form of an inverted cone, with a number of spiral floatboards winding round its surface, so as to be nearer one another at the smaller or lower end of the cone, than at the larger or upper end. When the water has acted upon these floatboards by its impulse, it descends along the spirals, and continues to drive the machine by its weight. A drawing of this machine will be seen in Ferguson's *Lectures*, vol. ii. App.

Dr Robison describes another wheel with spiral floatboards, which was moved by a screw. "It was," he says, "a long cylindrical frame, having a plate standing out from it about a foot broad, and surrounding it with a very oblique spiral like a cork screw. This was plunged about ¼th of its diameter (which was about 12 feet), having its axis in the direction of the stream. By the work which it was performing, it seemed more powerful than a common wheel, which occupied the same breadth of the river."

Reference to works on undershot wheels.

For farther information on the subject of undershot wheels, see Pitot, *Mem. Acad. Par.* 1729, 8vo. p. 359; Desagulier's *Experimental Philosophy*, vol. ii. p. 424; Du Petit Vandin, *Mem. des Scavans Etrangers*, tom. i.; Deparcieux, *Mem. Acad.* 1754, p. 614; Fabre *Sur les Machines Hydraulique*, p. 55; Bossut's *Traite D'Hydrodynamique*, vol. i. chap. xiv. xv. p. 482; vol. ii. chap. xviii. edit. 1796; Maclaurin's *Fluxions*, § 907. p. 728; Lambert, *Nouv. Mem. de l'Acad. Berlin*, 1775, p. 63; Smeaton's *Experiments on Mills*; Borda, *Mem. Acad. Par.*; Leopold's *Theatrum Machin. General.*; *Repertory of Arts*, vol. i. p. 385; Ferguson's *Lectures*, vol. ii. App.; and Dr Robison's *System of Mech. Philosophy*.

SECT. III. *On Breast Wheels.*

Breast wheels.

A breast water wheel is a wheel in which the water is delivered at a point intermediate between the upper and under point of a wheel with floatboards. It is generally delivered at a point below the level of the axis, as in Fig. 1, but sometimes at a point higher than the level of the axis, as in Fig. 2. On breast

PLATE CCCXXI. Figs. 1, 2.

wheels, buckets are never employed, but the floatboards are fitted accurately, with as little play as possible, to the mill course, so that the water, after acting upon the floatboards by its impulse, is retained between the floatboards and the mill-course, and acts by its weight till it reaches the lowest part of the wheel.

Smeaton's breast-wheel.

A breast wheel, as constructed by Mr Smeaton, is represented in Fig. 1, where AB is a portion of the wheel, MN the canal which conveys the water to the wheel, MOP the curvilineal mill course accurately fitted to the extremities of the floatboards, and *c d* the shuttle moved by a pinion *a*, for the purpose of regulating the admission of water upon the wheel.

Improved breast-wheel.

An improved breast wheel is shewn in Fig. 2. The water is delivered on the wheel through an iron grating *a b*, and its admission is regulated by two shuttles *c*, *d*, the lowermost of which, *d*, is adjusted till a sufficient quantity of water passes over it; while the other, *c*, which is generally moved by machinery, is made to descend upon *d*, so as to stop the wheel.

Effect of breast-wheels.

According to Mr Smeaton, "the effect of a breast wheel is to the effect of an undershot wheel, whose head of water is equal to the difference of level between the surface of water in the reservoir, and the part where it strikes the wheel, added to that of an overshot whose height is equal to the difference of level between the part where it strikes the wheel, and the level of the tail water.

M. Lambert observes, that when the fall of water is between 4 and 10 feet, a breast water wheel should be erected, provided there is enough of water; that an undershot wheel should be used when the fall is below 4 feet, and an overshot wheel when the fall exceeds 10 feet. He recommends also that when the fall exceeds 10 feet, it should be divided into two, and two breast wheels erected upon it. These rules are not of great value. The other results of Lambert's investigation, will be found either in his *Memoir*, or in Ferguson's *Lectures*, Appendix, vol. ii.

Comparative effects of Water Wheels.

Comparison of water wheels.

M. Belidor very strangely maintained that overshot wheels were inferior to undershot ones. It appears, however, from Smeaton's experiments, that in overshot wheels the ratio of the power to the effect is nearly as 3 to 2, or as 5 to 4, whereas in undershot wheels the ratio is only as 3 to 1; from which it follows, that the effect of overshot wheels is nearly double of the effect of undershot wheels. The Chevalier de Borda has concluded that overshot wheels will raise through the height of the fall a quantity of water equal to that by which they are driven; that undershot wheels moving vertically will produce $\frac{3}{8}$ths of this effect; that horizontal wheels will produce a little less than $\frac{1}{2}$ of it when the floatboards are plain, and a little more than $\frac{1}{2}$ when they are curvilineal.

SECT. IV. *On Wheels Driven by the Reaction or Counterpressure of Water.*

Dr Barker's mill.

The first mills which were driven by the reaction of water were called *Barker's* mill, and sometimes *Parent's* mill. We are not acquainted with the nature of M. Parent's claim to the invention; nor can we determine whether the priority is due to him or to Dr Barker. Dr Desaguliers, who seems to have been the first person who published an account of the machine, describes it as having been invented by Dr Barker. "Sir George Savile says, he had a mill in Lincolnshire to grind corn, which took up so much water to work it, that it sunk his ponds visibly, for which reason he could not have constant work; but now, by Dr Barker's improvement, the waste water only from Sir George's ponds keeps it constantly to work."

PLATE CCCXXI. Fig. 3.

Dr Barker's mill is shewn in Fig. 3. where CD is a vertical axis, moving on a pivot at D, and carrying the upper millstone *m*, after passing through an opening in the fixed millstone C. Upon this axis is fixed a vertical tube TT communicating with a horizontal tube AB, at the extremities of which A, B are two apertures in opposite directions. When water from the mill-course MN is introduced into the tube TT, it flows out of the apertures A, B, and by the reaction or counterpressure of the issuing water the arm AB, and consequently the whole machine, is put in motion. The bridgetree *a b* is elevated or depressed by turning the nut *c* at the end of the lever *c b*. In order to understand how this motion is produced, let us suppose both the apertures shut, and the tube TT filled with water up to T. The apertures A, B which are shut up, will be pressed outwards by a force equal to the weight of a column of water whose height is TT, and whose area is the area of the apertures. Every part of the tube AB sustains a similar pressure; but as these pressures are balanced by equal and opposite pressures, the arm AB is at rest. By opening the aperture at A, however, the pressure at that place is removed, and consequently the arm is carried round by a pressure equal to that of a column TT, acting upon an area equal to that of the aperture A. The same thing happens on the arm TB; and these two pressures drive the arm AB round in the same direction. This machine may evidently be applied to drive any kind of machinery, by fixing a wheel upon the vertical axis CD.

Improvement on Barker's mill by M. Mathon de la Cour.

In the preceding form of Barker's mill, the length of the axis CD must always exceed the height of the fall ND, and therefore when the fall is very high, the difficulty of erecting such a machine would be great. In order to remove this difficulty, M. Mathon de la Cour proposes to introduce the water from the millcourse, into the horizontal arms A, B, which are fixed to an upright spindle CT, but without any tube TT. The water will obviously issue from the apertures A, B, in the same manner as if it had been introduced at the top of a tube TT as high as the fall. Hence the spindle CD may be made as short as we please. The practical difficulty which attends this form of the machine, is to give the arms A, B a motion round the mouth of the feeding pipe, which enters the arm at D, without any great friction, or any considerable loss of water. This form of the mill is shewn in Plate CCCXXI. Fig. 4. where F is the reservoir, K the millstones, KD the vertical axis, FEC the feeding pipe, the mouth of which enters the horizontal arm at C. In a machine of this kind which M. Mathon de la Cour saw at Bourg Argental, AB was 92 inches, and its diameter three inches; the diameter of each orifice was $1\frac{1}{8}$ inch, FG was 21 feet; the internal diameter of D was two inches, and it was fitted into C by grinding. This machine made 115 turns in a minute when it was unloaded, and emitted water by one hole only. The machine, when empty, weighed 80 pounds, and it was half supported by the upward pressure of the water. This improvement, which was published in Rozier's *Journal de Physique* for January and August 1775, appeared about 20 years afterwards as a new invention of Mr Waring's in the *Transactions of the American Philosophical Society of Philadelphia*, who was probably not aware of the labours of M. Mathon de la Cour.

Fig. 4.

Form given to the machine by Professor Segner.

In the year 1747, Professor Segner of Gottingen published, in his *Exercitationes Hydraulicæ*, an account of a machine which differs only in form from Dr Barker's mill. It consisted of a number of tubes arranged as it were in the circumference of a truncated cone; the water was introduced into the upper ends of these tubes, and flowing out at the lower ends, produced, in virtue of its reaction, a motion round the axis of the cone.

Form given to the machine by Albert Euler.

Another form of this machine has been suggested by Albert Euler. He proposes to introduce the water from the mill course into an annular cavity in a fixed vessel of the shape nearly of a cylinder. The bottom of this vessel has several inclined apertures for the purpose of making the water flow out with a proper obliquity into the inferior and moveable vessel. This inferior vessel, which has the form of an inverted frustum of a cone, moves about an axis passing up through the centre of the fixed vessel, and has a variety of tubes arranged round its cirumference. These tubes do not reach to the very top of the vessel, and are bent into right angles at their lower ends. The water from the upper and fixed vessel being delivered into the tubes of the lower vessel, descends in the tubes, and issuing from their horizontal extremities, gives motion to the conical drum by its reaction.

History of this machine.

The excellence of this method of employing the reaction of water, was first slightly pointed out by Dr Desaguliers, and no further notice seems to have been taken of the invention till the appearance of Segner's machine in 1747. The attention of Leonhard Euler, John Bernoulli, and Albert Euler, was then directed to the subject, and it would appear, from the results of their investigations, that this is the most powerful of all hydraulic machines, and is therefore the best mode of employing water as a moving power. Leonhard Euler published his theory of this machine in the *Memoirs of the Berlin Academy*, vol. vi. p. 311; and the application of the machine to all kinds of work, was explained in a subsequent paper in the seventh volume of the same work, for 1752, p. 271. John Bernoulli's investigations will be found at the end of his *Hydraulics*.

Effect of Barker's mill.

Albert Euler concluded, that when the machine had the form given to it by Segner, the effect was equal to the power, and that the effect is a maximum when the velocity is infinite. Mr Waring, in the paper which we have already quoted, makes the effect of the machine equal only to that of a good undershot wheel driven with the same quantity of water falling through the same height. The Abbé Bossut has likewise investigated the theory of this machine, and has found that an overshot wheel, and a wheel of the form given to it by Albert Euler, will produce equal effects with the same quantity of water, if the depth of the orifice below the mill-course in the latter machine is equal to the vertical height of the loaded arch in the overshot wheel; and he, upon the whole, recommends the overshot wheel as preferable in practice. The preceding result, however, proves the inferiority of the overshot wheel, as the height of the loaded arch must be always much less than that of the fall. A new and ingenious theory of this machine has lately been given by Mr Ewart in the *Manchester Memoirs*.

Reference to authors.

For farther information on this subject, see Desaguliers's *Experimental Philosophy*, vol. ii. p. 453; Segner's *Exercitationes Hydraulicæ*, Gotting. 1747; L. Euler, *Mem. Acad. Berl* 1751, vol. vi. p. 311; *Id.* 1752, vol. vii. p. 271; Waring, *American Transactions*, vol. iii. p. 185; M. Mathon de la Cour in Rozier's *Journal*, Jan. and Aug. 1775; Krafft, *Nov. Comment. Petropol.* 1792, vol. x. p. 137; Robison's *System of Mechanical Philosophy*, Bossut's *Hydrodynamique*, tom. i. chap. xviii; Ferguson's *Lectures*, vol. ii. p. 97, and Appendix, p. 205; Gregory's *Mechanics*, vol. ii. p. 106.

SECT. V. *On Machines for Raising Water, and various Hydraulic purposes.*

1. *Description of a Sluice Governor for regulating the Introduction of Water upon Water Wheels of all kinds.*

Sluice governor.

As there is a particular velocity at which water wheels produce a maximum effect, and as the work to be performed is often injured by an irregularity in the velocity of the machinery, it is of great importance to regulate the admission of the water so as to prevent any increase of velocity when there is too much water in the mill-course. In corn mills, the meal becomes heated and injured by too great a velocity, and in cotton mills, the threads are broken from the same cause.

PLATE CCCXXI. Figs. 5, 6, 7, 8.

The machine for this purpose, which is minutely represented in Plate CCCXXI. Figures 5, 6, 7, and 8, was actually constructed by the late Mr Burns for Cartside cotton mill, who considered it of such advantage as to produce a saving of more than £100 per annum. The motion of the water wheel is communicated by a belt or rope going round the pulley I to the axis EF, which carries the balls G, H, Fig. 5. This motion is conveyed to the upright shaft T by the wheels and pinions Q, R, S, T, and the wheel N at the bottom of the shaft drives the wheels O, P, Fig. 6 and 7, in opposite directions. When the velocity of the wheel is such as is required, the wheels O, P move loosely about the axis, and carry the motion no farther. But when the velocity of the wheel is too great, the balls G, H, separated by the increase of centrifugal force, raise the box *a* upon the shaft EF. An iron cross *b c*, see Fig. 8, is fitted into the box *a*. This cross works in the four prongs of the fork *c b c*, Fig. 6, at the end of the lever *d q f e*, which moves horizontally round *f* as its centre of motion. When the box *a* is stationary, which is when the wheel has its proper velocity, the iron cross works within two of the prongs so as not to affect the lever *d f c*, but to allow the clutch *q q*, fixed at the end of the lever, to be disengaged from the wheels. When the cross *b c* rises, it strikes in turning round the prong 3, see Fig. 8. which drives aside the lever *e f d*, and throws the clutch *q* into the arms of the wheel P, Figs. 6, 7. This causes it to drive round the shaft DC in one direction. When the iron cross *b c*, on the contrary, is depressed by any diminution in the velocity of the wheel, it strikes, in turning round, the prong 4, which pushes aside the lever *e f d*, and throws the clutch *q'* into the wheel O. This causes the wheel O to drive the shaft in an opposite direction to that in which it was driven by P. Now the shaft DC, which is thus put in motion, drives, by means of the pinion C and wheel B, the inclined shaft BW, which, by an endless screw X working in the toothed quadrant Z, elevates or depresses the sluice KL, and admits a greater or a less quantity of water, according as the motion is given to the shaft by the wheel P or O. This change in the aperture is produced very gradually, as the train of wheelwork is made so as to reduce the motion at the sluice. The centre in which the sluice turns should be $\frac{1}{3}$ of its height from the bottom, in order that the pressure of the water on the part above the centre may balance the pressure on the part below the centre.

2. *Description of Archimedes's Screw.*

Archimedes's screw. PLATE CCCXXII. Fig. 1.

The screw engine for raising water invented by Archimedes, was formerly constructed so as to consist of a cylinder with a flexible pipe, wrapped round its circumference like a screw; but it is now more frequently constructed in the manner shewn in Plate CCCXXII. Fig. 1. where AB is a cylindrical axis, having a flat plate of wood or thin iron, coiled as it were round it like the threads of a screw. The plane of this plate is perpendicular to the surface of the cylindrical axis AB, but inclined to this axis at an angle, which must always exceed the inclination of the cylindrical axis AB to the horizon. This last angle is commonly between 45° and 60°. This wooden screw, with a very deep thread, is fixed in a cylindrical box CDEF, so that we have a spiral hollow groove as it were running up the tube from B to A, which will have the same effect as if a pipe of lead or leather had been coiled round the cylindrical axis.

The lower end B of the screw is plunged in the water of the vessel E, which is to be raised to the upper vessel F, and when the screw is turned round its axis, either by a handle or winch placed at A, or by any other power acting upon the pinion at A, the water at E will fall into the hollow spiral groove, and as the screw turns round, the water will necessarily remain in the lower part of the spiral, and will at last reach the top of the spiral pipe, where it is discharged as seen at F. In this engine, therefore, the water rises by a constant descent in the spiral tube. The operation of this engine, which appears at first sight to be paradoxical, will be best understood by wrapping a cord spirally round a bottle containing a little water, and inclining the bottle at a less angle to the horizon than the inclination of the cord to the axis. It will then be seen, that if water falls into the lowest part of the spiral when it is at rest, the motion of the bottle about its axis will remove as it were the spiral out from below the water, which must therefore occupy the part of the spiral immediately above it, and so on till the water reaches the top of it. When the outer case CDEF is fixed, and the screw revolves within it, the engine is called a *water screw*, which should be inclined only about 30° to the horizon.

Water screw.

As we conceive this engine to be entitled to more notice than it has generally received from practical mechanics, we have given a drawing of a very excellent screw engine, which was erected in 1816 at the Hurlet Alum works, upon the Water of Levern, near Paisley; for which we have been indebted to the kindness of John Wilson, Esq. one of the proprietors. The water-wheel A, constructed of iron, with wooden buckets, (see Plate CCCXXII. Fig. 2.) is 12 feet diameter, and conveys its motion to the screw by the bevel wheels C, C, and the shafts B, B, 126 feet long, and 5½ inches diameter. At the end of the shaft B is fixed another bevel wheel D, which works in a similar wheel D′, fixed on the circumference of the screw which rests upon an inclined plane of solid masonry, and is inclined 37° 30′ to the horizon. The axis KK of the screw, which is represented without its covering in Fig. 2. No. 2. is octagonal, and 8 inches in diameter. The diameter of the spiral is 22 inches, and the thickness of the covering 2 inches, so that the whole diameter is 26 inches. The distance of the threads is 9 inches, and their number 168. The thickness of the spiral is 2 inches, so that the spiral tube in which the fluid is to be raised is 7 inches wide, and 7 inches deep. The screw is supported on five sets of friction rollers, constructed as shewn at L in No. 3; two rollers having been found preferable to a greater number, which were at first employed. The well or stone cistern in which the foot of the screw is immersed, and from which the alum liquors are raised, is shewn at O; and at M there is an ingenious contrivance for supplying the pivot regularly with oil. The foot of the screw N is supported by a step of bell metal, inserted into a piece of wood, the socket for which is of cast iron wedged in the foot of the screw, and well lapped in woollen cloth dipped in rosin and tallow, to prevent the liquor from acting upon it. The fall of water which drives the wheel is 9 feet, and the water strikes the wheel 3 feet above the horizontal axle; the width of the mill course is 4½ feet, the depth of water 14 inches, and the aperture of the sluice 2½ inches. The water wheel revolves 12 times in a minute, and the screw performs two revolutions for one of the wheel, and consequently 24 revolutions in a minute. The quantity of liquor discharged is 70 wine gallons; but as the specific gravity of the fluid raised is 1.065, the weight of the quantity discharged in an hour is 17 tons. The pump is wholly built of timber, as the alum liquor acts upon the iron. Its total length is 127 feet, and the height to which the liquor is raised is = sin. 37° 30′ × 127 feet = 76 feet 9 inches. The water wheel, besides driving the screw, moves two pumps for lifting liquor to the height of 30 feet. The pumps make each 2½ strokes for one turn of the wheel, and the bore is 5½ inches in diameter.

Fig. 2.

Pattu's double screw engine. PLATE CCCXXII. Fig. 3.

A very ingenious double screw engine has recently been invented by M. Pattu, engineer of roads and bridges in the department of Calvados. It is represented in section in Fig. 3, and consists of two ordinary and concentric screws, one of which, AB, is long and narrow, and serves for the nucleus of the other, CD, which is much wider and shorter. These two screws turn round the axis in opposite directions, so that when one of them appears to be moving upwards, the other appears to be moving downwards. The screw is inclined 35° to the horizon. The water from the stream MN is introduced into the larger screw, and puts the whole in motion, and the water, after its fall into OP, enters the smaller screw, in which it is raised to the cistern at B. When it is used for draining, and when the moving power of the water can be applied at A, the small screw serves to drive the larger one, which raises the water to a height sufficient to carry it off, as shewn in Fig. 4. Figures 5 and 6, shew other modes of applying this screw. Fig. 5 is the form used for raising water to irrigate high grounds, to fill the reservoirs of baths, gardens, and manufactories. The large screw is here the moving power. Fig. 6 is the form used for keeping dry those places where foundations are building. The large screw is here the mover.

Figs. 4, 6.

M. Eytelwein has shewn that the screw should always be placed so that only one half of a convolution may be filled at each turn. When the height of the water is so variable that this precaution is impracticable, he prefers the water screw, although nearly one third of the water in this case generally runs back, and though it is easily clogged by accidental impurities in the water.

Fig. 7.

Fig. 7. shews the form of Archimedes's screw, as recommended by D. Bernoulli.

These machines are particularly useful when the water to be raised is not pure, but is mixed with gravel, weeds, or sand, which could not be elevated by ordinary pumps. For farther information on this subject, See *Vitruvius.* Pitot, *Mem. Acad. Par.* 1736, p. 173. Bernoulli, *Hydrodynamica.* Hennert *Dissertation sur* *la vis d'Archimede*, Berl. 1767. Euler, *Nov. Comment. Petrop.* tom. v. p. 259. Ferguson's *Lectures*, vol. ii. p. 113. Pattu, *Journal des Mines*, Nov. 1815, vol. xxxviii. p. 321. Eytelwein's *Handbuch der Mechanik*, Berl. 1805, chap. xxi. Gregory's *Mechanics*, vol. ii. p. 348.

3. *On the Spiral Pump, or Zurich Machine.*

Spiral pump, or Zurich machine.
PLATE CCCXXIII. Fig. 1.

This machine, represented in Plate CCCXXIII. Fig. 1, was invented about 1746 by Andrew Wirtz, a pewterer in Zurich, who erected it for a dye-house on the river Limmat. It consists of a spiral pipe ABCDEF, either coiled round in one plane, as shewn in the Figure, or arranged round the circumference of a cone or a cylinder. The interior end of the spiral G, or the remote end of it, is connected by a watertight joint to an ascending pipe GH, in which the water is to be raised. When this spiral, immersed in the water MN, which is to be raised, is put in motion in the direction ABCD, the scoop BA, which begins to widen from C, takes in a portion of water. As the scoop emerges, this water passes along the spiral, driving the air before it into the pipe GH, where it escapes. Air is again admitted into the scoop after it emerges, and when the scoop has performed one revolution, it again takes up another portion of water, which is driven along the spiral as before, and is separated from the first portion by a column of air of nearly equal length. By continuing to turn the spiral, a second column of water and another of air will be introduced, and so on. Now, the water, on every turn of the spiral, will have both its ends horizontal, and the included air will have its natural density. But as the diameter of the spirals diminish towards the centre, the column of water, which occupied a semicircle in the outer spiral, will occupy more and more of the inner spirals as they approach to the centre G, till there will be a certain spiral, of which it will occupy a complete turn. Hence it will occupy more than the entire spiral within this spiral, and consequently the water will run back over the top of the succeeding spiral, as at No. 4. into the right hand side of spiral No. 3. The water in spiral No. 3. will consequently be pushed upwards till it runs over at 3 into the right hand side of spiral No. 2., and so on till some of the water escapes at the scoop A into the cistern MN. When the water enters the pipe GH at G, and rises a little in it, the escape of the air is prevented when the scoop AB takes in its next quantity of water. "Here then," as Dr Robison has remarked, "are two columns of water acting against each other by hydrostatic pressure, and the intervening column of air. They must compress the air between them, and the water and air columns will now be unequal. This will have a general tendency to keep the whole water back, and cause it to be higher on the left or rising side of each spire, than on the right descending side. The excess of height will be just such as produces the compression of the air between that and the preceding column of water. This will go on increasing as the water mounts in the rising pipe; for the air next to the rising pipe is compressed at its inner end with the weight of the whole column in the main. It must be as much compressed at its outer end. This must be done by the water column without it; and this column exerts this pressure, partly by reason that its outer end is higher than its inner end, and partly by the transmission of the pressure on its outer end by air, which is similarly compressed from without. And thus it will happen, that each column of water being higher at its outer than at its inner end, compresses the air on the water column beyond or within it, which transmits this pressure to the air beyond it, adding to it the pressure arising from its own want of level at the ends. Therefore, the greatest compression, viz. that of the air next the main, is produced by the sum of all the transmitted pressures, and these are the sum of all the differences between the elevation of the inner ends of the water columns above their outer ends; and the height to which the water will rise in the main will be just equal to this sum."

PLATE CCCXXIII. Fig. 1.

History of the spiral pump.

The spiral pumps seem to have remained long unnoticed. They were erected, however, at Florence in 1778, with the improvement suggested by Bernoulli, of having the spiral coiled on the circumference of a cylinder, as represented in Fig. 2. In 1784, a spiral pump was erected at Archangelsky, near Moscow, which raised a hogshead of water in a minute to the height of 74 feet, and through a pipe 760 feet long. It has not yet been ascertained whether the plane, the cylindrical, or the conical spiral is best. The only practical difficulty consists in making the joint perfectly water-tight. The machine erected at Florence had its spiral cylindrical. Its diameter was 10 feet, and that of the pipe 6 inches. The enlarged part occupied $\frac{3}{4}$ of the circumference, and was $7\frac{1}{10}$ inches wide at the outer end. The enlarged part contained 6844 English cubic inches. The spiral revolved six times in a minute, and raised 22 cubic feet of water 10 feet high in a minute. Eytelwein considers this as a very powerful machine, and well deserving the attention of the engineer. The length of the pipe becomes extremely cumbersome when the water is to be raised through a great height. Dr Young found that 100 feet of pipe $\frac{3}{4}$ of an inch in diameter was necessary for a height of 140 feet; and he considers that the machine would succeed better if the pipes were entirely of wood, or of tinned copper, or even of earthen-ware. See Sulzer's *Sammlungen Vermischlen Schriften*, 1754; Daniel Bernoulli, *Nov. Comment. Petrop.* 1772, tom. xvii. p. 249; Bailey's *Machines approved of by the Society of Arts*, vol. i. p. 151; Dr Robison's *System of Mechanical Philosophy*; Eytelwein *Handbuch der Mechanik*, &c; and Dr Thomas Young's *Natural Philosophy*, vol. i. p. 330, &c.

Fig. 2.

4. *Description of Pitot's Bent Tube for measuring the Velocity of Water.*

Pitot's bent tube.

One of the most ingenious instruments for measuring the velocity of water, is the *tube recourbé*, or bent tube, invented by M. Pitot, and described in the Memoirs of the Academy of Sciences for 1732. It is represented in Plate CCCXXIII. Fig 3, and consists of a prism of wood ABCDEF, one of the angles of which is presented to the current. On the hinder face BCFE are fixed two tubes of glass parallel to each other, and having a graduated scale between them; one of them, viz. MNO, being bent into a right angle at O, so that the part MN may pass through the prism horizontally. When this instrument is plunged in a running stream, the general level of the current is shewn by the rise of the water in the straight tube PQ, while the height of the water in the bent tube MNO becomes a measure of the force of the stream. The difference between these heights will therefore be the height due to the velocity. In the practical use of this instrument, it is however difficult to fix it sufficiently steady, to prevent the water from oscillating in the tubes.

Fig. 3.

Improved by Du Buat.

M. Du Buat having examined the instrument experimentally, found that it could be trusted no farther than to give the ratio of different velocities. He therefore suppressed the tube PQ altogether, and substituted, in place of the bent tube of glass MNO, a simple tube of white iron, sufficiently large to admit a float for pointing out the height of the water in the tube. The lower end of the white iron tube is bent back as at MN, and is terminated by a plane surface, perforated at its centre with a small orifice, which will greatly diminish the oscillations of the elevated column. If we then take *two thirds* of the height of the water in the tube above the level of the stream, we shall have very exactly the height due to the velocity of the current for the depth to which the orifice is immersed. See Pitot, *Mem. Acad. Par.* 1730, 1772, p. 363; Du Buat's *Principes d'Hydraulique*, tom. ii. p. 332, edit. 1786; Bossut's *Traité d'Hydrodynamique*, tom. ii. p. 267, 268, edit. 1796.

5. *Description of the Hydraulic Quadrant for measuring the Velocity of Water.*

Hydraulic Quadrant. PLATE CCCXXIII. Fig. 4.

The hydraulic quadrant which has been recommended by several authors for measuring the velocity of water, is shewn in Plate CCCXXIII. Fig. 4. It consists of a quadrant ABC, with a divided arch AB, and having two threads moving round its centre. One of these CP is short, and carries a weight P, which always hangs in air, while the other CH or CM is longer, and carries a weight whose specific gravity is greater than that of water, and which plunges more or less deep in the current as the thread is lengthened. The instrument is then held as in the figure, so that the plummet CP passes through 0^0; and the angle ACD, or the angular distance of the other thread from a vertical line, will be a measure of the force, and consequently of the velocity of the current. Bossut has shewn that the force is as the tangent of the angle ACD, and that if u be the velocity when the thread has the position CH, and V the velocity when it has the position CM, we shall have $u : \mathrm{V} = \sqrt{\left(\frac{\sin. \mathrm{XCR}}{\sin. \mathrm{XRC}}\right)} : \sqrt{\left(\frac{\sin. \mathrm{XCS}}{\sin. \mathrm{XSC}}\right)}$. If we therefore know u, we also know V. We have therefore only to determine u, when H is at the surface, for any given angle ACD, and V will be had for any other velocity, either at the surface or at any depth below it. See Bossut's *Traité d'Hydrodynamique*, tom. ii. p. 265, 266. Eytelwein's experiments with the hydraulic quadrant will be found in the *Samml. zur Bauk.* 1799.

6. *Machines for discharging a uniform Quantity of Water.*

Floating tube. Fig. 5.

In Plate CCCXXIII. Figs. 5, 6, 7, we have represented three ingenious contrivances for discharging equal quantities of water from a vessel which is constantly emptying itself, or where there is a variable head of water. The contrivance in Fig. 5. where MNOP is a vessel nearly full of water, consists of a tube BA moving round a joint at B, and having its upper end B connected with a hollow floating ball C. The velocity with which the water enters the extremity B is that which is due to the height BC, or the depth of B below the surface. As the surface MN descends the float C also descends, so that whatever be the height of the water in the vessel, it will always enter B with the same velocity. The discharge at the other end A will not be quite uniform, as the water will acquire greater velocity in descending the tube BA when it is much inclined than when it is nearly horizontal.

Floating syphon. Fig. 6.

A floating syphon, which produces the same effect in a more correct manner, is shewn in Fig. 6, where ABD is a syphon with a hollow floating ball at its shorter end. This syphon is suspended by the chains EP, EP, which pass over two pulleys P, P upon a horizontal axle PP, and suspend at their other extremities counterweights W, W. As the water in the vessel MNOP sinks by being discharged at D, the syphon descends and the counterweights rise, and an uniform stream is obtained till the end A reaches the bottom of the vessel.

Floating cone. PLATE CCCXXIII. Fig. 7.

Another very ingenious contrivance for the same purpose is shewn in Fig. 7. A cone AB attached to a lenticular float C, and fixed upon the axis *e f*, rises and falls in the aperture *m n*, by which the water of the vessel MNOP is to be discharged. It is kept in an upright position by the horizontal axes *o p*, *r s*. Now, when the vessel is full of water, and the head therefore great, the velocity at *m n* will also be great; but as the float C rises with the surface MN, the aperture *m n* will be partly filled by a thicker part of the cone AB; whereas, when the surface MN has descended, the float AB will also descend, and the aperture at *m n* will be widened, in consequence of a smaller part of the cone being included in it. In this way, the varying diameter of the cone always adjusts the aperture *m n* to the variable head of water, so that the quantity discharged through the tube *m n o p* is nearly always the same.

7. *Water-blowing Machine, or Shower-Bellows.*

Water-blowing machine. Fig. 8.

The water-blowing machine, called *trombe* by the French, seems to have been first introduced in Italy about the year 1672, for the purpose of procuring a blast of air by the descent of water. It is represented in Figs. 8 and 9, where MN is a reservoir of water, in the bottom of which is inserted a long tube AB, consisting of a conical part *a b*, seen upon an enlarged scale in Fig. 9, communicating with a cylindrical tube *d* B, which enters the vessel CDEF. A number of openings *c*, *d*, &c. are made at the top of the tube *d* B, so that when the water is discharged at the conical aperture *b*, it drags along with it the adjacent air. This mixture of air and water falls upon a stone pedestal G, so as to separate the air from the water. The water descends to the bottom of the vessel, while the air escapes through the pipe CIK to supply the furnace. Another form of the machine is shewn in Fig. 9. where $\alpha\, \beta$ is the conical pipe, and the water is supplied with air from the pipes $\varkappa\, \beta$, $\partial\, \beta$.

Fig. 9.

In the water-blowing machines used in Dauphiny, in the neighbourhood of the town of Alvar, the diameter of *a b* is 12 inches at *a* and 5 at *b*; the diameter of *d* B is 10 inches. Only four holes are used at *c*, *d*, and the end B enters 1½ feet into the vessel CDEF, which is 4 feet high and 4 feet broad. The water is discharged at an aperture above F, a foot in diameter; and sometimes the admission of the water and its discharge are regulated by sluices *m* and *n*. A strong, equal, and continued blast is obtained by this machine; but it is thought to be too moist and too cold. We have seen in Switzerland one of these machines working with great effect at the lead works of M. Lenay, in the valley of Servoz near Chamouni.

Venturi's theory of water-blowing machines.

Kircher appears to have been the first who explained the production of wind by a fall of water. Barthes long afterwards gave another theory, and Dietrich and Fabri ascribed the wind to the decomposition of the water. In 1791, the Academy of Thoulouse invited philosophers to investigate this phenomenon, and it was probably in consequence of this that Venturi directed his attention to the subject. This ingenious philosopher has proved, that the air is dragged down upon the principle of the lateral communication of motion in fluids; and he has pointed out the best mode of constructing the machine, so as to produce the greatest quantity of air. The diameter of the tube *d* B should be at least

Water-Blowing Machine.

double of the aperture at *b*. To a height about 1¼ feet above CD, the tube should be completely air-tight, as well as the vessel CDEF, but above that part the tube *d* B may be perforated in every part with holes. M. Venturi has calculated, that the quantity of air which passes in one second into the tube is $=6.1\,a^2\sqrt{(a+b-1.4)} - 0.4\,a^2\sqrt{(a\times 0.1)}$, where *a* is the diameter of the aperture at *b*, and *b* the diameter of the tube *d* B. From this quantity about one-fourth should be deducted in practice, on account of the dashing of the scattered water against the lower part of the tubes. If the pipe CIK does not discharge all the air which is generated, the surface of the water in the vessel will descend, and part of the air will issue out of the lower apertures of the tube *d* B.

Ventaroli or natural blasts.

Phenomena similar to those produced by the water-blowing machine have been observed in nature. At the foot of the cascades which fall from the glacier of Roche Melon, on the naked rock of La Novalese towards Mount Cenis, Venturi found that the force of the wind arising from the air dragged down by the water, could scarcely be withstood. The *ventaroli* or natural blasts, which are most frequently found to issue from volcanic mountains, arise from the air carried down the hollows by the falls of water; and what are called the *rain winds* have the same origin. See Kircher's *Mundus Subterraneus*, lib. xiv. cap. 5. edit. 1663. Barthes, *Mem. des Sçavans Etrangers*, tom. iii. p. 378. Dietrich, *Gites de Minerai des Pyrenées*, p. 48, 49. Fabri, *Physic. Tract.* lib. ii. prop. 248. Belidor, *Arch. Hydraul.* tom ii. p. 1. Mariotte, *Traité des Mouv. des Eaux*, Part i. Disc. 3. *Arts et Metiers*, Art. des Forges, p. 88. Venturi in *Nicholson's Journal*, tom. ii. p. 487. *Nicholson's Journal*, vol. i. 4to, p. 2229, and vol. xii. 8vo, p. 48. Wolfius, *Opera Mathematica*, tom. i. p. 830. Lewis's *Commerce of Arts*. *Journal des Mines*, No. 91.

8. *Description of the Gaining and Losing Buckets.*

Gaining and losing buckets. PLATE CCCXXIII. Fig. 10.

This very ingenious machine seems to have been first proposed by Schottus, but was afterwards greatly improved and actually constructed by George Gerves, for Sir John Chester, Bart. at his seat at Chichley in Buckinghamshire. The object of this machine is to raise water from a well or spring A, Fig. 10. to a reservoir R. In order to effect this, a wheel WW, 6 feet in diameter, is fixed above R, and on the same axis another wheel *w w*, 2 feet in diameter. To the circumference of W is fixed a chain W *x*, to which is hung a small bucket *b* with a valve in its bottom, and suspended as seen at *b* in Fig. A. To the circumference of *w w* is fixed another chain *w w y*, fastened to a rod *y z*, to which is suspended the large bucket B, with a valve in its bottom, as seen above B. This valve is fixed at the end of the arm *o* B, and is kept in its place by the weight *m*, acting at the end of the lever *m o*, whose fulcrum is at *n*; but is raised from its place by raising the arm *m o*, as shewn in Fig. B.

Let us now suppose that the small bucket *b* is filled with water, and that in consequence of water being poured into the large bucket B, this bucket descends. The bucket *b* will therefore ascend till it strikes the hook at *s*. This hook catching the edge of the bucket, turns it to a side, as shewn in Fig. A. and empties it into the reservoir R. By this time the descending bucket B has reached nearly the bottom of the cistern z Z. The arm *m o* of the lever falling upon the projection M is raised, as shewn in Fig. B. The valve in the bottom is consequently raised also, and the water is discharged at B into the cistern Z. The small bucket *b* is now an overmatch for B, in consequence of its acting at the end of a longer lever, and therefore *b* descends to the cistern A, while B ascends to the position it has in the figure. When *b* reaches the cistern A, the lower end of the valve strikes against a fixed obstacle; it is therefore raised out of its place, and admits the water of the cistern into the bucket. At the same instant the arm *o n* of the lever in the large bucket B striking against the bottom of a valve, seen below *a*, in a branch *a* of the cistern A, raises it, and allows the water from the cistern to run into the bucket B, till the weight of the bucket is sufficient to raise *b* out of the cistern A. As soon as it has received this weight of water it descends, the valve below *a* falls into its place, the valve in the bottom of *b* also falls into its place, when it rises above the fixed obstacle, and the bucket *b* ascends as before, to discharge its contents into the reservoir, while the large bucket descends to M to get rid of its load of waste water. It is obvious that the equilibrium of the chains and rods will be different in different positions of the buckets. When *b* is at R, and B at Z, B will be loaded with an additional quantity of chain. In order to regulate the weight of the chains in every position, a quadrant Q moves round C as a centre, and a chain *c d* attached to the point C of the rod *c z*, is fixed to the lower end *d* of the arch *d* Q. A weight X is also fixed at the end of the radius *d* C. Now when B is down at Z, X will have descended to *p*, and from acting at the end of a shorter lever, will be a less load upon the rod *c z* than when it had the position at X; that is, the additional weight which the bucket B has received from the increase of its chain is counterbalanced by the diminution of weight occasioned by the descent of CX into the position CP. Desaguliers remarks, that one hogshead falling 10 feet will raise very nearly one hogshead 10 feet, or one-fourth of a hogshead 40 feet.

Gaining and Losing Buckets.

9. *Description of the Scoop Wheel.*

Scoop wheel. PLATE CCCXXIV. Fig. 1.

The scoop wheel is intended to raise water through a height equal to its semidiameter. It is represented by WW in Fig. 1, and consists of a number of semicircular partitions, shewn in the Figure. These partitions are open at both ends, viz. at the circumference and at the centre of the machine. As the wheel is turned round in the direction WXW, either by the hand or by any other power, the scoops take up the water, which gradually descends during the rotation of the wheel, till it runs into its hollow axle, which again discharges it into a spout O. The scoop wheel is one of the forms in which the Persian wheel is generally described.

10. *Description of the Persian Wheel.*

Persian wheel.

The Persian wheel is a double water wheel, with floatboards on one side, and a series of buckets on the other, which are moveable about an axis above their centre of gravity. The wheel is placed in a stream, which puts it in motion, by acting upon its floatboards. As the wheel turns, the moveable buckets dip in the water, and ascend filled with fluid. But when they reach the highest point, their lower ends strike against a fixed obstacle, so as to make them empty themselves into a reservoir placed at the top of the wheel. See Ferguson's *Lectures*, vol. i. p. 180.

Fig. 2.

Another form of the Persian wheel is shewn in Fig. 2, where WW is a common bucket wheel, moving in the direction WOW. The buckets dipping in the water MN, rise filled with it, and discharge their contents into the reservoir O near the summit of the wheel. The wheel for draining the moss of Blairdrummond belongs to this class. It is driven by floatboards fixed on its periphery like the common undershot wheel, and a current of water is brought in at a side to fill buckets placed on the concave side of the rim.

11. *On Throwing Wheels, or Flash Wheels.*

Throwing wheels. PLATE CCCXXIV. Fig. 3.

A throwing wheel, which is commonly driven by a windmill, and used for draining fens, is nothing more than an undershot wheel, the floatboards of which push the water up a curvilineal plane, inclined from a lower to a higher level. One of these wheels is represented in Plate CCCXXIV. Fig. 3, where WW is the wheel, MN the inclined plane, N the water to be raised or pushed up the declivity MN, and M the drain which is to carry it off.

12. *On the Chain Pump.*

Chain pump with plugs. Fig. 4.

The chain pump, represented in Plate CCCXXV. Fig. 4, consists of an endless chain WWBA, passing round the wheel WW, and after entering the water to be raised, returning through the tube BA into the cistern MN. This chain carries a number of flat cylindrical pistons *a. b, c*, of nearly the same diameter as the tube AB, one half of each piston being received in to openings in the circumference of the wheel. When the wheel is put in motion, the pistons enter the barrel BA, and pushing the water before them, raise it into the reservoir MN. When the wheel is turned with great velocity, the barrel is generally filled with water.

Pumps of this kind are frequently placed in an inclined position, and they raise the greatest quantity of water in this position, when the distance of the flat piston is equal to their breadth, and when the inclination of the barrel is about $24^0 21'$. The Spanish *noria* is the same as a chain pump, having a number of earthen pitchers placed between two ropes in place of a chain.

These machines are sometimes called *cellular pumps*, and when stuffed cushions are used in place of pistons, they are called *Paternoster pumps.*

Chain pump with buckets. Fig. 5.

Chain pumps are sometimes constructed without the piston *a, b, c*. In this case, the barrel AB is also removed, and they have the form shewn in Fig. 5, where W, W are two wheels with a set of buckets fixed to an endless chain, which passes round their circumference. By turning the upper wheel, the buckets dip into the water with their mouths downwards, and rising on the other side, convey the water into the reservoir at M.

13. *On the Hair Rope Machine of the Sieur Vera.*

Vera's hair rope machine. Fig. 6.

The hair rope machine of the Sieur Vera is shewn in Fig. 6. It consists merely of a rope AB made of hair, passing round a wheel W, and kept stretched by going round a pulley P, fixed in the water. By turning the handle H, the rope rises loaded with the water that adheres to it, and when it reaches the top, it passes through a small tube which rubs the water from it, into a cistern. In a machine of this kind, where the wheel was three feet in diameter, the rope half an inch in diameter, and the well 95 feet deep, a labouring man could produce only 60 revolutions in a minute, and could not continue the exertion long. This raised 6 gallons in a minute. A great deal of water was raised when the wheel made 50 turns in a minute, but very little when it made only 30 turns. The rope soon decays if it is not made of hair. See Rozier's *Journal de Physique*, tom. xx. p. 132; and Cavallo's *Natural Philosophy*, vol. ii. p. 441.

14. *Description of Whitehurst's Engine.*

Whitehurst's engine.

Mr Whitehurst, an ingenious watchmaker of Derby, appears to have been the first who entertained the ingenious idea of raising water by means of its momentum. A machine upon this principle was erected at Oulton in Cheshire, and was described in the Transactions of the Royal Society for 1775. This machine is represented in Plate CCCXXIV. Fig. 7, where AM is the reservoir of water, whose surface at M is on a level with B, the bottom of the reservoir BN. The main pipe AE is about 200 yards long, and 1½ inches in diameter, and the branch pipe EF is of such a size that the cock F is about 16 feet below the surface of the water at M. A valve box with its valve *a* is shewn at D, and C is an air vessel into which are inserted the extremities *m n* of the main pipe, which are bent downwards for the purpose of preventing the air from being driven out when the water is forced into it. Now, when the cock F is opened, the water will rush out with a velocity of nearly 30 feet per second. A column of water, therefore, two hundred yards long and 1½ inch diameter, is now put in motion, and must have a considerable momentum. Hence, if the cock F is suddenly shut, the water will rush through the valve *a* into the air vessel C, and condense the included air. This condensation will take place every time that the cock is opened, so that the included air being compressed, will press upon the water in the air vessel, and raise it into the reservoir BN. This simple and ingenious machine is obviously the same in principle as the hydraulic ram invented by Montgolfier, and which differs from it only in this, that the operation analogous to that of opening the cock F is produced by the motion of the water itself, as will be seen in the following description of this ingenious contrivance.

PLATE CCCXXIV. Fig. 7.

15. *Description of Montgolfier's Hydraulic Ram.*

Montgolfier's hydraulic ram. Figs. 8, 9, 10, 11.

This interesting machine was first constructed by Montgolfier about the year 1797, and has been brought to a very perfect state by a series of improvements which he has successively made upon it. The rams which we have represented in Plate CCCXXIV. Fig. 8, 9, 10, and 11, contain the improvements which have been made so late as 1816. The large pipe AB called the body of the ram, passes through the side of the reservoir PQ, from which the fall of water is obtained. It has a trumpet mouth at one end A, and at the other end an opening HH, which can be closed by valves C or D. When these valves are open, the water will issue at HH with a velocity due to the height AP; but when the internal valve C is closed, as in the figure, the water is prevented from issuing. When the valve C opens, it descends into the position shewn by the dotted lines GG, being guided between three or four stems *g g*, which have hooks at the lower ends for supporting the valves. In this case the water has a free passage between these stems, and the width of the passage can be increased or diminished by the screws with which the stems are fixed. The valve C is made of metal, and has a hollow cup or dish of metal attached to its lower surface. The seat HH of the valve is wider than the diameter of the pipe AB. It consists of a short cylinder or pipe screwed by its flanch *h h* into the opening of the upper surface of the head R of the ram; and the cylinder is so formed as to have an inverted cup or annular space *i i* round the upper part of it for containing air, which cannot escape when it is compressed by the water. A small pipe *k l*, leading from this annular space to the open air, is furnished with small valves, *k, l*, one of which, *k*, opens inwards to admit the air into *i, i*, but to prevent its return, while the other valve, *l*, admits a certain quantity of air, and then shuts and prevents any farther entrance. The

Description of the machine. Fig. 8, and Fig. A.

valve D is exactly the same as C, only it descends as in the figure when it shuts, and rises when it opens.

The upper part of the head of the ram at E is made flat, and has several valves which allow the water to pass freely from the pipe AB, but prevent its return. On each side of the head of the ram, at the part opposite to these valves is a hollow enlargement, shewn by the dotted lines K, forming a circular bason, through the centre of which the pipe ABR passes. This part of the construction is shewn more distinctly in Fig. 9. which is a transverse section through LEZ in a plane perpendicular to that of the paper. The pipe is here made flat instead of circular, as seen at E, Fig. 9. for forming the seats of the valves, and the bason KK is covered with an air vessel FF. This air vessel communicates all round the pipe B, with the bason KK, and with the vertical pipe M.

PLATE CCCXXIV. Fig. 9.

Operation of the hydraulic ram.

The machine being thus constructed, let us suppose the pipe ABR full of water, and the valve C to be opened, the water will lift the valve D, and escape with a velocity due to the height of the reservoir. In a short time, the water having acquired an additional velocity, raises the valve G, which shuts the passage, and prevents the escape of the water. The consequence of this is, that all the included water exerts suddenly a hydrostatical pressure on every part of the pipe, compressing at the same time the air in the annular space *i i*, which by its elasticity diminishes the violence of the shock. This hydrostatical pressure opens the valves at E, and a portion of the water flows into the air vessel F, and condenses the air which it contains. The valves at E now close, preventing the return of the water into the pipe, and the water recoils a little in the tube with a slight motion from B to A, in consequence of the reaction or elasticity of the compressed air in *i i*, and also of the metal of the pipe, which must have yielded a little to the force exerted upon it in every direction. The recoil of the water towards A produces a slight aspiration within the head R of the ram, which causes the valve D to descend by its own weight, and prevent the water X which covers it from descending into the tube. The air, however, passes through the pipe *l k*, opens the valve *k*, and a small quantity is sucked into the annular space *i i*; but the quantity is very small, as the valve *k* closes as soon as the current of air becomes rapid. During the recoil towards A, the valve C, being unsupported, falls by its own weight; and when the force of recoil is expended by acting on the water in the reservoir PQ, the water begins again to flow along ABR, and the very same operation which we have described is repeated without end, a portion of water being driven into the air vessel F at every ascent of the valve C. The air in this vessel being thus highly compressed, will exert a force due to its elasticity upon the surface of the water in the vessel F, and will force it up through the pipe M to a height which is sufficient to balance the elasticity of the included air.

The small quantity of air which is drawn into the annular space *i i* through the air tube *l k* at each aspiration, causes an accumulation of air in the space *i i*; and when the aspiration of recoil takes place, a small quantity of air passes from *i i*, and proceeds along the pipe till it arrives beneath the valves at E, and lodging in the small space beneath the valves, it is forced into the air vessel at the next stroke, and thus affords a constant supply of air to the vessel. The valves make in general from 50 to 70 pulsations in a minute.

When the fall of water, or PQ, is five feet, and the pipe AB six inches in diameter and 14 feet long, a machine with its parts proportioned as in the figure will raise water to the height of 100 feet. It will expend about 70 cubic feet per minute in working it, and will raise about 2¼ cubic feet per minute to the height of 100 feet. Mr Millington observes, that one of these machines is said to have raised 100 hogsheads of water in 24 hours to the height of 134 feet by a fall of 4½ feet.

Form of the ram for raising clean water with foul water. Fig. 10.

The form of the ram represented in Fig. 10. is suited to the case where a current of foul water AB, is employed to raise clean water from the well WW. This effect is produced by a bent pipe OPQ, containing a column of air from O to Q, and by another pipe T, with a suction valve *t*: The mode of action is precisely the same as in Fig. 8. When the valve C shuts, the sudden hydrostatical pressure forces the water up the bent tube at O, compresses the column of air OQ, which again presses, by its elasticity, on the surface of water at Q, and forces the clean water up through the valves into the air-vessel FF. The recoil of the water from B to A will produce a rarefaction in the column of air QO, in consequence of which, the atmospherical pressure upon the water in the well will raise the valve *t*, till as much water is admitted as was driven into the air-vessel. Montgolfier proposes to substitute a straight pipe in place of OQ, and to place a piston, moving freely in the pipe, which will transmit the pressure from the foul water to the clean water, without allowing them to mix. We conceive that the same effect might be obtained more simply and with much less friction, by a very loose diaphragm fixed in the tube.

Form of the machine for producing a current of air. Fig. 11.

When the ram is employed to produce a current of air, it has the form shewn in Fig. 11. The air is expelled through the air-pipe *w m*, in consequence of the mass of water rushing into the air-chamber W, by the shutting of the valve C. The water in W is prevented from following the air by a hollow ball of copper *n*, which floats on the water, and shuts up the lower end of the pipe, when the water dashes into W. When things are in the state shewn in the figure, and all the air expelled from the chamber W, the air compressed in the annular space *p p*, (which serves the same purpose as *i i* in Fig. 8.) produces a recoil of the water. The valve D shuts, C opens, the water quits the chamber W, and the valve *w* shuts, and prevents the admission of air. At the same time the valve *r* opens, and admits a fresh supply of air into the chamber; but when the water has descended below the float *e*, this float descends, and by its rod *e d* shuts the air-valve *d*. When the force of recoil is spent, the water flows again from A to B, and the operation which we have described is again repeated, so that there is a constant current of air in the pipe *w m*, which may be equalized by a water regulator, or any other contrivance. See the *Repertory of Arts*, Dec. 1816; Ferguson's *Lectures*, vol. ii. App.; and Brande's *Journal*, vol. i. p. 211, Lond. 1816.

16. *Description of the Chemnitz Fountain, or Hungarian Machine.*

Chemnitz fountain. Fig. 12.

The Chemnitz fountain is represented in Plate CCCXXIV. Fig. 12. where C is a collection of water, either in a mine or in a well, which it is required to raise to the reservoir B by means of a small head of water at A. In order to effect this, a pipe AFT, 4 inches in diameter, having a cock at M, enters the top of the copper vessel TD, 8½ feet high, 5 feet in diameter, and 2 inches thick, containing about 170 cubic feet, and extends to D within 4 inches of the bottom. The vessel TD has a cock at N, and a very large one at P, and from its top proceeds a pipe TOG, 2 inches in diameter, with a cock at O, entering the top of the vessel KE, which is 6½ feet high, 4 feet in diameter, 2 inches

Hydraulic Ram.

thick, and containing about 83 cubic feet. Another pipe EKHB, 4 inches in diameter, rises from E, within 4 inches of the bottom of the vessel KE, is soldered into its top at K, and rises into the reservoir B. The cylinder KE communicates by a tube with a cock at R, with the water C to be raised, and has a cock Q at its top. Let us now suppose that the cock M is shut, and all the other cocks open. The cylinder TD will contain air, and KE will contain water standing as high as the level of the water in the cistern C. Shut the cocks N, P, Q, and R, and open the cock M. The water from A will descend into the vessel TD, and after it rises above the mouth D of the pipe, it will compress the air in the vessel TD, in the pipe TOG, and in the upper part of the vessel KE. The action of this air upon the water in KE will force it up the pipe KH, till it is discharged into the reservoir B. This discharge into B goes on till the upper vessel TD is filled with water. As soon as this happens, the water is prevented from running into the pipe TO by a cork ball, or double cone, which hangs in the pipe TO by a brass wire, which is guided by holes into two cross pieces in the pipe. The ascent of the water into the mouth of the pipe at T pushes in this plug, and closes the pipe. The influx of water now stops; but the water still flows into B till the elasticity of the air in the lower vessel KE is no longer able to balance a column which reaches to H in the pipe KH. This cessation of the efflux into B generally ceases when KE is half full of water. When this takes place, the workman shuts the cock M, and opens the cock P, from which the water rushes with great velocity. Whenever ¾ths of the water in the vessel TD is discharged at P, which is measured in the vessel which receives it, the workman opens the cock R with a long rod, so as to fill the vessel KE with water. This drives the air out of KE through the pipe GO into the vessel TD, and consequently drives out all the remaining water. Every thing is now in the state in which it was at first, which is known to be the case when no more water flows out at P. The workman, therefore, shuts the cocks P and Q, and opens M, and the same operation is repeated. If the cock N be opened when the efflux has ceased at B, the water and air rush out together with prodigious violence, accompanied with hail and pieces of ice produced by the cold which attends the sudden expansion of air. It is usual to shew this sight to strangers, whose hats, when held opposite N, are sometimes pierced with the pieces of ice which are projected from it.

A considerable improvement upon this engine has been made by Mr John Whitley Boswell, who has added to it an apparatus which enables it to operate without any attending workmen. An account of this improvement will be found in Nicholson's *Journal*, 4to. vol. i. and 8vo. No. 5.

17. *Description of the Danaide invented by M. Mannoury Dectot.*

Mannoury Dectot's danaide.

This machine consists of a cylindrical trough of tinplate, nearly as high as it is broad, and having a hole in the centre of its bottom. It is fixed to a vertical axis of iron, which passes through the middle of the hole in the bottom, a vacant space being left all round to permit the water to escape. The axis turns with the trough upon a pivot, and is fixed above to a collar.

A drum of tin-plate, close above and below, is fixed upon the axis of the trough, and placed within the trough, so as to be concentric with it, and to leave only between the outer circumference of the drum and the inner circumference of the trough, an annular space not exceeding 1½ inches. This annular space communicates with a space less than 1½ inches, left between the bottom of the drum and the bottom of the trough, and divided into compartments by diaphragms fixed upon the bottom of the trough, and proceeding from the circumference to the central hole in the bottom of the trough.

Mannoury Dectot's Danaide.

The water comes from a reservoir above by one or two pipes, and makes its way into this annular space between the trough and drum. The bottom of these pipes corresponds with the level of the water in the trough, and they are directed horizontally, and as tangents to the mean circumference between that of the trough and of the drum. The velocity which the water has acquired by its fall along these pipes, makes the machine move round its axis, and this motion accelerates by degrees, till the velocity of the water in the space between the trough and drum equals that of the water from the reservoir; so that no sensible shock is perceived of the affluent water upon that which is contained in the machine.

This circular motion communicates to the water between the trough and drum a centrifugal force, in consequence of which it presses against the sides of the trough. This centrifugal force acts equally upon the water contained in the compartments at the bottom of the trough, but it acts less and less as this water approaches the centre.

The whole water then is animated by two opposite forces, viz. gravity, and the centrifugal force. The first tends to make the water run out at the hole at the bottom of the trough; the second, to drive the water from that hole.

To these two forces are joined a third, viz. *friction*, which acts here an important and singular part, as it promotes the efficacy of the machine, while in other machines it always diminishes that efficacy. Here, on the contrary, the effect would be nothing were it not for the friction, which acts as a tangent to the sides of the trough and drum.

By the combination of these three forces, there ought to result a more or less rapid flow from the hole at the bottom of the trough: and the less force the water has as it issues out, the more it will have employed in moving the machine, and of course in producing the useful effect for which it is destined.

The moving power is the weight of the water running in, multiplied by the height of the reservoir from which it flows above the bottom of the trough; and the useful effect is the same product diminished by half the force which the water retains when it issues out of the orifice below.

In order to ascertain, by direct experiment, the magnitude of this effect, MM. Prony and Carnot fixed a cord to the axis of the machine, which, passing over a pulley, raised a weight by the motion of the machine. By this means, the effect was found to be $\frac{7}{10}$ of the power, and often approached $\frac{71}{100}$ without reckoning the friction of the pullies, which has nothing to do with the machine. This effect exceeds that of the best overshot wheels. See the *Report of the Institute*, 23d August 1813; or Thomson's *Annals of Philosophy*, vol. ii. p. 412.

For farther information on Hydrodynamics, see Adhesion, Barley *Mill*, Capillary Attraction, Pneumatics, Pumps, Rivers, and Waterworks.

HYDROMETER. See Hydrodynamics, p. 437.

HYDROPHOBIA. See Medicine.

HYDROPHTHALMIA. See Surgery.

HYDROSTATICS. See Hydrodynamics, p. 425.

HYDRUS. See Ophiology.

HYGROMETRY.

Object of hygrometry.

1. Under the article Evaporation, we explained the manner in which water is supposed to be elevated, and suspended in the atmosphere: we now propose to take a view of the various contrivances which have been employed for detecting the presence of aqueous vapour in that fluid, and ascertaining, not only the relative, but the absolute quantity of moisture, which exists at different times in given portions of air.

General view of hygroscopic substances,

2. The foundation of almost all the contrivances which have hitherto been employed for that purpose, is the affinity for moisture possessed by a variety of substances. This affinity is exerted more or less by a considerable number of bodies; but it is displayed, in the most eminent degree, by sulphuric acid, the fixed alkalies, several of the earths, the salts denominated deliquescent, more especially the muriate and nitrate of lime; as well as by many substances of animal or vegetable origin, particularly hair, membrane, horn, ivory, whalebone, feathers, the beards of corn, wood, cordage, paper, &c. All these substances possess the property of abstracting moisture from the atmosphere; but the union which they form with it is so very slight, that they readily yield it up again to the air when that fluid has by any means become drier, either by an increase of temperature, or the deposition of the water which formerly existed in it in a vaporous state. Hence the condition of these bodies with respect to humidity, may be employed as an indication of the quantity of moisture contained in a given volume of the air by which they are surrounded. The epithet *Hygroscopic* has been applied to substances used for this purpose; and the various instruments which have been formed of them, are called *Hygrometers*, or *measurers of moisture*.

And hygrometers.

3. The alternations of dryness and humidity to which all hygroscopic bodies are subject, are accompanied with corresponding changes in their weight and dimensions; and, therefore, all hygrometers are constructed so as to have a reference by their indications, either to change of weight or change of volume The latter of these changes, though frequently less appreciable in its extent than variation of weight, is however more readily, as well as more conveniently estimated; and hence the greater number of hygrometers consist of some animal or vegetable substance, having a fibrous structure, the expansions of which by moisture are rendered more sensible by mechanical contrivances. Some hygrometers, however, are constructed, so as to indicate changes of humidity in the medium to which they are exposed, by changes of weight, arising from the absorption or extrication of moisture; and one of these instruments, invented by Mr Leslie, perhaps the most accurate of them all, is formed upon a principle which cannot be referred either to change of weight or of volume.

Imperfections of the first hygrometers.

4. It is only of late that hygrometers have been constructed with any degree of accuracy. The earlier instruments which bear that name, were extremely imperfect: the mechanical part was executed in a very rude manner, and no attention was paid to the graduation of the scale which marked the enlargement or contraction of the hygroscopic substance, farther than to make it point out mere differences in the state of the air with respect to moisture. No attempt was made to determine two fixed points, as in the case of the thermometer, by which the various scales might be reduced to a common standard; and still less to ascertain the absolute quantity of moisture in a given volume of air, corresponding to the different points of the scale employed. In short, nothing higher was aimed at in the construction of a hygrometer, than to obtain some substance which suffered considerable variations of bulk, by the absorption of moisture, without the smallest regard to the regularity of its dilatations. Almost all of them were very unwieldy; and none of them could be applied to nice researches into the hygrometric state of small portions of air. To describe the construction of them, with much minuteness, would therefore be as useless as inconsistent with the limits of this article.

Conier's hygrometer.

Plate CCCXXI. Fig. 1.

5. Both animal and vegetable substances of a fibrous structure, possess the property of being dilated by moisture, in a direction transverse to the fibres; and, accordingly, the lateral expansion of these bodies furnishes the principle upon which a considerable number of hygrometers are constructed. One of the earliest hygrometers of this kind was proposed by Mr Coniers in 1676. The whole contrivance is of the rudest kind; and though it is scarcely worthy of notice, we shall give a brief description of it, in order that some idea may be formed of the imperfect state of hygrometry at that period. AAAA represents a frame of wood grooved in the inside for admitting two pannels of deal B, B to play freely at top and bottom. The pannels, which are placed so as to have their fibres in a vertical position, are fastened to the frame at each side, and a sufficient interval is left between them, to allow full scope for the wood to dilate itself in a lateral direction. The axis of the index, which is at C, by receding from F, or approaching nearer to it, gives a circular motion to the index itself, by means of a slender metallic chain, which passes round the axis, and is fastened to one of the pannels at F. W is a weight or counterpoise connected with the axis by means of a string passing over the pulley D, and attached to the arm CG, and which causes the index to descend, as the pannels expand by moisture. Several other contrivances of a similar kind are described in the Philosophical Transactions for that period, but they are all equally rude and imperfect.

Whalebone hygrometer of De Luc.

Fig. 2.

6. The most accurate hygrometer, constructed on the principle of a lateral expansion, is that of De Luc. The substance he employs in preference to all others, is whalebone cut transversely into thin slips. Such is the tenacity of this substance, that, according to De Luc, these slips may be a foot long, and a line in breadth, without weighing above one-fourth of a grain, and yet be capable of supporting a weight of about 160 grains. The instrument is fitted up in various forms by different artists; but the general principles of its construction are nearly the same in all. Mr Adie, Edinburgh, constructs it in the following manner. ABCD represents the frame-work of the instrument, to the upper part of which is attached the graduated circle EF, capable of being elevated or lowered at pleasure, to suit the length of the slip of whalebone *a b*. The whalebone, which is usually about 10 inches in length, is fastened at *a* between two slips of brass by means of a

Plate CCCXXI. Fig. 2.

screw, and in a similar manner at *b*, where it is connected with a slender silk band which moves over the axis, to the extremity of which the index is fixed; and it is kept in a state of uniform distension, by a silk thread passing round the axis, (to which it is fixed,) in a direction contrary to that of the silk band, and fastened at the lower extremity to a spiral gilt silver wire *d e*. This spiral spring forms, by its reaction, an excellent counterpoise to the whalebone, as it acts with the smallest energy when the latter is most weakened by dilatation.

Method of obtaining the extreme points of the scale.

7. The extreme points of the scale, by which the intermediate divisions are graduated, are determined in the following manner: To obtain the point of extreme humidity, or complete saturation with moisture, De Luc is not satisfied with exposing the instrument to a portion of air perfectly saturated with the vapour of water, but he actually immerses it in that fluid, and allows it to remain in it, till it ceases to suffer any farther dilatation. The point on the circular scale, to which the index reaches, is then marked as *extreme moisture*. The opposite point, namely that of *extreme dryness*, is obtained by inclosing the instrument under a receiver with a quantity of dry quicklime, and allowing it to remain exposed to its action, till the whalebone attains its greatest degree of contraction, which is generally in about three weeks. The quicklime, by its attraction for moisture, gradually absorbs the watery vapour contained in the air, which, in its turn, abstracts moisture from the whalebone, till an equilibrium is established between the attraction of the two substances for vapour. As the whalebone becomes drier, its fibres continually approach towards each other; and at last, when it ceases to yield any moisture, it also ceases to suffer contraction, and the index points to extreme dryness. The length of the slip of whalebone is so proportioned to the diameter of the axis, or arbor to which the index is fixed, that the interval between the points of extreme moisture and dryness embraces a range which is somewhat less than a complete revolution; and this interval is then divided into 100 equal parts. The zero of the scale is usually marked at extreme dryness, and the divisions are in that case numbered upwards to extreme moisture, which is marked 100. Some artists, however, reverse this order, and place the zero at extreme moisture,—a practice, which cannot fail to lead to mistakes in recording the indications of the instrument.

Objections to the use of whalebone for the purposes of hygrometry.

7. Saussure, to whom we are indebted for many useful and interesting observations on hygrometry, has stated several objections against this instrument, applicable both to the substance of which it is formed, and the manner of determining the extreme points of the scale. He affirms, that whalebone, being a substance of a muscular or gelatinous nature, would admit of an indefinite relaxation by moisture, were it not for certain filaments, which connect the fibres with each other, but do not prevent them from separating beyond the limits, to which their hygroscopical affinity for moisture in the vaporous state would dilate them. He maintains, therefore, and we think with justice, that to immerse such a substance in water, in order to obtain the greatest relaxation of which it is susceptible, is to reduce it to a condition which it can never afterwards arrive at by the influence of vapour; and consequently, that all the divisions of the scale, which are included between the perfect humidity of the whalebone, and the point corresponding to the complete saturation of air with moisture, are entirely useless. He adds, that if whalebone is to be used at all in the construction of hygrometers, the point of extreme moisture should be marked probably where 80° stands in De Luc's scale.

Remarks on the substances employed to obtain the point of extreme dryness.

8. With respect to the use of dry quicklime as a desiccative, Saussure seems to suspect that this substance produces a degree of dryness less perfect, than the fixed alkalies in a caustic state; and that at any rate, the slowness with which it attracts moisture, renders it less fit for the purpose. Strongly concentrated sulphuric acid, or paper soaked in muriate of lime, and then well dried, absorb moisture more rapidly than either: the former, in particular, when inclosed under a receiver with a given volume of air, causes the index of a hygrometer to advance as many degrees towards extreme dryness, in a few hours, as dry quicklime would do in as many days. As the attraction of sulphuric acid for moisture varies, however, with its degree of concentration, it is proper to employ it always of the same specific gravity, otherwise the point of extreme dryness will not be the same in all hygrometers. An uniformity of scale would thus be obtained, whether the point of extreme dryness were absolute, or merely relative.

De Luc's hygrometer for examining small portions of air.

9. For examining the hygroscopic state of small quantities of air, De Luc gives the instrument a form, which renders it more commodious for being introduced under a receiver. Fig. 3. represents a front view of the instrument constructed for that purpose, of its actual size. *a a a a* is a frame of brass, which is connected with a similar frame behind. The dotted line *c b b b d* represents the slip of whale bone fixed at *c* to an adjusting screw, passing over the pullies *b b b b*, and joined at *d* to a slender metallic plate of annealed silver. This metallic plate *d e f* moves over a pulley *e*, and is joined at *f* to the moveable part *g* of the vernier *h h h h*. From the top of the moveable vernier *i* proceeds another slender metallic plate of the same pliant material, the opposite extremity of which is fixed to the pulley *k*. This pulley is supported on the same axis with a smaller pulley *l*, which is connected, by means of a slender metallic plate, with the upper extremity of the bent lever *m, n*, the shorter arm of which *n* is pressed by a spring. It is easy to see from the figure of the instrument, that when the whale-bone is dilated by absorbing moisture, the vernier will ascend by the action of the spring upon the lever; and *vice versa*.

Plate CCCXXI. Fig. 3.

Pocket hygrometers.

10. The instrument may be fitted up in the form of a watch, by fixing the whale-bone to the circumference of a wheel, and distending it gently by a weak spring. The contraction and enlargement of the whale-bone might then be indicated by a hand fixed to the arbor of another wheel, and moving along the circular graduation of a dial-plate. Other contrivances of a similar kind will readily suggest themselves to the ingenious artist.

De Luc's ivory hygrometer.

11. Hygrometers have also been constructed of substances, which seem to suffer a dilatation in all directions, by moisture. On this principle, De Luc constructed some time ago a hygrometer of ivory, by giving a portion of that substance intended to be affected by moisture, the form of a thin slender tube, and then inserting into it, at one extremity, a capillary tube of glass, about 14 inches long, and $\frac{1}{50}$ inch in diameter. The ivory is recommended to be taken from an elephant's tooth of considerable size, a few inches from the top, and as near the surface as possible, in order that it may be of an uniform grain in different instruments. This hygrometer is represented in Fig. 4. Plate CCCXXI. where *b g b* represents the ivory tube

Fig. 4.

PLATE CCCXXI. Fig. 4.

open at *b b*, and shut at *g*. This tube, which is 2 inches 8 lines in length, and 2½ lines in diameter, internally, is bored in the direction of its fibres, and reduced by turning it on a lath, till its thickness is about $\frac{1}{16}$ths of a line, except at the two extremities, where it is left somewhat thicker, to give it greater strength. The piece *a a d d*, which is made of brass, connects the ivory with the glass tube, by means of gum mastich, or any other adhesive substance. The part of the ivory tube *b c b c*, is protected from the moisture of the air by a brass verrel, which prevents it from splitting. Before being fitted up, the ivory tube is usually moistened on the outside, which may be done very conveniently, and to a proper degree, by surrounding it with wet cambric, and allowing it to remain till the moisture permeates through the ivory.

Manner of fitting up the instrument and graduating the scale.

12. The mercury is introduced by first inserting a horse hair into the bore of the glass tube, sufficiently long to pass completely through it, and reach about an inch beyond its lower extremity, into the ivory tube. A slip of paper, four or five inches long, is then wrapt round the upper part of the glass tube, and tied tightly to it; leaving about three inches of the paper projecting beyond it, so as to form a kind of funnel for pouring the mercury into the tube. A quantity of mercury being then poured into the paper tube, is afterwards gradually made to descend into the ivory tube, partly by gentle agitation, and partly by means of the horse hair, which is moved continually upwards and downwards, till the whole of the air is extricated, and the instrument filled with the proper quantity of mercury. This being done, the range of the scale is adjusted in the following manner: The instrument is immersed in a vessel of water, kept at the freezing point, by little bits of ice floating in it, where it is allowed to remain until the ivory has attained its greatest possible dilatation, which is known by the mercury in the tube becoming stationary. The lowest point which it reaches is then marked as the zero of the scale. One fixed point being thus obtained, the other divisions are determined by previously ascertaining the relation subsisting between the internal capacity of the ivory tube and that of the glass tube, and graduating the instrument accordingly. For this purpose, De Luc employed a glass tube which had formerly been used as a thermometer, the divisions of which he knew, and the bulb of which was intentionally broken, in order that the quantity of mercury contained in it might be accurately weighed. The weight of the mercury in the ivory tube being also determined, it was easy to form a new thermometrical scale adapted to the glass tube and the ivory bulb. For let M be the weight of the mercury in the original thermometer, D the length of a degree upon its scale, m the weight of the mercury in the ivory tube, and d the length of a degree upon its scale, we have evidently,

$$M : m :: D : d.$$

The scale affixed to the glass tube was accordingly divided into as many divisions as it admitted, each of which was made equal to d. By this mode of forming the scale, it is unnecessary to observe, that the instrument would be in reality a thermometer, provided the ivory were not affected by moisture; but the ivory being dilated and contracted by moisture, will give rise to corresponding deviations from the mere effect of temperature, and thus, by means of an attached thermometer, the effect due to dryness or moisture may be accurately separated from the rising and sinking of the mercury in the glass tube, by means of heat and cold. The excess of the hygrometrical degrees above the degrees indicated in similar circumstances by an ordinary thermometer, is to be considered as the sole effect of dryness in contracting the ivory; while a difference of a contrary kind is to be ascribed to an opposite cause.

Mr Leslie's ivory hygrometer.

13. Mr Leslie, who has devoted some attention to this instrument, has proposed a modification of which, as he himself remarks, has perhaps carried the hygroscope thus formed to as high a state of improvement as such an imperfect instrument admits. The shell of ivory is turned, in his construction, into an elongated spheroid, about an inch and a quarter in length, and reduced so thin as to weigh only eight or ten grains. At its greatest expansion it contains about 300 grains of mercury. The upper end, which is adapted to the body by means of a delicate screw, has a slender glass tube inserted into it, six or eight inches long, and a bore nearly $\frac{1}{11}$th part of an inch in diameter. The point of extreme humidity is determined, as in the case of De Luc's instrument, by immersing the bulb in water, or surrounding it with a wet bit of cambric. The divisions of the scale, however, are determined somewhat differently: Mr Leslie distinguishes the tube into spaces, which correspond to the thousandth part of the entire cavity, and each of which contains about $\frac{3}{13}$ths of a grain of mercury. The ordinary range of the scale includes about 70 of these divisions. The upper extremity of the tube is covered with a small ivory cap, which admits the air, but prevents the escape of the mercury, thus rendering the instrument portable. Mr Leslie remarks, that the contraction of the mercury corresponding to equal increase in the dryness of the air, is six times greater at the beginning of the scale than at the 70th division; and that it seems to be in general inversely as the number of hygrometric degrees, reckoning from 20° below. He therefore places another scale, on the opposite side of the tube, the interval between zero and 70° being divided into 100°, and corresponding to the unequal portions, from the number 20 to 120 in a logarithmic line, (see Plate CCCXXI. Fig. 5. By extending the logarithmic divisions farther, in conformity with the base of the scale, 320 of its degrees would correspond to 108 of the equable divisions, or a contraction of 108 parts in a thousand, with respect to the capacity of the bulb. At the dryness, however, of 300 of his own hygrometer, Mr Leslie never found the contraction of the ivory to exceed 105. It would have been more satisfactory, if the temperature at which the observations were made had been given, as we shall afterwards shew, that 300 on Mr Leslie's hygrometer may correspond to very different portions of moisture in the medium to which it is exposed.

PLATE CCCXXI. Fig. 5.

Cases in which ivory hygrometers may be used with advantage.

14. The instrument we have described, though very unfit for delicate observations, may nevertheless be used in certain cases with advantage. The slowness of its indications, when its scale has once been compared with that of a more accurate instrument, is well fitted to point out general results, corresponding to considerable intervals of time between the observations. Mr Leslie has suggested that, on this account, it may be usefully employed to ascertain the degree of humidity which prevails in the higher regions of the atmosphere, and to determine the hygroscopic state of certain kinds of goods, such as grain, wool, cotton, &c. For the latter purpose, all that is necessary is to thrust the instrument among the substances, whose condition, with respect to moisture, we wish to determine, and to observe

the degree which it indicates after it has been allowed to remain a suitable length of time.

Quill hygrometer of Chiminello.

15. Under hygroscopic instruments constructed on the principle of a general dilatation by moisture, we may briefly notice the hygrometer of Chiminello, to whom the prize proposed in 1783 by the Academy of Sciences at Manheim for the best comparable hygrometer was adjudged. The substance he employed was the barrel of a quill, fitted up in the same manner as the ivory hygrometers, already described. The graduation of the scale was determined by means of two fixed points. The point of extreme moisture was obtained by immersion in water; that of extreme dryness, by exposing the instrument, for the space of four hours, before a moderate fire, at a temperature equal to 25° of Reaumur, or 88$\frac{1}{4}$° of Fahrenheit. The quill, by exposure to heat, becomes somewhat contracted; and though the contraction is not so great as would be produced by extreme dryness, Chiminello considered it sufficiently uniform in different quills to serve as a fixed point in his scale. It is obvious, however, that an instrument graduated in so vague a manner is totally unfit for any philosophical purpose.

Reason why birds can foresee approaching rain, or fair weather.

16. Having alluded to this instrument, it may be worthy of remark, that it is probably owing to the hygroscopic property of their feathers that birds are enabled to judge of approaching rain or fair weather. For it is easy to conceive, that an animal having a thousand hygrometers intimately connected with its body, must be liable to be powerfully affected, with regard to the tone of its organs, by very slight changes in the dryness or humidity of the air; particularly when it is considered, that many of the feathers contain a large quantity of blood which must thus be alternately propelled into the system, or withdrawn from it, according to their contraction or dilatation by dryness or moisture. This view of the subject seems to afford a satisfactory explanation of the extreme sensibility which birds in general shew to coming changes in the weather.

> Haud equidem credo, quia sit divinitus illis
> Ingenium, aut rerum fato prudentia major;
> Verum, ubi tempestas, et cœli mobilis humor
> Mutavere vias; et Jupiter humidis Austris
> Densat, erant quæ rara modo, et quæ densa, relaxat;
> Vertuntur species animorum, et pectora motus
> Nunc alios, alios, dum nubila ventus agebat,
> Concipiunt.
>
> VIRGIL, Geor. lib. i. 415.

Rat's bladder hygrometer of Mr Wilson.

17. An hygrometer constructed upon similar principles, but much more delicate in its indications, has lately been proposed by Mr Wilson of Dublin. The substance he employs is rat's bladder; which, besides having an extensive range of dilatation, is affected by very slight changes in the hygroscopic state of the air. The scale is graduated by exposing the instrument to air saturated with moisture for the point of extreme humidity; and by afterwards inclosing it in a receiver, over mercury, with a quantity of concentrated sulphuric acid, for the point of extreme dryness. The interval between the range of these two points is then divided into 100 equal parts. These points, however, must obviously vary with the temperature of the mercury; and though this objection, which is applicable to all these mercurial hygrometers, may be obviated to a certain extent by enlarging the diameter of the tube, it cannot be entirely removed without diminishing the delicacy of the instrument, unless the precautions, adopted by De Luc, be observed in the construction of the scale. The rat's bladder hygrometer is liable to another objection, which, on account of the difficulty attending the construction of the instrument, is of considerable force: the elevation of the mercury in the tube, by the contraction of the membranous substance, must occasion a pressure in the bladder, which, in some cases, may amount to nine or ten pounds on the square inch, according to the range of the scale. The distension occasioned by such a pressure cannot fail to affect the accuracy of the instrument, and even to expose it to destruction. According to the observations of Lord Gray, this instrument corresponds pretty nearly in its indications with the whale-bone hygrometer of De Luc.

Allantois hygrometer of Jean Baptiste.

18. An hygrometer depending on the principle of a general expansion by moisture, and fitted up in the same manner as the hygrometer of De Luc just alluded to, has been strongly recommended by Jean Baptiste, a Capuchin friar of St Martin at Vicenza. The hygroscopic substance used in the construction of this instrument, is a narrow slip of the allantois of a calf, the thin membrane which envelopes the fœtus of animals before birth. The point of extreme moisture was fixed by exposing the instrument to air saturated with aqueous vapour. Another point was determined by heating to the temperature of 50° of Reaumur, or 144$\frac{1}{2}$° of Fahrenheit, a small stove, which was kept open, and preserved for some time as nearly as possible at the same temperature, and then introducing the instrument into it, where it was allowed to remain so long as the allantois suffered contraction. According to Jean Baptiste, the degree of dryness obtained by this process is fixed and invariable. The intermediate space on the scale, between the extreme points thus determined, was divided as usual into 100 equal parts. In a subsequent part of this article we shall demonstrate, that no fixed point can be obtained for the graduation of an hygrometer, by a mere exposure of the instrument to an elevated temperature; and, consequently, the scale of this hygrometer can no more be relied upon than that of Chiminello. The substance itself, however, we have reason to think, from the experiments we have made with it, is exceedingly fit for hygrometric purposes.

Hair hygrometer of Saussure.

19. But of all the hygroscopic instruments which we have hitherto described, and which are constructed on the principle of a general, or at least of a longitudinal expansion, the hygrometer of Saussure is by far the most delicate, as well as the most accurate and uniform, in its indications. The substance which he selected, in preference to every other, was a human hair, the elongations and contractions of which by moisture and dryness, though less extensive than some of the substances already mentioned, may be rendered sufficiently sensible by mechanical contrivances. As the value of this instrument has been greatly enhanced by the late researches of Gay Lussac, a particular description of it is the more necessary: we shall therefore give an account of the different parts of it in detail.

PLATE CCXXI. Fig. 6.

20. The general appearance of the instrument is nearly the same as that of the whalebone hygrometer of De Luc, which seems indeed to have been borrowed from it, the priority of invention being due to Saussure. The upright pillars *a a a a*, which support the dial-plate, are fixed to the rectangular frame *b b b b*, at each corner of which is a screw for fixing the instrument to the bottom of its case, when it is exposed to the external air. The dial-plate is made to slide along the pillars *a a*, and is thus capable of being raised to any particular altitude, in order to suit the length of the hair.

Plate CCCXXI. Fig. 6.

The screws *z*, *z*, only one of which is visible in the representation of the instrument, are intended to fix the dial-plate after it has been raised to the proper height. The lower extremity of the hair is held fast by the chops of the screw pinions *d*, and the upper extremity of it is fixed in a similar manner at *c*. The pinions *c* also serve to connect the hair with a thin slip of silver, which is rolled round the arbor *f e*, and fixed to it. The part of the arbor on which the silver thread is wound is usually cut in the form of a spiral groove, and made quite flat at the bottom, in order that the slip of silver may be always at the same distance from the axis of the arbor. The hair is kept in a state of equable distension by means of a small weight *g* of three or four grains, which is suspended on the opposite side of the arbor, and is sufficient to stretch the hair without breaking it. When the instrument is transported from place to place, the weight *g* is prevented from vibrating, by fixing it in the crayon *i*, which is intended to receive it, and in which it is securely fixed by means of the screw *k*. The crayon itself is moveable along the bar *h h*, and may be fixed in any position by the screw *l*. The index *o o* is fixed to the extremity of the pivot of the arbor *f e*, and points out, by its indications on the graduated arch of the dial plate, the hygrometric state of the hair.

Manner of determining the extreme points of the scale.

21. Saussure determined the point of extreme dryness, by placing the instrument under a receiver, with a suitable quantity of dry caustic alkali, and allowing it to remain till the hair ceased to suffer any contraction. The point of extreme dryness thus determined, though perhaps not absolute, gives, according to Saussure, a degree of dryness which is perfectly fixed and uniform. The point of extreme moisture is obtained, by placing the instrument over water in the inside of a receiver, the sides of which are kept constantly bedewed with moisture. The included air being thus surrounded on all sides with water, becomes completely saturated with moisture; the hair in its turn is gradually reduced to the same state, and soon attains its greatest degree of elongation, so that another fixed point in the scale is obtained. If the space described by the index between these two points is greater than a complete revolution, the hair may be shortened till its length is properly accommodated to the range of the scale. The temperature of the air at the time the two extreme points are determined is of no importance: it may indeed affect the hair thermometrically, in the same manner as it affects other substances, but it produces no change in the hygroscopic indications. The reason of this will appear afterwards, when we come to take a theoretical view of the instrument. At present it may be sufficient to remark, that, in this respect, the hygrometer of Saussure has a decided advantage over the whalebone hygrometer of De Luc, which, according to the temperature, ranges from 80° to 100° in air saturated with moisture, where of course it should remain stationary. Saussure divides his scale sometimes into 360°, and sometimes into 100°, the divisions being reckoned, in both cases, from extreme dryness, which is assumed for the zero of the scale, towards extreme moisture, which is marked 360°, or 100°, according to the division adopted.

Advantages of Saussure's hygrometer.

22. The principal advantages of Saussure's hygrometer are derived, 1st, From the unchangeable nature of the material of which it is formed, by means of which it retains its hygroscopic power longer than any other organic substance; 2d, From the extreme tenuity of the substance itself, which enables it to assume very quickly the state of the surrounding medium; and, 3d, From the little effect which, in consequence of this tenuity, it produces on the hygroscopic state of the medium to which it is exposed. De Luc has endeavoured, more it would appear from a desire to recommend his own instrument than to promote the cause of science, to shew that hair is totally unfit for hygrometric purposes; and having very gratuitously assumed the contractions and expansions of whalebone as a standard of reference for other hygroscopic substances, he has taken it for granted, that the indications of Saussure's hygrometer must be incorrect, because in certain circumstances they do not coincide with those of his own. He maintains also, that hair, after it attains its greatest degree of elongation, begins to suffer a contraction, particularly if it be allowed to remain beyond a certain time in air saturated with moisture; but this objection, which is only applicable to hairs of a peculiar structure, may be obviated by attending to the directions of Saussure, who was aware of the fact, and particularly enjoined, that such hairs as retrograded more than 2° should be rejected as unfit for the construction of hygrometers. On the whole, we have no hesitation in saying, that of all the hygroscopic instruments which have hitherto been formed of organic substances, the hygrometer of Saussure seems the most regular in its elongations and contractions; the least liable to be affected by exposure to the weather; and the best adapted for ascertaining the hygrometric state of small portions of air. The experiments of Gay Lussac, and the general results he has deduced from them, have given additional value to this instrument, by demonstrating that its expansions are subject to a regular law which admits of analytical investigation. We shall give an account of these afterwards. In the meantime, we shall conclude our remarks on the instrument with a general statement of its indications, compared with those of the whalebone hygrometer of De Luc.

Corresponding degrees of the hygrometers of De Luc and Saussure.

Saussure.	De Luc.	Saussure.	De Luc.
15.6 correspond to	5	88.8 correspond to	55
29.4	10	91.6	60
40.9	15	93.8	65
50.5	20	95.6	70
59.2	25	97.2	75
68 8	30	98.	80
73.	35	100.	85
78.3	40	100.	90
82.1	45	99.3	95
86.1	50	98.3	100

This comparative Table of the indications of the two instruments was drawn up by De Luc himself: its value, however, is greatly diminished by the temperature being omitted, at which the observations were made. The same remark is applicable to the following observations of Böckman, which differ somewhat from those of De Luc.

Saussure.	De Luc.
33 correspond to	10
54	20
65	30
80	40
86	45

Oat-beard hygrometer of Hooke.

22. Some hygrometers are constructed of organic substances of a fibrous structure, twisted either artificially or spontaneously during their growth. One of the earliest hygrometers of this description was propo-

sed by the celebrated Hooke, and formed of the beard of the wild oat, which twists and untwists itself according to the state of the air with respect to moisture. The beard is fixed at one extremity, and an index being applied at the other in a transverse position, its motions along the graduated circumference of a circle point out the hygroscopic state of the air.

Cat-gut hygrometer of Molyneux and Coventry.

Plate CCCXXI. Fig. 7.

23. Upon a similar principle, Mr Molyneux proposed, in 1685, to construct an hygrometer of whip cord or cat-gut, by suspending it from a hook, with a small weight at the lower extremity to give it a proper degree of tension, and carry at the same time an index over a graduated circle described on a fixed board below. We shall give a description of the instrument in a modified form, recommended by Mr Coventry of Southwark. AB represents the cat-gut, which may be of any convenient length. It is suspended from the bracket AD, and stretched by the weight F at its lower extremity. At B is a circular card of pasteboard attached to a round bit of cork, through which the cord is made to pass. The circumference of the card is graduated into 100 equal parts. Another card, connected with the cat-gut in a similar manner, and intended to record the revolutions of the other, is placed at C, at one-tenth of the ength of AB from the fixed point A, and divided into 10 equal parts. DE is a vertical line along the frame, which supports the cat-gut, and serves to point out the indications of the circular cards. In adjusting the instrument to extreme moisture, the cord is completely moistened with water, and when it ceases to untwist itself, both the circular cards are turned round till the zero upon each points to the vertical line DE. It is more difficult to obtain another fixed point; and indeed this is not very necessary, as the instrument, though it possesses great sensibility, can scarcely be used for any purpose but to point out general differences with respect to moisture.

Balance hygrometers.

24. The increase of weight, which all hygroscopic substances acquire by the absorption of moisture, furnishes another general principle for the construction of hygrometers. But as the accuracy of these instruments is liable to be gradually affected by changes in the hygrometric property of the substances themselves, as well as by the deposition of dust and other light bodies on their surfaces, few hygrometers have been constructed on this principle. The substances usually employed for the purpose are sulphuric acid, the deliquescent salts, and paper. The first of these substances was recommended by Mr Gould so early as 1684, who observed that sulphuric acid, after absorbing a certain portion of water from the atmosphere, continued to retain it till the air became drier, when it again yielded up a portion of the moisture it had previously acquired; and these alternations of the absorption and extrication of moisture always corresponded to the hygroscopic state of the air. He therefore placed a quantity of the acid in a cup in one scale of a balance, and a counterpoise in the other; and ascertained the relative state of the air with respect to moisture or dryness, according as either arm of the balance preponderated. A contrivance of this kind answers well enough for pointing out general results, but it is totally unfit for discovering the hygroscopic state of the air at any particular instant of time. We have found, however, that paper, soaked in a weak solution of the muriate of lime, and then dried, is very rapid in its indications, and capable of being affected by very minute changes; and indeed we have reason to think, from the observations we have made with a small slip of paper prepared in that manner, and suspended from one of the arms of a delicate balance, that an hygrometer constructed upon this principle might be obtained, possessing the utmost sensibility. Other hygrometers of a similar construction have been employed, but they are totally unworthy of notice.

Sulphuric acid recommended by Gould.

Paper soaked in muriate of lime.

Mr Leslie's hygrometer.

Plate CCCXXI. Fig. 8.

25. Mr Leslie has proposed an hygrometer, totally different in principle from any of those we have considered, but perhaps superior to all of them, both in point of accuracy and delicacy. Hygrometers formed of organic substances are liable to be affected by the partial decompositions, which, by exposure to air and moisture, such bodies continually undergo; and though some of them are composed of materials which resist the action of the weather better than others, none of them can be said to be indestructible, and all of them, in the course of time, lose in a great degree their hygroscopic properties. Their scales, therefore, however accurately constructed at first, are subject to a gradual derangement, and require occasional adjustments to render their indications at all correct. This is certainly a great objection to the use of these instruments; but it is an objection from which the hygrometer of Mr Leslie is entirely free, and as we have derived a formula by which the absolute quantity of moisture contained in a given volume of air may be accurately determined, in terms of the degrees of its scale, we must now consider it as by far the most accurate hygrometer that has yet been proposed. The instrument consists of two spheres of glass A, B, connected with each other by a bent tube CDEF, which is fixed to the stand GH, and contains inclosed a small portion of sulphuric acid, tinged with carmine to render it more distinctly visible. When the spheres, both of which are filled with air, are at the same temperature, the liquor in the recurved tube remains stationary; but if one of the balls, as A, be colder than the other B, the air in the latter, by its greater elasticity, immediately depresses the liquor in the limb FE, and raises it in an equal degree in the limb CD. One of the balls is accordingly covered with a coating of cambric, or tissue paper, and kept continually moist with pure water, conveyed to it by filaments of floss silk from an adjoining vessel. The evaporation of the water quickly cools the surface of the ball, in a degree proportioned to the rapidity with which the process is carried on, which will depend partly upon the temperature, and partly upon the dryness of the ambient medium; and hence the depression of the liquor in the limb FE becomes an indication of the relative dryness of the surrounding air. The caloric abstracted from the moistened ball by evaporation, is incessantly supplied by the air and the contiguous bodies, and in the course of two minutes the maximum of effect is produced. Were it not for this continual influx of temperature, no limits could be assigned to the degree of cold that might be induced. The scale is formed by dividing the interval between the boiling and freezing points into 1000 equal parts, so that 10° correspond to 1° of the centigrade thermometer, and 50° to 9° of Fahrenheit. This hygrometer acts equally well when the moisture on the balls is in a frozen state; but the heat required for the melting of ice being about a seventh part of what is necessary for the conversion of water into vapour, the temperature of the coated ball will, in like circumstances of the air with respect to moisture, sink a seventh part more than before; and therefore the degrees indicated by the instrument must, in that case, be reduced 1° in 7°, to adapt the scale to the actual state of things.

Graduation of the scale.

orm of the strument hen it is tended to portable.

LATE CCXXI. g. 9.

26. When the instrument is intended to be portable, Mr Leslie prefers the form delineated in Fig. 9. The two balls, being in the same perpendicular line, are protected from injury by a case of wood or ivory; and the instrument may thus be transported from one place to another with perfect safety. We shall conclude our description of this simple but ingenious instrument, by remarking, that an ordinary thermometer, having its bulb covered with moistened paper, gives the same indications, if its temperature be subtracted from the temperature of the air determined by a naked thermometer, placed in similar circumstances with the other.

Relation between the Indications of Hygrometers, and the absolute Quantities of Moisture in Vapour.

27. Having thus described the construction of the various kinds of hygrometers which have hitherto been employed, we shall now proceed to investigate the relation subsisting between the indications of these instruments, and the absolute quantities of moisture existing in a given volume of the medium to which they are exposed. To enable us to prosecute the subject with sufficient precision, it will be necessary, in the first place, to take a concise view of the quantity of vapour contained in a vacuum at different temperatures; and, secondly, of the quantity of it which can exist, in the same circumstances, under different pressures, in mixture with air. The experiments of Mr Dalton on the elasticity of steam at various temperatures, together with the recent researches of Gay Lussac, will enable us to solve both these problems with the most perfect precision.

ree of va-pur.

28. Mr Dalton has given a table, containing the results of his admirable experiments on the force of steam for every degree of Fahrenheit's thermometer, from zero to 325°, from which Biot has deduced the following Table, adapted to the centigrade scale.

Temperature.	Force of Vapour in Inches of Mercury.	Ratio of each term to the one which precedes it.
0.	.200	
6.25	.297	1.485
12.50	.435	1.465
18.75	.630	1.450
25.	.910	1.440
31.25	1.290	1.430
37.5	1.820	1.410
43.75	2.540	1.400
50.	3.500	1.38
56.25	4.760	1.36
62.5	6.450	1.35
68.75	8.550	1.33
75.	11.250	1.32
81.25	14.600	1.30
87.5	18.800	1.29
93.75	24.	1.27
100.	30.	1.25

29. The first column of this Table contains the temperature, in degrees of the centigrade scale, at the interval of $6\frac{1}{4}$ degrees; the second, the elastic force of vapour in English inches; and the third, the relation in which each term of the elastic force stands to the one immediately above it. It is obvious, that if the same relation subsisted between the terms, in successive order, the numbers in the third column would form a series of quantities in geometrical progression, the first term of which would be .2, and the last 30. The terms, however, continually decrease in a slow and regular manner, as the temperature increases, and therefore the elastic force of vapour cannot proceed in a geometrical series. In order to obtain a general expression for the law of its increase, Biot assumes that the ratio of the terms is constant, and equal to k; then calling F_n the elastic force, corresponding to the temperature $100 - n$,

$$F_0 = 30,$$
$$F_1 = 30\,k^1,$$
$$F_2 = 30\,k^2,$$
$$\text{And, in general, } F_n = 30\,k^n.$$
$$\text{Hence, Log. } F_n = \text{Log. } 30 + n \text{ Log. } k.$$

The supposition, on which this expression is founded, though not rigidly true, will lead to results sufficiently conformable to experiment to justify us in adopting it. The quantity n, Log. k, may be exhibited by a succession of terms of the form $a\,n + b\,n^2 + c\,n^3 +$ &c. and the expression then becomes,

$$\text{Log. } F_n = \text{Log. } 30 + a\,n + b\,n^2 + c\,n^3 + \text{ \&c.}$$

the co-efficients a, b, c being constant, and determinable from three equations in which F_n is given, and consequently n. It is unnecessary to take more than three terms of the series, as the co-efficients of the powers of n will be found to diminish much faster than the powers themselves increase. To determine the co-efficients a, b, and c, Biot employs the elastic force of vapour for the temperatures 25, 50 and 75, reckoned downwards from the boiling point; thus, we have,

$$n = 25 \qquad F_{25} = 11.25,$$
$$n = 50 \qquad F_{50} = 3.5,$$
$$n = 75 \qquad F_{75} = .91.$$

$$\text{And, Log. } F_{25} = \text{Log. } 30 + 25\,a + 625\,b + 15625\,c,$$
$$\text{Log. } F_{50} = \text{Log. } 30 + 50\,a + 2500\,b + 125000\,c,$$
$$\text{Log. } F_{75} = \text{Log. } 30 + 75\,a + 5625\,b + 421875\,c.$$

Substituting the values of Log. F_n and Log. 30, and transposing,

$$25\,a + 625\,b + 15625\,c = -\ .4259687,$$
$$50\,a + 2500\,b + 125000\,c = -\ .9330519,$$
$$75\,a + 5625\,b + 421875\,c = -1.5180799.$$

The solution of these equations gives,

$$a = -.013741955,$$
$$b = -.000067427,$$
$$c = +\ .0000000338.$$

30. The values of a, b, and c, thus determined, being substituted for these quantities, in the general equation, we obtain the following formula for the elastic force of steam at the temperature $100 - n$.

$$\text{Log. } F_n = \text{Log. } 30 - .013741955\,n - .000067427\,n^2 + .0000000338\,n^3.$$

Formula for the force of vapour adapted to the degrees of Fahrenheit.

31. If n be expressed in degrees of Fahrenheit's scale, the elastic force of vapour for the temperature $212 - n$ becomes,

$$\text{Log. } F_n = \text{Log. } 30 - .00854122\,n - 00002081\,n^2 + .0000000058\,n^3.$$

By help of this formula, we have calculated the following Table of the elastic force of steam, from zero to 100° of Fahrenheit, which includes the ordinary range of natural temperature. We have also annexed a column, exhibiting the elastic force of vapour, for the same range of temperature, as determined by Mr Dalton. The difference between the corresponding numbers in the two columns seldom exceeds the 1000th part of an inch, except between 75⁰ and 90⁰, where Mr Dalton's table seems to be a little faulty.

Force of Vapour, in Inches of Mercury, from 0⁰ to 100⁰ Fahrenheit.

Force of vapour in inches of mercury.

Temperature.	Force of Vapour in Inches of Mercury.		Temperature.	Force of Vapour in Inches of Mercury.	
	According to Biot's Formula.	According to Dalton.		According to Biot's Formula.	According to Dalton.
0	.06121	.064	51	.38640	.388
1	.06359	.066	52	.39977	.401
2	.06605	.068	53	.41356	.415
3	.06861	.071	54	.42779	.429
4	.07126	.074	55	.44249	.443
5	.07401	.076	56	.45764	.458
6	.07685	.079	57	.47328	.474
7	.07980	.082	58	.48940	.490
8	.08286	.085	59	.50604	.507
9	.08603	.087	60	.52320	.524
10	.08931	.090	61	.54089	.542
11	.09270	.093	62	.55913	.560
12	.09622	.096	63	.57795	.578
13	.09987	.100	64	.59735	.597
14	.10364	.104	65	.61734	.616
15	.10755	.108	66	.63795	.635
16	.11160	.112	67	.65919	.655
17	.11579	.116	68	.68108	.676
18	.12013	.120	69	.70364	.698
19	.12462	.124	70	.72688	.721
20	.12927	.129	71	.75083	.745
21	.13408	.134	72	.77551	.770
22	.13906	.139	73	.80092	.796
23	.14421	.144	74	.82710	.823
24	.14954	.150	75	.85407	.851
25	.15506	.156	76	.88184	.880
26	.16076	.162	77	.91042	.910
27	.16667	.168	78	.93987	.940
28	.17277	.174	79	.97017	.971
29	.17908	.180	80	1.00137	1.00
30	.18561	.186	81	1.03350	1.04
31	.19237	.193	82	1.06656	1.07
32	.19934	.200	83	1.10058	1.10
33	.20658	.207	84	1.13559	1.14
34	.21404	.214	85	1.17161	1.17
35	.22175	.221	86	1.20867	1.21
36	.22972	.229	87	1.24680	1.24
37	.23796	.237	88	1.28602	1.28
38	.24647	.245	89	1.32636	1.32
39	.25527	.254	90	1.36785	1.36
40	.26436	.263	91	1.41059	1.40
41	.27376	.273	92	1.45438	1.44
42	.28346	.283	93	1.49948	1.48
43	.29348	.294	94	1.54585	1.53
44	.30384	.305	95	1.59352	1.58
45	.31453	.316	96	1.64251	1.63
46	.32557	.328	97	1.69286	1.68
47	.33684	.339	98	1.74461	1.74
48	.34875	.351	99	1.79778	1.80
49	.36090	.363	100	1.85241	1.86
50	.37345	.375			

Investigation of the weight of vapour at different temperatures.

32. Having thus deduced a general expression for the elasticity or tension of vapour at different temperatures, we shall now proceed to investigate its density or absolute weight. The experiments of Gay Lussac, which were conducted with the utmost attention to accuracy, have established, beyond the possibility of doubt, that vapours, when they are subjected to pressure, suffer within certain limits, that is, so long as they retain the elastic form, the same reduction of bulk as permanently elastic fluids. Hence if P be the weight of the liquid reduced to vapour in grammes; N the number of divisions of the receiver, which it occupies in the vaporous state at the temperature of 100° centigrade; v the capacity of one of these divisions in litres at the freezing point: then since Nv would be the volume of the vapour, if the receiver itself suffered no expansion by the increase of temperature, its real volume will be $Nv(1+100\,k)$, the quantity k being the cubical dilatation of glass for each degree of the centigrade scale. Also if p be the pressure of the atmosphere at the time of the experiment, and h the height of the mercury in the receiver above its external level, both being expressed in metres, then the volume of vapour in litres, produced by the quantity of liquid whose weight is P, will be $\frac{Nv(1+100\,k)(p-h)}{.76}$, and that of a single gramme

$$\frac{Nv(1+100\,k)(p-h)}{.76\,P}.$$

Important experiment of Gay Lussac.

33. Now in one of his experiments, Gay Lussac found, that $\frac{6}{10}$ grammes of water being introduced under a receiver, and the temperature raised to 100°, gave a volume of vapour which occupied 220 divisions, each of which was equal in capacity to .00499316 litres; the column of mercury in the inside of the receiver was .052 metres above the external level, and the barometer at the time of the experiment stood at .7555 metres. As mercury is expanded $\frac{100}{5412}$ of its bulk from the freezing to the boiling point, or $\frac{1}{5412}$ for each degree of the centigrade scale, and the temperature of the mercury in the barometer at the time of the experiment was 15°, the height of the column of mercury in the receiver reduced to what it would be at the freezing point, is $\frac{1}{1+\frac{100}{5412}} \times .052$, or .051056 metres, and the height of the mercury in the barometer, corrected in like manner, is $\frac{1}{1+\frac{15}{5412}} \times .7555$, or .75341 metres. Hence $P = .6$; $N = 220$; $v = .00499316$; $p = .75341$; $h = .051056$; and since the cubical dilatation of glass is .0000262716 for each degree of the centigrade scale reckoned from the freezing point, $1+100\,k = 1.00262716$.

$$\text{And } \frac{Nv(1+100\,k)(p-h)}{.76\,P} =$$

$$\frac{220 \times .00499316 \times 1.00262716 \times \overline{.75341 - .051056}}{.76 \times .6} =$$

1.69641 litres. Therefore a volume of vapour equal to 1.69641 litres, would contain at the boiling point, under a pressure of .76 metres of mercury, a quantity of moisture equal in weight to a gramme; or a litre of vapour in the same circumstances would weigh .589481 grammes.

Reduction of the resu to English measures.

34. If we reduce the result of this experiment to English measures, we shall find that a cubic inch of vapour at the boiling point, when the barometer stands at 29.92196 inches, weighs .149176 grains troy; and consequently a cubic foot of vapour in the same circum-

stances weighs 257.776 grains.[*] But, according to the very accurate experiments of Biot and Arago, a litre of dry air at the boiling point, and under a pressure of .76 metres, weighs .9454476 grammes, and therefore the weight of vapour at the temperature 100° centigrade, is to the weight of air at the same temperature, and under the same pressure, as .589481 to .9454476, or as 5 to 8 nearly. Now as Gay Lussac has proved by experiment, that vapours, so long as they remain in the aeriform state, expand, by increase of temperature, precisely in the same manner as permanently elastic fluids, and suffer corresponding changes of volume by change of pressure; and as he has also determined that air expands $\frac{3}{8}$ of its bulk from the freezing to the boiling point of the centigrade scale, and that the expansion is uniform between these points; if P′ be the weight in grammes of a litre of vapour, at the temperature t; F_t, the corresponding elastic force; and P the weight, in grammes, of a litre of vapour at the boiling point,

$$P' = \frac{1.375\,PF_t}{.76(1+.00375t)}$$

$$\text{or } P' = \frac{\frac{11}{8}PF_t}{.76\left(\ +\frac{3t}{800}\right)}$$

35. If we substitute for P its value, viz. .589481 grammes,

$$P' = \frac{853.196F_t}{800+3t}, \text{ or } \frac{1.066495F_t}{1+.00375t};$$

And if the value of F_t, as determined by the formula laid down in § 30, be substituted for that quantity, the weight of the water contained in a litre of vapour, will be expressed entirely in known terms. If the pressure of the barometer be different from .76 metres, and expressed by β, the result must be multiplied by $\frac{\beta}{.76}$. The formula we have given is a little different from that of Biot.

Quantity of moisture in a cubic inch of vapour at different temperatures.

36. The value of P′ expressed in English grains, and corresponding to a cubic inch of vapour at the temperature t of Fahrenheit, requires several corrections. In the first place F_t must be determined by the formula in § 31. for Fahrenheit's scale, or taken from the Table constructed from that formula; and, in the next place, the co-efficients 1.375, and .00375, must be adapted, not only to the general graduation of that scale, but to the barometrical pressure at which the boiling point of it is fixed. In the centigrade scale, the boiling point is taken at a barometrical pressure of .76 metres, or 29.92196 English inches, whereas the boiling point of Fahrenheit's scale is fixed under a pressure of 30 inches; but 27 millimetres of increase in the pressure raise the boiling point 1° centigrade, and 30 inches being equal to .76199 metres, the boiling point of Fahrenheit's scale must be $\frac{1.99}{27}$, or about $\frac{2}{27}$ of a centigrade degree above the boiling point of the centigrade scale. Consequently the co-efficient 1.375 will be increased, by this correction, to 1.37528; and the co-efficient .00375, after being reduced in like manner to .0037528, must, to make it applicable to the degrees of Fahrenheit, be multiplied by $\frac{100\frac{2}{27}}{180}$, which makes it .002086.

37. By these corrections, our formula becomes

$$g = \frac{.37528\,GF_t}{30(1+.002086.\overline{t-32°})}$$

G being the weight in grains of a cubic inch of vapour at the boiling point, and g the weight expressed in the same denomination of an equal volume of vapour at the temperature t. Since G has a reference to the boiling point of Fahrenheit's scale, its value, as formerly determined, must undergo a slight correction, to adapt it to the pressure and difference of temperature at which the two scales are fixed. Under a pressure of 29.92196 inches, it was found to be .149176 grains, at the boiling point of the centigrade scale; but the boiling point of Fahrenheit having been shewn to correspond to $100\frac{2}{27}$ of the same scale, .149176 must be multiplied by $\frac{30}{29.92196}$ to correct it for pressure, and then by $\frac{1}{1+\frac{2}{27}\times.00375}$ to correct it for expansion, by the increase of temperature. These corrections reduce it to .1495204 grains. Therefore

$$g = \frac{1.37528\,GF_t}{30(1+.002086.\overline{t-32})} = \frac{1.37528\times.1495204F_t}{30(1+.002086.\overline{t-32})} =$$

$$= \frac{.0068544\,F_t}{1+.002086.\overline{t-32}}$$

38. This expression will give the weight, in grains, of the water contained in a cubic inch of vapour, at the temperature t, and under the pressure of 30 inches of mercury. For the purposes of calculation, it may be reduced to the form,

$$g = \frac{3.2859\,F_t}{479.4+\overline{t-32}} = \frac{3.2859\,F_t}{447.4+t}.$$

To illustrate this formula, let it be required to find the weight of a cubic inch of vapour at 66° of Fahrenheit, under a pressure of 30 inches of mercury.

$$g = \frac{3.2859\,F_t}{447.4+t} = \frac{3.2859\,F_{66}}{447.4+66};$$

And if we introduce the value of F_{66}, which will be found by the Table of the elastic force of vapour to be .63795,

$$g = \frac{3.2859\times.63795}{513.4} = .\overset{\text{grains.}}{408}\ 3$$

Hence a cubic foot of vapour, under the same circumstances, would contain 7.055 grains of moisture.[†]

39. The following Table, calculated from the formula $g = \frac{.0068544\,F_t}{1+.002086.\overline{t-32}}$, exhibits the quantity of moisture contained in a cubic inch of vapour, from zero to 100° of Fahrenheit, under a pressure of 30°.

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[*] As a cubic inch of water at the temperature of 60° weighs 252.576 grains, a cubic foot of vapour, and a cubic inch of water, in the circumstances stated, weigh very nearly the same.

[†] Saussure found, in one of his experiments, that a cubic foot French of vapour contained, at the temperature of 15.°16 Reaumur, or 66.°11 Fahrenheit, a quantity of moisture equal in weight to 11.069 grains French. This result, reduced to English measures, would be 7.498 grains to a cubic foot, differing very little from the quantity determined by our formula. The difference would have been still less, if the temperature had been exactly 66°.

Table of the Quantity of Moisture, in Grains, contained in a Cubic Inch of Vapour, from 0° to 100° of Fahrenheit.

Temperature.	Force of vapour.	Weight in grains of the water in a cubic inch of vapour.	Temperature.	Force of vapour.	Weight in grains of the water in a cubic inch of vapour.
0	.06121	.00044957	51	.38640	.00254757
1	.06359	.00046601	52	.39977	.00263044
2	.06605	.00048296	53	.41356	.00271574
3	.06861	.00050056	54	.42779	.00280358
4	.07126	.00051874	55	.44249	.00289415
5	.07401	.00053757	56	.45764	.00298729
6	.07685	.00055697	57	.47328	.00308325
7	.07980	.00057708	58	.48940	.00318197
8	.08286	.00059789	59	.50604	.00328366
9	.08603	.00061921	60	.52320	.00338832
10	.08931	.00064161	61	.54089	.00349599
11	.09270	.00066451	62	.55913	.00360679
12	.09622	.00068825	63	.57795	.00372089
13	.09987	.00071280	64	.59735	.00383826
14	.10364	.00073810	65	.61734	.00395897
15	.10755	.00076429	66	.63795	.00408317
16	.11160	.00079136	67	.65919	.00421091
17	.11579	.00081931	68	.68108	.00434230
18	.12013	.00084819	69	.70364	.00447745
19	.12462	.00087801	70	.72688	.00461639
20	.12927	.00090882	71	.75083	.00475930
21	.13408	.00094051	72	.77551	.00490628
22	.13906	.00097337	73	.80092	.00505729
23	.14421	.00100732	74	.82710	.00521259
24	.14954	.00104235	75	.85407	.00537226
25	.15506	.00107851	76	.88184	.00553634
26	.16076	.00111588	77	.91042	.00570487
27	.16667	.00115446	78	.93987	.00587810
28	.17277	.00119420	79	.97017	.00605617
29	.17908	.00123522	80	1.00137	.00623919
30	.18561	.00127758	81	1.03350	.00642708
31	.19237	.00132134	82	1.06656	.00662015
32	.19934	.00136636	83	1.10058	.00681843
33	.20658	.00141303	84	1.13559	.00702209
34	.21404	.00146102	85	1.17161	.00723121
35	.22175	.00151051	86	1.20867	.00744597
36	.22972	.00156156	87	1.24680	.00766648
37	.23796	.00161424	88	1.28602	.00789288
38	.24647	.00166852	89	1.32636	.00812529
39	.25527	.00172454	90	1.36785	.00836386
40	.26436	.00178229	91	1.41059	.00860918
41	.27376	.00184188	92	1.45438	.00885999
42	.28346	.00190325	93	1.49948	.00911783
43	.29348	.00196651	94	1.54585	.00938243
44	.30384	.00203178	95	1.59352	.00965392
45	.31453	.00209899	96	1.64251	.00993240
46	.32557	.00216827	97	1.69286	.01021807
47	.33684	.00223878	98	1.74461	.01051113
48	.34875	.00231326	99	1.79778	.01081165
49	.36090	.00238903	100	1.85241	.01111983
50	.37345	.00246714			

40. The formula, by which the above Table was calculated, being adapted to a pressure of 30 inches of mercury, if the pressure of the atmosphere be different, a corresponding correction must be applied: if the height of the barometer in inches be represented by β, then

$$g = \frac{\beta}{30}\left(\frac{.0068544\, F_t}{1 + .002086.\overline{t - 32}}\right),$$

$$\text{or, } g = \frac{.10953\, \beta\, F_t}{479.4 + t - 32} = \frac{.10953\, \beta\, F_t}{447.4 + t}.$$

If the value of g be taken from the Table, it must be multiplied by $\frac{\beta}{30}$.

Experiments of Gay Lussac on vapour in mixture with air.

41. The formulæ which we have deduced, for the elastic force of steam, and the weight of the water contained in a given volume of vapour, when the temperature and pressure are given, furnish also the means of ascertaining, under similar circumstances, the force and quantity of vapour which exist, in combination or mixture with atmospheric air. The experiments of Gay Lussac have decidedly proved, that vapours, so long as they exist in the aëriform state, not only undergo the same change of mechanical condition by change of temperature and pressure, but that the same thing holds true, when they are mixed with vapours of a different kind, or even with permanently elastic fluids. The apparatus which Gay Lussac employed for demonstrating this important fact, is delineated in Fig. 1. Plate CCCXXVI. AB represents a cylindrical tube, accurately graduated; R and R′ are two stop-cocks of iron; TT′ is a bent tube of glass, communicating with AB at T. The whole apparatus having been well dried, the tube AB was filled with dry mercury, recently boiled; a balloon, furnished with a stop-cock *r*, and filled with dry air, was then firmly connected with the tube AB, after which the stop-cocks *r* and R′ were opened, thus making a communication between them. The stop-cock R was next opened, and a quantity of mercury allowed to make its escape by the recurved tube *a b*. The gas was thus allowed to dilate itself, till it was reduced to some particular state of rarefaction. The stop-cocks R and R′ were then shut. The inclosed gas in the cylinder AB being rarefied, by its increase of volume, the level of the mercury in it is found to stand higher than that of the mercury in the bent tube TT′; but the gas is easily reduced to the pressure of the atmosphere, at the time of the experiment, by pouring mercury into the tube TT′, till H and *h* have the same level. The liquid to be reduced into vapour is introduced into AB, by removing the balloon, and applying another stop-cock R″, the tube connected with which is surmounted by a small funnel V. The stop-cock R″ has a small cavity on one side of it, capable of containing a single drop of the liquid to be subjected to experiment, and by means of which any given portion of it may be introduced into AB. The liquid being thus brought in contact with the dry gas, is gradually converted into vapour; and when the addition of it ceases to increase the volume of the gas, a sufficient quantity is introduced, to exist in the vaporous state, at the temperature and pressure at which the experiment is made. The elasticity of the gas being augmented by the vapour, the mercury is elevated in the tube TT′ above its former level, and the gas, together with the vapour with which it is mixed, thus sustains a greater pressure than that of the atmosphere. It would be easy to make an allowance for the difference of level, and determine by calculation the volume which both ought to occupy under that pressure; but the apparatus itself furnishes the means of obtaining the proper correction, by allowing

Plate CCCXXVI. Fig. 1.

the mercury to flow out at b, until its level in AB and TT′ is the same. If N be the number of divisions occupied originally by the gas, N′ the number of divisions occupied by the mixture, and p the pressure of the atmosphere, which we shall suppose remains the same during the experiment; the elastic force of the gas, in consequence of its increase of volume, will now be $\left(\frac{N}{N'}\right)p$, and if f be the elastic force of the vapour, the joint elasticity of both will be $f+\frac{Np}{N'}$. But this being exactly equal to the atmospherical pressure, we have

$$p=f+\frac{Np}{N'}.$$

$$\text{Hence } f=p-\frac{Np}{N'} \text{ or } p\left(\frac{N'-N}{N'}\right).$$

The elastic force of pure vapour, and vapour mixed with atmospheric air, the same.

42. It appears, by the experiments of Gay Lussac, that when the values of N′, N, and p are substituted for these quantities, the value of f deduced from the formula, is exactly the same as would be obtained for the elastic force of vapour at the same temperature, and under the same pressure, by the formula laid down in § 31. Hence it has been justly inferred that the vapour, in union or mixture with the gas, retains its own peculiar elasticity, and exerts the same tension as if no gas were present. This result furnishes by far the strongest argument which has yet been adduced, that vapour exists in air, not in a state of chemical union, but merely of mechanical mixture. In a hygrometrical point of view, this is a fact of the utmost importance, as it enables us to determine the precise volume which a mixture of vapour and dry air would occupy at a given temperature, and under a given pressure. All that is necessary is to determine f by the formula for calculating the elastic force of vapour at the given temperature, and then to substitute it for that quantity in the expression $f=p\left(\frac{N'-N}{N'}\right)$. We should thus obtain

$$N'=\frac{pN}{p-f}.$$

Expansion of air by the accession of vapour.

To illustrate this formula by example, let it be required to determine the enlargement of volume which dry air receives when saturated with vapour, at the temperature of 66° of Fahrenheit, and under a pressure of 30 inches of mercury. Since we wish to determine merely the relative increase of volume, N may be considered as unity; and $f_{66}=.63795$.

$$\text{Therefore } N'=\frac{pN}{p-f}=\frac{30}{30-.63795}=\frac{30}{29.36205}=1\tfrac{1}{46}.$$

Hence dry air at the temperature of 66° is, when saturated with moisture, expanded $\frac{1}{46}$ of its original bulk.*

43. The following Table constructed from the above formula, exhibits the dilatation of air by moisture, from 32° to 100°, under a pressure of 30 inches of mercury; and also the numbers by which the bulk of air, in a state of complete saturation with vapour, must be multiplied, in order to reduce it to its real volume, if it were deprived entirely of water. Its value in pneumatic researches will be duly estimated by the philosophical chemist.

Temperatures.	Increased volume, the original bulk being unity.	Multipliers.	Temperatures.	Increased volume, the original bulk being unity.	Multipliers.
32	1.0064	.99336	67	1.0225	.97803
33	1.0068	.99311	68	1.0232	.97730
34	1.0071	.99286	69	1.0240	.97654
35	1.0074	.99261	70	1.0248	.97577
36	1.0077	.99234	71	1.0257	.97497
37	1.0080	.99207	72	1.0265	.97415
38	1.0083	.99178	73	1.0274	.97330
39	1.0086	.99149	74	1.0283	.97243
40	1.0089	.99119	75	1.0293	.97153
41	1.0092	.99087	76	1.0303	.97060
42	1.0095	.99055	77	1.0313	.96998
43	1.0099	.99022	78	1.0323	.96867
44	1.0102	.98987	79	1.0334	.96766
45	1.0106	.98952	80	1.0345	.96662
46	1.0109	.98915	81	1.0357	.96555
47	1.0113	.98877	82	1.0369	.96445
48	1.0117	.98837	83	1.0381	.96331
49	1.0122	.98897	84	1.0393	.96215
50	1.0126	.98755	85	1.0406	.96094
51	1.0130	.98712	86	1.0420	.95971
52	1.0135	.98667	87	1.0434	.95844
53	1.0140	.98621	88	1.0448	.95713
54	1.0145	.98574	89	1.0463	.95579
55	1.0150	.98525	90	1.0478	.95440
56	1.0154	.98478	91	1.0493	.95298
57	1.0160	.98422	92	1.0509	.95152
58	1.0166	.98369	93	1.0526	.95002
59	1.0172	.98313	94	1.0543	.94847
60	1.0178	.98256	95	1.0561	.94688
61	1.0184	.98197	96	1.0579	.94525
62	1.0190	.98136	97	1 0598	.94357
63	1.0196	.98074	98	1.0617	.94185
64	1.0203	.98009	99	1.0637	.94007
65	1.0210	.97942	100	1.0658	.93825
66	1.0217	.97873			

Illustration of the Table by example.

To illustrate the use of the above Table† by example, let it be required to determine the enlargement of volume which a cubic foot of atmospheric air acquires by standing over water, when the temperature of the air is 70°, the barometrical pressure 29.23 inches, and the level of the water in the inside of the receiver 9.5 inches above its level on the outside.

The increased volume for the temperature 70° being 1.0248, the enlarged bulk of the air, under a pressure of 30 inches of mercury, is 1728 × 1.0248 or 1770.85 cubic inches. This accordingly would be the increased volume under that pressure; but the pressure being different, a corresponding correction must be applied to the result: in the first place, a column of water of the height of 9.5 inches is equivalent to a column of mercury of the height of .098 inches, the heights being

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* Saussure found by his experiments, that dry air at the temperature of 15°.16 Reaumur, or 66°.11 Fahrenheit, was expanded 1-54th, which is wonderfully near the truth, considering the manner in which it was determined.

† As the Table can only be applied with perfect accuracy, when the level of the water, in the outside and inside of the receiver, is exactly the same, the results afforded by the examples must be considered merely as near approximations.

inversely as their specific gravities; and, therefore, the actual pressure sustained by the air and the vapour, in the supposed circumstances, is equal to 29.25 — .098, or 29.152 inches of mercury; and, lastly, the expanded volume 1770.85 must be multiplied by $\frac{30}{29.152}$ to obtain its augmentation by the diminished pressure, which reduces it to 1822.36 cubic inches.

To propose an example of an opposite description, let it be required to find the actual volume of air contained in a receiver standing over water at the temperature of 60°, when the barometrical pressure is 30.45 inches, and the level of the water in the inside of the receiver eight inches above its level on the outside; supposing also the apparent quantity of air to be 850 cubic inches.

The multiplier in the table for the temperature 60° being .98256 the reduced volume, under a pressure of 30 inches, is $850 \times .98256$ or 835.176 cubic inches; and this result corrected for the pressure becomes $835.176 \times \frac{30.45 - .059}{30}$, or 846.061 cubic inches.

Additional experiments of Gay Lussac on the elasticity of vapour mixed with air in an attenuated state.

44. By means of the apparatus formerly described, Gay Lussac examined the tension of vapour when a smaller quantity of moisture was introduced into the cylinder AB, than was sufficient to saturate completely the space previously occupied by the air which it contained; and in all cases he found, that the elastic force of the vapour, in its attenuated state, was affected by variations of pressure, precisely in the same manner as permanently elastic fluids, the reduction of bulk which it sustained being always inversely proportional to the pressure. Thus, if N represent the bulk of the air, on introducing a single drop of water, the volume N was gradually enlarged to N′; and allowing a part of the mercury to flow out, until its surface in AB, and the bent tube TT′ was the same, the included air in mixture with the vapour was brought to the same pressure as at the beginning of the experiment. If an additional portion of mercury be now allowed to escape, the surface of the mercury in the bent tube descends below the surface of the mercury in the cylinder AB; so that if the difference of level be represented by h, the elastic force of the mixture of air and vapour will be $p-h$, the quantity p denoting, as before, the barometrical pressure at the time of the experiment. If the change of volume resulting from the change of pressure be now examined, it is found, in all cases, to be the same, as would be obtained with dry air; so that if N″ be the space occupied by the mixture in its new state of dilatation, we have, invariably,

$$\frac{N'}{N''}=\frac{p-h}{p}.$$

The elastic force of vapour inversely proportional to the reduction of volume by mechanical pressure.

45. To determine what change this result implies in the elastic force of the vapour, let f be the force which the mixture exerted when it occupied the space N′, and f' the force which it exerts under the volume N″; then since p is the pressure of the atmosphere, the elastic force of the air in the receiver, when, together with the vapour it occupied the space N′, must have been $p-f$, is now, on account of the enlargement of volume, reduced to $(p-f)\frac{N'}{N''}$. If to this elastic force of the air we add the elastic force of the vapour, we obtain for the elasticity of the mixture $f'+(p-f)\frac{N'}{N''}$; and, consequently,

$$f'+(p-f)\frac{N'}{N''}=p-h.$$

But it is found by experiment, that

$$\frac{N'}{N''}=\frac{p-h}{p}, \text{ or } p-h=p\left(\frac{N'}{N''}\right)$$

Therefore,

$$f'+(p-f)\frac{N'}{N''}=p\frac{N'}{N''}.$$

And, $f'=f\left(\frac{N'}{N''}\right)$.

This result, which has been deduced by Biot from the experiments of Gay Lussac, demonstrates what had been formerly stated by Dalton, that the elastic force of vapour, however attenuated the latter may be, changes in all cases with the volume, precisely in the same manner as that of the gases. Hence it may be concluded, that, so long as vapour retains the aëriform state, the quantity of it which can exist in mixture with air, is exactly the same as in a vacuum of equal extent, when the pressure and temperature are the same; and, therefore, the Table (§ 39.) which expresses the weight in grains of a cubic inch of vapour, from zero to 100° of Fahrenheit, may be applied with perfect accuracy to determine the weight of the moisture contained in a cubic inch of air, when the tensions or elasticities of both are the same. The only circumstance necessary for this application of the Table, so important to the purposes of hygrometry, is some means of ascertaining the elasticity of the vapour in admixture with the air. Mr Dalton has suggested one method of doing this, which is extremely simple, as well as susceptible of the greatest accuracy.

Method of determining the elasticity of vapour in mixture with air.

46. The method to which we have alluded, is founded on the principle, that if vapour, in an attenuated state, (that is, in a state such that the space which it occupies is capable of holding an additional portion of moisture in the vaporous condition,) be cooled down till it just begin to deposit itself in the form of dew, the volume to which it is then reduced must be completely saturated with moisture; and consequently the vapour in this reduced state must possess the same elasticity as unmixed vapour at the same temperature. In the case of the atmosphere, we can determine the temperature at which this deposition takes place, by presenting to it a body cooled down continuously from the temperature of the air, until its surface begins to be bedewed with moisture; and for this purpose, no contrivance seems more convenient than that proposed by Mr Dalton, which we shall now briefly describe.

47. Having taken a cylindrical glass vessel, Mr Dalton poured cold water into it, the temperature of which was gradually reduced by cooling mixtures when necessary. He then carefully watched, till he observed an incipient deposition of moisture on the surface of the jar; after which he examined the temperature the water, and assumed it as the temperature at which the moisture in the atmosphere would just be retained in a state of vapour. If a deposition of dew took place immediately, he allowed the jar to stand for some minutes to receive an increase of temperature, wiping it from time to time on the outside with a dry linen towel, till it entirely ceased to exhibit the appearance of moisture on its surface, and then examined the temperature of the water as before. If due precautions be employed, the temperature, at which the dew is formed on the surface of the jar, may be determined to the

fifth part of a degree of Fahrenheit. Let the temperature thus obtained be represented by τ, and let φ_τ be the corresponding elastic force of vapour at its maximum of solution; also let f' be the elastic force of the vapour, in the state of attenuation in which it actually exists in the atmosphere, at the temperature t; then since nothing more is necessary but to dilate this vapour from the temperature τ to the temperature t, in order to reduce it from the force φ to the force f',

$$f' = \varphi_\tau \left(\frac{1 + .002086\,\overline{t - 32}}{1 + .002086\,\overline{\tau - 32}} \right) = \varphi_\tau \left(\frac{447.4 + t}{447.4 + \tau} \right) =$$

$$\varphi_\tau \left(1 + \frac{t - \tau}{447.4 + \tau} \right)$$

Methods of finding the weight of the moisture in a given volume of atmospheric air.

48. Again, since the number of grains contained in a cubic inch of vapour at the temperature τ, and under a pressure of 30 inches of mercury is $\frac{.0068544\, \varphi_\tau}{1 + .002086\, \overline{\tau - 32}}$; and since $f' = \varphi_\tau \left(1 + \frac{t - \tau}{447.4 + \tau} \right)$; therefore if g' be the number of grains of moisture in a cubic inch of air, the temperature of which is t, and the point of deposition τ, and actual tension f',

$$g' = \frac{.0068544\, f'}{1 + .002086\, t} = \frac{3.2859\, f'}{447.4 + t}$$

$$\text{or } g = \frac{3.2859 \varphi_\tau}{447.4 + \tau}.$$

And if the pressure of the barometer be β,

$$g' = \frac{.10953\, \beta f'}{447.4 + t},$$

$$\text{or } g' = \frac{.10953\, \beta\, \varphi_\tau}{447.4 + \tau}.$$

To illustrate this formula by an example, let us suppose that when the temperature of the air is 65°, the point of deposition 54°, and the height of the barometer 29.5, it were required to find, in these circumstances, the number of grains of moisture in a cubic inch of air,

$$g' = \frac{.10953\, \beta\, \varphi_\tau}{447. + \tau} = \frac{.10953 \times 29.5 \times .42779}{447.4 + 54} = \overset{\text{grains.}}{.0027567}.$$

49. Another method of determining the value of f', and the corresponding value of g', may be derived from the formula of Mr Dalton, $\mathrm{E} = \frac{m}{30} \left(f_t - f' \right)$, in which E denotes the number of grains, evaporated in a minute, from the surface of water contained in a cylindrical vessel, 6 inches in diameter, and 1 inch deep; f_t the entire tension of vapour at the temperature of the air t; and f' the tension which it actually exerts. The coefficient m is different, in different circumstances: when the air is perfectly calm and tranquil, it is 120; in a moderate breeze, it amounts to about 150; and in a high wind it rises to upwards of 180. If we employ the mean 150, we obtain

$$\mathrm{E} = \frac{150}{30} \left(f_t - f' \right)$$

$$\text{or } \mathrm{E} = 5 \left(f_t - f' \right)$$

$$\text{Hence } f' = f_t - \frac{\mathrm{E}}{5}$$

These formulæ may be applied to the solution of several important problems in meteorology. Thus when the mean temperature and annual evaporation of a place are known, the formula $f' = f_t - \frac{\mathrm{E}}{5}$ will enable us to determine the mean state of the air of that place, with regard to moisture. Let us take for example the mean annual evaporation of Great Britain, which is reckoned about 24 inches; this in a minute would be ·00004563 inches, and applied to a cylindrical vessel 6 inches in diameter, would correspond to ·32587 grains.

Mean point of deposition for Great Britain.

$$\text{Hence } f' = f_t - \frac{\cdot 32587}{5}$$

And if we reckon the mean temperature 50°, and substitute for f_t the corresponding elastic force of vapour, taken from the table in § 31, we obtain,

$$f' = \cdot 37345 - \frac{\cdot 32587}{5} = \overset{\text{inches.}}{\cdot 308276}$$

Having found f' the number of grains corresponding to that tension, at the temp. 50°, may be found by the formula for determining g in § 38: we thus have

$$g' = \frac{3.2859\, f'}{447.4 + t} = \frac{3.2859 \times \cdot 308276}{447.4 + 50} = \overset{\text{grains.}}{\cdot 00203652}$$

It will be found by the table that this number of grains corresponds to 44°.1, which, in the present case, is the mean temperature at which moisture will begin to deposit itself in Great Britain; that is, about 6° below the mean temperature, [*]

50. The value of g' might have been found without having recourse to the formula $g' = \frac{3 \cdot 2859\, f'}{447 \cdot 4 + t}$, by taking a proportional part of the weight of moisture, held in the vaporous state, at the entire tension of 50°, corresponding to the actual tension ·308276. Thus the entire tension at 50°, being ·37345 inches, and the weight of the corresponding quantity of moisture, in the vaporous state, ·00246714 grains, we have

$$\overset{\text{inches.}}{\cdot 37345} : \overset{\text{inches.}}{\cdot 308276} :: \overset{\text{grains.}}{\cdot 00246714} : \overset{\text{grains.}}{\cdot 00203652}$$

Mean point of deposition for a place near the equator.

If we take the mean annual evaporation of a place near the equator, the mean point of deposition is found to be nearly the same number of degrees below the mean temperature, as we have determined it in the case of Great Britain. Thus at Whydah, on the coast of Africa, the mean temperature of which by the formula, $t = 58° + 27$ cos. 2 Lat. is 84°·2, the mean annual evaporation is stated at 64 inches, or at the rate of ·86899 grains per minute from the disc of Mr Dalton; and hence

$$f' = f_t - \frac{\mathrm{E}}{5} = f_{84 \cdot 2} - \frac{\cdot 86899}{5} = 1 \cdot 14279 - \cdot 173798 = \overset{\text{inches.}}{\cdot 968992}$$

By proceeding as before, the number of grains corresponding to a cubic inch of vapour, under the tension .968992 inches, and at the temperature 84°.2, will be found to be .00598944, which corresponds to the quantity of moisture, in a cubic inch of vapour, for the entire tension of 78°.6; so that, at Whydah, the mean point of deposition is 5°.6 below the mean temperature. It seems probable, from these results, that the mean point of deposition, for any place, is about 6° below the mean temperature; though we admit, observations are

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[*] Dr Dobson found by observation, that the mean temperature of deposition, at Liverpool, was 7° below the temperature of that place.

still wanting to warrant so general a conclusion. Mr Dalton affirms, that the point of deposition is generally from 1° to 10° below the mean heat of the 24 hours; we have usually found it to be from 6° to 7°. *

Mean annual evaporation in different latitudes.

51. The following formula, which we have deduced on the supposition that the mean point of deposition is 6° below the mean temperature, seems to agree pretty well with observation. Let t be the mean temperature; f_t the entire force of vapour corresponding to t; and φ_τ the entire force of vapour corresponding to the temperature τ, or $t-6$; then if A be the mean annual evaporation in inches,

$$A = 365\left(f_t - \varphi_\tau\left(1 + \frac{t-\tau}{447.4+\tau}\right)\right).$$

The mean daily evaporation, for any place, according to this formula, is $f_t - \varphi_\tau\left(1 + \frac{t-\tau}{447.4+\tau}\right)$, or nearly $f_t - \varphi_\tau$.

Let it be required to find, by it, the mean annual evaporation, at a place in Lat. 45°, the mean temperature of which is 57°.

$$A = 365\left(f_t - \varphi_\tau\left(1 + \frac{t-\tau}{447.4+\tau}\right)\right) =$$

$$= 365\left(f_{57} - \varphi_{51}\left(1 + \frac{57-51}{447.4+51}\right)\right) =$$

$$= 365\,(.47328 - .3864 \times 1.012) = \overset{\text{inches.}}{30.02}.$$

For the purposes of calculation, the expression may be reduced to the approximated, but more commodious form, $A = 365\left(f_t - \frac{81}{80}\varphi_{t-6}\right)$.

By means of this formula, we have deduced the following Table, which expresses the mean annual and daily evaporation, from the equator to either pole, for the different parallels of latitude, at the interval of 5°. The mean annual temperature corresponding to each latitude, was derived from Meyer's formula.

Latitude.	Mean Temp.	Mean Evaporation in inches.		Diff. in yearly evap. for every 5° diff. lat.
		Daily.	Yearly.	
0	85	.18938	69.10	
5	84.6	.18717	68.32	.78
10	83.4	.18085	66.01	2.31
15	81.4	.17073	62.32	3.69
20	78.7	.15786	57.62	4.70
25	75.4	.14133	52.32	5.30
30	71.5	.12769	46.61	5.71
35	67.2	.11222	40.96	5.65
40	62.7	.09785	35.72	5.24
45	58.	.08463	30.89	4.83
50	53.3	.07312	26.71	4.18
55	48.8	.06327	23.09	3.62
60	44.5	.05517	20.14	2.95
65	40.6	.04860	17.74	2.40
70	37.3	.04362	15.92	1.82
75	34.6	.03990	14.56	1.36
80	32.6	.03732	13.62	.94
85	31.4	.03584	13.09	.53
90	31.	.03537	12.91	.18

The last column contains the differences of the mean annual evaporation corresponding to every 5° of difference of latitude. These appear to increase, according to some regular law, from the pole to the parallel of 30°; after which they begin to diminish, and continue to decrease to the equator. The greatest differences take place near the limits of the trade winds. Hence it might be inferred, that the most copious depositions of moisture should occur a few degrees on either side of the tropics.

The point of deposition coincides nearly with the minimum temperature for the season.

52. As the temperature of every place, for the whole year, ranges between two extreme points corresponding to the alternations of summer and winter; so it exhibits every 24 hours, a corresponding difference with respect to the vicissitudes of day and night. In the case of the daily change of temperature there is some interval between the *maximum* and the *minimum*, which may be regarded as the temperature belonging to the season of the year; and, though this point will not always be a mean between these extremes, it will in general approach very near it. If this mean temperature were to rise and sink regularly, as the season advanced and declined, without being subject to daily fluctuation, the quantity of moisture which could exist in the atmosphere, at any given time, might be determined with the utmost precision; since nothing more would be necessary for that purpose, than to calculate the maximum quantity of vapour for the temperature, by the formula in § 39. A variety of causes, however, which are too complicated in their nature to admit of being reduced under any general law, (but of which the vicissitude of day and night is the principal,) continually conspire to raise and depress, by turns, the temperature of every place above or below its mean level for the season; and hence the quantity of moisture in the atmosphere will generally be less than the quantity corresponding to the mean temperature, but at all times nearly equal to that belonging to the minimum temperature. If it be less than the latter quantity, the process of evaporation will gradually supply the deficiency; if it be greater, the excess will quickly be precipitated in the form of dew, rain, or snow, according to the temperature, and the extent of its depression, below the minimum temperature.

In short, the mean point of deposition, which we formerly represented by τ, and for which φ_τ is the corresponding elastic force of vapour, must be nearly the same as the minimum temperature of any place on any given day.

It appears by the following observations, extracted from the meteorological journal for 1815 kept by the Rev. Mr Gordon of Kinfauns, that the minimum temperature of Perth, and consequently the mean point of deposition for that place, is about 6° below the mean temperature, thus coinciding very nearly with the result formerly deduced from theory, as the mean point of deposition for Great Britain and the globe in general.

In the following Table, the depression of the minimum temperature below the mean temperature for each month, has evidently some relation to the indications of Leslie's hygrometer. This relation will be better understood, after we have explained more particularly the manner in which that instrument is affected by the elasticity of the vapour existing in the atmosphere; at present we shall only remark, that as observations made with any hygrometer are of very little value, unless the

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* The mean point of deposition might also be ascertained, in a general way, by the mean height of the clouds, and the rate of the diminution of temperature as we ascend in the atmosphere.

temperature at the time be given, we have inserted in the last column the mean temperature of the air when the observations were taken.

Months.	Minimum Temperature.	Mean Temperature by four Observations.	Depression of Minimum below mean Temperature.	Monthly mean of Leslie's Hygrometer by three daily observations.	Temperature.
January	28.484	31.903	3.419	4.9	33
February	35.661	39.946	4.285	8.1	42
March	34.855	40.229	5.374	14.7	43
April	36.916	44.616	7.700	23.1	47
May	45.451	51.976	6.525	23.0	54
June	48.950	56.366	7.416	29.7	59
July	50.306	58.125	7.819	32.0	61
August	50.855	57.761	6.906	27.7	60
September	46.900	53.304	6.404	20.3	55
October	42.645	47.278	4.633	12.2	49
November	31.383	36.333	4.950	7.8	38
December	27.790	31.927	4.137	6.5	33
	479.196	548.764	69.568	210.0	57.4
Mean annual results.	39.933	45.730	5.797	17.5	47.8

Reason of the increased humidity of night air.

53. From what we have stated respecting the mean minimum temperature, it may be inferred, that since the quantity of moisture in the atmosphere must at all times be nearly equal to the maximum quantity of it, that can be maintained in the vaporous state at that temperature, a depression of a few degrees below it must in general be accompanied with a deposition of moisture in some form or other. Hence we can perceive the reason why the air becomes damper towards evening; and why more rain falls during the night than during the day.

Relation between the humidity of the air, and the diminution of temperature by evaporation.

54. The law by which evaporation is regulated, in a medium either absolutely dry or partially occupied with vapour, will enable us to investigate the relation subsisting between the diminution of temperature induced by that process, and the humidity of the ambient air. For, since we have shewn, under the article EVAPORATION, that water, during its transition into the state of vapour, absorbs 898° of caloric; and consequently, that the evaporation of about the 900th part of a given portion of that fluid would depress the temperature of the whole mass one degree, provided it had no communication with the surrounding bodies; and moreover, since the quantity of water evaporated, in the same circumstances, is proportional to f_t-f', it follows that the cold produced by evaporation must be a function of the same quantity. Therefore if D represent the reduction of temperature by evaporation, from the moistened bulb of a thermometer, covered with some bibulous substance; f_t the entire force of vapour for the temperature of the air t; and f' the force of the vapour actually existing in the atmosphere, we may evidently have an equation of the form, $D=m(f_t-f')$, in which m is a constant co-efficient to be determined by experiment, and modified afterwards, if necessary, by a correction depending on the diminished temperature of the evaporating surface.

55. The conditions implied in this equation, will receive considerable illustration, by representing, in a more palpable form, the different quantities concerned, by means of a diagram. Let AC, therefore, represent the temperature of the air, and consequently the temperature also of the covered thermometer, before moisture is applied to it; let the line AT represent the time reckoned from A, the parts AD, DD′, &c. being equal intervals; then, the bulb being moistened, if DE denote the reduction of temperature produced by evaporation in the time AD, and D d (some part of DE) the proportional quantity of heat which flows into the covered ball in the same time; since the reduction of temperature depends upon the constant quantity f_t-f', the bulb of the thermometer would cool uniformly, and to an indefinite degree, were it not for the incessant influx of caloric, which being always the same proportional part of the excess of the temperature of the air above that of the covered ball, gradually increases until BH (which is the same part of BG that D d is of DE,) becomes equal to DE. The diminution of temperature by evaporation being now exactly counterbalanced by the influx of heat from the contiguous air, the cooling process attains its utmost limits; and GH represents the difference between the temperature of the air and that of the covered thermometer, which henceforth continues stationary.

Explanation of the manner in which a reduction of temperature takes place in a thermometer with a moistened bulb. PLATE CCCXXVI. Fig. 2.

56. It must be evident, however, from the view we have taken of the cooling process, that a thermometer with a moistened bulb ought to be reduced through the same number of degrees in equal times, and thus reach the maximum of effect in a sudden and abrupt manner, —a supposition which is neither consistent with the law of continuity, nor conformable to observation: for, though the diminution of temperature is at first nearly uniform, the effect gradually diminishes as the process advances, and the differences, becoming every instant smaller and smaller, are at last altogether evanescent. The cause of this deviation from the state of things we at first supposed, is to be ascribed to the diminished evaporation arising from the cooling of the moistened surface; so that the reduction of temperature in the first interval of time, instead of being represented by E d, the difference between DE and D d, will properly be represented by de, the minute quantity E e being so taken, as to represent the diminished effect occasioned by the reduction of temperature already induced. In like manner, the total effect, instead of being accurately represented by HG, will be represented by H g; and the curve A g will thus exhibit the march of the thermometer from the beginning to the end of the process. The intervals A d, $d d'$, &c. will still represent equal portions of time; and the perpendiculars de, $d'e'$, &c. the reduction of temperature at the end of those times. A tangent to the curve at g will be parallel to AH,—a condition which is necessary to prevent a violation of the law of continuity.

57. It may be inferred from this graphical delineation, that since the extent of the evaporation, together with the reduction of temperature which it occasions, is diminished by the cooling of the evaporating surface, the expression $D=m(f_t-f')$ will require some correction; and as this correction must have a direct relation to D, the simplest way of applying it, is to give the equation the form,

$$D-\frac{D}{n}=m(f_t-f'),$$

$$\text{Hence } \left(\frac{n-1}{m\,n}\right)D=f_t-f'.$$

The co-efficients *m* and *n* being two constant quantities to be determined by experiment, the equation will resume the simplicity of its original form, by supposing $\frac{m\,n}{n-1} = p$; we thus have, $D = p\,(f_t - f')$. This equation, however, will only express the value of D by a near approximation. To render the expression consistent with the properties of the curve, whose ordinates represent the progressive reductions of temperature by evaporation from the moistened bulbs, it seems necessary to give it the form,

$$D = \left(p - \frac{D}{r}\right)(f_t - f').$$

Investigation of a formula for Leslie's hygrometer.

58. The co-efficients *p* and *r*, particularly the former, being important elements in any equation which should express the quantity of moisture contained in the atmosphere, in terms of f_t, f' and D, we instituted a series of the most laborious experiments to determine their values with accuracy. For this purpose we had recourse to Mr Dalton's method of finding the point of deposition, whose elastic force we formerly denoted by φ_τ; and, from the precautions we observed, we have reason to think, that our experiments were calculated to determine that point within the fifth part of a degree of Fahrenheit. We generally employed two jars of a cylindrical shape, one of glass, and the other of tin-plate. Each of them was about eight inches deep, and six inches in diameter; it being convenient to have them of a considerable size, that their temperature, when they are filled with cold water, may not be raised too quickly by the superior temperature of the surrounding bodies. We also used occasionally, for the same purpose, a vessel of silver, which, on account of its resplendent surface, is admirably fitted to shew the slightest deposition of moisture on it. These vessels were filled with water, cooled down several degrees below the point of deposition, and placed near one another on a table, at a sufficient distance from the thermometers employed to indicate the temperature of the air *t*, and the point of depression of the moistened bulb produced by evaporation. The experiments were generally performed in a large octagonal apartment, about 50 feet in diameter, and 30 feet high; and in order that the smallest deposition of moisture might be perceptible, the jars were observed at the distance of 15 feet with a powerful telescope. By this means, when no sensible deposition appeared to the naked eye however closely the jars were examined, the drops of moisture, which formed on their surfaces, were so much magnified, as to be seen increasing gradually in size. The jars were wiped from time to time with a clean dry towel; but unless this operation was performed with the utmost care, the telescope discovered large tracts of moisture, which could not be discerned without its assistance. The state of the thermometers was accurately observed at the same time, and a rotatory motion frequently given to the water. When the deposition of moisture on the surface of the jars was no longer perceptible, the temperature of the different thermometers was carefully noted. Sometimes the temperature of the water in the jars was again reduced, by stirring bits of ice in it till it was lowered a degree or two below the point of deposition, to remove all chance of error, and ascertain the limits within which it might range. The difference in the result seldom exceeded the fourth part of a degree. It is proper also to remark, that the point of deposition, as determined by the different jars, was always the same.

59. The temperature of the air at the time of these experiments was observed with two excellent mercurial thermometers, one of which was made by Jones, and the other by Adie; and the temperature of the water in the jars was determined by a good thermometer of Crichton. The reduction of temperature produced by evaporation was ascertained by two mercurial thermometers; two thermometers filled with spirit of wine, and covered with moistened tissue paper; and two hygrometers of Mr Leslie. One of the mercurial thermometers possessed the utmost delicacy, and had a range of scale, which easily gave the 10th part of a degree. The largest of the spirit of wine thermometers had a bulb 2⅝ inches in diameter; and its tube, which was two feet long, included a range of scale from 32° to 60°. This instrument, on account of its size, and the great capacity of alcohol for caloric, was more slowly reduced in its temperature than the other thermometers with covered bulbs; but, after a certain lapse of time, all of them became stationary nearly at the same point, the difference never exceeding a small fraction of a degree. It is easy to perceive, indeed, that whether the thermometrical ball be large or small, the inclosed fluid, whatever it may be, must ultimately reach the same temperature; for since the quantity $f_t - f'$, which regulates the evaporation, is constant, the evaporation must always cool down the moistened surface to the same pitch, and thus gradually abstract heat from the thermometrical fluid, precisely in the same manner as if the bulb consisted entirely of water, (due allowance being made for the difference of capacity for caloric,) until the reduction of temperature is counterbalanced by the influx of heat from the air. If the specific heat of the inclosed fluid be great, the process will be longer in producing its maximum of effect; but the diminution of temperature by evaporation, and the influx of heat by communication, being in all cases to each other in the same constant ratio, the reduction of temperature must be always the same. Hence the diminution of temperature indicated by Leslie's hygrometer invariably corresponds to that of the most sluggish thermometer, with a moistened bulb.

Influence of atmospherical pressure on evaporation.

60. To determine what influence the atmospherical pressure might have on these results, Leslie's hygrometer, having its bulb duly moistened, was placed with a quantity of sulphuric acid in a cup, under a large receiver, on the plate of an air-pump, and allowed to remain till it became stationary. In a few minutes it sunk down to 26°; the temperature at the time being 48½°, and the atmospherical pressure 29.6. The air was then exhausted till the gauge stood successively at 6, 12, 18, and 24 inches, when the following results were obtained:

Height of the gauge in inches of mercury.	Pressure.	Degrees of Leslie's hygrometer.
0	29.6	27
6	23.6	34
12	17.6	44
18	11.6	62
24	5.6	91

From these experiments it may be safely inferred, that within the limited range of atmospherical pressure, the evaporation from the moistened bulb of a thermometer is inversely proportional to the height of the barometer. This conclusion might, indeed, have been drawn from the fact, that the evaporation from the surface of water is, in all cases, proportional to $f_t - f'$; since the mechanical influence of pressure must be the same, whether resulting from the elasticity of air or vapour. Hence our formula $D = \left(p - \frac{D}{r}\right)(f_t - f')$ corrected for atmospherical pressure, becomes

$$D = \frac{30}{\beta}\left(p - \frac{D}{r}\right)(f_t - f').$$

It now only remains, therefore, to determine the co-efficients p and $\frac{1}{r}$; and for this purpose two equations are necessary.

61. In one of the experiments which we made to ascertain the necessary data, when the barometer stood at 29.75, Leslie's hygrometer at 85°, and De Luc's at 27°.6, the temperature of the air was 67°.2, that of the thermometers with moistened bulbs 52°, and the point of deposition 35°.7. We thus have

$$f_t = f_{67.2} = .66357 \quad \text{- - - - - - - -} \quad \S\ 31.$$

$$\varphi_\tau = \varphi_{35.7} = .22723 \quad \text{- - - - - - - -} \quad \S\ 31.$$

$$f' = \varphi_\tau\left(\frac{447.4 + t}{447.4 + \tau}\right) = .24223 \quad \text{- - - - - -} \quad \S\ 47.$$

$D = 67.2 - 52 = 15.2$ by the covered thermometers,

or $D = 85 \times \frac{9}{50} = 15.3$ by Leslie's hygrometer § 25.

$$D = \frac{15.2 + 15.3}{2} = 15^\circ.25, \text{ using the mean.}$$

The values of f_t, f', and D being substituted in the general equation $D = \left(p - \frac{D}{r}\right)(f_t - f')$, we obtain

$$15.25 = \frac{30}{29.75}\left(p - \frac{15.25}{r}\right)(.66357 - .22723)$$

$$\text{And } p - \frac{15.25}{r} = 34.66$$

$$\text{or } p = 34.66 + \frac{15.25}{r}$$

In another experiment of the same kind, when the barometer stood at 30.025, Leslie's hygrometer at 38°.3, and De Luc's at 42°, the temperature of the air was 56°.42, the temperature of the thermometers with moistened bulbs 49°.51, and the point of deposition 39°.5. From these data we have,

$$f_t = f_{56.42} = .46421$$

$$\varphi_\tau = \varphi_{39.5} = .25981$$

$$f' = \varphi_\tau\left(\frac{447.4 + t}{447.4 + \tau}\right) = .26895$$

$D = 56.42 - 49.51 = 6.91$, by the covered thermometers.

$D = 38.3 \times \frac{9}{50} = 6.89$, by Leslie's hygrometer.

Using the mean $D = \frac{6.91 + 6.89}{2} = 6.9.$

Hence we have by substitution, as before,

$$6.9 = \frac{30}{30.025}\left(p - \frac{6.9}{r}\right)(.46421 - .26895)$$

$$\text{And } p = 35.34 + \frac{6.9}{r}$$

$$\text{But } p = 34.66 + \frac{15.25}{r}$$

Therefore $p = 35.9$, and $r = 12.3$.

Formula for the force of vapour actually existing in the atmosphere.

62. It appeared by the mean result of a very great number of experiments, performed with the utmost care, and in various states of the air with regard to pressure, temperature, and humidity, that the value of p must be greater than 35.5, but less than 36.5. The value of r embraced a wider range, and varied from 5 to 15; it is obvious, however, from the nature of the equation, that p is the more important of these co-efficients, and that the value of D can be but slightly affected by any change in the value of r. We cannot err greatly, therefore, if we take 36 for the value of p, and 10 for that of r. The formula $D = \frac{30}{\beta}\left(p - \frac{D}{\beta}\right)(f_t - f')$ will thus become

$$D = \frac{30}{\beta}\left(36 - \frac{D}{10}\right)(f_t - f')$$

$$\text{And } f' = f_t - \frac{\frac{\beta}{30}D}{36 - \frac{1}{10}D}$$

$$\text{Or } f' = f_t - \frac{\frac{1}{6}\beta D}{180 - \frac{1}{2}D}$$

This formula will enable us to find, by means of the Table in § 39, the absolute quantity of moisture contained in the atmosphere, when the pressure of the barometer, the temperature of the air, and that of a thermometer having its bulb covered with moistened paper, are given. Thus, let it be required to find the quantity of moisture contained in a cubic inch of air, when the barometrical pressure is 29.35, the temperature of the air 65°, and the temperature of a thermometer with a moistened bulb 51°.5.

$$f' = f_t - \frac{\frac{1}{6}\beta D}{180 - \frac{1}{2}D} = f_{65} - \frac{\frac{1}{6} \times 29.35 \times 13.5}{180 - 6.75} =$$

$$= .61734 - .38116 = .23618$$

And by § 50,

$$\overset{\text{in.}}{.61734} : \overset{\text{in.}}{.23618} :: \overset{\text{grains.}}{.00395897} : \overset{\text{grains.}}{.0015146}$$

Hence, in the supposed state of things, there is .0015146 gr. of moisture in a cubic inch of air, which would correspond to 35°, as the point of deposition. The point of deposition by actual observation was 35°.45; and De Luc's hygrometer stood, at the time, at 27°.

63. If we substitute the value of f' for F_t in the formula $g' = \frac{.10953\,\beta\,F_t}{474.4 + t}$, (as laid down in § 40.) we obtain

Formula for the quantity of moisture in a cubic inch of air.

$$g' = \frac{.10953\left(f_t - \frac{\frac{1}{6}\beta\ D}{180 - \frac{1}{2}D}\right)\beta}{447.4 + t}$$

This expression will accordingly give the weight in grains, of the moisture in a cubic inch of air; when f_t, the entire force of vapour for the temperature of the air t; D, the difference of the temperature between a naked thermometer, and one with a moistened bulb covered with tissue paper; and β, the height of the barometer, are known. The value of f_t is obtained by the Table in § 31; and that of D and β by observation.

Application of the formula to Leslie's hygrometer,

64. The manner in which the formula is expressed, renders it capable of being easily reduced to the different graduations of the thermometrical scale. Thus if D be expressed in degrees of Leslie's hygrometer, since the interval between the freezing and boiling points in that instrument is divided into 1000 equal parts, if L denote the number of degrees which it indicates,

$$g' = \frac{.10953\left(f_t - \frac{\frac{1}{6}\beta\,\mathrm{L}}{1000 - \frac{1}{2}\mathrm{L}}\right)\beta}{447.4 + t}$$

And in the centigrade scale,

and the centigrade scale.

$$\mathrm{P}' = \frac{1.066495\left(f_t - \frac{\frac{1}{6}\beta\,\mathrm{D}}{100 - \frac{1}{2}\mathrm{D}}\right)\beta}{1 + .00375\,t}$$

P′ being the weight in grammes of the moisture in a litre of air, and β the height of the barometer in metres.

Methods employed by Mr Leslie to find the quantity of moisture in the air, in terms of the degrees of his hygrometer.

65. As the conclusions which Mr Leslie has deduced from his experiments, lead to results differing in some respects from those we have obtained, it may be proper to give a brief account of the mode of investigation he adopted. This is the more necessary, as he expressly mentions that two different methods led to the same results. "One of these methods," to use his own words, "was in a large close room, to bring an hygrometer, conjoined with a thermometer, successively nearer to a stove intensely heated, and to note the simultaneous indications of both instruments; or to employ two nice thermometers placed beside each other, and having their bulbs covered respectively with dry and with wet cambric. By taking the mean of numerous observations, and interpolating the intermediate quantities, the law of aqueous solution in air was laboriously traced. But the other method of investigation appeared better adapted for the higher temperatures. A thin hollow ball of tin, four inches in diameter, and having a very small neck, was neatly covered with linen, and being filled with water nearly boiling, and a thermometer inserted, it was hung likewise in a spacious close room, and the rate of its cooling carefully marked. The experiment was next repeated, by suspending it to the end of a fine beam, and wetting with a hair pencil the surface of linen, till brought in exact equipoise to some given weight in the opposite scale. Ten grains being now taken out, the humid ball was allowed to rest against the point of a tapered glass tube, and the interval of time, with the corresponding diminution of temperature, observed when it rose again to the position of equilibrium. The same operation was successively renewed; but as the rapidity of the evaporation declined, five, and afterwards two grains only, were, at each trial, withdrawn from the scale. From such a series of facts, it was easy to estimate the quantities of moisture which the same air would dissolve at different temperatures, and also the corresponding measures of heat expended in the process of solution. By connecting the range of observations," continues Mr Leslie, "it would appear, that air has its dryness doubled at each rise of temperature, answering to 15 centesimal degrees. Thus at the freezing point, air is capable of holding a portion of moisture represented by 100 degrees of the hygrometer; at the temperature of 15 centigrade, it could contain 200 such parts; at that of 30°, it might dissolve 400; and at 45° in the same scale 800. Or, if we reckon by Fahrenheit's divisions, air absolutely humid, holds at the limit of congelation the hundred and sixtieth part of its weight of moisture; at the temperature of 59° the eightieth part; at that of 86° the fortieth part; at that of 113° the twentieth part; and at that of 140° the tenth part. While the temperature, therefore, advances uniformly in arithmetical progression, the dissolving power which this communicates to the air mounts with the accelerating rapidity of a geometrical series."

Discrepancy between Mr Leslie's conclusions and the law of aqueous solution determined by our investigations.

66. Before we examine the results of these experiments, which we have no doubt were conducted with every attention to accuracy, we may state, that the conclusion which has been drawn from them respecting the law of aqueous solution, is totally irreconcileable with the results obtained by Dalton and Gay Lussac. This will appear, by comparing the weight of a cubic inch of vapour for the various temperatures, in Table § 31, deduced from their experiments; and according to which, the solving power follows a different law from that stated by Leslie, though chiefly, we believe, on account of its simplicity, it is the one generally admitted. It will be seen by the following Table, that if the temperatures be taken in an arithmetical progression, the quantities of moisture held in solution, form a succession of quantities, the terms of which increase in a faster ratio than the terms constituting a geometrical series.

Quantity of Moisture in Solution.	Successive Temperatures at which the solving Power is doubled.	
	According to Leslie.	By our Table.
100	32	32.
200	59	53.2
400	86	75.6
800	113	99.4

Rate at which the solving power increases.

According to the experiments of Leslie, the solving power is doubled every 27 degrees; whereas, according to our Table, this takes place at different intervals, which increase slowly with the temperature, the mean being 23.4 from the freezing point to 100° of Fahrenheit.

Comparative results, as deduced by Mr Leslie's method and our formula.

67. We shall now compare the result furnished by our formula, with that derived by Mr Leslie from his mode of determining the point of deposition; and we shall take the example from his Treatise on the Relations of Air to Heat and Moisture. "Suppose," says he, "the hygrometer to mark 52°, while its wet ball has a temperature of 20 centesimal degrees, or 68° by Fahrenheit; the dissolving power of air at this temperature being 252,* its distance from absolute humidity will therefore be 200, which is the measure of solution answering to 15 centesimal degrees, or 59° by Fahren-

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* Mr Leslie does not describe how this number is obtained; but it is obviously, according to his views, the tenth term of a geometrical series, of which the first term is 200, the last term 400, and number of terms 26.

heit. The same air would consequently, at the depressed temperature of 59°, shrink into a state of absolute saturation; and if cooled lower, it would even deposit a portion of its combined moisture, losing the eightieth part of its weight at the verge of freezing." Such is the result deduced by Mr Leslie. We shall now compare it with the weight of the moisture in a cubic inch of air, as determined by our formula. The moistened ball having a temperature of 68°, while it indicates 52, the temperature of the air t is $68° + \frac{9 \times 52}{50}$, or 77°.2; the height of the barometer is not taken into account, but we shall suppose it 30. We thus have,

$$g' = \frac{.10953\left(f_{77.2} - \frac{5 \times 52}{1000 - \frac{s}{2}}\right) \times 30}{447.4 + 77.2} =$$

$$= \frac{.10953 \times \overline{.91631 - .26694} \times 30}{524.6} = .00\overset{\text{grains.}}{40}675$$

The point of deposition different, but the absolute quantity of moisture nearly the same, by the two methods.

This result would correspond by the Table to 66° nearly, being 7° higher than the point of deposition found by Mr Leslie. The absolute quantity of moisture, however, in a cubic inch, as deduced by his method, agrees very nearly with the result given by our formula. According to his view, air absolutely humid holds at the temperature of 59°, the eightieth part of its weight of moisture; now a cubic inch of atmospheric air, at the same temperature, weighs .3121 grains, and the eightieth part of that quantity is .00390125 grains, which being corrected for the actual temperature of the air, 77°.2, becomes .0037602 grains, differing very little from the quantity given by the formula. In general, the coincidence of result is still more striking.

68. The method which Mr Leslie employed to determine the relation between the degrees denoted by his instrument, and the absolute quantity of moisture in the atmosphere, is very ingenious, though on account of the necessity of employing logarithms, for the interpolation of the terms of the series in which that relation is expressed, it must often be attended with a good deal of trouble and inconveniency. By comparing the relative capacity of air for caloric, with the measure of heat requisite to convert a given portion of water into vapour, he concluded that atmospheric air, at the temperature of the moistened ball, would take up the 16,000th part of its weight for each degree marked by the hygrometer. He was led to this conclusion, by assuming, from several concurring observations, that the capacity of air for caloric was $\frac{1}{2}$ of that of water, being only a fifth part of what it is usually reckoned; and as the quantity of caloric necessary to convert water into steam is equal to 6000 degrees of his instrument, that measure of heat would suffice to raise an equal mass of air, 16000 millesimal degrees, or those 6000 degrees increased in the proportion of 8 to 3. But, according to the view taken by Mr Leslie at the state of equipoise, the portion of heat deposited by air in touching the moistened bulb, or the depression of temperature which it suffers by this contact, is equal to the opposite measure of heat abstracted by it, on dissolving its corresponding share of moisture. Wherefore, he concludes, at the temperature of the wet ball, atmospheric air would take up moisture amounting to the 16,000th part of its weight, for each degree marked by the hygrometer.

Objections to Mr Leslie's views respecting the nature of the evaporating process.

69. This view of the relation subsisting between the evaporating process, and the reduction of temperature which it induces, is somewhat different from the one we have taken in § 54. According to the explanation we have there given of that relation, the heat necessary for converting the moisture applied to the bulb, into the state of vapour, is derived immediately from the water itself, at the moment the vapour is disengaged from its surface. The water having thus lost a portion of its heat, instantly abstracts caloric from the bulb, and the bulb, in its turn, from the inclosed thermometrical fluid, until an equilibrium is established by the influx of heat from the air, counterbalancing the dispersion of it by evaporation. The heat of the air is therefore imparted to the ball, merely by absorption; and sets limits to the progress of refrigeration, by the increasing rate at which it flows into the cooling surface, as the temperature of that surface recedes from the temperature of the air. This view of the subject is equally applicable to vaporization, whether the process be carried on in the open air, or under an exhausted receiver; and it is finely illustrated by the result of an experiment which we have described under the article Evaporation, p. 220, and which demonstrates that the caloric necessary for the formation of vapour is derived almost entirely from the water itself, and scarcely at all from the contiguous bodies. In short, we cannot perceive how Mr Leslie's hypothesis can afford an explanation of the great reduction of temperature which is produced by evaporation under an exhausted receiver, where, according to his opinion, there is no solvent present to convert the water into vapour. He speaks, indeed, of air having its scale of watery solution extended by rarefaction; but this is merely a gratuitous accommodation of fact to theory, and does not at all explain why the greatest solution takes place, when the supposed solvent is most deficient in quantity, or entirely excluded. At the same time, it must be admitted, that the results which he has deduced from the theoretical view he has taken of his hygrometer, accord remarkably well with the quantity of moisture in the air, as determined by actual experiment.

Confirmation of the coincidence between the point of deposition and the minimum temperature.

70. In a preceding part of this article, (§ 52.) we endeavoured to shew that the point of deposition for any place must, in general, coincide nearly with the minimum temperature for the season. The truth of this opinion is amply confirmed by applying our formula, for Leslie's hygrometer, to the very accurate observations made with that instrument by Mr Gordon, to which we formerly adverted. The point of deposition assigned by the formula, will be found in the following Table to correspond almost exactly with the mean minimum temperature for each month, by actual observation. The coincidence is greatest, as might be expected, when the temperature of the season is declining, and least liable to sudden changes. The barometrical pressure was introduced into the formula.

1815.	Degrees of Leslie's Hygrom. by 3 daily observ.	Temper. at time of observations.	Mean Height of Barom. by two daily observ.	Mean Minimum temp.	Point of Deposition by formula.	Grains of moisture in a cubic inch of air.	Rain, in inches.
January	4.9	33	29.808	28.5	29.1	.001238	0.945
February	8.1	42	29.552	35.7	36.8	.001612	2.007
March	14.7	43	29.407	34.9	33.8	.001451	1.990
April	23.1	47	29.834	36.9	33.9	.001458	0.999
May	23.0	54	29.741	45.5	44.3	.002050	2.334
June	29.7	59	29.794	48.9	47.9	.002304	0.871
July	32.0	61	29.977	50.3	49.7	.002444	1.743
August	27.7	60	29.707	50.9	49.9	.002463	1.324
September	20.3	55	29.793	46.9	46.7	.002214	2.193
October	12.2	49	29.701	42.6	42.9	.001967	3.362
November	7.8	38	29.788	31.4	32.6	.001396	1.643
December	6.5	33	29.599	27.8	27.9	.001177	1.343
Annual Results	17.5	48	29.725	40	39.6	.001814	20.754

The difference between the point of deposition determined by the formula, and the mean minimum temperature for each month, of the particular year in which these observations were made, scarcely ever exceeds half a degree, except in April. The great difference in that month seems to be owing, partly to the copious discharge of moisture from the atmosphere, during the two preceding months, the rain for February and March amounting, by Mr Gordon's meteorological journal, to 3.997 or nearly 4 inches; and partly to the unusual depression of temperature, for the season, during the last of these months.

The indications of hygrometers relative, not absolute. Necessity of attending to temperature and pressure.

71. It may be proper to remark, in reference to the above results, that the indications of an hygrometer, of whatever kind, even when they are numerically the same, may imply very different portions of moisture in the air. Thus the hygrometer in April and May stood at 23, though the absolute quantities of moisture in the atmosphere, during these two months, were extremely different;—a proof that the reports of hygrometrical observations only tend to mislead, when the temperature and pressure of the air at the time they were made, are omitted. Hence also we can perceive the reason why no hygrometer can have its scale accurately graduated by exposing it to a particular temperature, in order to obtain the point of extreme dryness.

Application of hygrometry to small portions of gaseous fluids.

72. If the researches of hygrometry were confined to the atmosphere, the methods which we have already described for detecting the quantity of moisture contained in a given portion of it, would be sufficient for all the purposes of meteorology; but these methods are scarcely applicable to small quantities of aerial fluids, the hygroscopic state of which it is often necessary to determine, in order to conduct with accuracy their chemical analysis. This branch of the subject is of considerable importance to the chemist; and indeed, without some knowledge of it, he cannot investigate with success the properties of aerial fluids, which demand much delicacy of research.

Researches of Saussure.

73. Saussure was perhaps the first person who endeavoured to ascertain, in a systematic and philosophical manner, the relation between the degrees of the hygrometer, and the quantity of moisture in determinate portions of air, at different temperatures; but though he prosecuted his inquiries with much ingenuity and care, the methods he employed to obtain a solution of the problem did not admit of the same degree of accuracy as those which were afterwards employed by Gay Lussac. The instrument, however, which he invented for these researches, was admirably adapted for the purpose, as the extreme tenuity of the substance used in the construction of it, rendered it peculiarly fit for being introduced into small portions of air, without affecting, in any sensible degree, the hygroscopic state of the surrounding medium, by the moisture it absorbed.

74. Having inclosed his hygrometer in a vessel containing air previously dried by caustic alkali, Saussure introduced under the receiver, at successive intervals, small quantities of water, by means of bits of moistened linen; and after allowing these to remain a sufficient length of time, he again withdrew them, and determined the loss they had sustained by evaporation, observing at the same time the progress of the hygrometer, for each additional portion of moisture. He performed this experiment at various temperatures, and found that at the same temperature the index uniformly stood at the same point, when the quantity of moisture evaporated was the same. Among other results, he found that a French cubic foot of air at 15°.16 Reaumur took up, in the form of vapour, 11.069 grains French of moisture, expanding at the same time $\frac{1}{54}$ of its original volume; and that the same quantity of air, at the temperature 6°.18 Reaumur, was able to hold in the vaporous state 5.65 grains French. If we reduce these results to English measures, the former would be .0043391, and the latter .0022123 grains in a cubic inch, for the respective temperatures 66°.11 and 45°.91 Fahrenheit; differing little from the results given by our formula in § 39, as is easily ascertained by comparing them with the quantities of moisture for the corresponding temperatures in the Table. In both cases, the hygrometer stood at 98°. The quantity of moisture answering to other divisions on the scale of the instrument were proportional to the numbers in the following Table, in which complete saturation for each temperature is expressed by unity.

Deg. of hygrometer.	Proportional quantity of moisture for temp 45°.91 Fahr.	Proportional quantity of moisture for temp. 66°.11 Fahr.
10	.045	.042
20	.112	.099
30	.191	.163
40	.271	.233
50	.370	.316
60	.480	.423
70	.597	.578
80	.720	.726
90	.871	.882
98	1.000	1.000

Reason why the hygrometer of Saussure stands at the point of extreme humidity in all cases of complete saturation.

75. It appears by various experiments which have been made with the hygrometer of Saussure, that when the receiver in which it is inclosed contains air completely saturated with moisture, whatever be its temperature and density the index always arrives at a fixed point in the scale, namely, that of extreme humidity; and hence it has been justly inferred, that the indications of this instrument, as well as the degrees marked by hygrometers in general, are to be regarded as having a reference to the relative, and not to the absolute quantity of moisture contained in the medium to which they are exposed; as expressing, in short, the relation of the quantity of moisture actually existing in that medium, to the whole quantity which could exist in it at the particular temperature when the observation is made. This view of the subject will receive considerable elucidation, by considering the hygroscopic substance as exerting an affinity for moisture; and, like other desiccatives, reducing the vapour to which it is exposed to the liquid or perhaps the solid state, until its affinity is counterbalanced by the increasing tendency of the moisture to maintain itself in the vaporous condition. In all cases of complete saturation, the smallest attraction for moisture must be sufficient to precipitate the vapour; and since the quantity of water absorbed by the hair is so very minute that it can produce no sensible change in the density of the vapour, it is easy to perceive, that when the medium in which the hygrometer is placed is completely charged with moisture, the hair must continue to abstract water, until its affinity for that fluid terminates in saturation. Whatever, therefore, be the temperature or the elasticity of the vapour, provided it be at its maximum quantity for that temperature, the hair must absorb the same portion of moisture, and consequently reach the same degree of elongation.

Intermediate indications between perfect dryness and humidity.

76. The result however must be very different, when the instrument is inclosed in a medium which contains vapour possessing a tension less than that of the maximum for the temperature. In this case, the hair will only continue to absorb moisture till its affinity is counterbalanced by a force proportional to $f_{\prime} - f'$, or the difference between the whole elastic force of vapour corresponding to complete saturation at the given temperature, and the elastic force of vapour at the same temperature corresponding to the actual quantity of moisture in the medium. The point at which an equipoise is established between these opposing forces, will depend upon the law by which the affinity of the hair for moisture is modified by temperature, and the quantity of water already absorbed. Saussure attempted to discover this law by experiment; but, though his researches were conducted with very great care, the results he has given can scarcely be regarded sufficiently accurate to authorise our application of them to circumstances greatly different from those in which they were obtained. The problem, however, has been solved by Gay Lussac in a manner so general and satisfactory, as to raise this branch of hygrometry from an empirical collection of facts to a subject of the most precise and rigid analysis.*

Researches of Gay Lussac to determine a formula for Saussure's hygrometer.

77. Having procured an hygrometer, on the accuracy of which he could sufficiently rely, Gay Lussac inclosed it in a receiver with a quantity of water, or a solution of some salt of a known specific gravity, and observed the degree marked by the instrument, corresponding to the saturation of the space with the vapour which was formed. He thus determined the degrees of the hygrometer answering to the observed tension of the liquid; and by making experiments, at the same temperature, for different tensions, between extreme dryness and complete saturation with the vapour of water, he procured as many terms of the correspondence as were deemed necessary. He obtained in this manner, at the temperature of 10° centigrade (50° Fahrenheit), the results laid down in the following Table, in which the tensions are expressed in decimal parts of the tension of water, the latter being denoted by unity:

Solutions.	Specific gravity at the temp. of 50° Fahr.	Tension of the solutions at the temp. 50°.	Degrees of the Hygrometer, corresponding to the different tensions.
Water, ...	1000	100.0	100.0
Muriate of soda,	1096	90.6	97.7
Do.	1163	82.3	92.2
Do.	1205	75.9	87.4
Muriate of lime,	1274	66.0	82.0
Do.	1343	50.5	71.0
Do.	1397	37.6	61.3
Sulphuric acid,	1493	18.1	33.1
Do.	1541	12.2	25.3
Do.	1702	2.4	6.1
Do.	1848	0.0	0.0

Plate CCCXXVI. Fig. 3.

78. To form a general idea of the nature of these results, it will be found very convenient to represent by a diagram the tensions reckoned from a given point A along the line AB for the abscissæ, and the corresponding degrees of the hygrometer as rectangular ordinates of the hygrometrical curve. If the former be represented by x, and the latter by y, then at the origin A of the line of abscissae, $x = 0$, and $y = 0$; while at the opposite extremity (AB) $x = 100$, and (BC) $y = 100$, because 100 degrees of the instrument correspond to the tension denoted by 100.

By laying down from a scale of equal parts, the abscissæ and ordinates belonging to the intermediate results, Gay Lussac found that the line connecting the extremities of the ordinates was an hyperbola, concave towards the line of the abscissæ, and having its axis BV inclined to the same line at an angle of 45°. The axis cuts the line of the abscissæ at the point where x is

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* The account in the text of the method of investigation employed by Gay Lussac, is extracted from the admirable work of M. Biot, lately published, entitled, *Traité de Physique Experimentale et Mathematique*, tom. ii. p. 199.

equal to 100; and as y is equal to 100 at the same point, the curve is symmetrically disposed, with regard to these two values of x and y.

79. To render the calculation more simple, the co-ordinates x and y are transformed into x' and y', which are also at right angles to each other, but immediately related to the axis of the hyperbola, and having their origin in some assumed point of it. Hence the new line of abscissæ will form an angle of —45° with AB; and if X and Y be taken to represent the primitive co-ordinates of that line, corresponding to the point of new origin, we shall have

$$x = \mathrm{X} + \frac{1}{\sqrt{2}}(x' + y') \text{ or } \mathrm{X} + \mathrm{Cos.}\,45^\circ\,(x' + y')$$

$$y = \mathrm{Y} + \frac{1}{\sqrt{2}}(y' - x') \text{ or } \mathrm{Y} + \mathrm{Cos.}\,45^\circ\,(y' - x')$$

Before reducing these equations, it will be convenient, for the sake of operating with small numbers, to represent by unity, the abscissæ x corresponding to the tension 100: then, from the inclination of the axis of the hyperbola, the equation for the axis, in terms of x and y, will be $y = 1 - x$; and since the primitive co-ordinates X and Y must be similarly related, $\mathrm{Y} = 1 - \mathrm{X}$. The general expressions for x and y, thus restricted, become

$$x = \mathrm{X} + \frac{1}{\sqrt{2}}(x' + y')$$

$$y = 1 - \mathrm{X} + \frac{1}{\sqrt{2}}(y' - x').$$

By adding together both sides of these equations, the quantity X is exterminated, and the following values of y and y' are obtained,

$$y = 1 - x + y'\sqrt{2}$$
$$y' = \frac{x + y - 1}{\sqrt{2}}.$$

80. If the values of x and y be substituted for these quantities, as determined by experiment, (taking for example the muriate of lime, whose specific gravity is 1397;) then $x = .376$; $y = .613$;

$$\text{And } y' = \frac{.376 + .613 - 1}{\sqrt{2}} = -.00777818.$$

The value of y' thus determined is so small, that the point in the curve to which its extremity refers, nearly coincides with the axis, and might be taken, without any great error, for the vertex of the hyperbola; but to avoid the introduction of any unnecessary inaccuracy, it will be better to assume the origin of the abscissæ of x', at that point of the axis where the latter is intersected by y', and then X will be determined by adding to .376 the projection of y' on the axis, along which the abscissæ of x are reckoned, that is, Cos. 45° × .0077718 or .0055. We thus obtain $\mathrm{X} = .3815$, and $x' = (x - .3815)\sqrt{2} - y'$. When x and y are given, we obtain the value of y' by the equation $y' = \frac{x + y - 1}{\sqrt{2}}$, and that value being substituted for y', in the equation $x' = (x - .3815)\sqrt{2} - y'$, the value of x' is also determined. In this manner were found the following values of x' and y', from the corresponding values of x and y, as ascertained by observation.

Primitive Co-ordinates.		New Co-ordinates.	
x	y	x'	y'
.000	.000	+.167584	—.707107
.122	.253	+.074953	—.441942
.376	.613	.000000	—.007778

81. These data are sufficient to determine completely the nature of the hyperbola; for since its axis coincides with the line of the abscissæ x', it must necessarily have an equation of the form,

$$y'^2 = a + 2\,b\,x' + c\,x'^2,$$

in which a, b, and c are three constant coefficients, the values of which may be determined by the several values of x' and y', given above. The solution of the resulting equations gives the following values:

$$a = .0000605$$
$$b = 1.149338$$
$$c = 4.08683$$

82. If the value of $(x - .3815)\sqrt{2}$ be represented by s, then $x' = s - y'$, and $y' = s - x'$. This value of y' being substituted for that quantity in the general equation of the hyperbola, we obtain,

$$(s - x')^2 = a + 2\,b\,x' + c\,x'^2$$

The solution of this quadratic gives,

$$x' = \frac{-(s + b) + \sqrt{(s^2 - a)(c - 1) + (s + b)^2}}{c - 1}$$

$$\text{And } y' = \frac{s\,c + b - \sqrt{(s^2 - a)(c - 1) + (s + b)^2}}{c - 1}$$

83. The value of y' being determined by the last formula, and substituted for it in the equation,

$$y = 1 - x + y'\sqrt{2}$$

will give the value of y in terms of x. By means of this formula, Biot calculated the following Table, which he found to accord almost exactly with actual observation:

Table of the tension of vapour for the degrees of Saussure's hygrometer at the temp. 50°.

Degrees of Saussure's Hygrom.	Tension of Vapour, the tension of complete saturation being unity.	Degrees of Saussure's Hygrom.	Tension of Vapour, the tension of complete saturation being unity.
0	.0000	19	.0895
1	.0045	20	.0945
2	.0090	21	.0997
3	.0135	22	.1049
4	.0180	23	.1101
5	.0225	24	.1153
6	.0271	25	.1205
7	.0318	26	.1259
8	.0364	27	.1314
9	.0410	28	.1369
10	.0457	29	.1423
11	.0505	30	.1478
12	.0552	31	.1536
13	.0600	32	.1594
14	.0648	33	.1652
15	.0696	34	.1710
16	.0746	35	.1768
17	.0795	36	.1830
18	.0845	37	.1892

Table of the tension of vapour for the degrees of Saussure's hygrometer at the temp. 50°.

Degrees of Saussure's Hygrom.	Tension of Vapour, the tension of complete saturation being unity.	Degrees of Saussure's Hygrom.	Tension of Vapour, the tension of complete saturation being unity.
38	.1954	70	.4719
39	.2016	71	.4851
40	.2078	72	.4982
41	.2145	73	.5114
42	.2212	74	.5245
43	.2279	75	.5376
44	.2346	76	.5525
45	.2413	77	.5674
46	.2486	78	.5824
47	.2559	79	.5973
48	.2632	80	.6122
49	.2706	81	.6289
50	.2779	82	.6457
51	.2858	83	.6624
52	.2938	84	.6792
53	.3017	85	.6959
54	.3097	86	.7149
55	.3176	87	.7339
56	.3266	88	.7529
57	.3357	89	.7719
58	.3447	90	.7909
59	.3537	91	.8109
60	.3628	92	.8308
61	.3731	93	.8508
62	.3834	94	.8707
63	.3936	95	.8906
64	.4039	96	.9125
65	.4142	97	.9344
66	.4258	98	.9563
67	.4373	99	.9781
68	.4489	100	1.0000
69	.4604		

Applications of the Table.

This Table affords the means of knowing by inspection the relation between the degrees of Saussure's hygrometer, and the density of the vapour to which the instrument is exposed; and, consequently, it enables us to determine the absolute quantity of moisture contained in a given portion of air, the temperature of which is 50° Fahrenheit. All that is necessary for this purpose is, to multiply .00246714, the weight in grains of the moisture in a cubic inch of vapour at the temperature of 50°, by the relative tension opposite the degrees of the hygrometer, and the product will be the weight in grains of the moisture in a cubic inch of air. Thus, let it be required to determine the quantity of moisture in a cubic inch of air, when the barometer stands at 30 inches, the thermometer at 50°, and Saussure's hygrometer at 77°.

The tension corresponding to 77° being .5674, if we multiply .00246714 by this number, we obtain .00139985, as the weight in the fractional part of a grain, of the moisture in a cubic inch of air, in the supposed state of things.

Extension of the Table to other temperatures.

84. As the formulæ by which the preceding Table was constructed, are neither very easily deduced, nor capable of being applied without some degree of difficulty, it is natural to enquire how far the results obtained for the temperature of 50° are applicable to other temperatures. At first sight, one would be apt to conclude, that since, in all cases, the hygrometer stands at 100° when it is exposed to vapour at the maximum tension for the temperature, whatever the temperature may be; at inferior tensions it would, in like manner, always point to the same degree, when the tensions have the same relation to the maximum tension of their respective temperatures. This is certainly the most natural conclusion; and if it were well founded, it would be easy to determine, with the assistance of the Table, the absolute quantity of moisture in a given volume of air for any temperature, in the same manner as has already been done for the temperature of 50°. There is reason to suspect, however, that the affinity of the hair for moisture is somewhat modified by temperature; and that the hyperbola, which connects the tensions of the vapour with the degrees of the hygrometer, undergoes a corresponding change with regard to the relations of its co-ordinates. That something analogous to this takes place might have been inferred from the experiments of Saussure, described in § 74, by which it appears, that the indications of the instrument have a different relation, at different temperatures, to the relative densities of the vapour at these temperatures; and Biot mentions a fact which leads to the same conclusion.

The results of the Table, therefore, can only be extended to other temperatures by approximation; but until additional experiments shall have determined the necessary corrections, the tensions corresponding to the degrees of the hygrometric scale for the temperature of 50°, may be applied to other temperatures, without leading, we may presume, to any great error. To ascertain how far the results obtained by this extended use of the Table coincided with the quantity of moisture in the atmosphere, as determined by our formula in § 63, we made the following observations, which we have arranged in a tabular form, in order that the coincidence may be more distinctly perceived.

Temperature of the Air.	Temperature of a Thermometer with moist. Bulb.	Barometrical pressure.	Degrees of De Luc's Hygrometer.	Degrees of Saussure's Hygrometer.	Grains of Moisture in a cubic inch of Air.	
					By our Formula.	By Table.
53.75	47.50	30.400	37.0	75.2	.0016292	.0015037
51.40	47.54	30.156	38.0	76.2	.0015692	.0015775
60.00	51.50	30.100	35.0	73.0	.0018225	.0017327
62.55	52.45	30.154	34.7	72.4	.0018093	.0018476
68.20	56.00	30.106	33.1	71.4	.0021334	.0021309
70.00	63.80	29.748	51.0	86.6	.0034837	.0033529
72.00	67.00	29.718	53.2	87.8	.0039888	.0036753

The two last columns contain the weight in fractional parts of a grain of the moisture in a cubic inch of the air at the time the observations were made; the first having been derived by our formula for a thermometer with a moistened bulb, and the last by Biot's table for Saussure's hygrometer. It is proper to remark, however, in reference to these results, that the degrees of Saussure's hygrometer were obtained, not by actual inspection, but by reducing the degrees of De Luc's whalebone hygrometer to the corresponding degrees of the former, by means of the comparative relations of the two instruments laid down in § 22. In making the observations, two whalebone hygrometers were employed, and the mean of the degrees which they indicated was taken. This was the more necessary, as they frequently exhibited a difference of 5°, though the scales of both had been recently adjusted. In these circumstances, the coincidence of result is greater perhaps than might have been expected; and as the best hair hygrometers often deviate several degrees from one another in the same humid medium, the results deduced from the Table at different temperatures, are probably within the limits of the aberrations of different instruments.

Investigation of a formula for De Luc's hygrometer.

85. The preceding results furnish data sufficiently varied, to determine a general formula for De Luc's hygrometer, the indications of which are by far too anomalous to become the subject of rigid analysis. Without attempting, therefore, any thing like precise investigation, we shall be satisfied with an expression for this instrument, which may apply, with tolerable accuracy, to the ordinary hygroscopical state of the atmosphere. If the degrees of this hygrometer, reckoned from extreme dryness, had the same relation to the whole range of the scale, as the quantity of moisture in a given volume of the medium to which it was exposed, had to the whole quantity of moisture that could be maintained in the vaporous state at the temperature of that medium: then if g were the weight in grains of the moisture in a cubic inch, for the entire tension belonging to the temperature of the medium; g' the corresponding weight of moisture for the actual tension: and L the degrees of the instrument, we should evidently have an equation of the form,

$$g'=g\left(\frac{L}{100}\right)$$

The dilatation of the whalebone, however, is influenced by a law too complex and irregular to be expressed by this simple formula; and to trace it with sufficient precision, we must at least assume

$$g'=g\left(m\left(\frac{L}{100}\right)+n\left(\frac{L}{100}\right)^2\right)$$

the coefficients m and n being two constant quantities to be determined by two equations, in which the values of g', g, and L are known.

86. If we employ in this investigation the data furnished by the 2d and 5th observations in § 84, we obtain for the first equation,

$$g'=.0015692$$
$$L=38$$

and the quantity of moisture in a cubic inch for the entire tension of the temperature, 54.4 being (by § 39) .0028398 grains, we have also $g=.0028398$. In like manner, the data of the 5th observation give for the second equation,

$$g'=\overset{\text{grains.}}{.0021334},\ L=33.1,\ \text{and}\ g=\overset{\text{grains.}}{.0043693}.$$

$$\text{Hence the formula } g'=g\left(m\left(\frac{L}{100}\right)+n\left(\frac{L}{100}\right)^2\right)$$

$$\text{becomes } .0015692=.0028398\,(.38\,m+.38^2\,n),$$
$$\text{and } .0021334=.0043693\,(.331\,m+.331^2\,n);$$

or,

$$.55257=.38\,m+.1444\,n,$$
$$\text{and } .48827=.331\,m+.10956\,n.$$

By the solution of these equations, we obtain $m=1.6$ and $n=-.4$ nearly; and these values of m and n being substituted in the equation

$$g'=g\left(m\left(\frac{L}{100}\right)+n\left(\frac{L^2}{100}\right)\right) \text{ we have}$$

$$g'=g\left(1.6\left(\frac{L}{100}\right)-.4\left(\frac{L^2}{100}\right)\right)$$

If $\frac{L}{100}$ be represented by l, this equation will assume the form,

$$g'=g\,(1.6\,l-.4\,l^2)$$
$$\text{or } g'=\frac{2\,l}{5}(4-l)\,g.$$

This formula being applied to the degrees of De Luc's hygrometer, in the third observation, in which l was .35; the temperature of the air 60°, and consequently (by § 39.) g was .00338832, we obtain

$$g'=\frac{2\,l}{5}(4-l)\,g=\frac{.70}{5}\times\overline{4-.35}\times.00338832=$$

$$=.14\times3.65\times.00338832=\overset{\text{grains.}}{.0017314}.$$

This result differs so little from the quantity of moisture in a cubic inch of the air, as deduced in the same circumstances, both by our formula for a thermometer with a moistened bulb, and by Biot's Table for Saussure's hygrometer, that we have no hesitation in adopting the formula, under the restrictions which we formerly mentioned. It is proper to add, that the point of extreme moisture was fixed, in the instruments with which the observations were made, by immersing them for six hours in pure water; and that the point of extreme dryness was determined by inclosing them for several days in a receiver at the temperature of 50°, with a considerable quantity of sulphuric acid, the specific gravity of which was 1.84435.

Point of extreme humidity.

87. According to the formula which we have deduced for De Luc's hygrometer, the instrument ought to indicate extreme humidity in the gaseous medium to which it is exposed, before it reaches the point marked 100 on the scale; for if g, and g' be equal to each other, (which will be the case at complete saturation,) and if, at the same time, $\frac{2\,l}{5}(4-l)$ be represented by unity, we shall have

$$l^2-4\,l=\frac{5}{2}.$$

Therefore $l=.7753$, and $L=77.53$.

Hence we may infer, that the division marked 77.5 corresponds to the extreme range of the whale-bone hygrometer, in so far as the expansions of the instrument are effected by mere vapour. This conclusion accords remarkably well with the observations of Saussure, who inferred, from numerous experiments with this instrument, that the 80th or 81st degree of De Luc's scale, corresponds to the term of saturation, or extreme humidity; and that all the divisions above these points measured, not the quantity of moisture in the vaporous state, but the quantity of water which had combined with the whale-bone, after it had been condensed on its surface.

Table for De Luc's hygrometer.

88. By substituting in the expression $\frac{2\,l}{5}(4-l)$, the value of l for every 5° from zero to 77°.5, we obtain the relative tensions of vapour for the following divisions of De Luc's scale:

Degrees of De Luc's Hygr.	Relative tension of vapour.	Degrees of De Luc's Hygr.	Relative tension of vapour.
5	.079	45	.639
10	.156	50	.700
15	.231	55	.759
20	.304	60	.816
25	.375	65	.871
30	.444	70	.924
35	.511	75	.975
40	.576	77.5	1.000

This Table may be employed to calculate, by approximation, the number of grains in a cubic inch of air, when the degrees of De Luc's hygrometer, the temperature, and barometrical pressure are known. Thus, if we employ the data of the example in § 62, in which De Luc's hygrometer stood at 27°, the thermometer at 65°, and the barometer at 29.35": The tension corresponding to 27° in the Table, is found by taking a proportional part for the excess above 25° to be .403; and the weight of the moisture in a cubic inch of air, for the entire tension of the temperature being .00395897 grains, and corrected for barometrical pressure .00387319 grains, we thus obtain .00387319 × .403, or .00156089 grains, as the weight of the moisture in a cubic inch of air in the given circumstances. This result coincides very nearly with the quantity of moisture deduced from the same data by the formula in § 62.

Consequences resulting from the indications of hygrometers being relative, and not absolute.

89. It must be sufficiently obvious, from all we have stated, that the degrees marked by hygrometers, of every description, are entirely relative; and that the absolute quantity of moisture held in the vaporous state, in any medium, cannot be accurately inferred from these instruments, unless the temperature and barometrical pressure be also taken into account. Though, in one respect, this property of indicating relative degrees of humidity, may be considered as an imperfection of hygrometers, it renders them more valuable for certain purposes, than if they pointed out, in a less indirect manner, the actual quantity of moisture in a given volume of the medium in which they are placed. By expressing, for instance, the relative condition of the atmosphere with regard to moisture, they shew at the same time its capacity for receiving an additional portion of vapour in admixture with it; or, what is of equal importance, its tendency to deposit, by a diminution of temperature, part of that which it already contains. Hence, for the ordinary purposes of meteorolgy, they are more useful than if they indicated absolute differences; and as the extent to which they are affected, corresponds to the effects of moisture on other hygroscopic bodies, placed in similar circumstances, they may be used with equal advantage to point out the simultaneous condition with respect to humidity of various articles of commerce, such as corn, cotton, wool, silk, &c. the portion of water absorbed from the air by these substances being regulated, not by the absolute quantity of moisture existing in the atmosphere, in a vaporous state, but by the relation which the latter quantity bears to the whole moisture that could be maintained in that state, at the temperature. Thus, if the temperature of the air were 50°, and the point of deposition 40°, the whole quantity of moisture which could exist in a cubic inch of air at the former temperature being .0025476 grains, and at the latter .0017823, the relative moisture of the air would be expressed by the fraction $\frac{17823}{25476}$, or .6996, complete saturation being denoted by unity; in like manner, if the temperature of the air were 70°, and the point of deposition $58\frac{1}{2}$°, the relative humidity of the air would be also .6996. Now, in the state of things we have supposed, the actual quantities of moisture in the air would be to each other, as 17823 to 32296, or as 1 to 2 nearly, and yet the hygrometer of Saussure, or that of De Luc, would, in both cases, stand at the same points of their respective scales, the former at 85° and the latter at 50°. The quantity of moisture absorbed by hygroscopic substances would also be the same, or nearly the same, in the circumstances stated; so that hygrometers, though indicating merely relative differences, may nevertheless be employed for practical purposes, to point out the extent to which such bodies are affected in their weight by humidity, after the relation subsisting between their increase of weight and the degrees of the instrument has been determined by experiment.

Correspondence between the indications of the hygrometer, and the effects of moisture in the animal system.

90. As the organs of living beings are relaxed by humidity, somewhat in the same manner as the fibres of inanimate substances, the indications of hygrometers serve to apprize us of the effects which the moisture of the atmosphere, such as it exists in that fluid, is calculated to produce on the general tone of the muscular frame; and that, too, in a way much more direct and immediate, than if the graduation of their scales had referred to absolute, instead of relative degrees of moisture. In proof of this assertion we need only remark, that the quantity of moisture in a warm apartment is generally greater than that contained, at the same time, in an equal volume of the external air; and yet if we were to judge either by our feelings, or the apparent indications of the hygrometer, we should be led to draw an opposite conclusion. The hygrometer, therefore, though it only announces relative degrees of humidity, conveys to us the species of information respecting the state of the air, in which we feel most interested; namely, the extent to which its hygroscopic condition will affect our personal comfort.

Mean state of the hygrometer.

91. In this country, the mean height of De Luc's hygrometer, in the open air, is about 65°. Above this point, the degrees of the instrument may be considered as indicating the state of the air to be damp and unwholesome. In a room heated to the temperature of 60°, the index remains pretty steadily at 35°, which corresponds nearly to the air being half saturated with moisture.* A thermometer, with a moistened bulb, stands in the same circumstances, from 9° to 10° below the temperature of the room. Mr Leslie mentions, that on one occasion his hygrometer stood at Paris in the month of September, at 120°, so that a thermometer with a moistened bulb would have remained, in the same circumstances, 21°.6 below the temperature of the air.

Proofs by direct experiment, that moisture is held in the state of vapour by temperature only.

92. Having given a detailed view of the nature of hygrometric scales, both as they refer to absolute and relative degrees of humidity in the ambient medium, we shall devote the remainder of this article to the explanation of some important meteorological appearances more immediately connected with hygrometry. It appears by the principles which we have established,

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* It appears by the *Meteorological Journal* of the Royal Society, that the mean height of De Luc's hygrometer, at London, is about 66°. During a period of 11 years, from 1792 to 1803, the lowest height at which it was observed, was 30°.

that water is maintained in the atmosphere, in a vaporous state, by the influence of heat alone; and that it is supported in the air, not in consequence of any chemical affinity for that fluid, but by its superior levity, its weight having been shewn (§ 34) to be to that of air, under the same temperature and pressure, as 5 to 8. This important fact was first stated in a philosophical manner by De Luc, who considered vapour to be an aeriform fluid, rendered elastic by the action of caloric, independent of the presence of air. The density which vapours can acquire, says he, (*Idées sur la Meteorologie*, tom. i. p. 26), or the degree of proximity which their particles can attain, without being precipitated, has a *maximum* which is determinate in the same temperature, but which changes with the temperature, and increases as it is more elevated. Beyond this maximum of density, vapours, he adds, are partially precipitated, till they are reduced within its limits. These views were afterwards more fully developed in a memoir which he published in the *Philosophical Transactions* for 1792. By his excellent experiments on the force of vapour at different temperatures, Mr Dalton gave to this theory a precision and a generality which it by no means possessed before he turned his attention to the subject; though, it must be admitted, that the opposite opinion, which ascribed the formation of vapour to the influence of chemical action, aided by temperature, could not be said to have been fully disproved till Gay Lussac took a part in the investigation, and demonstrated by a series of accurate experiments, which Biot * afterwards illustrated by the most rigid analysis, that vapour has the same mechanical properties, whether it exists in a pure unmixed state, or in combination with atmospheric air. As almost all the conclusions which we have deduced respecting the hygrometric state of the air are either founded upon this fact, or intimately connected with it, we were anxious not to quit the subject till we had ascertained, by direct experiment, how far the quantity of moisture in a given volume of air coincided with the results laid down in some of the preceding Tables; but the minuteness of the quantity of moisture maintained in a vaporous state, even in the largest receiver, together with the difficulty of abstracting the whole of it from its mechanical admixture with air, presented considerable obstacles to an accurate solution of this nice and delicate problem. The method employed by Saussure, mentioned in § 74, of introducing small bits of moistened linen under a receiver, containing a certain volume of dry air, is liable to many obvious objections; and after trying it on a large scale, without obtaining results sufficiently satisfactory, we abandoned it for the following mode of research, which, from the coincidence of the results it afforded in the same circumstances, is, we conceive, well calculated to determine, with the utmost precision, the object in view. The method alluded to, consisted in causing a large volume of air, saturated with moisture, to pass slowly in a small stream through a sufficient quantity of sulphuric acid, or dry muriate of lime, cut off from all communication with the atmosphere; and then observing the increase of weight which these substances acquired, in consequence of the air being transmitted through them. After briefly describing the apparatus we employed, we shall state the results which we obtained in several experiments performed with the utmost care, at temperatures considerably remote from each other. ABCD Fig. 4. represents the gasometer, or air-vessel used in these experiments; its capacity was 11,320 cubic inches, and to preserve the air which it contained at an uniform temperature, it was enclosed in another vessel filled with water, the temperature of which was easily regulated. The air was expelled from the gasometer by pouring water of the same temperature into the funnel RS, the stop-cock E being previously turned; it thus passed along the bent tube EFG, one extremity of which G descended about $\frac{1}{8}$th of an inch below the surface of a quantity of mercury in the bottom of the vessel FVTL. The bent syphon tube HIK contained a small portion of mercury, and served to indicate the pressure to which the air was subjected during the experiment. From the vessel FVTL, the air was conveyed by the tube LMN into the vessel MN, which was filled with concentrated sulphuric acid to the depth of four inches. Passing through a very small aperture at N, it ascended in a succession of bubbles through the acid, and at last made its escape at the extremity of the tube OP, which was inserted under the surface of mercury. The junctures at F, H, L and O having been luted so as to be air-tight, it is easy to see, that since all communication was thus cut off between the external air and the acid in MN, any addition of weight which the acid acquired must have been derived solely from the vapour in mixture with the air, which was urged through it from the gasometer. The acid, therefore, being carefully weighed before and after the experiment, with an excellent balance, which, when loaded with a pound, turned with the 500th part of a grain, the increase of weight which it received afforded an accurate test of the weight of the vapour which existed in mixture or combination with the air. To prevent any of the moisture from being deposited in the tubes, the temperature of the air on which the experiment was made, was kept by means of the water in the external vessel VWYX two or three degrees below the temperature of the surrounding air; and as the direct communication between the moist air in the gasometer, and the acid which absorbed the vapour, was cut off by the mercury in the bottom of the vessel FVTL, the quantity of moisture dissolved could not be affected by the diminished elasticity of the air arising from the incessant absorption of the vapour. Some of the experiments were repeated with muriate of lime instead of sulphuric acid, by diffusing a solution of it over an extended surface, by means of flannel, which was afterwards well dried, and then wrapped loosely round the tube, which descended to the bottom of the vessel MN. With this apparatus we obtained the following results:

Description of the apparatus employed.

Plate CCCXXVI. Fig. 4.

Results of the experiments.

Volume of air subjected to experiment in cubic inches.	Temp. in degrees of Fahrenheit.	Barometric Pressure.	Total quantity of moisture deposited in grains.	Grains of moisture in a Cubic Inch.	
				By Experiment.	By Table.
3194	49	29.625	7.550	.0023641	.00235916
10892	54	29.750	28.780	.0026424	.00278021
10814	59	30.000	35.545	.0032867	.00328366
3442	77	29.924	19.574	.0056880	.00568580
11240	83	29.848	75.840	.0067473	.00678455

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* In alluding once more to the hygrometric researches of this distinguished mathematician and philosopher, we gladly embrace the opportunity of correcting a slight mistake which we committed, in giving an account (see § 77. of this article) of the labours of Gay Lussac to determine the relation between the tension of vapour, and the indications of Saussure's hygrometer. We have found,

In the above Table, the first column contains the quantity of air, in cubic inches, which was submitted to experiment, after making the necessary corrections for pressure, and expansion by the accession of vapour; the second column contains the temperature of the moist air, which, as we already remarked, was kept two or three degrees below the temperature of the apartments in which the experiments were performed; and the two last columns exhibit the quantities of moisture in a cubic inch of air, as determined by the Table in § 39, as well as by actual experiment. The coincidence between the results is sufficiently near to confirm, in the most satisfactory manner, the extreme accuracy both of Mr Dalton's experiments on the force of vapour, and of Gay Lussac's researches into the relation subsisting between dry air, and the quantity of vapour contained in the space which it occupies. The greatest deviation occurs in the second experiment; but it is easily accounted for on the ground, that the air submitted to trial had only stood three hours over water; whereas, in all the other cases, it had been allowed to remain in that situation from ten to twenty-four hours. Hence we may safely conclude, that the Table in § 39, deduced from the experiments of Dalton and Gay Lussac, exhibits with a degree of accuracy, which cannot deviate more than the hundredth part of the whole from the truth, the quantity of moisture in a cubic inch, either of pure vapour, or air perfectly humid, at the various temperatures, from zero to 100° of Fahrenheit. It is, therefore, a valuable acquisition to hygrometry.

Effects produced on vapour by change of temperature and intermixture, at different temperatures.

93. The quantity of moisture maintained in the vaporous condition having been thus demonstrated to be solely the effect of caloric modified by pressure, it follows, that the elevation of water in the atmosphere, in the state of vapour, and the subsequent deposition of it, under the various forms in which it again descends to the surface of the earth, must be ascribed chiefly to changes of temperature. Thus if a cubic inch, having in solution its maximum quantity of vapour at the temperature of 80°, were suddenly to be reduced to the temperature of 50°; since, in the former case, it is capable of holding in solution ·00623919 grains of moisture, and in the latter only ·00246714 grains, it would deposit by the change of temperature ·00377205 grains. Or, if a cubic inch of air, in the same circumstances, at the temperature of 80°, should be intermixed with a cubic inch of air at the temperature of 50°, the mean temperature induced would be 65°, and the whole quantity of moisture in both, ·01001633 grains, or ·00500816 in a cubic inch; but at the temperature of 65°, a cubic inch is capable of holding in solution only ·00393897 grains; therefore by the intermixture of the two airs, ·00209838 grains would be deposited in the liquid state. Nor is it necessary to suppose that the two airs, or to speak more correctly, the spaces which they occupy, are completely saturated with moisture at their respective temperatures, or mixed together in equal quantities: thus, if we take two cubic inches of air at the temperature of 80°, whose point of deposition is 75°, and three cubic inches at 40°, whose point of deposition is 36°; the former would contain ·01074452 grains, and the latter ·00468468 grains of moisture; the intermixed airs, amounting to five cubic inches, would therefore have together ·01542920 grains, or ·00308580 grains to a cubic inch. The temperature induced by the mixture would be $\frac{2 \times 80 + 3 \times 40}{5}$ or 56; but, at the temperature of 56°, a cubic inch can only hold in solution ·00298729 grains; and consequently, in the case we have supposed, ·00009851 grains of moisture would be deposited by each cubic inch.

94. The facts which we have stated, are well calculated to elucidate the opinions of Dr Hutton respecting the cause of rain; but before we develope more fully the beautiful and simple theory, which that distinguished philosopher advanced to explain this very familiar, though hitherto the most perplexing of all meteorological phenomena, it may be proper, in the first place, to take a general view of the hygrometric constitution of the atmosphere: this will both facilitate our researches, and give them a greater decree of precision and generality.

Absolute quantity of moisture in the atmospherical columns, for the different latitudes.

94. In a preceding part of this article, we endeavoured to shew, that the mean point of deposition for the globe in general, is about 6° below the mean temperature; and though this conclusion, we admit, was drawn by a very limited induction, it seems, as far as observation extends, to be sufficiently conformable to the actual state of things, to be received into the class of general facts. We have also shewn (§ 34.) that at the boiling point, the weight of air is to that of vapour under the same pressure, as .9454476 to .589481, or as 1 to .623537; and since both are affected in their bulk precisely in the same manner, by changes of temperature and pressure, this relation must hold in all cases, so long as the vapour retains the elastic state. Now, if we assume that the mean point of deposition, in the different strata of the atmosphere, has throughout the same relation to the temperature as we have attempted to shew it possesses at the surface of the earth, it will be easy, on this principle, to determine the absolute quantity of moisture in the atmospherical columns for the different latitudes, adapted to the standard pressure. All that is necessary for this purpose, is to take the elasticity of vapour for a temperature 6° below the mean temperature of the latitude; to multiply it by .623537, and then divide the product by 30; and lastly, to multiply the quotient by 407.4, the height in inches of a column of water, equal to the mean weight of a corresponding column of the atmosphere: the product will be the mean height in inches of a column of water, equal to the whole moisture contained in a column of the atmosphere, having the same base. By proceeding in this manner, we have deduced the following Table, which exhibits the quantity of moisture in the atmosphere, in its mean hygrometric state, from the equator to either pole.

Lat.	Mean Temp.	Column of Water equal to column of Vapour in Inches.	Lat.	Mean Temp.	Column of Water equal to column of Vapour in Inches.
0	85	8.315	50	53.8	2.882
5	84.6	8.112	55	48:8	2.468
10	83.4	7.809	60	44.5	2.124
15	81.4	7.326	65	40.6	1.854
20	78.7	6.717	70	37.3	1.647
25	75.4	6.037	75	34.6	1.495
30	71.5	5.315	80	32.6	1.391
35	67.2	4.611	85	31.4	1.332
40	62.7	3.968	90	31.0	1.313
45	58	3.385			

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however, from re-examining M. Biot's works, that the discovery of that relation being expressible by the co-ordinates of an hyperbola, was made, not by Gay Lussac, as we have stated, but by Biot himself.

Mean quantity of moisture existing at the same time in the atmosphere.

It appears by this Table, that if the atmospherical columns at the equator were to deposit the whole of their watery stores, the moisture precipitated would cover the surface of the earth only to the depth of 8.315 inches. As we advance towards the poles, the quantity of moisture held in solution gradually decreases, in a ratio which diminishes faster than the temperature, and which seems to have some relation to the mean quantity of rain in the different latitudes. The mean quantity of water existing in the vaporous state in a column of air, having a square inch for its base, and reaching to the summit of the atmosphere, may be reckoned by the Table equal to 4 cubic inches; and since the whole surface of the globe is about 790,000,000,000,000,000 square inches, the whole moisture in the atmosphere may be computed to be about 3,000,000,000,000,000,000 cubic inches, or 11,794 cubic miles of water.

Quantity of moisture in the strata of the atmospherical columns, at various heights.

96. Having thus formed a general estimate of the absolute quantity of moisture, existing at the same time in the atmospherical columns in the mean hygrometric state of the air, we shall now endeavour to determine the absolute humidity of the various strata of these columns, at different elevations, above the surface of the earth.

The observations which have been made on the hygrometric condition of the air, at considerable heights above the level of the sea, though they evidently prove that the quantity of moisture in the more elevated strata of the atmosphere is extremely small, yet as they generally have a reference to the state of the human body, such as great thirst, the parched state of the skin, and other effects of a similar kind, which might be produced either by absolute or relative degrees of dryness, we must be satisfied, in the absence of the more precise indications of the hygrometer, with the results deduced from the general principles we have already established, and still suppose that the same relative degree of humidity pervades the whole atmosphere, as we have endeavoured to shew, prevails near the surface of the ground. The supposition, taken in conjunction with that of an uniform decrease of temperature, amounting to 3°.7 for every thousand feet of ascent, (the rate at which the heat of the air diminishes according to the best observations,) will enable us to compute the humidity of the successive strata of the atmospherical columns, and explain the cause of the great dryness which is observable in very elevated situations.

97. That the mean relative humidity of the atmosphere is nearly the same at various elevations, is neither improbable nor inconsistent with the few hygrometric observations of which we are in possession. Thus in a range, which embraced about 7000 feet of difference of level among the Alps, it appears, from some observations* recorded by De Luc, that his hygrometer differed no more than 10⁰ at the upper and lower stations, though the absolute quantity of moisture in the same volume of air must have been thrice as much in the one case as in the other. The difference, which might have been occasioned by partial changes in the hygrometric state of the air, or even by the influence of temperature in modifying the affinity of the whalebone for moisture, would only have indicated, at the same temperature, a deviation of $\frac{1}{7}$th from the same relative degree of humidity. Hence the suppositions we have made, cannot lead to results differing greatly from the truth. The following Table, constructed on the principles we have laid down, and adapted to the mean temperature of the parallel of 45⁰ of latitude, exhibits the mean quantity of moisture in grains contained in a cubic inch of air for every 1000 feet of elevation, from the level of the sea to the height of 15,000 feet.

Height in Feet.	Mean Temp.	Relative Tension of the Vapour.	Quantity of Moisture in a Cubic Inch of Air, in Grains.
0	58.0	.827	.0026315
1000	54.3	.796	.0022533
2000	50.6	.766	.0019268
3000	46.9	.737	.0016448
4000	43.2	.709	.0014035
5000	39.5	.683	.0011976
6000	35.8	.657	.0010192
7000	32.1	.632	.0008665
8000	28.4	.608	.0007360
9000	24.7	.585	.0006246
10000	21.0	.563	.0005295
11000	17.3	.542	.0004488
12000	13.6	.522	.0003800
13000	9.9	.502	.0003210
14000	6.2	.483	.0002710
15000	2.5	.465	.0002287

Colonel Beaufoy's account of the extreme dryness he experienced on the summit of Mont Blanc.

The first column contains the altitude in feet, and the second the corresponding temperature; the numbers in the third column express the elasticity of the vapour, on the supposition that the point of deposition for the various strata is 6° below the temperature, the entire tension of vapour for the mean temperature of each stratum being denoted by unity; and the last column shews the weight in grains of the moisture in a cubic inch of air at the different heights. It appears by the Table, that the absolute quantity of moisture contained in a given volume of the air, at various heights, is reduced about one half for every 4500 feet of ascent. This great diminution of moisture is not detected immediately by hygrometers, for reasons which we have fully explained in § 89; but it is sensibly discovered by the extreme thirst and parched state of the skin which it occasions. Colonel Beaufoy describes the latter effects so well, in his account of his journey to the summit of Mont Blanc, that we shall make no apology for stating in his own words the feelings he experienced: "We had not proceeded far," says he, in giving an account of his ascent, "when the thirst, which, since our arrival in the upper regions of the air, had been always troublesome, now became intolerable. No sooner had I drank than the thirst returned, and in a few minutes my throat became perfectly dry. Again I had recourse to water, and again my throat was parched. The air itself was thirsty; its extreme dryness had robbed my body of its moisture. Though continually drinking, the quantity of my urine was almost nothing; and of the little there was, the colour was extremely deep. The guides were equally affected. Wine they would not taste; but the moment my back was turned, their mouths were eagerly applied to my cask of water." The cause of these effects will be distinctly perceived, by attending to the different circumstances in which a person is placed at the top and bottom of a lofty mountain. Near the level of the sea, in the latitude of 45⁰, we shall suppose a person inhales air, which, in its mean hygrometric state, contains, according to the preceding Table, .0026315 grains in a cubic inch, and expels it

Loss of moisture by breathing.

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* *Idées sur la Meteorologie*, tom. ii. p. 9.

again by the process of breathing, so charged with moisture that the point of deposition is 85°, as we have determined by experiment. Hence each cubic inch must carry off, at an average, .0072312 grains of moisture; but as a cubic inch of the air inhaled contained .0026315 grains, the actual loss of moisture by breathing is .0045997 grains for every cubic inch of air expelled. Now, a man usually makes about 12 inspirations in a minute; and since each inspiration requires about 25 cubic inches, he should thus lose by the process of breathing, in the circumstances we have supposed, nearly eight cubic inches of water daily. Again, at the height of 15,000 feet above the level of the sea, a cubic inch of air, in its mean hygrometric state, contains, according to the Table, only .0002287 grains of moisture; and therefore each expiration must carry off .17506 grains of water from the body. But if we suppose the number of inspirations to be inversely as the density of the air, a person in that elevated situation should make about 18 inspirations in a minute; and therefore lose by breathing about $\frac{1}{10}$ grains of moisture in the same time, or nearly 18 cubic inches of water daily. The quantity of moisture lost by breathing being more than double in the latter case of what it is in the former, accounts in a very satisfactory manner for the great thirst and parched state of the fauces, which all travellers have experienced at considerable heights in the atmosphere.

Cause of the varying humidity of caves and cellars.

98. We shall conclude these general remarks on the hygrometric state of the atmosphere, by observing, that since the dryness of the air depends upon the excess of its temperature above the point of deposition, in winter, when the temperature of caves, cellars, &c. is greater than that of the air, these subterraneous places will always seem dry; whereas in summer, when their temperature is below the mean temperature of the air, the contrary should be found to hold, and they ought to appear damp. In this country, the daily mean *minimum* temperature of the season will be observed to coincide with the mean temperature of these situations about the middle of April, and to exceed it from that time till the middle of September. Hence caves, mines, &c. which have a free communication with the air, ought to be damp from April to September, and dry from September to April. The same remark is perhaps applicable to places situated near the sea, particularly in high latitudes.

Quantity of moisture deposited in the different parallels of latitude.

99. The preceding investigations having conducted us to an accurate and precise knowledge of the constitution of the atmosphere with respect to humidity, we shall finish the subject of hygrometry with a concise view of the quantity of moisture which, under the various forms of dew, rain, hail, and snow, descends, during the annual round of the seasons, to the surface of the earth, in different latitudes. The principal and perhaps the only cause which occasions a precipitation of moisture, by making it pass from the vaporous to the liquid state, must be change of temperature; and since we already know the mean quantity of moisture which exists in the atmospherical columns for the different latitudes, it would not be difficult to determine what portion of it ought to be precipitated at some particular place, provided we also knew the extent of the change of temperature to which the superincumbent atmosphere was exposed. But though we can ascertain with tolerable accuracy the mean annual temperature of a place, in terms of the latitude, it would seem to defy the powers of calculation to anticipate, with sufficient precision, the temperature which the different strata of the atmosphere immediately over it will possess on some particular day; and therefore, all we can do in the present case, is, to endeavour to form an estimate on general principles, and calculate the mean annual quantity of rain, for different situations, on the supposition that in the course of a year corresponding changes of temperature take place throughout the whole mass of the atmosphere. As these changes will give rise to depositions of moisture, which must be more or less copious according to the mean quantity of vapour existing in the atmospherical columns over any place, it will be easy to determine, on the principles we have laid down, and with the assistance of the Tables in § 51 and § 94, the mean quantity of rain for the different latitudes. For, since by the Table in § 51, the mean annual evaporation is 36.2 inches, and the mean quantity of moisture in the atmosphere at once 4.1 inches, for each of the atmospherical columns having a square inch for its base, it appears that the quantity of moisture evaporated annually is $8\frac{4}{5}$ times as great as the atmosphere retains in the state of vapour at a time. Hence if the numbers which express in inches the heights of the aqueous columns, equal to the columns of vapour existing in the atmosphere, for the mean temperature of the latitudes, as stated in the Table in § 94, be multiplied by 8.8, the products will give the mean annual quantity of rain, also in inches, for the several latitudes, at the interval of 5°. We thus obtain the numbers in the following Table, which will be found to coincide pretty accurately with the mean quantity of rain which falls in different places, as determined by observation.

Lat.	Depth of Rain, in inches.	Lat.	Depth of Rain, in inches.
0	73.17	50	25.36
5	71.39	55	21.72
10	68.72	60	18.69
15	64.47	65	16.32
20	59.11	70	14.49
25	53.12	75	13.16
30	46.77	80	12.24
35	40.58	85	11.72
40	34.92	90	11.55
45	29.79		

100. The limits prescribed for this article will not allow us to follow out this branch of the subject in detail; but we shall resume the consideration of it under the head of METEOROLOGY. In the mean time we may remark, that the change of temperature by which the deposition of moisture from the atmosphere is produced, will be of four descriptions: 1st, The annual change of temperature; 2d, The daily change of temperature; 3d, The change of temperature occasioned by the transference of the aerial columns from one parallel of latitude to another; and 4th, The change of temperature arising from the elevation or depression of the atmospherical strata, by the inequalities of the earth's surface. If all these circumstances be duly taken into account, they will explain, in the most satisfactory manner, every anomaly respecting the quantity of rain for places under the same parallel of latitude. (A)

HYPATE Prima, in music, is an interval, which M. Henfling has so denominated, its ratio being $\frac{2}{3} = 358\Sigma + 7f + 31m$, or the *Major* Fifth; which see.

HYPATIA, a lady celebrated for her beauty and her mathematical knowledge, was the daughter of Theon of Alexandria, and was born about the end of the fourth century. Her public lectures on geometry and astronomy were numerously attended, and she ranked among her pupils many of the most distinguished individuals of the age. She was cruelly murdered in 415, in a popular commotion which is said to have been excited by Cyril bishop of Alexandria, on account of her adherence to paganism. See Brucker's *History of Philosophy*; Beckmann's *History of Inventions*; and our article Mathematics.

HYPERBOLA. See Conic Sections, vol. vii. p. 143.

HYPERBOLIC Logarithms. In musical calculations, these express the decimal values or multiples of an interval, whose ratio is $\frac{1}{2.7182818}$, &c. $= 882.9718866\Sigma + 17f + 77m$, which answers to 1.0000000 of the hyperbolic logarithm tables; in the same manner as $\frac{1}{10} = 2033\Sigma + 40f + 176m$ answers to 1.0000000 (xxiv) of the Common *Logarithms*, (which see); $\frac{1}{2} = 612\Sigma + 12f + 53m$ to 1.0000000 (viii) of Euler's or the Binary *Logarithms*, (which see); $\frac{80}{81} = 11\Sigma + m$, to 1.00000000 (c) of major comma logarithms; and so of many other species of logarithms: every one of which species represents a particular scale of musical intervals. See Logarithms.

HYPEROCHE, in music, is a name by which different musical writers have distinguished several small intervals of the scale, viz.

Hyperoche of Dr Busby, (*Mus. Dict.* art. *Hyp.*) ∂—ℰ (*fc*) has the ratio $\frac{2097152}{2109375}$, $= 5\Sigma + f$, and is the *Major* Residual (of Rameau,) which see.

Hyperoche of Dr Callcott, (Overend MS. II. 42, 83,) has the ratio $\frac{16,677,181,699,666,569}{16,777,216,000,000,000}$, $= 5\Sigma + 2f$, and is the *Greater* Residual (R) of Overend, which see.

Hyperoche *Major*, of Overend, Dr Busby?, and others, (π) has the ratio $\frac{3072}{3125}$, $= 15\Sigma + f + m$. See the Table in Plate XXX. of Vol. II.

Hyperoche *Medius*, of Farey, (D), has the ratio $\frac{19683}{20000}$, $= 14\Sigma + f + m$, which has already been fully described in our article Dieze *Minime*.

Hyperoche *Minor*, of Farey, (φ), has the ratio $\frac{36,472,996,377,170,786,403}{36,893,488,147,419,103,232}$, $= 10\Sigma + f + m$, and is called Prisma, in the Table above referred to. See that article.

Hyperoche of Ptolemy, has the ratio $\frac{128}{129}$, which therefore is not a diatonic interval, because involving the large prime 43, in its ratio: it is the sharp temperament of the false trumpet 4th ($\frac{32}{45}$); is $= 6.88806\Sigma + m$, $= 6.89592\Sigma$, $= .6264543 \times c$, $= .01122725 \times$ viii; and its common log. is .9966202,5935, &c. (ε)

HYPOCHONDRIASIS. See Medicine.

HYPOTHENUSE. See Geometry.

HYPOTHESIS, from the Greek ὑποθεσις, from ὑπο and τιθημι, is a term used in physics to denote a system of one or more facts gratuitously assumed, for the purpose of giving an explanation of a particular class of phenomena. If all, or nearly all, the phenomena are well explained by the fact assumed, or if the truth of this fact is rendered probable by evidence independent of the phenomena which it is intended to explain; it is then called a *theory*. A theory therefore differs from a hypothesis, principally in the degree of probability which attaches to the system. The two terms are however used by the best authors without much discrimination. Every person agrees in calling the Cartesian system of vortices a hypothesis, and the Newtonian system of gravitation a theory; for, independent of the positive objections to the explanations derived from the vortices, there is not the slightest probability of their existence, while the doctrine of the mutual attraction of matter is rendered highly probable from considerations independent of astronomy. The system by which Æpinus has explained the phenomena of electricity and magnetism, is properly an hypothesis, from there being no evidence whatever of the existence of a magnetical and electrical fluid; but from the admirable explanation which it affords, (when in a slight degree modified, by the substitution of two fluids instead of one) of all the phenomena, it is almost universally denominated a *theory*.

HYRCANIA is the name of a country of ancient Asia, to the south of the eastern part of the Caspian Sea. It was bounded by Margiana on the east, Parthia on the south, and Media on the west, and was covered with mountains and forests. Hyrcania was the capital, and its principal towns were Barange, Adrapsa, Casape. Aberbina, Amarusa, Sinica, Sale or Sacæ, Asmura and Mausoca.

HYSSOP. See Horticulture, vol. xi. p. 282.

HYSTERIA. See Medicine.

HYTHE, is the name of a market town of England in Kent, and one of the principal Cinque Ports. It consists principally of one long street parallel to the beach, and crossed by two or three smaller streets. The church, which stands on the side of the hill above the town, is built in the form of a cross, with a tower at the west end. The court hall and market place stand in the middle of the principal street, and the theatre, which is a small one, is situated in one of the streets which runs towards the sea. The coast is here defended by martello towers, and by several small forts. Ranges of barracks for infantry were erected on the heights above the town, with numerous mud-wall cottages for the accommodation of the wives and families of soldiers. In 1811 the town and parish contained

Inhabited houses	268
Number of families	458
Do. in trade	167
Males	995
Females	1323
Total population	2318

See Hasted's *History of Kent*, vol. iii. and the *Beauties of England and Wales*, vol. viii.

I & J.

JACCATRA: See JAVA.

JACK, is a word used by practical mechanics to denote any simple or trifling piece of mechanism.

Jacks and *Jack Sinkers*, are parts of a stocking-frame, see CHAIN-WORK; and lace machines are also provided with parts called jacks. A harpsichord has a jack at every key. Brewers have a large vat which they call jack back. Masons employ a hand jack, screw jack, or jack in a box. Carpenters use a jack plane. Jack towels and roasting-jacks are to be found in every kitchen.

We shall here give a description of the roasting-jack and the hand-jack, both of which are complete machines in themselves; whereas most of the other kinds of jacks are only small parts of other machines.

Hand jack.

PLATE CCXCIX. Fig. 6.

Hand Jack, or *Jack in a Box*, is a simple and portable mechanical power for assisting the hand in heaving up or moving heavy bodies to a small distance, as for instance, to raise the end of a large block of stone or piece of timber sufficiently to put rollers beneath to remove it, to turn a stone or tree over, or to put a chain round it, to repair buildings, and to lift up an angle of a wall to undermine the foundation. Many other purposes to which a machine of this description is applicable are too obvious. The simple lever, or wedge, will, in many instances, perform all that is desired from a hand jack; but the lever will not retain the load at the height to which it is raised, and the drawing of wedges is a tedious operation. The power of the common or simple hand jack, is obtained by a rack and pinion. See Plate CCXCIX. Fig. 6. A block of wood about 2 feet 6 inches long, 10 inches broad, and 6 inches wide, is perforated with a square hole or mortice through it lengthwise, for the reception of an iron rack B. This rack is formed with a double claw or horn at its upper end. A small pinion C is made to engage in the teeth of the rack. The axis of the pinion is supported in iron plates bolted to each side of the block, and one end of the axis projects through the side plate, with a square to receive a winch or handle, which, being turned round, the pinion elevates the rack B in the mortice, and raises the claw or horn up to the load to which it is applied. To prevent the weight of the load running the pinion back, the handle is detained by a hook or link *a* fastened to the outside of the block. When a greater power is required than the simple rack and pinion are capable of exerting, a combination of wheelwork is used, as shewn in the same Figure, where AA is the block of wood, which in this case is made sufficiently wide to contain the cog-wheel F, fixed to the pinion C, which acts in the teeth of the rack B. G is a second pinion of four leaves, working in the wheel F; and the axis of this pinion projects through the side of the block for the winch H to be fixed on it. The block AA is made in two halves, and the recess for the wheel F and pinion G is cut out in one of the halves; the other, being laid flat against it, supports the front pivots of the wheel and pinions. The two halves are bound together by strong iron hoops *b*, *b*, driven over the outside. The rack has a claw N at its lower end, projecting out sidewise through an opening or slit cut through, in the front half of the block. This claw can be introduced beneath a stone which lies nearly flat upon the ground, and which consequently could not be acted upon by the claw on the top of the rack. To prevent the rack descending when it has a load upon it, the small click *a* drops into its teeth, but clears it in going up; when it is not required to detain the rack, this click can be turned out of the way sidewise.

Screw jack. PLATE CCXCIX. Fig. 7.

Fig. 7. is a screw-jack. The block of wood AA is perforated nearly its whole length with a hole sufficiently large to allow the screw B to move up and down without touching. The screw passes through a nut *n*, fixed firm into the top of the block A; and if the screw is turned round, it must rise up through the nut, and elevate the claw F. This claw is fitted on the top of the screw with a round collar, which allows the screw to turn round without turning the claw; and the claw N, which projects through a groove or opening made in the side of the block, is fitted to the screw with a smaller collar. The bottom of the block has four short points to prevent the machine slipping when used upon hard ground. To give motion to the screw, the lower half of it is formed into a square, and a worm-wheel C is fitted upon the square. The teeth of this wheel are engaged by a worm on the axis of the winch H, and plates of iron *a*, *b*, are bolted on each side of the block, near the middle of its height, to carry the ends of the axis of the winch, and of the worm which is concealed behind the worm-wheel C. When the winch is turned round, it causes the wheel C to revolve by the action of the worm in its teeth; and as the wheel is fitted on the square part of the screw, it compels it to turn with it, but at the same time allows the screw to move up and down.

Another screw jack. Figs. 8, 9.

The friction of this kind of screw-jack is very considerable; nor is its strength so great as the screw-jack shewn in Figs. 8. and 9. In this the screw is not made to turn round, but only to rise and fall; and the worm-wheel C, being placed very near the top of the block A, has a nut, for the screw B to pass through, cut in its centre. By this means the nut is turned round instead of the screw, and it requires no collar either at the top or bottom of the screw. The axis of the worm, like the former screw-jack, is supported by two iron plates *a*, *b*, and the end which projects through the plate *a* is made square to apply the winch H. The worm-wheel is shewn dotted in Fig. 9. The circular part D is a part of the wheel C, and forms a collar for the wheel, and gives also a greater depth of nut for the screw to work in.

Bramah's hydrostatic jack. Fig. 10.

Fig. 10. shews a jack on the hydrostatic principle discovered by Pascal, and applied to practice by the late Mr Bramah to presses, cranes, and various other purposes. It is the most powerful of any machine whatever, and very commodious. A is a large block of wood, bolted together in two halves around a cast-iron cylinder, which resembles a mortar or cannon. It is closed at its lower end, and furnished with a piston B, which is turned truly cylindrical, and embraced by a collar of leather in the head of the cylinder *a*; which will prevent any water from leaking out of the cylinder by the side of the piston; a small copper pipe *b* is con-

PLATE CCXCIX. Fig. 9.

nected with the cylinder near its top; the other extremity of this pipe is carried to a small injecting pump C, standing in the cistern R, and actuated by the lever H. At each stroke of the pump a small quantity of water is forced or injected into the large cylinder, and this causes the piston B to rise through the collar of leather a very small quantity each time. This quantity will bear the same proportion to the motion given to the piston of the pump C as the area of that piston bears to that of the large piston B. The force applied to the small pump, and that exerted by the great cylinder, will be in the inverse proportion of these areas.*

The pump rod is confined to a perpendicular motion by an iron frame P, through which it passes.

The top or head of the large cylinder is made larger than the lower part, as shewn by the dotted lines, and the shoulder which rests on the top of the block to sustain the cylinder. When the weight or burden is to be lowered down, it is done by opening a discharge valve in the pump, the handle of which is seen at *p*: this allows the water to return by the small copper pipe *b*, and escape from the cylinder *a* into the pump cistern R. When the power of the lever H is not found sufficient to perform its work, it can be augmented, by taking out the centre pin *r*, which forms the fulcrum of the lever, and inserting it into another hole which is nearer the centre of the pump.

Roasting jack.

Roasting Jack, is a machine for turning round meat when placed before the fire, so as to expose every part of the surface to the heat. These jacks are constructed in different ways; and are either put in motion by dogs, by the smoke which ascends the chimney, by a weight, or by a spring.

When a dog is employed, the spit on which the meat is placed is mounted before the fire, and put in motion by a wheel, in which the dog walks in the same manner as men turn the walking wheel crane; this kind of jack is now out of use.

Smoke jack. Fig. 5.

A smoke jack is represented in Fig. 5. where AA is the brickwork of the chimney, which is contracted to a circular figure at AA; B is a strong iron bar, placed upon an arch of brickwork over the fire-place, to form a support for the wheel-work of the jack; C is a horizontal wheel placed in the circular funnel AA; it is made of iron plate, with a number of vanes radiating from the centre, each being placed at an angle of about 30° to the plane of the wheel; the heated air which ascends the chimney will strike the vanes and turn the wheel; the lower end of the spindle D, on which the wheel is fixed, has a pinion E fixed on it, and turns a contrate or crown wheel F on the horizontal spindle G; on the other end of this spindle is a pulley H, for an endless chain, which descends to the spit on which the meat is placed; the pulley pinned on the end of the spit is laid in the loop formed by the endless chain, so that this chain at the same time suspends one end of the spit, and gives motion to it; the upper pivot of the spindle D is supported in an iron bracket *m*, projecting from the inside of the chimney, and the lower pivot rests on the top of a standard *n*, which also carries one end of the horizontal spindle G; when the chimney requires to be swept, the wheel C is lifted out of its centre, to allow a boy to pass; these jacks are always in motion when the fire is kept up.

Roasting jack with a weight. Fig. 3.

A roasting jack to be turned by the descending power of a weight, is shewn in Fig. 3. A is the barrel on which the cord for the weight winds. The barrel is not fixed upon the main axis, which is shewn by dotted lines: It slips round upon it quite freely in the direction proper for winding up the weight; but is prevented from turning in the other direction, by a ratchet concealed within the barrel near the cog wheel B. The cog wheel B is fixed fast on the main arbor, and its teeth turn a pinion *b* on one end of the arbor C; the other end of this carries a worm wheel, which cannot be seen in the drawing, but its teeth act in the worm cut on the vertical spindle T. On the top of the spindle is the fly-wheel D, which regulates the motion of the jack, and prevents the main arbor from turning too fast by the power of the weight. A wooden pulley E is fixed on the main arbor on the outside of the frame, for the endless chain *e*, which gives motion to the spit, and the pulley has several grooves to receive chains for two or more spits at the same time. Two legs or standards I, K are rivetted to the frame G, to fix the jack against the wall over the fire-place.

PLATE CCXCIX. Fig. 3.

The weight for giving motion to the jacks is generally suspended by a pair of blocks, with two or three sheaves. The end of the line, or fall from the pulleys, is wound on the barrel A; and the weight is usually placed outside the house, and contained in a sort of a chimney, to defend the lines of the pulleys from the weather. When pulleys are used, the jack will continue its motion longer without winding, but the weight must be much heavier than if it was simply suspended to the end of the cord.

When the weight is run down, a handle is applied to the square part *s* of the arbor of the barrel A, which projects through the frame H. By turning the handle round, the barrel goes with it and winds the rope upon its circumference; but as the barrel slips round on the main arbor when the barrel is turned in that direction, the wheel B continues to revolve and carry the spit by the momentum of the fly-wheel D as long as is requisite to wind up the weight.

Spring jack. Fig. 4.

A spring Jack is shewn in Fig. 4. From the figure of the external case of this kind of jack it is called a bottle jack. No spit is used with this jack, but the meat is suspended before the fire, and the jack keeps it constantly in motion, by turning it round, first in one direction, and then back again; for this purpose the jack is hung upon an arm, projecting from the arch over the fire-place by the loop *q*, at the upper end of the bottle, and the meat is suspended to the hook fixed to a small axis L *m*, which is kept in constant motion by the wheel-work within the bottle, and the motion is governed by the fly-wheel O.

The spiral spring is coiled up into a box, which is marked A in the Figure, and is fastened to the frame. The interior end of the spiral spring is connected with the main arbor B, which is supported by the plates R, S. On this arbor the wheel C with its ratchet-wheel Z is fixed, and turns the small pinion D on the second arbor E; at the end of this arbor, the contrate or escape-wheel F is fixed; and G is a vertical arbor with two pallets *a* and *b* projecting from it, the one engaging in the teeth on the upper side of the contrate-wheel, and when the pallet *a* is not in action, the pallet *b* intercepts the lower teeth of the wheel. This is a crown-wheel escapement, such as is used in common watches, and gives motion to the arbor G alternately in a backwards and forwards direction. On the lower end of the arbor G a sector C is fixed, and is cut into teeth at its circumference, to form a segment or portion of a wheel. It gives motion to the pinion H on the short vertical arbor *d*; and the wheel I is fixed on the same arbor, to give mo-

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* See the article HYDRODYNAMICS in this volume, p. 482.

Spring jack. PLATE CCXCIX. Fig. 4.

tion to the pinion L, in the centre of the jack, which is fixed on the vertical arbor *m*, that passes through the bottom plate of the bottle, and has the fly-wheel O fixed to it, with the hook P for suspending the meat. The arms of the sector *c* are sufficiently extended to admit the arbor *m* between them. The arbor is sustained by the fixed cock *i*, and is also suspended by a number of small catgut strings going up through the centre of the jack to the top of the neck of the bottle, and attached to the cross pin *r*. These strings take off part of the weight of the meat which is suspended on the hook P, and diminish the friction on its collar. This effect is also partly produced by a small spiral wire spring *t* coiled round the arbor, and bearing on the cock *i*.

The spring jack is wound up by the key Q, when applied to the square part *s* of the main arbor; and in the act of winding, the great wheel C is not turned round by the ratchet wheel *z*, because the click fixed to the great wheel slips over the sloping side of the teeth. To prevent the spring from breaking, a pinion *n* is fixed on the end of the main arbor; beyond the plate it works into the wheel *o*, which turns upon a pin fixed into the side plate S of the frame. When the main arbor has made a sufficient number of revolutions to wind up the spring, the leaves of the pinion *n* come in contact with a part of the wheel *o*, which has no space in it, and this prevents the arbor being turned any further, so as to endanger the breaking of the spring. The maintaining power of the spring, when wound up, gives motion, by the wheel C and pinion E, to the escape wheel F, the upper tooth of which meets with the pallet *a*, and carries it along with it, turning the vertical arbor round upon its pivots. This motion is communicated by means of the sector C to the pinion H, and its wheel I, and thence to the sector pinion L, and the fly wheel, and consequently to the meat. The use of the wheel-work CHL is to make the meat turn round several times before the tooth of the wheel escapes the pallet *a*, and then the tooth on the underside of the escape wheel meets with the pallet *b*, and turns the vertical arbor G, and the fly wheel back again, in a contrary direction to that in which it was before turned by the pallet *a*, because the underside of the escapement wheel is going in a contrary direction to the upper side; when the under tooth of the wheel escapes from pallet *b*, the pallet *a* comes into action again, and thus a continuous motion is kept up, first in one direction for a few turns, then in the opposite direction, and so on, till the maintaining power of the spring becomes exhausted, when it must be wound up again by the key Q. The tube resembling the neck of the bottle is to give length to the catgut strings before mentioned, and which, by their twisting and untwisting, perform nearly the same office as the pendulum spring in a watch, and make the fly wheel return back readily. The bottom V of the bottle is screwed to a flaunch or projecting rim round the bottom of the bottle, by removing these screws, and taking out the cross pin *r* in the top of the neck which hold the strings; the frame containing the wheelwork may be withdrawn from the case *x x* to be repaired or oiled as occasion may require. (J. F.)

JACKSON, PORT. See BOTANY BAY and *New* HOLLAND.

JAEN is a town of Spain, and the capital of the ancient province of the same name, which is now under the government of Andalusia. Jaen is supposed by some to be the *Oningi* of Pliny, the *Oringi* of Livy, and the *Mentessa* of the Romans. The city, which is situated at the foot of a mountain of mixed marble, is surrounded by walls flanked with towers. The town is of a middle size, and has some squares, one of which is spacious. The water, with which the town is well supplied, is distributed in the squares, streets, and houses. Jaen is the see of a bishop, suffragan of the archbishop of Toledo, formerly fixed at Bäeza. The diocese contains two cathedral chapters, one at Bäeza, and the other at Jaen; two collegiate chapters, one at Bäeza, and the other at Ubeda; seven archpriests, and 438 parish churches. The principal public buildings are the cathedral and parish churches, and a great number of monasteries, nunneries, and two hospitals. The cathedral is a noble piece of architecture. The eastern front, flanked with two fine towers, is adorned with eight Corinthian columns, and has three doors embellished with bas reliefs. The chapel of the Sacrario is esteemed a fine piece of architecture. The parish church of St Claire contains an exquisite painting of the Virgin and our Saviour. The convent church of the nuns of St Claire is a handsome building, and the principal altar is adorned with some excellent paintings by Angel Nardi. Jaen was formerly a rich and commercial town, but its silk manufactories failed about the end of the 16th century. About the middle of the 18th century, 5000 tape looms, 1200 ribbon looms, and several silk ones, were set to work, but they did not succeed, and few of them remain at present. The country around Jaen is rich and beautiful; the silk-worm is reared, but not in great quantities. Population 30,000. See Laborde's *View of Spain*, vol. ii. p. 117.

JAFFA, is a seaport town of Palestine, situated upon the declivity of a hill on the eastern shore of the Mediterranean. It has a good wharf, but the harbour, which seems to have been of considerable size formerly, is now small, and is only frequented by coasting vessels making the voyage to Syria. By clearing it out, it has been conceived capable of receiving 20 vessels of 300 tons, such as are now obliged to anchor in the roads, where they are always ready to slip their cables, from the frequency of sudden storms. On all the coast of Syria there is scarcely a safe harbour. The declivity upon which the town of Jaffa stands, is so unequal, that the streets are paved in steps. The whole is surrounded by walls, fortified with tolerable regularity, and capable of defence, though commanded by a height. On the southern side, it has one large bastion, with several towers crowned with artillery, which flank the line of walls; but these are said not to be of sufficient strength. There were recently two principal gates, and a third of a smaller size; but one of the former was shut up. The houses are neatly built of stone; and being distributed on the declivity, rise above each other like the seats of an amphitheatre, and there is a tower or citadel on the summit. There are three small convents here of Christians, Greeks, and Roman Catholics, whose numbers are probably much smaller since pilgrimages to the Holy Land have become less frequent. In 1807, there were but four Roman Catholics in their monastery, and they were all Spaniards. Only a few Jews are in the town, the population consisting of a mixed race, among whom is a numerous garrison of Turkish and Maugrabin soldiers; the total amounting to about 6000 or 7000. Water is scarce in Jaffa, notwithstanding the vicinity of a small river: It may be obtained, however, by digging for it on the coast;

and it is said, that one of its governors who engaged to remedy this inconvenience, was strangled by order of Djezzar, Pacha of Acre. The climate seems to have a tendency to insalubrity, which has been attempted to be corrected by draining extensive marshes. Soap is the principal manufacture of this town, as it is of several considerable towns of Syria, from all of which it is sold under the name of Joppa soap, and is exported for supplying Egypt. Oil of olives was one of its chief ingredients; but the groves of olive trees which covered the neighbouring country, and also those of oranges, lemons, and other fruits which adorned the town, were destroyed by the Mamelukes during the sieges of Ali Bey and his successor. Spun cotton is exported in small boats to Acre, whence it is shipped for other places, and also the provisions, the produce of the country. Jaffa is governed by an officer, who is said to be appointed by the Kislar-Aga or chief of the Black Eunuchs in the Turkish emperor's service, but the regulations under which the military subsist are not explained. The governor pays a small tribute to the Porte, which he levies in customs from merchandize and taxes on the town and villages dependant on him: his authority seems to have been very low about thirty years ago, but events more recent have rendered Jaffa of greater importance. The town subsists by its commerce, and the resort of pilgrims to the Holy Land, who find a reception in some of the monasteries: part of the money paid by them for this privilege, however, is diverted into a different channel. Jaffa is celebrated as the Joppa of Scripture: the spot where the Roman Catholic monastery stands is said to have the site of the house of Simon the tanner: and on a rising ground, about a mile east of the town, are some ruins, called those of the house of Tabitha, who was raised from the dead by St Peter, and where Pococke supposes there was a church dedicated to her, as the Greeks resort hither to perform their religious rites on the day of her festival. In profane history it is equally celebrated; for here Perseus is believed to have rescued Andromeda from danger; and Jerome affirms that in his time the rock to which she had been bound was still pointed out. Jaffa was destroyed by the Sultan Saladin in 1191, after which it was rebuilt and fortified by the Christians.

During the arduous contest which subsisted for so many years among the principal European powers towards the close of the eighteenth century, a French army invaded Egypt. A force of 12,428 men commanded by Bonaparte was detached to act against Syria in February 1799, principally, it is said, with the view of reducing Acre, in retaliation for the capture of the fort of El Arisch by Djezzar. This army succeeded in taking every place on the route with facility, and at length reached the walls of Jaffa on the 7th of March of the same year. With regard to the consequences of the ensuing siege, the keenest controversies have been agitated by our contemporaries: on the one hand it has been said, that the French exercised unheard of enormities on the captured garrison: on the other, these have been as strenuously denied.

The Turks believing themselves invincible behind their walls, cut off the head of a messenger who carried a summons from Bonaparte to surrender, and did not answer it. But the French batteries being completed in three days, the fire of twelve-pounders opened at seven in the morning of the 7th, the summons having been sent at day-break, and was directed against a kind of square tower where the wall seemed weakest, on the south-west of the town. The breach appearing practicable by three o'clock, the signal was given for storming, amidst a fire well sustained by the garrison. The French advanced boldly; but no sooner had they penetrated the streets, than they gave themselves up to the fury sanctioned by an assault, massacring who ever ventured to oppose them. "All the horrors which accompany a storm are seen in every street, and repeated in every house. Here are heard the screams of some youthful female, the victim of violation, vainly imploring succour from her outraged mother, or calling on the name of her father, who is mercilessly murdered. No asylum is respected: streams of blood are flowing: and at each footstep appears a being groaning in the agonies of death." General Berthier ordered an officer M. Miot, to take a detachment, and carry the wounded off the breach; on arriving at the spot, he found that his whole detachment had forsaken him. Thus disappointed, he entered the city. "What a spectacle," he exclaims, "was there! the pallid hue of the inhabitants; their terror; the shouts of the soldiers; women wandering about despoiled of their veils, recognizing their dead or dying relatives among the disfigured bodies. The ground was overspread with dresses and furniture, and the soldiers selecting the richest from among the pestiferous garments." While all this was going on, a considerable portion of the garrison had retired into one of the forts, where they laid down their arms, and were conducted to bivouac before the tents of the general's staff. The Egyptians were selected from among them, and removed; and the remainder, consisting of between 2000 and 3000, Sir Robert Wilson seems specifically to affirm 3800, Turkish artillerymen, Maugrabins and Arnauts, were put under the guard of a strong detachment. Next day they were sparingly supplied with biscuit, and parties of them were carried to get water in some vessels with which they had been furnished.

Meantime Bonaparte, elated with his conquest, issued proclamations to the inhabitants of the various towns of Palestine, giving them an option of peace or war, declaring that he was merciful to the troops surrendering at discretion, but those were treated with severity who had infringed the rights of war. He also solicited the friendship of Djezzar, and his hostility towards the Mamelukes and the English.

It does not appear how these overtures were received, or what time was allowed for an answer; but on the 10th of March, a little after mid-day, the prisoners of Jaffa were put in motion, surrounded by a vast square battalion formed by the French divison of General Bon. Suspicions arising in the French army regarding their disposal, induced many not appointed for that duty to accompany the columns of Turks, who marched in profound silence. At length, having reached the sandy downs, about a mile south-west of Jaffa, they were halted near a marsh containing turbid water, when the commanding officer of the French directed that the whole should be partitioned into small groups. The order being accomplished, the victims were conducted to different points, and inhumanly butchered in cold blood: an atrocity unexampled in the modern history of civilized nations. Notwithstanding the number of troops employed in it, the execution of this horrible sacrifice required a long time, and it is affirmed that it was only with extreme repugnance that the soldiers fulfilled the duty imposed upon them. All the prisoners suffered with the most heroic fortitude, with the exception of a single youth, who made a fruitless appeal to the humanity of his merciless conquerors. Those who could accomplish it, with uncommon resignation performed that ablution which their religion enjoins, by means of the stagnant water, and then bid each other adieu; but none ever attempted to escape. In narrating these events, M. Miot observes, "I saw a respectable looking old man, whose manner and appearance denoted superior rank, I saw him coolly cause a hole be dug in the sand at his feet, deep enough to admit of his being buried alive.—Doubtless, he wished to perish by his own hands. He stretched himself on his back in this melancholy tomb, which now afforded him protection, while his comrades, offering supplicatory prayers to heaven, soon covered him up with sand. Then they stamped on the earth thus enshrouding him, as if to give a more speedy termination to his sufferings. This spectacle made my heart palpitate within me. It took place while the groups scattered on the downs were massacred. At last, of all the prisoners none remained but those who were beside the marsh. The cartridges of our soldiers were now expended; and it was necessary to dispatch them with swords and bayonets. I could no longer support this horrible butchery. I fled from it pale and ready to sink; but several officers told me in the evening, that some of those miserable beings, yielding to that irresistible impulse which prompts mankind to avoid destruction, leapt on each other, and thus received in their limbs the blow which was aimed at their hearts. If the truth must be disclosed, a frightful pyramid was reared of the dead and dying, streaming with blood; and it became necessary to remove those who had expired, in order to murder others who, sheltered by this terrific rampart, had not yet been struck." Their bones are said to have lain long in heaps, and to have been shewn to travellers; but Dr Clarke could not find any traces of them, nor even obtain the most distant information that such a massacre had ever taken place.

In regard to the inducements which led to an event so noted in the history of Jaffa, the French affirm, that these were unconnected with the thirst of revenge, or the love of cruelty. Their army, already reduced by the sieges of El Arisch and this unfortunate town, daily became still more enfeebled by the ravages of disease. Great difficulty of subsistence was experienced, and the soldier rarely received his ration complete. The scarcity was increased by the hostile disposition of the inhabitants of Syria and Palestine towards the French. "To maintain the prisoners," they pleaded, "by keeping them along with us, was not only augmenting our necessities, but would have been a constant restraint on our motions. Confining them in Jaffa was admitting the possibility of revolt, considering the slender guard that could be left to watch them, without removing the former inconvenience. Sending them back to Egypt would have required a considerable detachment, and reduced our troops greatly. To liberate them on their parole was, notwithstanding all engagements, hazarding an addition to the number of our enemies, and particularly to the garrison of Acre. Thus there remained only one universal measure of conciliation; it was frightful, but it was judged the result of necessity."

The exact number of the Turkish garrison thus massacred by the French is not exactly ascertained. Sir Robert Wilson states it at 3800: M. Miot, a spectator of the victims, thinks there were not quite so many. But possibly Bonaparte's manifesto to the Egyptians may be considered an ingredient of evidence, wherein he says, "he found at Jaffa about 5000 of the troops of Djezzar. He destroyed them all; very few saved themselves by flight." Such is a brief account of this memorable tragedy, the truth of which has been so keenly controverted in Europe.

The French have been charged with another atrocity in poisoning 580 of their own sick and wounded in the hospitals at Jaffa; but happily it has not yet received the same confirmation we believe as the former. In their retreat from Acre in May 1799, they seized on all the stores found in Jaffa, and blew up the fortifications, which have since been repaired. Distance from Acre 40 miles South. Lat. 32° 2′ N. Long. 34° 58′ E.

JAGAS. See CONGO.

JAGGERNAUT. See JUGGERNAUT.

JAGO, ST. See CUBA.

JAGO, ST. one of the *Cape de* VERDE *Islands*, which see.

JAGO, ST DE COMPOSTELLA. See COMPOSTELLA.

JALAP. See MATERIA MEDICA.

JAMAICA.

Situation and extent.

JAMAICA, the most considerable as well as by far the most valuable of the British West India islands, is situated in the Atlantic Ocean, among what are called by geographers the Greater Antilles, in 18° 12′ of North Latitude, and 76° 45′ West Longitude from London. The latitude of Kingston, the principal town, is 18° north; the latitude of Morant point east is 17° 56′, and its longitude 76° 6′; and the latitude of South Negril Point west is 18° 16′, and its longitude 78° 32′. Jamaica is nearly of an oval form; 140 English miles in length, and in its broadest part about 50. It is the third in size of the islands of the Archipelago. It is bounded on the east by the island of St Domingo, from which it is separated by the channel called by English seamen the Windward passage: by Cuba on the north; by the Bay of Honduras on the west, and by Carthagena in New Spain on the south.

Divisions and principal towns.

Jamaica is divided into three counties; Middlesex, Surry, and Cornwall. The county of Middlesex is divided into eight parishes, which contain one town and thirteen villages. The town is called St Jago de la Vega, or Spanish Town; and as this is the residence of the governor, it is accounted the capital of the island. The county of Surry contains seven parishes, in which there are two towns and ten villages. The chief of these is the town and parish of Kingston. Port Royal is also in this county, and likewise the villages of Port Morant and Morant Bay, the latter of which is a place of considerable importance, on account of its shipping. The parish of Portland in this county contains the vilage of Port Antonio, the harbour of which is one of the most commodious and secure in the island. The parish of St George contains Annotto Bay, a shipping place. The county of Cornwall contains five parishes, in which are situated two towns and eight villages. The towns are Savannah le Mar, which being destroyed by the hurricane in 1780, consists at present only of 60 or 70 houses; and Montego Bay Town on the north coast. The villages of Jamaica are generally small hamlets on the bays, where the produce is shipped in the *droggers*, to be conveyed to the ports of clearance. The few other places worthy of mention are Falmouth on the north coast, on the south side of Martha Brea harbour; Lucca harbour, also on the north coast; Bluefield Bay on the south coast, three leagues east of Savannah le Mar, the usual rendezvous of the homeward bound fleets; and Carlisle Bay, also on the south coast. The chief headlands of the island are Point Morant, more generally known to seamen by the name of the East End of Jamaica, and dreaded by them for its thunder and lightning squalls. Nepil by North and Nepil by South are two promontories on the west end of the island. The islands deserving mention near Jamaica, are the Pedea Keys and Portland Rock, on a large bank south of the island, and Morant Keys, eight leagues south-east of Morant Point.

Mountains and face of the country. The island is crossed longitudinally by an elevated ridge, called the Blue Mountains. What is called the Blue Mountain Peak, rises 7431 feet above the level of the sea. The precipices are interspersed with beautiful savannahs, and are clothed with vast forests of mahogany, lignum vitæ, iron wood, logwood, brazilletto, &c. On the north of the island, at a small distance from the sea, the land rises in small round topped hills, which are covered with spontaneous groves of pimento. Under the shade of these is a beautiful and rich turf. This side of the island is also well watered, every valley having its rivulet, many of which tumble from overhanging cliffs into the sea. The back ground in this prospect, consisting of a vast amphitheatre of forests, melting gradually into the distant Blue Mountains, is very striking. On the south coast the face of the country is different; it is more sublime, but not so pleasing. The mountains here approach the sea in immense ridges; but there are even here cultivated spots on the sides of the hills, and in many parts vast savannahs, covered with sugar canes, stretching from the sea to the foot of the mountains, relieve and soften the savage grandeur of the prospect.

Soils. The soil of Jamaica is, in many places, deep and fertile. On the north side, chiefly in the parish of Trelawney, there is a particular kind of soil of a red colour, the shades of it varying from a deep chocolate to a rich scarlet. In some places, it approaches a bright yellow; but it is every where remarkable, when first turned up, for a glossy shining surface; and for staining the finger like paint, when it is wetted. It seems to be a chalky marl, evidently containing a large portion of calcareous matter, from the circumstance of its holding water, when formed into ponds, like the stiffest clay. What is called the *brick mould* in Jamaica, is a deep, warm, mellow, hazle mould, with an under stratum so retentive, as to retain a considerable degree of moisture even in the driest season. This is the best soil in the West India islands for sugar canes, next to the ashy loam of St Christophers, and is followed by the deep black mould of Barbadoes. On the whole, however, the cultivated soil of Jamaica is not remarkably fertile.

Rivers. The island has upwards of one hundred rivers, rising in the mountains, and running with great rapidity to the sea on both sides. This rapidity, as well as the obstructions from rocks, renders them unnavigable except by canoes. The deepest is the Black River on the south coast, which flows gently through a considerable tract of level country, and is navigable by flat boats for 30 miles. There are some medicinal springs, warm, sulphureous, and chalybeate. The most remarkable of these is in the eastern parish of St Thomas, in the neighbourhood of which, a village called Bath has been built. The heat of this spring raises the thermometer to 123 degrees. It is said that the Spanish settlers once wrought mines both of copper and silver; and one of lead was opened a short time since in the parish of St Andrew, but it was soon abandoned.

Climate. The climate of Jamaica, even on the coast, is temperate, the medium heat at Kingston, throughout the year, being 80, and the least 70. In ascending towards the mountains, the temperature quickly alters with the elevation; eight miles from Kingston, the maximum is only 70; at the distance of 14 miles from this town, where the elevation is 4200 feet, the average range of the thermometer is from 55 to 65, and the minimum in winter 44. On the summit of Blue Mountain Peak, 7431 feet above the sea, the range in the summer is from 47 at sun-rise to 58 at noon; and the minimum in winter is 42. The year may be divided into four seasons; the first commencing with the vernal or moderate rains in April or May, which usually last six weeks; the second season includes June, July, and August, and is hot and dry; the third includes September, October, and November, or the hurricane and rainy months; and the fourth December, January, February, and March, which are the most serene and the coolest months.

Vegetables and fruits. Besides the staple exports of Jamaica, consisting of sugar, indigo, coffee, and cotton; the cultivated vegetables are maize, Guinea corn, and calavances for the food of the negroes, and almost all the kitchen vegetables of Europe, besides many indigenous ones, as the sweet potatoe, yam, eddar root, callaloo, a kind of spinach, and the commonest substitute for greens, cassara, okasy, &c. Few of the northern European fruits thrive, but the indigenous ones are numerous and delicious; the principal are the plantain cocoa-nut, guava, sour-sop, sweet-sop, papaw, custard apple, cashew apple, granidella, prickly pear, pine apple, &c. The orange, lime, lemon, mango, and grape, have been naturalized, as well as the cinnamon tree, of which there are now considerable plantations. The bread-fruit tree, with other useful plants, has been introduced by the exertions of Sir Joseph Banks. This island abounds in various grasses of an excellent quality. **Grasses.** Of the native grass, good hay is made, but in no great quantity; but there are two exotic grasses that are extremely valuable, and yield an abundance of food for cattle; the first is an aquatic plant called Scots grass, from a single acre of which five horses may be maintained for a whole year. The seed of the other kind, called Guinea grass, was introduced into the island, about 70 years ago, as food for some birds brought from the coast of Guinea. Cattle are remarkably fond of this grass, and thrive wonderfully upon it. The greater part of the grazing and breeding pens throughout the island are supported chiefly by means of this invaluable herbage. **Forest trees.** The principal forest trees have been already mentioned; many of them rise to a prodigious height, as the papaw and the palmeto royal, the latter of which is frequently found 140 feet high; the trunks of the ceiba, or wild cotton tree, and the fig-tree also, often measure 90 feet from the base to the limbs; the former, when hollowed out, has been known to form a boat capable of holding one hundred persons. Of softer kinds of wood for boards and shingles, there is a great variety of species; and there are many well adapted for cabinet work, such as the breadnut, the wild lemon, &c. In mentioning the vegetable productions of this island, the wild pine ought not to be omitted; it is a plant that commonly takes root in the great forks of the branches of the wild cotton tree; by the conformation of its leaves it catches and retains the rain-water, each leaf resembling a spout, and forming at its base a natural reservoir, which will hold about a quart of water.

Wild pines.

Animals.

When Jamaica was discovered, it contained eight species of quadrupeds, the agouti, the pecare, the armadillo, the opossum, the racoon, the musk-rat, the alco, and the monkey. Of these only the agouti and the monkey remain. There are many varieties of the lizard, some of them very beautiful. The most delicious of the wild fowl are the ring-dove, and the rice-bird of South Carolina; the latter, after fattening upon the rice plantations in that district, visit Jamaica in prodigious numbers in October, to feed on the seeds of the Guinea grass. Parrots are still found in the groves, but the flamingo is no longer to be seen.

Few cattle are bred here, the asses and mules being imported from the Spanish Main, and the horses from England and America; the latter are in general excellent, and sell at from £100 to £140 currency. The black cattle are of a large size. There are also asses and sheep; the mutton is well tasted, but the wool is hairy and coarse. There are likewise goats and hogs in great plenty; sea and river fish; wild, tame, and water fowl. Near the coast there are salt ponds, from which formerly the inhabitants supplied their own consumption.

Commercial productions.

The commercial productions of the island are sugar, rum, molasses, coffee, cocoa, cotton, indigo, pimento, and ginger.

In the year 1673, the chief productions of Jamaica were cocoa, indigo, and hides. The cultivation of sugar had just commenced. It appears from the following statement, that the increase in the growth of this staple article of the island has been very gradual.

In the year 1722	. .	11,000 hhds. were exported.
1739	. .	33,155
1744	. .	35,761
1768	. .	55,000
1774	. .	78,304
1790	. .	105,400
1802	. .	140,000

A new species of sugar-cane, far more valuable than that formerly in use, has lately been introduced into Jamaica. It was first imported into the French islands of Guadaloupe and Martinique, from the islands of Bourbon and Mauritius, and is called the Bourbon or Otaheite Cane. It is much higher, and four times as large as the cane formerly grown exclusively. It will grow on boggy land, and yields one-third more sugar than the old cane; but the sugar is not of such a compact grain. The average expence of the cultivation of sugar is 20s. 10d. per cwt. independent of the interest of capital and the produce of rum. The works necessary for making 200 hogsheads of sugar annually cost £10,000 Jamaica currency; and an estate producing such a quantity, requires £40,000 to establish it, viz. 250 negroes at £70 sterling each, amounting to £17,500; 180 cattle and mules at £30 each, amounting to £5400; buildings for the manufacture, and houses for negroes and owners, £7000; and land, £10,100. The value of the buildings and machinery on the sugar plantations varies from £4000 to £25,000 sterling. The greatest crop of sugar on an estate with one set of works ever grown, was 1030 hogsheads, of 18 cwt. each; but estates in general, with one set of works, make from 100 to 300 hogsheads. Estates containing 1500 negroes and a due proportion of whites, require about £10,000 sterling of supplies annually of British manufactures and provisions. One hundred barrels of herrings are required for 250 negroes in the course of the year.

Produce, expence of cultivation, &c.

Produce, expence of cultivation, &c.

The following table, extracted from the Report of the Committee of the House of Commons in the year 1807, on the commercial state of the West Indies, exhibits the outgoings, and the produce of a sugar estate in 1806, which was cultivated by 519 negroes, and 434 head of stock.

OUTGOINGS.

British and Irish Supplies.

Lead, mill-work, and ironmongery utensils .	£671
Medicines, oil, tallow, grain, wine, &c. .	306
Osnaburghs, negro clothing, hats . .	516
Wood-hooks, ox-bows, rope, stationery, pottery, &c.	231
Convoy-duty, custom-house entries, and shipping charges	481
Provisions, and herrings with charges .	667
Coals and fire-bricks, with charges . .	843

Expences in the Island.

American lumber, salt-fish, flour . .	1492
Cattle purchased in the island . .	603
Fresh beef, medical attendance, wharfage, tradesmen, &c.	1367
Hired labour	184
Taxes	566
Attornies commissions, overseers and bookkeepers' salaries	961
Total . . .	£8888

PRODUCE.

	Hhds.	Tierces.
Sugar . . .	472 . . .	81
	Puncheons.	
Rum . . .	164	

Formerly it was calculated, that where two hogsheads of sugar were made, there was at least one puncheon of rum; but latterly the proportion has been greater; the average annual quantity of rum being nearly 54,000 puncheons.

Coffee.

Coffee was little cultivated in Jamaica till the year 1788. The coffee plantations are generally situated in the hilly regions, of which nearly two-thirds of the island consist, and which are, from their soil, climate, and situation, unfit for sugar plantations. The increase of coffee plantations may be seen from the following facts, taken from the report already referred to.

Cotton.

Indigo.

Ginger.

Pimento.

In the four years ending the 30th September 1791, the average exportation of coffee was 1,603,066 lbs.: in 1804, it amounted to 22 million pounds; and during three years ending 30th September 1807, the average exportation was more than 28½ millions, which, at £6 per cwt. its cost in Jamaica, produced more than £1,700,000. It is calculated that £20,000,000 is invested in coffee estates. Cotton is not cultivated to any very great extent: it was attempted to cultivate it on ground worn out by sugar; but it was found that such soil would not grow either cotton or coffee, and would produce only very inferior grass. Indigo is now very little cultivated, and, in all probability, will never again become a staple commodity. Blome, who published a short account of Jamaica, in the year 1672, mentions that there existed at that time, about 60 cocoa walks: at present, there is scarcely a single plantation in the whole island. Ginger is little cultivated. All the produce of the arnotto plant, which is at present exported from Jamaica, is gathered from the trees that grow spontaneously. The pimento trees also grow spontaneously, and in great abundance, especially in the hilly regions of the North. The returns from a pimento walk, in a favourable season, are very great: a single tree has been known to yield 150 lbs. of the raw fruit, or 100 lbs. of the dried spice.

The following Tables will further illustrate the value, and produce, and expence, of cultivating Jamaica estates at different periods.

Value of estates.

Common Valuation of an Estate.

	Sterling.
Cane land, the canes upon it valued separately	£22 per acre
Plants	22 do.
Cane land in ratoons and young plants	15 do.
Pasture land	8 do.
Wood land	4 do.
Provisions	14 do.
Negroes	57 do.
Mules	22 do.
Steers	10 do.
Breeding cattle, &c.	5 do.

Works, water, carts, &c. from £7000 to £10,000.

View of the Property and chief Produce of the whole Island in 1786.

Property and produce in 1786.

Counties.	Sugar estates.	Other settlements.	Slaves.	Produce of sugar. Hhds.	Cattle.
Middlesex . .	323	917	87,100	31,500	75,000
Surry . . .	350	540	75,600	34,900	80,000
Cornwall . . .	368	561	90,000	39,000	69,500
Total	1061	2018	255,700	105,400	224,500

To this produce should be added about 53,000 puncheons of rum.

Comparative View between the Years 1768 and 1786.

Compared with 1768.

	MIDDLESEX in		SURRY in		CORNWALL in		Total in		Amount of increase.
	1768.	1786.	1768.	1786.	1768.	1786.	1768.	1786.	
Sugar estates . .	239	323	146	350	266	388	651	1,061	410
Sugar hogsheads .	24,050	31,500	15,010	34,900	29,100	39,000	68,160	105,400	37,240
Negroes	66,744	87,100	39,542	75,600	60,614	93,000	166,900	255,700	88,800
Cattle	59,510	75,000	21,465	80,000	54,775	69,500	135,750	224,500	88,750

Rates of Contingent Charges on Jamaica Estates from 1763 to 1806, taken from the Report of the Committee of the House of Commons.

Expence of estates from 1763 to 1806.

	1763 to 1773.	1773 to 1783.	1783 to 1789.	1789 to 1794.	1794 to 1799.	1799 to 1806.
Head Overseer's salary, ...	£70 to £100	£70 to £100	£100 to £120	£100 to £150	£120 to £180	£150 to £215
1st Bookkeeper's and Distiller's, . .	£21 to £28	£28 to £35	£35 to £43	£43 to £45	£45 to £50	£50 to £60
Junior Bookkeeper,	£17 to £20	£20	£20 to £22	£22 to £25	£25 to £35	£35 to £50
Red oak staves, per 1000, ...	£6 to £8	£8 to £11	£7 to £10	£8 to £15	£15 to £33	£22 to £30
White ditto, . .	£7 to £10	£7 to £21	£9 to £12	£9 to £22	£22 to £36	£28 to £32
Mules, ...	£19 to £21	£19 to £28	£18 to £22	£22	£22 to £36	£36
Steers, ...	£7 to £10	£9 to £14	£9 to £11	£8, 10s. to £14	£14 to £29	£29

Provision and lumber.

Provisions and Lumber, for the Plantations, imported into Jamaica in 1806, taken from the same Report.

	From the United Kingdom.	British America.	United States.	Other Counties.
Corn, bushels, ...	15,972	1450	82,043	
Bread, flour, and meal, cwts. . .	8405	381	142,350	
Rice, barrels, ...	16		4094	
Beef and pork, barrels, . . .	32,281	1262	9567	
	Bar. Quint.	Bar. Quint.	Bar. Quint.	
Fish, dry, ...	186 478	0 17,408	0 25,039	
Do. pickled, barrels, ...	48,838	29,416	30,834	
Cows and oxen, ...	8			684
Sheep and hogs, ...			662	136
Oak and pine boards, and timber in feet, ...		753,588	9,501,734	
Shingles, No.		208,225	17,621,756	
Staves, do.		246,760	12,395,732	

The annual value of the lumber and provisions formerly imported into Jamaica from the United States, amounted to above £ 1,000,000, in return for which, the Americans were allowed to take only rum and molasses. Of the former, they used to take annually 30,000 puncheons; but since they began to distil spirituous liquors themselves, they seldom take more than 5000 puncheons.

Importation and exportation of slaves.

The following Table exhibits the importation and exportation of slaves for four years, previous to the abolition of the slave trade.

Years.	Vessels from Africa.	Tonnage.	Crew.	Slaves imported.	Slaves exported again.
1802	32	10069	1004	8933	2712
1803	21	6799	476	6391	2092
1804 till 5th July . .	8	2258	245	2034	1665
1804 10th of October, to 1805 ditto.	21	6513		5684	

Of which, 160 were exported to the Danish colonies, 270 to the Spanish colonies, and 85 to Honduras; in all 515.

Commerce.

The official value of the imports from Jamaica into Britain, and the exports to the island, were, in

	Imports.	Exports.
1809 . . .	£ 4,068,897 . . .	£ 3,033,234
1810 . . .	4,303,337 . . .	2,303,179

The following Table exhibits the total amount of exports of the chief produce of Jamaica for the years undermentioned.

Years.	Sugar.			Rum.		Ginger.		Pimento.		Cotton.	Coffee.
	Hhds.	Tierces.	Barrels.	Puncheons.	Hhds.	Casks.	Bags.	Casks.	Bags.	Bags.	Hhds.
1793	77,575	6,722	612	34,755	879	62	8,605	420	9,108	13,029	3,983,576
1794	89,532	11,158	1,224	39,843	1,570	121	10,305	554	22.153	16,842	4,911,549
1795	68,851	9,537	1,225	37,684	1,475	426	14,861	957	20,451	17,766	6,318,812
1796	89,219	10,700	858	40,810	1,364	690	20,275	136	9,820	9,903	7,203,539
1797	78,373	9,963	753	28,014	1,463	259	29,098	828	2,935	——	7,931,621
1798	87,896	11,725	1,163	40,823	2,234	119	18,454	1,181	8,961	2,859	7,894,306
1799	101,457	13,538	1,321	37,022	1,981	221	10,358	1,766	28,273	30,693	11,745,425
1800	96,347	13,549	1,631	37,166	1,350	444	3,580	610	12,759	——	11,116,474
1801	123,251	18,704	2,692	48,879	1,514	12	239	648	14,084	——	13,401,468
1802	129,544	15,405	2,403	45,632	2,073	23	2,079	591	7,793	——	17,961,923

The principal articles of export were, in

Years	Coffee. Cwt.	Sugar. Cwt.	Rum. Gallons.	Pimento. lbs.	Cotton. lbs.
1809	314,415	1,104,612	3,470,250	2,219,367	1,886,748
1810	252.808	1,611,422	3,428,452	2,372,964	1,798,172

Gallons of rum imported into Great Britain, in the year ending 5th January 1812, 4,604,771; and in 1813, 3,763,281. Sugar imported in the year ending 5th January 1813, 1,455,954 cwt.

Shipping.

Ships belonging to Jamaica.

Years.	Ports.	Ships.	Tonnage.
1792	Antonio.	4	431
1805	Ditto.	2	58
1792	Kingston.	125	6109
1805	Ditto.	44	3952
1792	Montego Bay.	48	3602
1805	Ditto.	44	1343
1792	St Lucca.	3	308
1805	Ditto.	4	131
1792	Savannah le Mar.	7	221
1805	Ditto.	3	78

In the year 1807, the number of vessels that cleared out from the island, was—

	Vessels.	Tonnage	Seamen.
For Great Britain	242	63,471	7,748
For Ireland	10	1,231	91
For British America . . .	66	6,133	449
For the United States . .	133	13,041	493
For the Foreign West Indies	22	1,903	155
For Africa	1	109	8
Total	474	85,888	9,344

Population.

Progressive Population of Jamaica.

Years.	Whites.	Free People of Colour.	Slaves.
1658	4,500	—	1,400
1670	7,500	—	8,000
1734	7,644	—	86,146
1746	10,000	—	112,428
1768	17,947	—	176,914
1775	18,500	3,700	190,914
1787	30,000	10,000	250,000
1805	—	—	280,000

Official returns for 1812.

In the papers relative to the West Indies, ordered by the House of Commons to be printed, 12th July 1815, there is much important information respecting the statistics of several of the parishes of Jamaica, in the year 1812, the substance of which we shall give, as we shall thus exhibit the latest official statement on this subject.

In Kingston parish, the number of slaves assessed was 6840; but it was supposed there were considerably more: the free blacks of colour amounted to 8000: the extent of the city and parish from east to west is six miles; from north to south one and a half.

In Vere parish, the number of whites was 359; of free people of colour 260; of slaves 14,359; and the number of acres 128,597.

In Westmoreland parish, the number of white men was 432, women 129, boys 70, girls 57—in all 688: persons of colour, men 158, women 266, boys 175, girls 191—in all 790: free blacks, men 47, women 65, boys 1, girls 6—in all 119. The number of slaves was 21,019; of stock 20,575; and of acres 185,116½. In this parish, the increase of slaves in 1809 was, males 181, females 174—total 355; and the decrease, males 226, females 195—total 421; making the actual diminution of males 45, and of females 21—total 66. In the year 1810, the actual diminution was, males 28, females 16—total 44.

In the parish of St Thomas, the number of white males was 369, females 49, children 16; of slaves 26,341. The births of slaves in the December quarter of 1807 was 176, the deaths 543. The number of free persons in 1812 was, males 207, females 142, children 114; the number of acres 143,475.

In the parish of St George, the number of slaves was 13,233; their increase by births above deaths from 1800 to 1807, both years inclusive, was 196. Of free persons of colour, there were, in 1812, adult males 63, female 97; male children 103, female 80; in all 343. Free blacks, males 4, females 28. The number of acres in this parish is 92,927¾. The number of negroes returned in the parish of St Anne, was 23,261. In Portland parish there were 7651, of which 3949 were males, and 3702 females. The white population amounted to 415, of which there were males 217, females 96; boys 53, and girls 49. The free persons of colour amount to 180, of which there were, males 73, females 58; boys 23, and girls 26. The extent of this parish is nearly 20 miles. In 1810, the births of slaves were 94, the deaths 89; increase 5.

In the parish of St David's, the white population amounted to 131, of which there were, males 116, females 10, and children 5. The free persons amounted to 29, of which there were, males 5, females 11, and children 13. The number of slaves was 7203. The births of slaves in the December quarter of 1806 were 58, the deaths 56; increase 2. The number of acres in this parish is 46,619.

Slaves, stock, and cultivated acres in 1812.

The following Table exhibits the number of slaves, stock, and cultivated acres in all the parishes of Jamaica, in the year 1812, according to the return laid before parliament. The reader will observe that there is some difference, with respect to acres, between this Table and the previous statements, though both are taken from the same parliamentary papers.

Parishes.	Slaves.	Stock.	Acres.
St Andrew's	16,570	5,181	83,427
St Anne	23,702	24,537	230,224
St Catherine	8,479	6,868	68,281
Clarendon	20,228	9,564	221,847
St David	7,203	2,208	50,831
St Dorothy	5,130	2,958	36,743
St Elizabeth	22,280	23,237	276,838
St George	13,400	3,710	93,100
Hanover	23,167	7,201	105,198
St James	24,970	6,628	127,743
St John	6,690	1,133	65,795
Kingston	5,370	604	1,786
St Mary	25,781	16,010	122,557
Portland	7,440	1,640	50,263
Port Royal	7,980	223	29,126
St Thomas in the East	26,291	5,374	143,475
Ditto in the Vale . . .	11,973	2,503	78,029
Trelawney	27,950	6,380	173,768
Vere	14,359	4,691	109,946
Westmoreland	21,109	12,769	85,413
	319,912	143,419	2;254,387

As the whole island is calculated to contain upwards of 4,000,000 acres, it appears from this Table that there is little more than half of it cultivated. Of the acres in cultivation, about 700,000 are under sugar lands, and nearly the same quantity in pasture.

Government.

The governor of Jamaica is appointed by the king, and can be recalled at pleasure; there is besides a council, and a house of assembly. The former is generally chosen by the crown from amongst the most respectable inhabitants; the members are twelve; they are *ex officio* justices of the peace, and form a privy council to the governor. The house of assembly consists of forty-three members, who are chosen by the freeholders; every parish sends two members, except Spanish Town, Kingston, and Port Royal, which send three each. The electors must be white, of age, and possess a freehold of ten pounds per annum in the parish. The representative must possess a freehold of £300 per annum in any part of the island, or a personal estate of £3000. The supreme court of judicature, called the grand court, and combining the jurisdiction of the courts of king's bench, common pleas, and exchequer in England, is held in Spanish Town on the last Tuesday of February, May, and November. Assize courts are held every three months in Kingston for the county of Surrey, and in Savannah la Mar for the county of Cornwall.

Revenues.

The revenues of the island are perpetual and annual. The former were imposed by the revenue law of 1782; they amount to about £12,000 per annum: the latter are occasional grants of the legislature. The principal taxes consist of a duty on negroes imported; an excise on rum, &c.; a poll tax on slaves and stock; and a rate on rents and wheel carriages. The revenue generally amounts to about £300,000 Jamaica currency.

Ecclesiastical establishment.

There are nineteen beneficed clergymen in the island, each of whom receives £420 per annum, subject to a deduction of 10 per cent. for a widows' fund. Besides this stipend, there are surplus fees, which in Kingston, Spanish Town, and St Andrews, are very great; the last has also considerable glebe lands annexed to the living.

Militia.

All white males, from the age of fifteen to sixty, are obliged by law to provide themselves with their own accoutrements, and to enlist either in the cavalry or infantry of the militia.

Coins.

Besides the Spanish and Portuguese coins, which are current in the island, there is a small silver coin called a *bit*, of the value of 7½d. currency. One hundred pounds sterling amounts to one hundred and forty pounds currency.

History.

Jamaica was discovered by Columbus in 1494; in 1509, it received a Spanish colony from Hispaniola; in 1655, all the establishments were abandoned except St Jago de la Vega. This year it was conquered by the English under Penn and Venables. The first British colonists were 3000 soldiers, disbanded from the parliamentary army. These were soon followed by 1500 royalists. Till the Restoration, the government was entirely military. On the surrender of the island to the English, the negro slaves of the Spaniards fled to the mountains; their descendants, called Maroons, committed great depredations till 1738, when a treaty was concluded with them, by which their freedom was secured, and 1500 acres of land granted to them. They remained peaceable till the year 1795, when a new Maroon war broke out; at first they were rather successful, but at last, by a more vigorous system of hostilities, and the introduction of bloodhounds from Cuba, with which they were threatened, though not actually attacked, they were driven to the mountains, and ultimately obliged to submit on condition that their lives were spared. Soon afterwards, 600 of them were conveyed to Nova Scotia, where lands were granted to them.

See Beckford's *Descriptive Account of Jamaica*; Edwards' *History of the West Indies*, 2d edit. vol. i.; Dallas' *History of the Maroon War*; Renny's *History of Jamaica*; Tuckey's *Maritime Geography*, vol. iv.; and *Parliamentary Reports and Papers on the West Indies*, 1807 and 1815. (J. S.)

IAMBIC VERSE. See PROSODY.

JAMES I. II. III. IV. V. VI. See the *History of* SCOTLAND.

JANIZARIES. See TURKEY.

JAN SEILAN, or JUNK CEYLON, is an island of Asia in the Bay of Bengal, situated on the west side of the Malay peninsula. It is separated from the continent by a narrow sandy isthmus, about a mile long and half a mile in breadth, which is covered at high water, and whereon spring tides rise 9 or 10 feet. This island is between 40 and 50 miles in length, about 15 in breadth, with good anchorage around its whole circuit, and it has an excellent harbour on the north called Popra, besides others. Its name, Jan Seilan, is of uncertain etymology, and it is frequently called Junk Ceylon by Europeans.

The climate here is particularly agreeable, for the heat is moderate. Rains begin to fall gently in July, and continue until November, with frequent intermissions of fine weather, attended with cool north-east winds at night. There is no considerable river in the island, both from its size, and the hills being low; but several streams run through flat marshes of mangroves into the sea.

A great quantity of tin is obtained in this island, of which about 500 tons are exported yearly. The produce was greater formerly; but it seems to have been reduced by restrictions on the miner, who was obliged to carry all his ore to a Chinese smelter farming this privilege from the government. Besides paying 12 per cent. for smelting, the miner could only obtain the metal on having delivered a certain quantity of ore, though the extract exceeded what he received, and after all a duty of 25 per cent. was payable previous to exportation.

The interior of the island contains large plains of rice well cultivated, and hither the inhabitants can come up the creeks in their small vessels; but the skirts are kept in a state of nature, for the purpose, it is supposed, of obstructing the access of an enemy. Rice is the staple product; and of other vegetables there are oranges, limes, and most of the tropical fruits and roots. The wild animals are deer and hogs: the domesticated ones are elephants, and a few goats; but the islanders have neither horses, sheep, dogs, nor cats, and their common poultry is not numerous.

The population of the whole island has been calculated at 12,000. This number, however, must be dependant on a state of peace or warfare, and during the latter it is probably lower. The features of the people resemble those of the Malays, intermixed with a good deal of the Chinese aspect. They are well made, but rather slender: they speak the Siamese language, and in general understand the Malay tongue: and, like Europeans, they write from left to right. Unrestrained polygamy is practised, as every man marries as many women as he can afford to maintain; but it is the privilege of the first wife to rule the household. No woman is permitted to leave the country.

The inhabitants are distributed in towns and villages, of which 16 are named, but all of them are inconsiderable. Terowa, the chief town, situated on a creek, where a strong current runs, consists only of about 80 houses. A wooden pagoda, covered with palm leaves, stands here, which is served by about 20 talapoins or monks, who live in a state of celibacy, and dwell in small apartments adjoining to it. Their heads are shaved and uncovered: they wear a yellow garment, and carry a white rod in their hands, but it appears that they can resign their monastic vocation at pleasure. The governor of Jan Seilan has also a dwelling at Terowa, and another eight miles inland.

Tin is the principal export of the island, which formerly carried on considerable commerce with several Asiatic ports; but this has greatly decreased since the establishment of a British colony on Penang. Its exports, besides that metal, are elephants teeth, biche demer, and sayhan. The imports are principally opium, a contraband article, for which there was a great demand about the middle of the preceding century; and after being carried in British vessels from Bengal, it was sold to the Malays and Buggess prows for the tin of the island. Hindostan piece goods, brass utensils of Java, European cloth and cutlery, were likewise among the imports. Commerce is injured, from a practice not unusual in the East, of the government or its officers being the principal dealers. Hence the king's merchant sometimes purchases a whole cargo on the arrival of a vessel, and immediately upon its being landed, retails it at a great profit. This impolitic interference restrains the competition and consequent advantages of unfettered commerce. The currency of the island consists of conic frustums of tin, of two or three pounds weight, with correspondent halves and quarters, which cannot be exported without payment of duty. Spanish dollars are the most acceptable money, but all kinds of Indian coinage pass current.

When the French had much interest at the court of Siam, one of the most powerful and brilliant of the East towards the latter part of the seventeenth century, they proposed to make a settlement in Jan Seilan. It is probable, that the benefit which would result from the presence of a commercial nation could be appreciated by a native of the Ionian islands, then prime minister of Siam, who was well acquainted with the trade and manufactures of Europe. But the history of this settlement, which we believe commenced in 1688, is not preserved; and it most probably terminated soon after the fall of that minister in 1689.

As this island is too small to maintain its independence, it must necessarily be controlled by the continental powers. It was long in the possession of the kingdom of Siam, and when visited by Captain Forrest in 1784, it was governed by a viceroy from that country, who had three associates or counsellors. Each of these officers had about sixty military retainers armed with a musquet and bayonet, sword and dagger, who, receiving little pay, lived in some respect on the community. The inhabitants being then dissatisfied with the imposts upon them, particularly with that which was laid upon their staple commodity, wished to shake off the yoke of Siam; but it is not known that they adopted any active proceedings. In the following year, 1785, the Birmans, who had for some time been extending their dominions, had gained so much territory on the continent, that, with the possession of Jan Seilan, they could have prevented the Siamese from any other channel of communication with India than the gulf of Siam. In order, therefore, to effect its conquest, they fitted out eleven ships of war at Rangoon for the conveyance of troops and warlike stores, while an army of 8000 men marched to Mergui, a port on the peninsula, for the purpose of cooperation. Having made a movement against the island in March, they attacked and carried the fort, which is situated on the east side, and found in it much valuable booty. But the governor, who had retired to the interior, rallied his forces, and compelled the enemy to retreat, after sustaining great loss. The Birmans, nevertheless, did not abandon their object, and after a long interval returned in 1810, when they effected the total conquest of Jan Seilan, and consigned the whole inhabitants to slavery in Pegu: At a still later period it continued to be the subject of contest between them and the Siamese. East Long. 94° 18′. North. Lat. from 7° 46′ to 8° 9′. (*c*)

JAPAN.

Japan.

Japanese islands, situation of.

The Japanese islands lie near the coast of Corea on the eastern side of Asia, in the North Pacific Ocean, between 31° and 41° of N. Lat. and 129° and 142° E. Long.

Empire of Japan, extent of.

The Empire of Japan is composed of an extensive cluster of islands, by much the largest and most important of which is called Niphon or Jepuen. This island is of a triangular form, and is upwards of 700 miles long, but does not exceed 80 miles in breadth. Adjoining to the south-west point of Niphon are Kiusiu or Saikoff, 140 miles long by 90 broad, and Sikoff, 95 miles long by 45 in breadth. The island of Jesso or Matzumay, on the north of Niphon, from which it is separated by the straits of Sangar, about nine miles in breadth, was conquered from its original inhabitants the Ainos, and is now also included in the Japanese dominions; but though larger than the two last, its dimensions are not mentioned by geographers. These are environed by other islands of inconsiderable size and note.

Discovery of.

The discovery of this extensive insular power, abounding in natural and artificial resources, and of an overflowing population, does not reach farther back than the middle of the 16th century. It appears that we are indebted to the travellers Rubruquis and Marco Polo for the first mention of the existence of this country. Fernando Mendez Pinto, sailing in a Chinese junk from Macao to the Likeo islands, was wrecked on the Japanese coast in 1542, and he accordingly has the merit of being the first European discoverer of Japan. Three other Portuguese dispute with Pinto this honour, pretending that they touched on the coast of Satzuma the same year; but luckily neither the year of discovery, nor the nation of the discoverer, is affected by this dispute.

Visits of Europeans.

Japan was soon after visited by the Spaniards, and (what is a singular circumstance) their first visit, like the original discovery of the island, was owing to a shipwreck. The governor of Manilla, on his voyage from New Spain, being wrecked in 1609 on the Japanese coast, was sent with his attendants by the Emperor of Japan to Acapulco. An embassy, with rich presents from the Spaniards to the emperor, followed in 1611. But all Christians being extirpated from his dominions, both Spaniards and Portuguese were excluded; nor has an intercourse been again attempted, although, from the vicinity of the Philippine islands, a commerce mutually advantageous might be expected. The Dutch, from their enterprizing spirit of trade, could not fail to regard Japan with a longing eye; and as no Europeans had acquired a permanent footing there, they were eager to push their commercial interests in that quarter. An accident favoured their views. In 1600 a squadron of five ships, which sailed from the Texel for the East Indies, was lost in the straits of Magellan, with the exception of one Dutch ship, steered by an Englishman of the name of William Adams, which reached the harbour of Bungo in Lat. 35° 30′. Adams was fortunate enough to ingratiate himself with the Emperor of Japan, who loaded him with presents, but would not consent to his returning home.

Establishment of the Dutch.

The accounts he sent to Batavia, with the prospects he held out of a beneficial commerce between the two countries, induced the Dutch East India Company to dispatch a ship thither in 1609; and thus, through the intervention of an individual, are the Dutch indebted for their establishment at Japan. They are the only people that have contrived to retain the favour of the Japanese, who, under humiliating restrictions, permit them to carry on a trade, limited to the dispatch of two small ships annually from Batavia to Japan. Nearly about the same time, the English also, by means of their countryman Adams, had permission to build a factory on the island of Firando; but though they were well received, and allowed to traffic on advantageous terms, the trade was abandoned for reasons hitherto unexplained. The Dutch thus remained the only European merchants in Japan.

Dutch policy.

In conformity with their policy, they endeavour to throw a veil of secrecy over the scene of their commercial pursuits, being probably apprehensive lest their transactions should be viewed in too strong a light. Notwithstanding this prohibition of intelligence, we have been furnished with full and pretty accurate details concerning the state of the Japanese islands.

Accounts of Japan.

In addition to the corrected accounts transmitted us by Kæmpfer and Thunberg, Captain Krusenstern, who was selected by the present Emperor of Russia to carry the Russian flag for the first time round the world, and on board whose ship an embassy was conveyed to Japan, has given us valuable information about the Japanese coasts and harbours.

Harbour of Nangasaky.

Although it appears that Japan has been visited for upwards of two centuries by different European nations, and the harbour of Nangasaky, one of the best in the world, has been annually frequented, yet no plan of it has been taken, nor have even the latitude and longitude been correctly ascertained, until it was explored by Krusenstern in 1804.

Description of.

The entrance of the harbour of Nangasaky is in 32° 43′ 45″ N. Lat. and 230° 15′ W. Long. in the middle of the bay of Kiusiu, which is formed by Cape Nomo to the south, and Cape Seurote to the north. The entrance bears 51 miles E. by N. from Cape Gotto in 32° 34′ 50″. It is necessary to ascertain correctly the true entrance; for, by steering on Cape Nomo, there is danger of being becalmed, or driven by the tides on the rocks, and of mistaking another entrance in Lat. 32° 40′, which has not been explored. The safest course is to keep midway between the Gotto islands and Kiusiu, steering N. E. until the parallel of the entrance, and then, due east. The harbour contains three roads, all perfectly secure. The outermost is to the west of the island of Papenberg, the second in the middle to the eastward of the same, and the inner road at the bottom of the harbour in front of the city. The outer road is well defended from every wind but the N. W. and W. N. W. which, however, never blow very strong. The anchorage is excellent, over a bottom of fine grey sand, in depths varying from 33 to 18 fathoms. The middle road is surrounded on all sides by the land, and has better anchoring ground than the inner, but not so good as the outer road. From the middle to the inner road the course lies N. E. 40°, and the distance is about two miles and one-third, the depth of water decreasing gradually from 18 to 5 fathoms. About half way, where the channel narrows to 400 fathoms, are placed the imperial batteries or Emperor's guard, as they are styled, a number of buildings without a single cannon. From the narrowness of the approach, the city of Nangasaky, if well fortified, could defy any assault; in its present state it would fall before a single ship of force. The anchorage here is not equal to either of the other roads, the bottom being a thin clay, and the S. W. channel open to the sea. Krusenstern was the only person, except La Perouse, who navigated the western coast between Niphon and the Corea; and although the state of the weather was unfavourable to his making observations, yet he appears to have reached the northern point of Jesso, the extreme limit of the Japanese empire, without much difficulty.

Japanese coasts, general character of.

Of the Japanese coasts it may be observed generally, that they are in most places rocky and precipitous, presenting a chain of bold promontories, deep bays, and rugged peninsulas, abounding with shoals and islets, the whole invested with a turbulent sea; whence the navigation is intricate and dangerous.

Climate.

The climate of Japan is variable throughout the year. The heat of summer would be insupportable, were it not moderated by the sea breezes. The rainy months begin at midsummer, when abundance of rain falls, and to which is to be ascribed the fertility of the country. In winter, the wind blowing from the Arctic Ocean, makes the cold severe. Snow falls in quantities, and is followed by intense frost. Hurricanes and earthquakes are not uncommon, and thunder storms also frequently occur.

State of thermometer.

At Nangasaky, the thermometer was never in August higher than 98°, nor in January lower than 35°.

Rivers.

As the geography of Japan has not been fully illustrated, we can give but an imperfect account of the rivers, lakes, and mountains of this country. The largest river is said to be the Jodo or Yodo, which rises from the great central lake of Oitz, and pursues a south-west course. The Ujin, Aska, and Oomi, figure in Japanese history. This last is said to have burst from the ground in one night. Over the Nogofa and Jedogawa are projected cedar bridges from 300 to 360 feet long. There are various other rivers, of which we know little except the name. The above mentioned lake of

Mountains, volcanoes, &c.

Oitz sends forth two rivers, and is said to be 50 Japanese leagues in length, but of inconsiderable breadth. Among the mountains are volcanoes, and in the province of Figo one constantly emits flame. The principal mountain is Fusi, which is covered with snow the greatest part of the year. But the courses of the different ranges have not been traced. Near the lake of Oitz is the sacred mountain of Jesan, said to be decorated with 3000 temples!

Division into provinces, &c.

Aspect of the country.

Agriculture.

Crops.

The Japanese islands are divided into provinces and districts, like other civilized countries. The face of the country of Japan is agreeably diversified by mountains, hills, and vallies, and is well watered with rivers and lakes, the general aspect presenting a soil cultivated with industry and freedom. Even mountains and hills form no obstacle to cultivation. Agriculture being in high estimation in Japan, it meets with the greatest encouragement from the government.* The chief produce is rice, barley and wheat being little used. A kind of potatoe is common, and several sorts of beans and peas, turnips and cabbage, abound. The rice is sown in April, and gathered in November. The sides of the hills present a singular spectacle to the stranger, from the mode of cultivation which is adopted. Stone walls support level platforms sown with rice or roots; and thousands of these are scattered over the mountains, affording a favourable picture of the ingenuity and industry of the inhabitants. Though the space should not exceed two square feet, a stone wall is raised at the bottom, the inclosure filled with earth, and carefully sown with rice, or planted with esculent roots. As may be easily supposed from this state of general cultivation, few forests are suffered to grow: these are confined to the sides of such mountains, probably, as can be subdued by neither agricultural labour nor skill.

Mode of cultivating the hills.

There are no fences used in dividing the cultivated grounds in this country; and the fields often resemble kitchen gardens divided into narrow beds, which are separated from each other by a deep trench, nearly as broad as the divisions which are under crop. After a certain interval the trenches are filled up with earth, so as to be converted in their turn into beds, and give the soil a rest from constant bearing. In these beds the corn is sown sometimes lengthwise, but more commonly across; and after the crop is cut down, another kind of grain is sown in the same season, between the stubble of the old crop, so as to make the same field produce twice in one year. The greatest care is bestowed upon manuring and cleaning the ground. Every kind of substance which can be converted into manure is carefully collected; and, together with urine and foul water from the kitchen, is mixed up in a liquid state. It is then carried in large pails to the fields, and, by means of a ladle, it is poured upon the plant after it is about six inches in height. Irrigation also is much practised, wherever water can be procured in the vicinity of the fields. The weeds are so completely cleared away, that "the most quick-sighted botanist," says Thunberg, "would scarcely be able to discover a single plant of another species among the corn." The grain is frequently separated from the straw merely by beating the sheaves against a post or barrel; but is commonly threshed on straw mats in the open air by means of flails with three swingles. There are no pasture grounds among the cultivated tracts; and the few cattle used in the country are all fed in the farm-yards. Thunberg affirms, that the soil throughout Japan is naturally barren, and has been rendered so remarkably productive only by the labour and skill of the husbandman.

Vegetable productions.

Japan abounds in rare and beautiful plants; and as there is a great similarity in the vegetable productions of China and this kingdom, no doubt from the vicinity of the two countries, they are mutually indebted to each other for an interchange of useful vegetables. The ginger, soy bean, black pepper, sugar, the cotton and indigo plant, though not indigenous, are cultivated with success, and in abundance, in Japan. Two sorts of mulberry grow; one which feeds the silk worm, and the other is manufactured into paper. It is said that the beautiful black varnish is produced from a gum which exudes from the bark of the rhus vernix. The citrus japonica, a species of orange peculiar to this country, is found in a wild state. But as the botany of Japan has been treated at length by Kæmpfer and Thunberg, our botanical readers are referred to them for particulars on this subject.

Mines.

Gold, silver, and especially copper, are found in abundance in Japan, large quantities of which have been exported at various times by the Portuguese and Dutch. No mine can be opened without the permission of the emperor, who claims two thirds of the produce, leaving only one third to the proprietor for his expences. Iron is scarcer than other metals, and the Japanese will not allow it to be exported.

Sulphur is found in sufficient abundance, particularly in a certain island near Satsuma; and pit-coal is not uncommon in the northern provinces. Red agate, asbestos, porcelain clay, flesh-coloured steatite, pumice stone and white marble are also found in Japan; and there are several warm mineral waters, especially at Obamma and the mountain of Omfen, which are used by the natives in the cure of various diseases.

Animals.

It is singular that neither sheep nor goats are propagated in the Japanese dominions. The latter, and swine, are deemed destructive of cultivation. Horses are rare, and cattle still more so, these last being reserved solely for agricultural purposes. Buffaloes with a bunch on their backs are sometimes seen employed in drawing carts. The cows are very small in size, and are used rather for draught than for their milk or their flesh. Dogs are common in the domestic state, and are said to be kept from superstitious motives. Cats of various colours are to be seen in every house, and are said to be the general favourites of the ladies. The wolf is found in the northern parts, and foxes in different districts, but are regarded with peculiar detestation, as demons incarnate. Hares of a grey colour, and rats as in other countries, have been seen by travellers in Japan; and, in the least inhabited tracts, bears, monkeys, deer, &c. are reported to be found. The common kinds of poultry are reared in considerable abundance; and great numbers of wild geese frequent the waters between the islands, and other places at a distance from the towns or villages. Herons are seen following the ploughman in the fields; and the Chinese teal, the quail, the crow, pigeon, and bulfinch, were all observed by Thunberg. Serpents are said by the natives to be occasionally seen; but few of the amphibia are met with in the country. Fish, which are an

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* The farmer pays a considerable part of the produce as rent to his feudal chief, and is restricted only to one condition, viz. to have all his land in cultivation. Should he leave any part of his fields untilled, he forfeits the possession of that portion, which is occupied by another husbandman.

important object to the Japanese, and a principal part of their subsistence, are very numerous around the coasts, especially salmon, perch, eels, shrimps, oysters, crabs; and the flesh of the whales, which are killed by harpoons, is sold in the markets as an ordinary article of food among the poorer people. Many curious shells, especially those that were of a small size and elegant shape, are collected by the Japanese, fixed with rice-glue upon carded cotton, and sold to the Dutch traders.

Natives. The original population of Japan has been little illustrated. The present Japanese seem to be a kindred race with the Chinese, having at the same time, according to Kæmpfer, a language radically distinct. Perhaps, in the earlier stages of society, as is observed by Pinkerton, the Japanese may have emigrated from China, and their complete insular separation may have given birth to a language rendered peculiar by the progress of a distinct civilization. **Described by Thunberg.** The people of this nation are described by Thunberg to be well made, active, free and easy in their motions, and stout limbed, though yielding in strength to the northern inhabitants of Europe. The men are middle sized, and in general not corpulent, all over of a yellowish colour; in some brown, in others white predominates. The lower classes, from exposure to the sun, are brown, but ladies of distinction, who seldom go abroad uncovered, are perfectly white. **Discriminating mark, the eye.** The discriminating mark of the Japanese, as of the Chinese, is the eye. This organ wants its characteristic rotundity, being oblong, small, and sunk deep in the head, whence these people have the appearance of being pink-eyed. The colour of their eyes, however, is dark brown, or rather black; and the eyelid forming a deep furrow, makes the Japanese look sharpsighted. Their head is in general large, their neck short, and their hair black, thick, and shining from the use of oils.

They are said to be an intelligent and provident people, inquisitive and ingenious, frugal and sober, friendly and courteous, frank and good humoured, upright and honest, brave and unyielding, capable of concealing and controuling their feelings in an extraordinary degree; but distrustful, proud, unforgiving, and revengeful.

Dress. The usual dress of the Japanese is a short upper garment with wide sleeves, and a complete gown underneath, fastened round the neck, and reaching quite down to the feet; the dress much resembling that of European females, except in being more confined from the hips downwards, which produces great embarrassment in walking. But this exercise is seldom resorted to by a Japanese, except from compulsion. The rich are clothed in silks, the poor in coarse woollen stuffs. The upper garment is generally black, the under dress is of mixed colours. **Family arms, how worn.** Every one has his family arms, about the size of a half dollar, wrought into his clothes in different places, a practice common to both sexes. Thus persons of a particular family may be easily recognized. A young lady wears her father's arms till after marriage, when she assumes those of her husband. The greatest honour a prince or governor can confer, is to present a cloak with his arms upon it; and the person who is thus honoured puts his own arms upon some under part of his dress. In winter they wear five or six dresses over each other; but though the weather is bad in January and February, they use neither cloth nor furs in their apparel. Instead of shoes they have soles merely of straw, fastened to the great toe by a loop, and these are taken off when they enter a room. Although they have their heads half shorn, they are regardless of a burning sun, or piercing cold. They do not use parasols in sunshine, nor umbrellas in rainy weather; but in travelling, conical caps, fans, umbrellas, and cloaks of oiled paper, are very commonly used. **Toilet.** The toilets of the Japanese must occupy a considerable share of attention, as they are very particular in anointing and dressing their hair, which is collected in a tuft on the crown of the head. Small pincers are employed to pluck out the hairs on their chin, and these, with a small metal looking mirror, are found in the possession of every Japanese. **Remarkable cleanliness of person.** They cannot be denied, Krusenstern observes, to study great cleanliness of person, although they make no use of linen; and this appears a governing propensity of the Japanese of every rank. Hence, in almost every house, a bath forms an essential part of domestic arrangement and comfort. But in one respect their customs are extremely offensive. The privies, which are also indispensible in every house, are all built towards the street or road, and open outwards, exhibiting large jars sunk in the earth, to receive every kind of ordure and refuse. Hence the stench is insupportable, and the putrid exhalations, as Thunberg affirms, injurious to the eyes of the natives.

Houses, construction of. In Japan the houses are of wood, never exceeding two stories, the upper one consisting chiefly of garrets and lumber rooms. Though the house is commodious, it consists in general of one room, capable, by moveable partitions, and screens, of being divided into apartments. Neither tables nor chairs are used, the people sitting squat on straw mats, in which position they eat their food.

Diet. The diet of the Japanese is composed of a greater variety of articles than that of any other people in the world. Not contented with the numerous kinds of wholesome and nutritive food supplied by the produce of their lands and waters, they contrive, by their modes of preparing their victuals, to render the less valuable and even the poisonous parts of animal and vegetable substances useful, or at least harmless articles of subsistence. Their meats are cut into small pieces, thoroughly stewed or boiled, and always highly seasoned with strong spices and sauces. At their meals, the company are seated on the floor-mats, with a small square table before each person, whose portion is served up in neat vessels of porcelain, or of japanned wood, which are tolerably large basons, always furnished with lids. The guests salute each other with a low bow before they begin to eat; and, like the Chinese, take up the food by means of two small pieces of wood, held between the fingers of the right hand, and used with great dexterity, so as to pick up the smallest grain of rice. Between each dish they drink warm sacki, or rice beer, out of shallow saucers, and at the same time occasionally take a bit of a hard boiled egg. Some of the most common dishes are fish boiled with onions and a kind of small beans, or dressed with oil; fowls, stewed and prepared in numerous modes; and boiled rice, which supplies the place of bread for all their provisions. Oils, mushrooms, carrots, and various bulbous roots are used in making up their dishes. Tea and rice beer are the only liquors used by the Japanese; and it is with difficulty that they can be persuaded to taste wines or spirits. The sacki, or rice beer, heats and inebriates when taken to any extent, but the intoxication which it produces passes off speedily. Tea, which is always ready, is the usual beverage for quenching thirst. It is customary to eat three times a day; at eight o'clock in the morning, two in the afternoon, and eight in the evening. The women eat by themselves, apart from the men. The practice of smoking tobacco, which is supposed to have been introduced into Japan by the Portuguese, is very common with both sexes. Their pipes are very short, seldom more than six inches in length, and scarcely contain half a thimble full of tobacco. The stem is made of lackered bamboo, and the mouth-piece and bowl of copper. They are smoked out by a very few whiffs, and require to be repeatedly filled. The apparatus used by persons of distinction consists of an oblong box, about eighteen inches in length and a foot in breadth, of a brown or black colour, which contains, besides pipes and tobacco, three cups; one, which is lined with brass, for holding a live coal to light the pipe, another to receive the ashes of the tobacco, and a third to serve as a spit-box. At visits, this apparatus is the first thing that is placed before the guests, and is sometimes carried by a servant to places where tobacco is not expected to be presented. The poorer classes have their tobacco pouch and pipe slung to their girdle by a silken cord.

Polygamy permitted.

Polygamy is allowed in Japan, as in other Asiatic countries; though, in general, all but one female, who is acknowledged a wife, are merely regarded as concubines. This, of course, applies to the higher classes; the poor can only maintain one woman. The husband here, as in all eastern countries, exerts a complete despotism, but the wives are not so closely shut up as in China. Married women distinguish themselves in some places by painting their teeth black, and in others by pulling out the hair of their eye-brows. They are known also by wearing the knot of their girdle before, while others have it behind. Marriages are solemnized in the open air, in the presence of the priests and relations of the parties, without much pomp or solemnity. The bridegroom and bride advance together to an altar, erected for the purpose, with a torch in their hands, and, while the priest reads a form of prayer, the latter, having lighted her torch at a burning lamp, holds it out to the bridegroom, who lights his torch from hers. The guests then congratulate the new married couple, and the ceremony is concluded. The suitor makes a present to the father-in-law before obtaining his daughter; so that the more daughters a man has, and the handsomer their persons, so much the richer is he esteemed. The women often paint their lips with a violet colour; and are described by Thunberg as not remarkable for modesty. Nor are they the less esteemed for having served in the public brothels, establishments which are found in every town and village.

Funeral obsequies.

The bodies of persons of distinction are burned, while others are interred. The funeral pile is erected in a small house of stone fitted for the purpose, and provided with a chimney. The body is brought thither accompanied by men and women, and attended by a numerous train of priests, who are continually occupied in singing. Upon reaching the place for burning, one of the priests sings the eulogy of the deceased, and having thrice waved a lighted torch over the body, throws it away. It is then picked up by one of the children, or other relatives of the deceased, and applied to the funeral pile. The ashes are carried away in a costly vessel, and preserved for some time in the house, but afterwards are buried in the earth. Those who are not burned, are inclosed in a wooden chest, and let down into a grave in the customary manner. Fragrant spices are cast into the grave, and flowers planted on the earth which covers it. The surviving relatives visit the tombs of their friends for many years after their death, and sometimes during the whole of their lives, besides observing, as in China, the feast of lanthorns in honour of the dead.

Festivals.

In every superstitious country, we find the celebration of festivals attended by a relaxation of public morals, but in Japan a salutary check is imposed upon an abandonment to licentiousness by a wise regulation, prohibiting the celebration of national feasts for days successively. In conformity with this law, the feast called Kermes is held on the 11th, 13th, and 15th days of October. Krusenstern mentions a feast celebrated on the 1st of April called Mussume Matzury, on which occasion parents present dolls to their children. Trifling as the object of this festival appears, the Japanese seem to regard it otherwise, as they gravely requested the suspension of the work of the ship carpenters ashore during its celebration, which consists in dances, dramatic representations, and magnificent processions. The usual holidays in Japan are the first day of every month, when they rise early, dress in their best clothes, and visit their superiors or friends to wish them joy of the new moon; the fifteenth day, when the moon is at the full; and the twenty-eighth day, or the day before the new month. Besides these monthly festivals, they celebrate five others which happen only once in the year, namely, the first day of the new year; the third day of the third month; the fifth day of the fifth month; the seventh day of the seventh month; and the ninth day of the ninth month. These, which are all uneven numbers, are regarded by the Japanese as unlucky days; and, therefore, laying aside all business, they are dedicated to mirth and mutual congratulations. On some of these days, in preference to ordinary days, they choose to celebrate their nuptials, and to give their entertainments. Their amusements on these occasions consist chiefly in dramatic representations and dances. In their theatres, the spectators sit on benches fronting the stage, which is a little elevated, but so small and narrow as seldom to allow room for more than one or two actors at a time. They generally represent some great exploit or love story of their divinities and heroes, which are frequently composed in verse, and sometimes accompanied with music. No machinery or decorations are brought forward; but the chief part of the amusement seems to consist in the frightful dresses and uncouth contortions of the actors. The dances at private entertainments are performed by young women and boys hired for the purpose, who exhibit a variety of pantomimical gestures and evolutions, expressive of some heroic action or love intrigue, regulating their steps at the same time by the music.

Religion, and modes of worship.

The most prevalent religious sects in Japan, are those of Sinto and Budsdo. That of Sinto, which is the most ancient, though its adherents are now least numerous, is conceived to have originated from Babylonian emigrants, and to have been originally very simple and pure in its tenets. Its followers acknowledge a Supreme Being, who inhabits the highest heavens, and who is far too great to require their worship; but they admit a multitude of inferior divinities, who exercise dominion over the earth, water, air, &c. and have great power in promoting the happiness or misery of the human race. They have some conception of the soul's immortality, and believe, that a happy abode immediately under heaven is assigned to the spirits of the virtuous, while those of the wicked shall be doomed to wander to and fro under the firmament. Their practical precepts are directed to inculcate a virtuous life, and

Religion, and modes of worship.

obedience to the laws of the sovereign. They abstain from animal food, and are reluctant to shed blood, or even to touch a dead body. Their churches contain no visible idols, nor any representation of the Supreme Being, but sometimes a small image is kept in a box, to represent some inferior divinity to whom the temple is consecrated. In the centre of the temple is frequently placed a large mirror, made of well polished cast metal, which is designed to remind the worshippers, that in like manner as their personal blemishes are therein displayed, so are their secret evil thoughts exposed to the all-searching eyes of the immortal gods. The worshippers approach these temples with great devotion of manner, and with the most scrupulous attention to cleanliness of person and apparel. Advancing reverently to the mirror, they bow themselves to the ground, prefer their prayers, present their offerings, and then repair to their amusements. The Kubo professes himself to belong to this sect, and is bound to make a visit annually in person, or by an ambassador, to one of their temples, to perform his devotion, and present gifts.

Budsdo's doctrine was brought originally from the coast of Malabar, and is considered the same with that of Budha in Hindostan. Passing from China into Japan, it became blended with that of Sinto, and gave birth to a monstrous mixture of superstitions. Its peculiar tenets are, that the souls of men and of beasts are equally immortal, and that the souls of the wicked are condemned to undergo punishment and purification, by passing after death into the bodies of the lower animals. There are many other sects, very opposite in their tenets and observances; but they are said to live together in great harmony, or rather to share in all their mutual superstitions. The Dairi, or ecclesiastical sovereign, seems to be the general head of all those different sects, and appoints the principal priests throughout the country. Every sect has its respective church, and peculiar idols, which are commonly remarkable for their uncouth and hideous form. Thunberg mentions one colossal wooden image, which measures ten yards across the shoulders, and affords room for six men to sit upon its wrist. The inferior divinities are innumerable, as almost every trade has its tutelar god; and in one temple not less than 33,333 are said to be ranged around the supreme deity. The temples are commonly built in the suburbs of the town, on the most elevated and suitable spots, to which are frequently attached beautiful avenues of cypress trees, with handsome gates. The idols are usually exhibited upon an altar surrounded with flowers, incense, and other decorations. They are filled with the lower or secular priests, who attend to keep them clean, to light the lamps and fires, to present the flowers and incense, and to admit worshippers at all times of the day. Even strangers are allowed to enter, and sometimes to lodge in the temples. To some of the more noted churches it is common to perform pilgrimages, especially to the temple of Tsie, the most ancient in the empire, and almost completely decayed with age, notwithstanding the utmost care to preserve its ruins. Its sole ornaments are a mirror, denoting that nothing can be hid from the supreme being, and slips of white paper hung round the walls, to signify that nothing but what is pure should approach his presence. To this place the emperor must send an ambassador on the first day of every month, and every individual must make a visit, at least once in the course of his life. Such a pilgrimage, besides its general merit, is rewarded with an indulgence, or remission of sins for a whole year. There are also in Japan orders of monks or nuns; one of which consists of blind persons, a kind of beggars dispersed over the empire, and another called monks of the mountain, are a species of fortune tellers and quack-doctors, who are bound to live on roots and herbs, to practise constant ablutions, and to traverse deserts and mountains once in the year. There are likewise several philosophical sects in the country who disclaim all external worship; one of the most celebrated of which adopts the tenets of the Chinese Confucius, and resembles in its general principles the ancient school of Epicurus. Its followers acknowledge a kind of *anima mundi*, but limit the existence of man to the present life; and inculcate the general practice of virtue, but allow and even applaud the commission of suicide. Almost immediately after the discovery of Japan by the Portuguese, the Christian religion was introduced into the country by the Jesuit missionaries in the year 1549; and made such rapid progress that several princes of the empire were soon ranked among its converts, and about the year 1582, a public embassy was sent from the Japanese court with letters and valuable presents to the Roman pontiff. But the Portuguese who had settled in great numbers in Japan, intoxicated by the extent of their commerce, and the success of their religion, became so obnoxious to the natives by their avaricious and domineering conduct, that the representations of the heathen priests became at length sufficiently powerful to procure a prohibition from the emperor against the new religion, which threatened to overturn all the ancient institutions of the country. A violent persecution was commenced against the Christians, of whom 20,000 are said to have been put to death in the year 1590. Still did the number of proselytes continue to increase, and in 1591 and 1592, twelve thousand were converted and baptized. One of the emperors, named Kubo Fide Jori, with his whole court and army, embraced the Christian name; and had the Portuguese settlers in the country acted with ordinary prudence and gentleness, their cause must have triumphed; but the insolence of some of their prelates to some prince of the blood, became so insupportable, that a new persecution arose in the year 1596, which was carried on without intermission for the space of 40 years, and ended in the year 1638 with the total extermination of the Christians, and the banishment of the Portuguese from the country. The Japanese government, considering the unwarrantable conduct of these settlers to be inseparable from their principles as Christians, have persevered in the enforcement of the most efficacious measures to prevent their re-introduction into the country; and in order to detect any concealed adherent of these proscribed sentiments, all persons are required to prove their freedom from such heresy, by publicly trampling, at the festival of the new year, upon the images of the Catholic saints.

Form of government.

The form of government at present in Japan is pure despotism, to the exclusion of pontifical interference in the executive part. But as the Dairis, or spiritual monarchs, reigned through a long period of hereditary succession, we can only account for the ascendancy of the secular princes, by supposing that the former, resigning themselves to the more congenial and pleasing cares of religion, held the reins of government with a feeble hand. This change was effected not without bloodshed and commotion. The veneration with which the Dairi are still regarded resembles the

Form of government.

honours paid to the gods themselves. His person is considered as too sacred to be exposed to the air and sun, and still less to the view of any human creature. He never passes beyond the precincts of his court; and if he is at any time under an absolute necessity of going out of his palace, he is generally borne on men's shoulders that he may not touch the earth. His hair, nails, and beard are never suffered to be cut or cleaned, unless by stealth, and while he is asleep. He never eats twice from the same plate, and all the vessels once used in his meals, which are purposely of an inferior kind of porcelain, are usually broken to pieces, that they may not be profaned by unhallowed hands. His attendants are with few exceptions selected from his own kindred; and beyond the precincts of his court few persons know even his name till long after his death. Since the retrenchment of his power he derives his revenues from the town and district of Miaco, from an allowance out of the Kubo's treasury, and from the large sums which he acquires by conferring titles of honour. This ecclesiastical court is likewise the principal seat of literature, and may be considered as the only university in the empire. The students are maintained and instructed at his expence in the history of the country, mathematics, poetry, music, &c. The Kubos, or secular emperors, now reign in hereditary succession. Each province of the empire is governed by a prince, who is responsible to the emperor for his administration. He enjoys the revenues of his government, keeps his court, and defrays all the civil expences. Such an order of things appears to us only safe against turbulence and faction by powerful checks. Perhaps it is secured in Japan, by mutual jealousy, and the impressions of unlimited submission to the emperor, a feature of character peculiarly Asiatic.

Laws.

Thunberg informs us, that the laws of Japan are few, but rigidly enforced, without regard to persons. We have little acquaintance, however, with the Japanese code. We are told that most crimes are punished with death, and that none may incur this from ignorance, a brief code in large characters is posted up in every town and village, and regularly read in the temples. This, however, respects rather the crimes prohibited than the penalties annexed, which are said to be in some cases purposely kept unknown, and this uncertainty they affirm to have a salutary effect in deterring offenders.

Arts and sciences.

The Japanese have been celebrated for their proficiency in the arts and sciences. Perhaps the safest standard of comparison, in this respect, will be their neighbours the Chinese. They excel in manufactures of silk and cotton. Their swords are of curious workmanship. Their varnish is well known as inimitable, but for this they are chiefly indebted to the vegetable, from which it is made. The Japanese cultivate music, painting, drawing, geography, astronomy, and history. They are totally unacquainted with anatomy; and have no farther knowledge of natural philosophy and chemistry than a few notions gathered from European physicians. Their surgery consists almost entirely in burning pellets of moxa (or the leaves of mugwort rubbed soft like cotton) upon the place which is supposed to be the seat of disease; and thus forming an issue, which is kept open for some time. They also puncture with a silver needle where pains are felt. Krusenstern mentions that one of the talks, (or interpreters of the Dutch language) knew that Teneriffe belonged to the Canary Islands, and St Catherines to Brazil; from which we may conclude that they are no despicable geographers for Asiatics. Their drawings, we suspect, may challenge competition with those of China, like them, bidding defiance to perspective; and so scrupulous are they in copying from originals, that ugliness meets with no flattery from their portrait painters. Though we are not acquainted with the exact extent of their astronomical knowledge, we know that there is a set of people, called Issis, inhabiting temples near Jeddo, who foretel eclipses of the sun and moon. Their predictions are inserted in calendars, of which two sorts are published annually at Jeddo, one complete for the rich, and another abbreviated for the poor. Their art of printing is confined to the use of blocks, with which they impress only one side of the paper.

Schools.

Schools generally abound, and corporal punishment, it is said, is not introduced into their system of education. Their children are stimulated to emulation, and worthy achievements, by the recital of songs in praise of their deceased heroes. A few of the more studious acquire the Chinese language, and some of the physicians are able to understand the Dutch, and even the Latin. They have some knowledge of engraving; and are tolerably versed in the practical part of surveying, so as to possess pretty accurate maps of their own country and its towns.

Manufactures.

Their artificers work very skilfully in iron and copper, and in a mixture of gold and copper, called sowas, which they have the art of staining black or blue by means of their ink. They excel in the fabrication of steel instruments, and their swords are of incomparable proof. They are acquainted with the art of making glass, and grinding it for telescopes; with the construction of watches which they learned from their European visitors; and with the manufacture of paper from the bark of the mulberry tree. Their silk and cotton stuffs are equal, and often superior to similar productions of other eastern countries; and their laquering or varnishing in wood surpasses all the attempts which have ever been made in that department by any other people in the world.

Varnish.

This varnish is made from the juice of the rhus vernix, which upon its first exuding from the tree, is of a lightish colour, and of the consistence of cream; but the surface exposed to the air immediately becomes black. It is of so transparent a nature, that when it is laid unmixed upon boxes, and other articles of furniture, every vein of the wood may be clearly seen. But they make it of various colours, especially black or red, by mixing it with powdered substances of these colours. They apply it with a brush, and with as smooth a surface as possible; and when well dried in the sun it becomes harder than the board on which it is laid. It is then rubbed with a smooth stone and water, till completely polished, when it is covered with a mixture of turpentine oil. This varnish flies and cracks like glass when struck with a hard substance; but is capable of being exposed to boiling water without receiving any damage.

Chief cities.

Jeddo, the capital city, is situated in a bay on the south-east side of the island of Niphon. As Europeans have little freedom here, no accurate idea can be formed of its extent. A large river runs through it. The emperor's palace and its appendages compose of themselves a town. It may be included among metropolitan cities of the first class, in point of size. Miaco, the second city of the empire, stands inland about 160 miles south-west of Jeddo. It is the first commercial and manufacturing city in these dominions. Here is fixed the Dairi's palace and court, whence

Miaco may be considered the seat of the arts and sciences. Its population has been rated at about 400,000 souls, and that of the capital at half a million. We do not vouch for the accuracy of this computation. There are from 30 to 40 other cities, of which the greatest part are flourishing, and of considerable extent.

Edifices.

The imperial palace, and edifices of the nobility, seem almost to rival in splendour those of China. The saloon of the hundred mats is 600 feet long by 300 broad. Cedar, camphor, and other precious woods, are employed in the pillars and ceilings.

Public roads and travelling.

The public roads are constructed and kept with great care. They are made very broad, with a ditch on each side to carry off the water; and are frequently bordered with hedges, which sometimes are formed of the tea-shrub. Posts are regularly erected to indicate the miles, which are all measured from the capital, and also to direct the traveller at every cross road. At the time when the princes of the country make their annual journey to the court, the roads are freed from every kind of dirt, sprinkled with water in hot weather, and sometimes even swept with brooms. In travelling on these roads, it is the rule for all who are going towards the capital to keep to the left, and for those who move in an opposite direction to take the right; or rather for each passenger to keep always to the side on his left hand. The roads are more easily preserved in so good a state, as no wheel-carriages are used in the country for travelling, except a few carts near the capital, which are confined to one side of the highway; and the horses are commonly provided with straw covers to their feet, instead of iron shoes. The poorer classes travel on foot, and others either on horseback or in palankeens. Several persons, and sometimes a whole family, are mounted on one horse. In such cases, the man sits on the saddle with his legs extended forwards on each side of the horse's neck, and the rest of the party are carried in baskets on each side, while a person walks before to lead the animal. The palankeens, or Kangoes and Norimons as they are called in Japan, are of various sizes; but the better kind are so large, that the traveller may lie down, or sit at his ease, on stuffed mattrasses and cushions. There are windows in the sides, and various conveniences within these vehicles. The pole by which they are carried passes along the roof, and is borne on the shoulders of the bearers, who generally keep time by a song, and travel at the rate of a league in the hour, or ten leagues in the day. When any of the grandees is going to court through the streets of the capital, it is the fashion for his bearers to carry the pole aloft on their hands, and to move at the utmost speed in their power.

Population.

As we have no certain data on which to estimate the population of the Japanese empire, we feel more at a loss on this branch of our subject than any other. Some hold China to be a fair standard of reference for Japan, and accordingly assign 30,000,000 as the proportionate amount. Others are content to rate the population at little more than half of this estimate; yet, as all travellers agree in stating that an overflowing population is seen moving about the streets and highways, we must reckon Japan one of the most populous countries, in proportion to the extent of surface, in the world.

Military force.

The same difficulty occurs in stating the military force of the kingdom. Some compute the army at 400,000 men, we know not how correctly. According to our ideas of a navy, the Japanese may be said to have none! The arms of the military consist of bows and arrows, scymitars and halberts. Their bows are large, and the arrows of great length; and the soldier, in discharging them, places himself with one knee upon the ground. The scymitar is their chief weapon, and is worn by all except the peasantry. The blade is about a yard in length, and slightly curved; so excellently tempered, that they are said to cut a large iron nail asunder, without their edge being turned, and are considered by the Japanese as the most valuable part of their property. They make little use of fire-arms, and the few muskets seen in the country appear to be chiefly employed in salutes. Of military tactics they are entirely ignorant; but courage, fortitude, and love of their country, have hitherto sufficed to preserve their independence, and to repel more than one foreign invasion of their territories.

Revenues.

The revenues yielded by the different provinces are stated to amount to 2834 tons of gold, or (at £10,000 sterling per ton), to £28,340,000 sterling. The emperor, however, only benefits by the revenue of the five provinces of his own fief or government. But, as before mentioned, he is entitled to two thirds of each mine that is opened; and he is said to possess a large treasure, disposed in chests containing each 1000 taels.

Political relations.

From the genius of their government, and jealousy of foreign interference, it does not appear that the Japanese have any external political relations. Their most natural allies would be the Chinese; yet it is certain that they do not treat even the Chinese merchants, who frequent the harbour of Nangasaky, with much ceremony and respect; and the Dutch at Japan seem to be reconciled to mortification, without gaining any adequate compensation by traffic.

Commercial relations.

Though these last have been established at Japan about two centuries, their trade has declined, instead of having increased; and as we have no right to infer want of vigilance on the part of the Dutch in watching over their commercial interests, we must suppose, either that they have nothing to offer the Japanese worth their acceptance, or that these latter are not to be seduced, by any means, to make an inconsiderate surrender, or depart from their maxims of state. When we reflect how often the independence of nations is sacrificed to commercial toleration, we must give the Japanese rulers credit for great prudence in their councils.

Dutch commerce.

The chief articles which the Dutch carry to Japan are bullion, European cloths, silks, spices, printed linens, sugar, sapan wood, tin, ivory, tortoise-shell, horns of the sea unicorn, which last is highly valued by the Japanese as a medicine. But, as before stated, they are restricted to the dispatch of two ships annually from Batavia. The cargoes of 13 ships between 1784 and 1793 inclusive, amounted to 3,534,521 florins. The returns made from Batavia to Japan during the same period, which consisted principally of copper and camphor, amounted to 2,764,879 florins.

Chinese commerce.

The Chinese send annually 12 ships from Ningpo, (or Simfo, as it is called by the Japanese,) five of which arrive in June and sail in October; the other seven arrive in December, and sail in March or April. They import chiefly sugar, ivory, tin plates, lead, silk stuffs, &c. They export copper, camphor, japanned wares, gold thread, buffalo horns, sowaas (an artificial metal) painted and coloured paper, umbrellas, and particularly the dye-fish, used as a medicine in China. Besides these, a kind of sea plant, and large dried mussels, called *awaby*, considered a great delicacy. Each Chinese vessel, or junk, being about equal to a ship of 400 tons, it would appear that their cargoes must be very considerable; yet Krusenstern remarks, that two ships of

500 tons each might stow away what is conveyed in all the twelve.

Historical epochs.

Kæmpfer has divided the Japanese history into three epochs, the fabulous, the doubtful, and the certain. The first reaching beyond the Mosaic æra of the creation, our acquaintance with it must be particularly unprofitable. The second, being mixed with Chinese history, and from the admission of Chinese symbols, demonstrates that Japan, in the earlier stages of society, was connected with China, and tends to fix a common origin. The certain period begins with the hereditary succession of the Dairis from 660 years before the Christian æra, to the year of our Lord 1585. In the reign of Gonda, the 90th Dairi, Japan was menaced by a great invasion from the Monguls, the invading fleet and army, amounting to 240,000 men, being dispersed and almost annihilated by a furious tempest, the Japanese piously ascribed their deliverance to the interposition of the gods. In 1585, the generals of the crown, or Kubos, assumed the supreme power, and these continue to reign uncontrolled, the Dairi having his separate court at Miaco, and presiding over the religious and literary concerns of the empire.

Account of Russian embassy.

We shall present our readers with some account, (for which we are indebted to Krusenstern,) of the reception of the Russian embassy by the Japanese; this relation may serve both to amuse the reader, and to illustrate the national character. Notwithstanding the national character for jealousy of the arrival of strangers on its coast, yet the Russian ambassador seems to have expected a favourable result to his mission. From the extent and contiguity of the Russian dominions, his excellency seems to have flattered himself that the offer and assurance of friendship of a powerful monarch would meet with a distinguished reception. But we cannot blame the policy which viewed with jealousy and distrust, the interference of so formidable a power as Russia in commercial pursuits. Whatever the arguments and motives of the Japanese politicians were, the Russian mission failed completely in its object, and even the permission formerly obtained, of sending a ship annually to Nangasaky, was recalled. Krusenstern is pretty liberal of abuse and sarcasm on the closeness of Dutch policy at Japan. It was not to be expected that the Dutch would favour the views of the Russian ambassador, or assist in opening a door of commercial competition to his nation. His excellency the councillor of state and chamberlain Resanoff, the Russian ambassador, and an adequate suite, arrived in the ship Nadeshda, in the harbour of Nangasaky, in October 1804. On the arrival of the Nadeshda, the first step resorted to by the Japanese, was the depriving the ship of its powder and fire arms, even to the officer's fowling-pieces. This measure was defended on the principle of national etiquette, the subjects of a foreign power not being allowed to go about armed in his Japanese majesty's dominions. But whatever the mortification and feelings of the ambassador were, their situation appears to have been particularly irksome to Krusenstern and his crew. At first they were prohibited from going ashore, and even from rowing about.

At length, after six weeks negociation, and on the plea of the ambassador's health, a spot was assigned as a walk, not exceeding 100 paces in length and 40 in breadth, in the immediate vicinity of which were two watch-towers. A debarkation of a single boat was attended by a fleet of 10 or 15 vessels surrounding it; in the same manner the boat was escorted back to the ship. So strict were the Japanese, that the Nadeshda was debarred intercourse with the Dutch ships, and letters were not even allowed to be sent by them to Batavia. The ambassador alone was permitted to transmit a report to the Emperor of Russia, translated by the interpreters into Dutch with such scrupulous accuracy, that every line of the translation terminated with the same letter as the lines of the original. This copy was deposited with the governor. On the departure of two Dutch vessels, Krusenstern having wished the captains a happy voyage, and made enquiries after their health, received in reply a sign with their speaking trumpet. For this silence, the chief of the Dutch factory apologised by letter to the ambassador, on the grounds that the captains had been forbidden to utter a word. Here our author breaks forth into a violent philippic against the Dutch, for their mean and servile compliance with Japanese prejudices, yielded in the true spirit of gain; and though Krusenstern may write under the influence of pique, we do not dissent from the justice of his observation, that such conduct is unworthy of the character of an enlightened and great nation. The important point being at length settled, of the ambassador having permission to land, a considerable building called Megasaky, was appointed for his residence, and watched with as much care as the seven towers of Constantinople. The situation of his excellency's quarters appears to have been selected with a remarkable regard to security. The building was placed on a neck of land, so near the sea, that at high water the tide came close to the walls. The windows were armed with double lattice-work, and consisted of spaces about a foot wide, calculated to admit a very moderate allowance of light. The whole habitation was secured by a bamboo fence, even on the sea side, the waves being deemed but an insufficient barrier by the Japanese. Large gates, with double locks, at which were stationed porters to take charge of the keys, and who seem to have executed their trust with troublesome fidelity, were placed on the land and sea sides. Besides, guards watched the spot, who did not slumber on their posts. Though our author expatiates on this barbarous intolerance of the Japanese, yet he does them the justice to admit, that such materials as he required for the repair of the ship were readily granted. The supply of provisions was also liberal to the ship's company. The landing of the Russian ambassador on the 17th December, was attended with circumstances of considerable pomp and ceremony. The Prince of Fisen's boat, a barge surpassing in size and magnificence every thing of the sort, (being 120 feet long,) was destined for the reception of his excellency. The walls and ceilings of the numerous cabins were varnished in the handsomest manner, and the stairs of red wood so highly polished, as to have the appearance of lacquer. On the decks were spread mats and the most costly carpets; and the whole boat was hung round with double rows of various coloured silk. On the ambassador stepping on board, the Russian imperial standard waved with the flag of the Prince of Fisen, whose guard took their station close to the standard. The Japanese fortresses were decorated with new flags and curtains, and manned by troops in their best dress. An innumerable fleet of boats accompanied the ambassador to the town of Nangasaky. So far his excellency was ushered into his Japanese majesty's dominions in a manner suitable to the representative of a powerful monarch. But he had no sooner landed and entered into his dwelling, than he was locked up like a state criminal, and the keys were sent to the governor. The day

Account of Russian embassy.

after the ambassador left the ship, two Banjos, accompanied with a great number of boats, come on board to receive the presents. Two boats lashed together, with a platform of strong planks laid across, covered with red cloth, was appointed to receive the large mirror. All attempts to persuade them to remove this valuable covering were ineffectual, as the respect with which every thing was attended destined as a present to the emperor, required to be scrupulously enforced, and rejected all paltry consideration of economy. A guard instantly jumped into the boat for the honour of the mirror. One of the interpreters being asked how it would reach Jeddo, replied, it would be carried there. An objection being raised on the ground of the distance and number of men required to carry it, the interpreter gravely answered, that nothing was impossible to the emperor of Japan; and that a live elephant, a present from the emperor of China, had been so transported. We are furnished with another trait of Japanese character by the same author, which shews with what exactness the emperor's orders are executed. A Chinese junk was driven ashore on the east coast of Japan in a gale of wind, and lost her masts and rudder. According to an ancient regulation, every ship touching on the Japanese coast, by whatever accident, must be brought to Nangasaky. Accordingly this junk must find its way there. This could only be effected by a process of towing; and the great probability was, that during the voyage, which lasted 14 months, the towing-fleet, consisting of 100 boats and 600 men, with the said junk, would all go to the bottom. But neither the intricacy of the navigation, nor perils by storm frequent on this coast, nor the length of the voyage, nor the inadequate compensation of so much toil by the object being attained, weighed for a moment, when placed in competition with established custom and the emperor's orders. On the 19th February 1805, the Russian ambassador received intimation that the emperor of Japan had sent a person, attended by eight nobles, with full powers to treat with him. The person deputed was said to be of the highest rank, and one who was permitted to view the emperor's feet, though not to elevate his look higher.

The Japanese plenipotentiary having arrived, much altercation took place on both sides in adjusting the ceremonies to be observed at the audience. It was settled that the ambassador should pay the plenipotentiary an European, and not a Japanese compliment. This last is said to be so very degrading, that not even the lowest European would submit to it. The ambassador, however, was to appear without his sword or shoes, nor would they allow him a chair, or any kind of European seat. He was to sit with his feet tucked under him, in front of the governor and plenipotentiary. A norimon, or sedan chair, was allowed the ambassador, but the officers of his suite were to walk. The arrangements being finally made, the 4th of April was appointed for his first audience. The ambassador and his suite, consisting of five persons, and a serjeant to carry the standard of Russia, were conveyed in a barge adorned with flags and curtains, and landed at a place called Mussul Trapp. On an occasion, for which such preparations were made, and expectation raised, merely an exchange of compliments took place, and a few insignificant questions were put. The second audience was of the same nature, and here ended the matter. An order was delivered to the ambassador, prohibiting any Russian ship from again visiting Japan. The presents, and even the letters from the Emperor of Russia, were refused. It was enjoined that any Japanese cast upon the coast of Russia, should be delivered over to the Dutch, who would send them by way of Batavia to Nangasaky. Finally, the Russians were prohibited from offering presents and making purchases, and from visiting or receiving the visits of the Dutch factor. The repair of the ship, and the supply of provisions, were declared to be taken into the imperial account. And it was notified, that the Emperor of Japan had sent 2000 sacks of salt, and 100 of rice, besides 2000 pieces of cassock or silk wadding, the former as a present for the crew, and the latter for the officers. The reason assigned for refusing the presents was, that the Emperor of Japan would be obliged to make a suitable return to the Emperor of Russia, and to send an ambassador to St Petersburgh; and that it was contrary to the laws of the empire for any Japanese to quit his country. Such was the result of an embassy, of which such sanguine hopes had been formed in Russia. Not only were no new advantages gained, but the written permission granted to the Russians to visit Nangasaky was revoked. All communication is now suspended between Russia and Japan, nor is it expected that it will be again opened until some great change takes place in the Japanese government. Nor, perhaps, is such a change very remote. At the very moment of our writing this article, we find it mentioned, among continental intelligence, that the Dairi of Japan has been intriguing in secular affairs, and endeavouring, by means of his priests and adherents, to gain the people to his cause. Whence the supremacy of the Kubo is threatened, and a popular insurrection apprehended.

Latest accounts from Japan.

The Ainos described by Krusenstern.

We shall conclude this article, by offering to our readers a description, from Krusenstern, of the Ainos, a race of people but little known in Europe. As this author's account has simplicity of narrative, and the appearance of truth to recommend it, we shall make no apology to our readers for presenting it in his own words. We shall only premise, that the island of Jesso was wrested from the Ainos, its original inhabitants, by the Japanese; the former are now confined to a small space, which alone retains the name of Jesso, the rest of the island being called Matzumary, from the principal Japanese settlement here. The Japanese discipline exists in full force in the most northerly part of the island, the farthest limit of their empire.

Island of Jesso.

"The Ainos," Krusenstern observes, "are rather below the middle stature, being at the most five feet two or four inches high, of a dark, nearly black, complexion, with a thick bushy beard, black rough hair hanging straight down, and excepting in the beard, they have the appearance of the Kamtchadales, only that their countenance is much more regular. The women are sufficiently ugly: their colour, which is equally dark, their coal black hair combed over their faces, blue painted lips, and tattooed hands, added to no remarkable cleanliness in their clothing, do not give them any great pretensions to loveliness; this at least was the case with those we had an opportunity of seeing on the north side of Jesso. We perceived, indeed, in Aniwa bay, some who were younger, whose eyes had not lost their brightness, and who on this account were not quite so ugly: but I confess that the impression even these made upon me was equally unfavourable. They are modest however in the highest degree, and in this point form the completest contrast with the women of Nukahiwa and of Otaheite. Their modesty even amounted to bashfulness, occasioned perhaps by the jealousy of their

Japan.
Account of the Ainos.

husbands, and the watchfulness of their parents: they never quitted for a moment, while we were on shore, the huts in which they had assembled, and were extremely distressed when Dr Telesius made drawings of them.

The characteristic quality of an Aino is goodness of heart, which is expressed in the strongest manner in his countenance; and so far as we were enabled to observe their actions, they fully answered this expression. These, as well as their looks, evinced something simple, but noble. Avarice, or rather rapacity, the common fault of all the wild inhabitants of the southern islands in the eastern ocean, they are entirely strangers to: in Romanzoff bay they brought fish on board, which they immediately left to us, without demanding the least thing in return; and much as they were delighted with the presents made to them, they would not admit them as their property, until they had been frequently assured by signs of their being intended for them.

"The dress of the Ainos consists chiefly of the skins of tame dogs and seals; but I have seen some in a very different attire, which resembled the parkis of the Kamtschadales, and is, properly speaking, a white shirt worn over their other clothes. In Aniwa bay they were all clad in furs; their boots were made of seal skins, and in these likewise the women were invariably clothed. In Romanzoff bay, on the contrary, we saw only two fur dresses, one of which was a bear's skin, the other made of dogs' skins; and the rest of the people were dressed in a coarse yellow stuff, made of the bark of a tree, (as we ascertained in their houses,) which a few wore, bordered with blue cloth. Under this dress they had another of a fine cotton stuff, that they probably purchase of the Japanese. Here we saw no boots such as were worn by every one in Aniwa bay; but, instead of them, they used Japanese straw slippers. A few of them covered their legs with a kind of half stockings stitched together, of the same coarse stuff as their upper garments. This difference in the dress of the Ainos of Jesso and Sachalin seems to prove a much greater degree of wealth in the latter island, and the men here appeared to wear a more cheerful aspect; but whether this is owing to their superior wealth in fish and furs, which find a certain market with the Japanese, or to their little dependence on these latter, I cannot pretend to decide, though I am inclined to believe the former. The greatest part of them went with their heads uncovered; others wore a straw hat, pointed in the middle. I fancy it is not the custom of the country to shave the hair, though I saw several of them with their heads half shorn, probably only in imitation of the Japanese. The women, even the youngest, use no ornaments on their heads; but, as I have already mentioned, they invariably paint their lips blue,—a practice which, to an European accustomed to the rose colour, appears extremely ugly. On the contrary, many of the male sex wore ear-rings, which were commonly merely a brass ring. I purchased a pair off a young man, made of silver, with large false pearls suspended from them. The possessor seemed to set great value on these ornaments, being very unwilling to part with them; and twice he repented of his bargain, took them back again, and demanded a higher price. An old coat, two cotton cloths, and a piece of flat white metal, were the treasures for which he at last exchanged them. Buttons and old clothes were the articles the Ainos most sought after, and for which they gave their pipes and other trifles.

"The huts we saw in Aniwa bay were, as I have already said, probably newly built, and served only for their summer residence. In Romanzoff bay they appeared to be their constant abode both in winter and summer. The two we visited, and near to which were balagans for drying fish, consisted of a single large room, which, with a small division at one end, occupied the whole interior of the house. Their construction did not seem to me to be very solid, and, unless the houses are entirely covered with snow, as in Kamtschatka, I cannot conceive how they are able to bear the cold, which must be intense here in the winter; since, even in the month of May, the thermometer only shewed three degrees of warmth. In the middle of the room was a large hearth, around which the whole family, consisting of eight or ten persons, was seated. The furniture consisted of a large bed, over which a Japanese mat was spread, and several boxes and barrels. All their utensils were of Japanese manufacture, and mostly lacquered. It appeared, from the interior of the house, that the inhabitants possessed a degree of affluence such as is not found among the Kamtschadales, still less among the Aleuti, and the unfortunate inhabitants of Kodiack. The great provision of dried fish bore indeed rather a disgusting appearance; but no objection can be taken to this when we reflect, that their existence depends upon them, fish being probably their only nourishment, and their houses on this account being chiefly scattered along the shore. We perceived no symptoms of cultivation, not even any plantations of vegetables; nor did we see any tame fowls or domestic animals except dogs, which they had in great abundance; and Lieutenant Golowatscheff found in Mordwinoff bay, on the west coast of Patience bay, above fifty in one place. In all probability they use them for their journeys in the winter; for we saw in Aniwa bay a sledge which bore a perfect resemblance to a Kamtschadale narte. Dog skins, also, are here an important article of dress. We were struck on perceiving, that snow-water was the common beverage of the people on the north side of Jesso, although that of the river, which flowed into the bay, was extremely good. Perhaps the fear of cold in the winter, as they would have to fetch their water from the river, which is not very near to their houses, has so accustomed them to snow-water, that they prefer it to that of the river so long as they are able to procure it. It seemed also the custom here, (at least, it was so in all the houses which either I or any of my officers visited,) to bring up a young bear in the house, to which a place was assigned in one of the corners of the room, and which was decidedly the most restless of any of its inhabitants. One of our officers was desirous of purchasing one of these bears, and offered his great-coat in exchange for it; but he could not persuade the proprietor, although cloth is of great value in the eyes of the Ainos, as the Japanese are unable to supply them with it, to part with his young elève.

"It would be presuming too much to enter into any detail upon the form of government and the religion of the Ainos, as our stay here was much too circumscribed for us to have instituted any inquiries into these subjects; but, with their limited population, it is not easy to imagine any other than a patriarchal constitution. During our visit to one of their houses in Romanzoff bay, we observed in the family, which consisted of ten persons, the happiest state of harmony, or rather a perfect equality. We continued there some hours, and were scarcely able to distinguish the head of the family, so little assuming were even the oldest towards its

Account of the Ainos.

youngest members. Accordingly, in dividing a few presents among them, I preserved a most perfect equality, which they all appeared pleased with, no one, not even the oldest, remarking, that I had given him too little in proportion to the others; on the contrary, they called my attention to a little girl, about eight years old, whom I had overlooked, and who now obtained her share. This unanimity, and the silence which reigns among them, awake the most favourable feelings towards them. Here was no loud talking, no immoderate laughter, and still less any disputing. The satisfaction that appeared in all their countenances as they spread the mats round the hearth for us; their readiness, when we were going away, to launch their canoes and carry us across the shallows to our boat, when they perceived that our boatmen were stripping themselves for this purpose: but still more than all this, their modesty never to demand any thing, and even to accept with hesitation whatever was offered to them, wherein they differ very much from the inhabitants of the west of Sachalin, whose diffidence La Perouse could not speak of with praise; all these uncommon qualities, for which they are not indebted to any polished education, but which are merely the marks of their natural character, make me consider the Ainos as the best of all the people that I have hitherto been acquainted with.

"I have already mentioned their inconsiderable numbers, particularly in Jesso. On the north of this island we counted only eight dwelling-houses, and if we admit ten as the number of each family, this makes that of the inhabitants of this district only eighty. Farther inland they probably have no establishments; for as their whole nourishment consists of fish, they only settle on the sea shores. In Salmon Bay, and Tamary Aniwa, the Ainos probably amount to three hundred; but we were there at the time of the fishery, and it is chiefly from hence that the Japanese procure this article, for which they are obliged to have recourse to the inhabitants of the neighbouring bays, who settle here at such times, in order to prepare so large a quantity. Not only the recently built houses of the Ainos in the vicinity of the Japanese factory is a proof of this, but also the number of houses provided with furniture but destitute of inhabitants in Mordwinoff Bay, where Lieut. Golowatscheff, who visited that part, found but a few persons, and these not merely to guard the property, for they seemed to consider it as their own.

"According to the most ancient accounts we have of this island, its inhabitants are said to be covered with hair. The Chinese describe it as a large country full of wild people, whose whole body is covered with hair, and with such enormous beards that they are forced to raise them up in order to drink. The Dutch in the well known expedition in 1643, under the command of Captain Vries, and the Russians under Spanberg in 1739, confirmed this description. Although so many concurring accounts seem to testify the fact of the natives of Jesso being overgrown with hair, nevertheless I am disposed, from our experience, to declare this report to be fabulous. The Jesuit Hieronymus de Angelis, the first European who, in 1620, visited Jesso, merely mentions their bushy beards, but says not a word of their hairy bodies; and as he resided for some time amongst them, he certainly had a better opportunity of examining their personal qualities than could be found in the short visits of the Dutch, the Russians, or the Chinese, and he would not have failed to make known so striking a circumstance. On the north of Jesso we examined some people, but found that, except their bushy beard and the hair on their faces, there was not the least thing to give probability to such a story. In Aniwa I got several of them to uncover their breasts, arms, and legs, and we were here convinced to a certainty that the greater part of the Ainos have no more hair upon their bodies than is to be found upon those of many Europeans. Lieut. Golowatscheff found indeed in Mordwinoff Bay a child of eight years old, whose body was entirely covered with hair; but he immediately examined its parents and several other grown up persons, and found them all in that respect like Europeans. I will not flatly contradict the report of older and modern navigators, whose credibility I do not argue against; but I believe that they have exaggerated this story respecting the Ainos, or, what is the same thing, the natives of the southern Kuriles: at least it is not equally true with regard to all. Perhaps the impression which the Dutch received from their bushy beard, hairy face, and lank locks, added to the uncleanliness of their persons, left an idea that their bodies must be as much covered as their faces; and as they did not wait to examine whether this were really the case, this gave rise to a story which has been ever since repeated as a fact."

The following notices respecting Japan, communicated in a discourse to the Literary and Scientific Society at Java by the Honourable Governor Raffles, and drawn from the information of Dr Ainslie, who had resided four months in Nangasaki, may be considered as the most recent intelligence on the subject of this article.

Recent account of the Japanese by Dr Ainslie.

Every information obtained by that gentleman tends to confirm the accuracy, ability, and impartiality of Kæmpfer, whose account of Japan is represented as one of the most complete works of the kind that was ever produced in the same circumstances. The Japanese acknowledge that from this book they know their own country; and their first enquiry to the English commissioners was for a copy of Kæmpfer. In expressing the estimation in which his writings were held among them, they literally observed, that "he had drawn out their heart from them, and laid it palpitating before us, with all the movements of their government, and the actions of their men!" The natives are represented by Dr Ainslie as a nervous, vigorous people, whose bodily and mental powers assimilate much nearer to those of Europe, than what are usually attributed to Asiatics; as possessed of masculine features perfectly European, except the small lengthened Tartar eye, which almost universally prevails; as perfectly fair and even blooming in their complexion; and actually exhibiting among females of the higher class more of the hue of health than is usually found in Europe. He describes their proficiency in the sciences, especially in metaphysics and judicial astrology, as sufficient to evince a vigorous intellect; and their skill in the arts as by no means resembling the stationary mediocrity of the Chinese, but as the effect of an ardent and progressive principle of improvement. Nothing, he tells us, is so offensive to the feelings of a Japanese, as to be compared, in any one respect, with the Chinese; and the only occasion on which he ever saw the habitual politeness of a native surprised into a burst of passion, was when, upon a similarity between the two nations being unguardedly asserted, the latter laid his hand upon his sword. They have at least none of that uniformity of character which the artificial system of government has produced in China; and their women particularly, associate among themselves like the ladies of Europe. Dr Ainslie was present at frequent entertainments among the natives; and on one of these occasions particularly, a lady from the court of Jeddo performed the honours of the table with an ease, elegance, and address, that would have graced a Parisian. The usual dress of the Japanese women, even of the middle rank, is remarkably costly; and its value might supply the wardrobe of an European lady of the same rank for twenty years. The Japanese, with an apparent coldness, derived from that system of espionage and principle of disunion dictated by the government, are eager for novelty, and warm in their attachments, strongly inclined to foreign intercourse, notwithstanding the prohibitory political institutions of their country, and apparently ready to throw themselves into the hands of any nation of superior intelligence; but at the same time full of contempt for every thing below their own standard of morals and habits. The failure of the embassy from Russia in 1814, which might seem to contradict this remark, Dr Ainslie considers as attributable to particular circumstances, which however are not sufficiently detailed, but are intimated as originating in the influence of the interested competitor at the head of the Dutch establishment. The warehouse in which the Russian mission had been lodged was pointed out to Dr Ainslie, who observes, that, "as the rats were let out, the count and his suite were let in, where they remained for six long months with scarce room to turn; the mark of obloquy to the Japanese, and the laughing stock of the European factory." So lively was the impression of the occurrence, that the chief Japanese officer asked the English commissioner, "if he too would condescend to play the part of the Russian count?"—the officer answering to his own question, "No, I trust not." Even the illiberality of the Japanese on the subject of religion, is affirmed by no means to correspond with the representations hitherto made of their character; and the annual test of trampling on crucifixes and other Catholic images, is said to be denied and derided as a foolish story by the native priests. Upon visiting the great temple on the hills of Nangasaky, the English commissioner was received with marked respect, and sumptuously entertained by the patriarch of the northern provinces, a man eighty years of age; and when one of the English officers present heedlessly exclaimed in surprise, Jasus Christus! the patriarch, turning half round with a placid smile, bowed significantly, expressive of a hint to avoid that subject in that place, and took leave with a hearty shake of the hand. It is mentioned as an extraordinary fact, that, for seven years past, since the visit of Captain Pellew, notwithstanding the determination of the court not to enter into foreign commerce, the English language has, in obedience to an edict of the Emperor, been cultivated with considerable success by the younger members of the college of interpreters, who were found very eager in their inquiries after English books. While the commissioner was at Nangasaky, there arrived a large detachment of officers of rank, who had been employed nearly four years in making an actual survey of every foot of the empire and the dependent isles, one fourth part of which they had not yet completed. The survey appeared to be conducted on a scientific principle, to be most minute and accurate in its execution, and to have for its object the completion of a regular geographical and statistical description of the country. The Japanese, in short, are wonderfully inquisitive in all points of science, and are anxious to receive information, without inquiring from what quarter it comes; and, in the opinion of Dr Ainslie, are a people with whom the European world might hold intercourse without compromise of character. The result of all that the commissioners observed, is said to be an impression on the minds of those who are most competent both to judge and act in the matter, that a commercial intercourse between Great Britain and Japan might easily be opened. See Kæmpfer's *History of Japan;* Thunberg's *Travels*, vols. iii. and iv; Krusenstern's *Voyage round the World;* and the *Transactions of the Literary and Scientific Society at Java.*

JAPANNING, is a mode of ornamenting various articles with a hard varnish, which bears a good polish, and can be made of brilliant colours and ornaments.

The natives of Japan and China practise this art in great perfection. They have a decided advantage over the European japanner in their materials. They use a kind of resin called lac, which is the sap or juice of a tree. The Japanese make incisions in the lower part of the trunk, and receive the lac, which flows in pots set beneath the incisions; this lac is at first of the colour and consistence of cream, but it becomes black on the surface when it is exposed to the air. The whole mass is required to become black before it is used, and for this purpose it is put into very shallow bowls, and continually stirred with an iron rod during twenty-four hours, so as to expose every part to the action of the air; this makes it thicker than before, and of a fine black colour, which they heighten by adding powdered charcoal.

When this lac is laid on the work, and dried, it is polished with a stone and water, and the polished surface is ornamented by gilding or painting, which is secured by an external coat of varnish, made of oil and turpentine, boiled to a proper consistence.

The japanning among Europeans is differently performed, but the work bears a near resemblance to that of the Japanese when finished; it is applied to wood, papier-maché, leather and iron, or tinned iron. When the articles are of that nature, that they will not bear heating in a stove to dry and harden the japan, they must be done with lac similar to the real japan; but as the lac is only brought to Europe in a solid form, it must first be reduced to a fluid state, by dissolving it in alcohol, or some essential oil; and this varnish being spread on the work, the alcohol or oil will evaporate, and leave a hard superficial coat of lac. The varnish may be mixed with the requisite colours, or the colours may be painted upon the surface of the varnish, between the successive coats which are applied; and in the latter case admit of painting according to a design.

For such goods as will admit of sufficient heat in a stove, a more economical method is pursued, the principal coats of japan being made of boiled linseed oil, with proper colouring matters. These are dried and hardened in the stove, and the painting or gilding is laid on; a thin lac varnish is lastly applied, to give the external surface; but it assimilates so well with the first coats of japan, that the whole wears as well as if it was done with solid lac in the Japanese method.

Japanning with lac.

Japanning with lac. This is principally used for ornamenting wood, leather, and paper, but the latter can be japanned by heat like the metals.

The following receipts are given in the Handmaid to the Arts, for the varnishes which are to form the grounds or surfaces on which the painting or gilding are to be laid. Dissolve two ounces of coarse seed lac, and two ounces of resin, in one pint of rectified spirits of wine. This varnish must be laid on in a warm place; and the work will be better done if the substance to be japanned can be warmed also, but all moisture and dampness must be carefully avoided. Two or three coats of this coarse varnish must be applied, preparatory to laying the grounds, which contain the colour, and which are made as follows.

For a white ground.

For a white ground, prepare flake white, or white lead, by washing it with water, and then by grinding it with one-sixth of its weight of starch; when this is dried, temper it properly for spreading, with mastic varnish, which is prepared by dissolving mastic in spirits of turpentine, by a gentle heat in a water bath; or the colour may be compounded with gum anime, reduced to powder, and ground first with turpentine, and then ground with the colours, adding as much of the mastic varnish as is necessary to make it work with the pencil. When this white japan is laid on, the external varnish which is applied upon it after the painting or ornaments are finished, must be of the most transparent nature, that it may not injure the whiteness of the colour. For this purpose select the clearest and whitest grains from a large parcel of seed lac, reserving the coarser grains for other varnishes; take two ounces of this chosen lac, and three ounces of gum anime, reduce them to a gross powder, and dissolve them in a quart of spirits of wine; five or six coats of this varnish must be laid on over the white colour. The seed-lac will give a slight tinge to the colour, but the hardest varnish cannot be made without it; when hardness is not so essential, a less proportion of seed-lac may be used, and to take away the brittleness of the gum anime, a small quantity of crude turpentine may be added. Another varnish, either for mixing up with the white colours, or for covering them when laid on, is made of gum anime, dissolved in old nut or poppy oil, by gently boiling the oil, and putting into it as much of the gum as it will take up. This varnish must be diluted with oil of turpentine for use; it will not bear polishing, and must therefore be applied very carefully to lay it smooth.

For blue japan grounds.

For blue japan grounds, use a bright Prussian blue, or smalt, or verditer, glazed over by Prussian blue; the colours are best mixed with shell lac varnish, and brought to a polishing state by five or six coats of seed lac varnish. If the blue ground is bright, and the shell lac varnish is laid on, it will give a green hue, owing to its own yellow colour; the varnish of oil and gum anime, as above, being used for the external varnish, will have a clearer colour, but it is not so hard.

For red japan grounds.

For red japan grounds vermilion may be used to produce a scarlet ground, but it has a glaring effect when used alone. This will be in some measure corrected by glazing it over with carmine, or fine lake, or even with rose-pink. For a very bright crimson, instead of glazing with carmine, Indian lake should be used; the lake may be dissolved in the spirit of which the varnish is composed, and a coat of this being laid on, the shell lac varnish may be used to produce the external surface, as it will very well transmit the tinge of the Indian lake.

For yellow japan grounds.

For yellow japan grounds, for bright yellow, king's yellow or turbeth mineral should be employed, either alone or mixed with fine Dutch pink. The effect may be heightened by dissolving powdered turmeric root in the alcohol, which is used for making the external varnish. The alcohol should be strained off from the dregs of the turmeric, before the seed lac is put in to form the varnish. Dutch pink alone, if of the best quality, will make a good yellow ground.

For green japan grounds.

For green japan grounds, king's yellow and bright Prussian blue may be mixed to make a green, or turbeth mineral and Prussian blue; and a common kind may be made of verdigris, mixed with either of the above yellows, or with Dutch pink. For a very bright green, the crystals of verdigris, called the distilled verdigris, should be employed; and to heighten the effect, the colour should be laid on a ground of leaf-gold, which renders it very brilliant.

For orange japan grounds.

For orange japan grounds, mix vermilion or red lead with king's yellow, or Dutch pink, or orange lake used alone is a fine colour. To prepare this, take of the best annotto four ounces, and of pearl ashes one pound; put them together into a gallon of water, and boil them for half an hour, then strain the solution through paper. Make also another solution of a pound and a half of alum, in a gallon of water, and mix this gradually with the solution of pearl ashes and annotto; a precipitate of the colouring matter will be formed, which being dried in cakes or lozenges, is the orange lake.

For purple japan grounds.

For purple japan grounds, a mixture of lake and Prussian blue may be used, or vermilion and Prussian blue for a coarser purple.

For a black japan ground.

For a black japan ground. Ivory black and lamp black are the proper materials for this purpose. They should be laid on with shell lac varnish, and the external varnish may be of seed lac, as the tinge of it can do no injury.

For a ground of gold.

For a ground of gold. Gold leaf may be laid on over the whole surface. See *Japanners* GILDING. Or the imitative gold or silver powder may be used with the size there described. When the desired ground is obtained, the ornamental painting is next performed. The colours for painting are mixed up with varnish of shell or seed lac, dissolved in spirits of wine, or otherwise by varnish of mastic, dissolved in oil of turpentine; to which gum anime may be added, as before directed, for mixing up the colours of the white ground, and which applies to all the other grounds. There is, in fact, no difference between the manner of preparing the colours for laying the grounds, or for painting upon the ground. The pencils must be moistened either with the spirits of wine or oil of turpentine, so as to make the colours work. In some very nice works, the colours may be tempered in oil, for the more free use of the pencil, and to obtain greater dispatch. The oil should previously have one-fourth part of its weight of gum anime dissolved in it, or gum sandarac or mastic. When this oil is used, it should be diluted with spirit of turpentine, that the colours may lie more even and thin.

When the painting is to be on a ground of gold, water colours may be used for the ornamental painting. They are prepared with isinglass size, corrected with honey or sugarcandy. The ornamental gilding for japanners work is explained in the article GILDING.

External varnish.

External varnish. The hardest varnish is made of seed lac, as before mentioned, but has a yellow tinge. To make this, wash the seed lac in water to clean it from impurities; dry it, and powder it coarsely; then put three ounces of it into a bottle with a pint of rectified spirits of wine. The bottle should not be above two-thirds filled, and must be gently heated, and shaken frequently, until as much of the lac is dissolved as can be, and the varnish is then to be poured off into a bottle, and kept stopped very close. The more highly rectified the spirit is, the more lac it will dissolve. This varnish must be laid on in a dry warm place, and the work previously made perfectly dry: no part should be crossed or passed twice over in laying the same coat, if it can be avoided.

When the outer varnish has been as often repeated as is necessary, the work is polished with a rag dipped in fine powdered pumice stone, or rotten stone; and when a good surface is thus obtained, it is finished by rubbing it with the hand alone, or with butter or oil.

About the middle of the last century, almost all elegant furniture was japanned by these means; but it is now disused, except for coaches, and for some small articles. The japanning of such articles as will bear the heat of a stove, to harden the varnish, is now brought to a very high perfection, and is very cheap compared with the lac japan.

Japanning of tin and paper wares by the stove.

Clear japan varnish.

Japanning of tin and paper wares by the stove. This is distinguished into two kinds; clear work, in which the japan is required to be transparent; and black japan, which is opake. The *varnish for clear work* is composed of raw linseed oil, umber, and a little amber, with a small portion of white rosin. These materials are boiled for several hours in a cast-iron pot, which is set in brickwork over a furnace, and the mouth of the pot surrounded by a funnel or chimney of brickwork, with only one opening to obtain access to it; and this opening is provided with an iron door to shut close in case the materials should take fire. The boiling evaporates the most fluid parts of the oil, and the varnish becomes thick. It is known to be sufficiently boiled by letting fall a drop on a piece of tinplate; and if it does not spread upon the surface, but keeps in a circumscribed spot, the varnish is esteemed sufficiently boiled, and may be taken out of the boiler. This varnish is to be mixed up to a proper consistence for working with spirit of turpentine, the varnish being a little warm.

Black japan varnish.

The black japan varnish is made by the same process, but asphaltum is used instead of amber; and it is thinned for use with tar spirit instead of spirit of turpentine; also lamp black is added to the varnish.

Either of these varnishes are to be laid upon the work by a soft hog's hair brush, such as is known by the name of a painter's tool, and it must be prepared by drawing out all the hairs which are thicker than the others, or all those which have the flesh end downwards. The work must be carefully cleaned from dirt, resin, &c. and with this brush it is thinly coated over with the varnish. It is left for a few minutes to set, and it is then put into the drying stove, the heat of which at first makes the varnish more fluid, and it flows with great evenness over all the surface; but when the spirits evaporate, the varnish becomes solid, and in thirty or forty minutes may be taken out, and suffered to cool previous to varnishing again. The proper time for the second application, is known by applying the finger on the varnished surface with a moderate pressure; if the adhesion of the varnish is such that the finger will not slide over the surface, at the same time that there is no actual sticking to the finger, it is then in the right state to receive another coat of varnish. The work should not be suffered to dry beyond this state, otherwise the successive coats will not adhere so firmly. A second varnish being applied, the article is dried again; then a third coat is applied, and the work is left in the stove five or six hours, or all night, to harden and dry off the varnish. If it is the clear varnish which is thus treated, this time will be sufficient; but it will grow darker in proportion as it is longer exposed to the heat, or as the heat is increased. For black work the heat is raised as high as possible, without melting the soldering, or charring the varnish; and this is continued three or four days. This process makes the hardest and most durable of all varnishes, and of a most brilliant jet black colour.

To obtain a smooth surface, it is rubbed with woollen rag with pumice stone powder and water, and it is polished by rottenstone powder, and finished by the friction of the bare hand with a little butter.

Mottled japan, in imitation of tortoise shell.

Mottled japan in imitation of tortoise shell. This is done by covering the tin with one coat of varnish as above, mixed with Venetian red, and then it is coated with black varnish. The fingers are drawn over the varnished surface in a waving direction, to distribute the varnish unequally, and thus cause the red colour to be shewn through in spots or clouds, imitating tortoise shell. Otherwise the tin is painted in spots with vermilion mixed in shell lac varnish; and this is coated with the clear varnish, which is afterwards stoved till it becomes deeply coloured, and is rather opake, so that it shews the vermilion spots and the surface of the tin beneath in an imperfect manner, and much resembles the clouds of tortoise shell.

Some simple articles in wood may be treated in this way, provided they are not put together in pieces with glue, and are not liable to be split by the heat; for instance, walking canes are most beautifully ornamented at Birmingham. These processes of japanning by heat are to be found in some receipts by Kunkel, but do not appear to have been practised till the Birmingham manufacture was begun.

When ornamental painting or gilding is required, it is done upon a clear japan ground when the same is set. A layer of gold size being spread over the surface, (see GILDING,) the leaf gold or gold powder is applied, and also the required painting, the colours being mixed as before directed for lac japanning. Stencils are sometimes used to lay the gold powder in particular patterns: they are pieces of paper with openings cut out in particular forms; and being applied upon the surface of the work, if the powder is applied by a piece of rag it will be laid according to the pattern cut out. A variety of different coloured metallic bronze powders are used in the Birmingham ware; and for the smaller parts they lay them on with stump brushes.

Transparent or Pont-y-pool japan.

Transparent or *Pont-y-pool Japan.*—The articles japanned in this way are prepared by a good ground of black varnish made very smooth; a layer of gold size is then laid on, and the whole surface is covered with silver powder; upon this is laid a coat of thin varnish mixed with the desired colour, such as Prussian blue, or lake mixed with spirit of turpentine, to make it spread. When this is dry, it is sized over, and painted or ornamented with gilding in silver leaf or powder. The whole is coated with an external varnish of a gold colour, which changes the colour of the silver leaf to that of gold.

The use of the first coat of silver powder is to give a resplendency to the colour, which is very beautiful.

The French have a mode of producing flowered stains of colour of the most brilliant hues, which are waved very much like the flowers which are found in a frosty morning upon the windows of an apartment. We are informed that it is done by means of an acid applied to the surface of the tin before it is japanned.

The stoves for japanning are built of brick or stone, generally three stories high, with three stoves upon each floor. The fire is at the bottom, and is covered over with a strong iron plate. The flues are carried up at the sides and ends of the stoves, and are made to afford three different degrees of heat, for drying off the clear varnish, or for darkening it, or for darkening the black varnish. (J. F.)

JAVA.

Situation. JAVA,[*] the southernmost of the Sunda islands, is situated between 6° and 9° of south latitude, and between 105° and 115° of east longitude from Greenwich. It extends, nearly in the direction of east and west, about 650 miles, and its average breadth is about 95. On the north lies the island of Borneo; on the north-east, Celebes; on the east, the islands of Bali and Madura; on the south and west, the Indian ocean; and on the north-west, the island of Sumatra, from which it is separated by the Straits of Sunda, which, at the narrowest point, are about 20 miles broad. On entering these straits a fine prospect opens to the view. The low coast of Sumatra appears covered with trees, behind which its majestic mountains rise in gradual ascent; while the opposite coast of Java, not inferior in beauty, indicates the fertility of its soil, by its numerous rice fields, and groves of cocoa-nut and palm trees.

Description. The whole of the north coast of Java is low, swampy, and woody ground, except a little to the west of Bantam, where the high land stretches down to the sea-coast. On this side are several bays, where there is safe anchorage during the good or south-east monsoon; but in the bad monsoon, when the north-west wind blows hard, it is dangerous to anchor near the coast. The south coast is less known than the northern, and is a bold rocky shore almost inaccessible. A chain of high mountains, commencing at the eastern extremity, in the province of Balambouang, running to the westward, and gradually decreasing in height, divides the island longitudinally into two parts, of which the northern section is the largest and best.

Volcanoes. In several mountains of this great chain are observable the craters of volcanoes, which were formerly violent in their eruptions, and many of which still emit smoke after heavy rains. Numerous mineral springs of various virtues and temperatures, are found in their vicinity. An account of a very curious natural phenomenon in the plains of Grobogan, about 50 miles N. E. of Solo, has been published by Mr Brande, which may be deserving of notice in this place as a species of volcanic eruptions. As a party from Solo "approached the village of Kuhoo, they saw, between two trees in a plain, an appearance like the surf breaking over rocks, with a strong spray falling to leeward. The spot was completely surrounded by huts for the manufacture of salt. **Mud volcanoes.** Alighting, they went to the bludugs, as the Javanese call them, and found them to be on an elevated plain of mud, about two miles in circumference, in the centre of which immense bodies of salt mud were thrown up to the height of from ten to fifteen feet, in the form of large globes, which, bursting, emitted volumes of dense white smoke. These large globes or bubbles, of which there were two, continued throwing up and bursting seven or eight times in a minute by the watch. At times, they throw up two or three tons of mud. The party got to leeward of the smoke, and found it to smell like the washing of a gun-barrel. As the globes burst, they threw the mud out from the centre with a pretty loud noise, occasioned by the falling of the mud upon that which surrounded it, and of which the plain is composed. It was difficult and dangerous to approach the large globes or bubbles, as the ground was all a quagmire, except where the surface of the mud had become hardened by the sun. Upon this they approached cautiously to within fifty yards of the largest bubble, or mud pudding, as it might very properly be called; for it was of the consistency of a custard pudding, and of very considerable diameter. They also got close to a small globe or bubble, (the plain was full of them of different sizes,) and observed it closely for some time. It appeared to heave and swell; and when the internal air had raised it to some height, it burst, and the mud fell down in concentric circles, in which shape it remained quiet, until a sufficient quantity of air was again formed internally to raise and burst another bubble. This continued at intervals from about one half to two minutes. From various other parts of the quagmire, round the large globes or bubbles, there were occasionally small quantities of mud shot up like rockets to the height of 20 or 30 feet, and accompanied by smoke. This was in parts where the mud was of too stiff a consistency to rise in globes or bubbles. The mud, at all the places they came near, was cold on the surface; but they were told it was warm beneath. The water which drains from the mud is collected by the Javanese, and, by being exposed in the hollows of split bamboos to the rays of the sun, deposits crystals of salt."

Rivers. Java is watered by a great number of rivers, which descend from the central chain of mountains; but, on account of their shallow channels, and the sand banks at their outlets, none of them is navigable by vessels even of a moderate size. All along the coast of the island, high and low water occur only once in 24 hours, and the changes of the moon have no influence on the tides.

Roads. A military road traverses the island nearly from west to east for upwards of 700 miles; and will remain a monument of the perseverance and enterprize of General Daendels. Twelve thousand men are said to have perished in its formation, from the insalubrity of the tracts through which it runs. It is conducted over mountainous regions of vast extent, through immense forests, and numerous marshes and rice fields. There are numerous roads in the environs of Batavia, shaded with trees, ornamented with handsome villas in their vicinity, and crossing in various directions rivers and streams on stone and timber bridges. The new eastern road towards Buitenzorg presents every advantage for expeditious travelling. On this road, extending as far as Kalatigas, 700 miles east of Batavia, there were formerly regular post stages at every five or six miles; but the relays of post horses have been lately withdrawn between Buitenzorg and Samarang, and the same facility of passing through the regencies does not now exist. The ordinary country roads in the interior are passable only for the native carts drawn by buffaloes.

Towns and stations. The principal towns and stations in Java, besides Batavia the capital of the country, are Weltervreeden, Cornelis, Bantam, Samarang, Solo or Soura Carta, Djoejocarta, and Sourabhaya. Weltervreeden, about

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[*] By Ptolemy it is called the Island of Barley, and its name Yava is said to have that signification; but the grain is unknown to the inhabitants, and will not grow in the island, except in some mountainous tracts, where it has been raised by Europeans as a curiosity.

Towns and stations. **Weltervreeden.** three miles from Batavia, was selected by the Dutch government as a military station, being greatly preferable in point of healthiness and local advantages to any other spot in the vicinity of the capital, and is now the head-quarters of the British troops. To this place General Daendels had intended to remove the seat of government, and all the public offices both civil and military; and, for this purpose, a large commodious building had been nearly completed before the capture of the island by the British. **Cornelis.** Cornelis, a few miles from Weltervreeden, was the field of action in the recent invasion of the island; but few traces of its fortified lines now remain, as the works have been razed, and the fertility of the soil has already spread a wide jungle over the spot where British valour decided the fate of Java. **Bantam.** About sixty-one miles west from Batavia are situated the ruins of the once flourishing city of Bantam, in a low situation, surrounded by jungle and stagnant waters, and remarkable for the insalubrity of its climate. **Samarang.** Samarang, about 343 miles from Batavia, is the chief central station on the island, and has a considerable European population. It is a large town, defended by a stone parapet and rampart, with bastions, and a wet ditch. The town has a neat appearance, and a number of good houses; a large church, a new town-house, and a variety of public buildings, both elegant and commodious, are within and without the city. The climate is greatly preferable to that of Batavia, and has a corresponding effect on the European inhabitants. The environs are ornamented with numerous villas; and beautifully variegated hills and dales enhance the scenery. **Solo.** Solo, or Soura Carta, the capital of the Soesoehoenan, or emperor, is a large populous town, 61 miles from Samarang. The crattan, or residence of the emperor, is very spacious, and contains several palaces in its area. The European town and fort are very neat; and the latter, about 800 yards from the Crattan, contains a British garrison. The Dutch had acquired such ascendancy over the native princes, that they were allowed to erect forts close to their respective capitals, by means of which they forcibly secured the influence which they had artfully obtained. **Djoejocarta.** Djoejocarta, about 87 miles from Samarang, is the residence of the sultan of that name. The population within the Crattan is very considerable. At the entrance on the north side is an extensive square for the exhibition of fights of wild beasts, and various tournaments. The interior of the Crattan is filled with palaces, the most remarkable of which is an ancient edifice in the midst of a large lake. The only entrance is by a covered way under water, to which light is communicated by windows, in turrets which appear above the surface. **Sourabhaya.** Sourabhaya, a large town with a numerous population, European, Chinese, Javanese and Malayan, 540 miles from Batavia, is situated on a fine river, which vessels of some burden navigate up to the town. The mouth of the river is defended by Fort-Calamaas, a circular battery, mounting 40 guns. General Daendels expended large sums in the construction of works for the defence of the harbour, and designed to render the place a principal port for the trade to the eastward. Guns were cast, and a fine arsenal formed; and vessels were built from the timber which the neighbouring forests supplied, and which was floated down the river. The British resident lives at Simpang, in a large building close to the river; and in the same quarter is the general hospital, almost unrivalled for extent and commodiousness. The country in the vicinity is accounted healthier than most other parts of the sea-coast, and the district is exceedingly populous and productive.

History. The early history of Java is entirely lost in the fables of antiquity. Its annals give accounts of political relations having subsisted in more modern times between the island and various states in Sumatra and Borneo; and this is partly confirmed by the circumstance of the written language and the language of the court in these districts being Javanese, while the indigenous dialect is entirely different. **Government.** History and tradition relate that the inhabitants of Java were once united under one sovereign, which is corroborated by the similarity of their language and institutions; but when the Dutch first established themselves in the island, about the year 1619, it was divided into three great states, namely, Bantam, Jacatra, and the empire of the Soesoehoenan, or emperor; which last was the most extensive, and comprehended more than two-thirds of the whole island. It is at present divided into five principal states or governments, namely, Bantam, Jacatra, Cheribon, the empire of the Soesoehoenan, and that of the Sultan. Bantam, which lies towards the south-west, is separated from Jacatra by a narrow slip of land called Grending, and by a chain of mountains called Goenong Tjeberum, terminating to the south in the bay of Wynkoopsbergen. In 1751, it became subject to the Dutch East India Company, who had been invited to interfere in its intestine commotions: (See Bantam.) Jacatra, rather larger but less populous than Bantam, was conquered by the Dutch in 1619, and taken entirely under their government, who built Batavia near its ancient capital Jacatra: (See Batavia.) Cheribon, about half the size of Jacatra, and situated to the east of it, is divided between two princes, who are feudatories of the Company. The empire of the Soesoehoenan, before the war of 1740, comprehended all the rest of the island to the east of Cheribon; but, after that period, thirty of its fifty-six provinces were ceded to the Company, and seven to the Sultan Manko Boeni. Of these seven provinces the most extensive and important is that of Mantaram, which is washed by the southern ocean. All these princes were vassals of the Company, to whom they were bound to deliver all the produce of their respective countries at fixed prices, and to act with them offensively and defensively against every enemy. The whole of these countries were divided by the Dutch into 123 districts, in each of which they established a resident to secure the fulfilment of their commercial privileges, and also a native chief or governor, called Tomogong, to collect the produce payable by the peasants for the use of the sovereign, the Dutch and themselves. The Dutch, especially in later times, held the supremacy in the island by a very precarious tenure; and were obliged to adopt the policy of fomenting disunion among the more powerful native princes, who governed as their tributaries and allies, as well as of bringing large reinforcements of troops from Europe to keep them in due subordination. In the year 1811, a British armament sailed from India against the settlements in Java, and speedily succeeded in reducing the whole island under the dominion of the East India Company.* Its new masters immediately instituted numerous schemes for its improvement; and, in a short time, rendered the greatest benefit to the whole community, by clearing and cultivating the waste and unhealthy grounds around the capital, by abrogating the

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* See an account of the capture at the conclusion of this article.

extreme severity of the Dutch code, in the punishment of crimes, while the police was rendered more effectual for their prevention; by collecting the revenue in a more equal and less oppressive manner, and by augmenting the colonial and coasting trade of the island. All the courts of justice were modelled on the plan of those of Great Britain, so as to separate the judicial from the police duties, and insure the more prompt and impartial administration of justice. The principal courts were established at Samarang, Sourabhaya, and Batavia, which last was supreme. Regular customhouses were appointed at the same places; and no vessels were allowed to enter for trade at any other port in Java. At Batavia a duty of 6 per cent. and at Samarang and Sourabhaya of 8 per cent. *ad valorem*, was levied on all goods and merchandise imported by sea, and required to be paid within one month. Cloths, which were the manufacture of native eastern ports, paid 15 per cent.; and 12 per cent. was laid upon all European and Chinese goods imported in European and Asiatic vessels. Goods transferred in the roads paid the same duties, as if actually landed for sale; but on goods landed for exportation, and not for sale, the importer paid half duty on the invoice value, and gave security that they should not be sold on the island. All goods and merchandise having paid the import duty were exempted from export duty. For the defence of the island, a Javanese corps of 4000 men was raised, and 1500 men of one of the native princes taken into British pay, and clothed with the British uniform. Instead of the indefinite exactions, and forced services, and inadequate rates of price for the native produce, imposed by the Dutch, a moderate land-tax, equitably arranged, was exacted by government for the security of property and protection of person. This new duty, fixed and explicit, was acceded to by the natives with universal satisfaction, and paid with the utmost alacrity. The exertions of the cultivators being thus encouraged by the certainty of possessing whatever they should raise beyond the proportion paid to the government, the agriculture of the island was remarkably improved and extended. The revenue, instead of being diminished, was raised to six times its former amount. In 1808, under General Daendels, it was only 818,128 rupees; while in 1814, under Governor Raffles, it amounted to 5,368,085, leaving a clear surplus revenue of 2,800,000 rupees per annum. In this flourishing condition the island of Java has been restored by treaty to its former masters; a measure to which the native authorities are said to have manifested the greatest reluctance.

Climate. In Java, as in most tropical climates, the year is divided into two seasons, namely, the east or dry monsoon, and the west monsoon or rainy season. The east, or good monsoon, commences in the month of April or May, and terminates about the end of September or beginning of October. During its continuance, the sky is generally clear, (except that sometimes in the evening, and towards the end of the season, a thunder cloud comes down over the mountains,) and the trade winds blow from four or five leagues off shore, through the whole of the Indian seas to the south of the line, from the south-east, and east-south-east. The west or bad monsoon, generally begins about the end of November; and, while it continues, the westerly winds often blow with great violence, accompanied by heavy torrents of rain, and storms of thunder. About the beginning of March, they become more variable, till they give place in April to the easterly winds. March and October, with part of the preceding and following months, are called the shifting seasons, or the breaking up of the monsoons, and are considered as the most unhealthy periods of the year. Along the whole coast, the alternate land and sea breezes blow regularly throughout the whole of the year, and greatly moderate the intensity of heat. During the east monsoon, the sea breeze is generally confined between north-east and north; but, in the west monsoon, it goes as far as north-west. It begins to blow about 11 or 12 o'clock in the forenoon, and increases gradually until evening, when it imperceptibly dies away to a perfect calm about eight or nine. The land wind begins at midnight, or a little before, and continues till an hour or two after sun-rise, when it falls calm, till the accustomed hour of the sea breeze. From the month of July to November, the thermometer on the coast generally ranges between 80° and 90° during the hottest time of the day; and, during the coolest part of the morning, is seldom lower than 76°. In ascending towards the higher grounds, the warmth of the atmosphere gradually diminishes from 85°, the ordinary heat in the plain, to 50°, the temperature experienced on the summit of the mountains, which are even occasionally covered with snow. In the highest parts that are cultivated, the heat during the day is from 60° to 65°, and at night as low as 54°. The climate on the coast, and especially at Bantam, is more pernicious to the health of Europeans, than that of any other country where settlements have been formed. Of persons newly arrived, the usual calculation is, that three in five will die during the first year, and of the survivors from nine to twelve in the hundred annually; exclusive of the troops and seamen, among whom, in consequence of their irregularities, the mortality is truly deplorable. The weight of the air is nearly the same throughout the year; but does not possess so much elasticity as in northern regions. The barometer seldom varies more than two or three tenths of an inch; and experiments in electricity do not succeed so well as in Europe.

Soil. The soil of the island is generally a pure vegetable mould, resting on clay, or argillaceous iron-stone, or coarse limestone of a loose and porous texture; and is equal in fertility to that of any country in the world. The northern coast rests entirely on coral fabrics; and, near the foot of the mountains are several mineral springs impregnated with iron; but nothing more is known of the mineralogy of the country.

Productions. The soil in its natural state is covered with the most luxuriant vegetation, and yields a great variety of valuable and curious productions. Many places are covered with thick forests, rendered impenetrable by the quantity of underwood and creeping plants, forming a kind of net-work, through which a passage cannot be effected without the aid of a cutting instrument. Forest-trees. The large forests, which belonged to the Dutch India company as sovereigns of the country, especially those on the north-east coast, furnish an abundance of timber for ship-building and other purposes. In these native woods, the numerous tribe of palms or cocoa nut trees are distinguished by their luxuriant growth, and sometimes reach the astonishing height of 150 feet. This tree is to the natives of Java what the bamboo is to those of China. Its stem furnishes the standards, rafters, and laths of their houses; and its leaves are used as thatch. The pulpy substance of the nut affords a sweet and nutritive food; the liquid which it contains, an agreeable and refreshing beverage; and the kernel yields by pressure a useful oil for various purposes.

The shell of the nut is converted into cups, which are often carved with wonderful neatness and skill; and the fibres of the husk are manufactured into mats, coarse cloth, and cordage. A milky fluid also which exudes from the young nut during its growth, is collected by the natives with great care into vessels suspended at the extremity of the branches, which in its first stage of fermentation is called palm-wine, and in its second becomes a pleasant vinegar. It is a material ingredient in the distillation of arrack; and, if slowly evaporated over a fire or in the open air, leaves as a residue a kind of coarse brown sugar. The celebrated *upas*, or poison tree, described as situated in the centre of the island, and destroying by its noxious effluviæ all animal and vegetable life in its vicinity, to the extent of ten or twelve miles around, is now ascertained to have no real existence. There are in Java several plants and trees, from which a poison called *ipo* or *upas* is extracted; but these are generally found in the most fertile places, surrounded by the most luxuriant vegetation.[*] Fruit-trees. Fruit trees of various kinds are remarkably abundant; and many of them extremely beautiful. The most remarkable, is the Mangoostan, accounted the most delicious fruit in the world, equally pleasing to the eye and gratifying to the taste, of a round form and purple colour; and growing on a very beautiful tree, which bears like the orange both fruit and flowers at the same time on the extremities of the branches. The mango, another exquisite fruit, grows on a large spreading tree like the walnut. The rambootan, a hairy fruit, a cool and agreeable fruit of a delicate sub-acid flavour, grows on a showy and elegant tree. The doorian, a large fruit, resembling the bread-fruit in appearance, of a most disgusting smell, and of a flavour like a custard, seasoned with garlic, but said to become by frequent use extremely fascinating, grows on a lofty tree with small pointed leaves. The boa lansa, in great estimation among the lower classes, grows upon a tree of a moderate size, in clusters like grapes, of which each individual fruit resembles the famous li-tchi of China, and has a pulpy substance with a delicate sub-acid taste. Pine apples are produced in such abundance, that they are sent to market in cart loads, and sold at the rate of a halfpenny a piece, but are not much esteemed in the country, except for preserving. Out of many other fruits, may be mentioned the atrocarpus or jack fruit, which grows wild in great abundance; the averrhoa much used for tarts and pickle; the eugenia or rose apple, sweetsop, custard apple, dates, pomegranates, tamarinds, figs, guavas, annanas, bananas, oranges, lemons, citrons, shaddocks, grapes, melons, and pumpkins. Most of the fruits of Europe have been transplanted to the island; but except strawberries and a few others, which are said to thrive in the interior parts of the country, most of them are found to dwindle and degenerate in that equinoctial climate. Remarkable trees and shrubs. Among the trees and shrubs which are remarkable for singularity or beauty, may be noticed the casuarina equisetifolia, whose pendant branches resemble the hair of the cassowary; the mitchelia tchampaca, bearing flowers of an exquisite fragrance, which yield by distillation a spirit more powerful, but not less delicate, than the perfume extracted from roses; the terminalia catappa, a large and beautiful tree, bearing a nut, usually known by the name of the Indian almond: the bombax, which bears a long pod full of a silky substance, used for stuffing cushions, &c. the coral trees, lyriodendrum, tulipifedrum, magnolia, milia, bignonia, all showy and elegant trees. The gardenia florida, Arabian jasmine, clove, cinnamon, tuberose, nutmeg, plumeria, seree or lemon-grass, are cultivated in the gardens on account of their beauty and fragrance. Among the rarer plants are the elastic gum-tree, the convolvulus Jalappa, the styrax liquida, the bread-fruit, and the mountain cabbage-tree of the West Indies. But the most extraordinary vegetable production of Java, and the other eastern islands, is the nepenthes distillatoria, or pitcher plant, which is found in the most arid situations, but is provided with a curious contrivance for securing a sufficient supply of moisture. To the footstalk of each leaf is attached a small tube, shaped like a pitcher, covered with a lid, which is moveable on a kind of hinge or strong fibre passing over the handle, and connected with the leaf. By the contraction of this fibre the lid is opened, when the weather is showery or the dews fall; and, when the moisture has filled the pitcher, closes again so firmly as to prevent evaporation, securing the water for the sustenance of the plant.

Agricultural productions.

The agricultural productions of the country are highly valuable in a commercial point of view, and are raised with little trouble by the native cultivator. The soil is slightly tilled by a clumsy plough drawn by one or two buffaloes; and the only manuring, which it receives, consists in burning upon the fields all the weeds and rubbish, which have sprung up on their surface. When a piece of ground ceases to yield an adequate crop, it is merely suffered to lie fallow for a few years, to bring it again into a fertile state. Garden grounds are moistened with water, in which oil-cakes and various excrementitious substances have been dissolved, which renders the soil extremely productive. The principal production of Java is *rice*, which in whiteness, flavour, and other qualities, excels that of all the eastern archipelago, and ranks next to that of Japan. The island produces this grain in such abundance, that it has been called the granary of the East. Besides furnishing a sufficiency for its own consumption, it supplies many of the adjacent countries, and all the more easterly Dutch settlements. In the year 1767, the quantity of 14,000 tons was sent to Batavia, Ceylon, and Banda. In reaping the rice, a small knife is used instead of a sickle, with which every stalk, singly, is cut about a foot below the ear, and they are then bound in sheaves, the tenth of which is the reward of the reaper. The rice is separated from the husk, by stamping it in hollow wooden blocks; and the more it is stamped, the whiter it becomes when boiled. The next staple commodity of Java is *pepper*, of which there are various kinds, and which is chiefly produced in the western parts of the island. The whole quantity produced in the country amounted, in 1777, to six millions of pounds weight, and the regulated price at which the king of Bantam was then bound to deliver it to the Dutch Company, was about two pence halfpenny per pound. The pepper of Java is esteemed next in point of quality to that which comes from the coast of Malabar. *Sugar* is raised in Java in considerable quantities, but chiefly in the province of Jacatra. In 1768, the whole produce exceeded fifteen millions of pounds, and was capable of being greatly augmented. The cane grows luxuriantly, and is a favourite object of culture with the Chinese inhabitants, who are the great planters and manufacturers of sugar on the island. It is planted from September to April, and

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[*] See Memoir by M. Leschenault in the *Annales du Museum d'Histoire Naturelle*, cap. xi. and xii. p. 457.

Agricultural productions.

stands twelve or fifteen months on the field, according as the land is rich or poor; and if the soil be good, it can be cut four times. The sugar, after being manufactured, is divided into three kinds or qualities, of which the first is sent to Europe, the second to India, and the third, which is the brownest, to Japan. *Coffee*, though not indigenous, is raised in large crops, especially in the provinces of Cheribon and Jacatra. It was introduced about the year 1720 by Governor-General Zwaardekroon, who procured the plants from Mocha. It is cultivated in the same manner as in the West Indies; and, in 1768, about five millions of pounds were produced on the island, which did not cost the Company above two pence halfpenny per pound. The *cotton shrub* is cultivated in almost every part of the island, except Bantam, where very little of it grows. The yarn spun by the natives is sold to the Company according to its quality, from 9d. to 1s. 6d. sterling per pound. *Salt* is brought in considerable quantities to Batavia from Rembang, and is exported chiefly to Sumatra, where it is sold at an immense profit. *Indigo*, though not originally produced in Java, has been cultivated with great success since the Dutch had possession of the country, and is exported principally to Europe. *Turmeric* and long pepper, sago and cocoa, are among the productions and exports of the island. The *catjang*, a species of dolichos, is extensively cultivated by the Chinese inhabitants for the sake of the oil, which is expressed from the seed, and of which a considerable portion is sent to China. The cajaputta oil, expressed from the melaleuca leucadendrum, and so celebrated as a specific in rheumatic affections; the nardus or spikenard, sandal wood, and calambac or aloes wood, are also products of Java, and form a part of its trade with China. The cassia fistula, once considered as one of the most approved laxatives, was formerly sent in great quantities to Europe. The roots of the water caladi (the arum esculentum) are boiled as an article of food, and its broad leaves are considered as an efficacious topical application for dispelling the pains of the gout.

Animals.

Horses.

Buffaloes.

Buffaloes.

Lacerto Gecko.

Boa.

Birds.

Insects.

Fish.

Of the numerous animals found in Java, a few only of the more remarkable can be noticed. The native horses are well formed, but of a diminutive size, and extremely vicious. They are trained in a very remarkable manner for hunting antelopes. When the game is started, the sportsman pursues at full speed, lying close to the horse's neck and regardless of the reins, as the horse follows the prey like a greyhound; and, on overtaking the antelope, endeavours to secure it by throwing a noose over its horns. Should the rider lose his seat, the horse nevertheless continues the pursuit; and instances have occurred of his pawing the antelope to the ground, or by mouthing and kneeling, holding it fast till the arrival of the hunting party. Buffaloes are generally employed in the draught, both for ploughs and carts. They are very large animals with small eyes, great ears, and commonly immense horns bending inwards. They are almost amphibious, remaining always in ponds, unless when obliged to go in quest of food; and when domesticated, requiring to be led three times a day to cool themselves in the water, without which they could not be brought to work. Antelopes are found in the forests, and are frequently kept in parks by the princes. The rhinoceros of Java is of a huge size, and found chiefly in the mountainous districts. In the eastern part of the island are large uncultivated tracts, covered with thick woods, abounding with tigers, wild buffaloes, wild hogs, leopards, and very large apes. For one species of the monkey tribe, called the Wow-wow, the Javanese profess a kind of fellow-feeling, in consequence of a tradition among them, that their ancestors originally sprung from that species of ape. There is a species of wild hedgehog, which sometimes contain in their gall bladder a stone, called by the Portuguese the pedra da porco, and considered by the Dutch as possessing the most wonderful medicinal properties. When put into a glass of wine for an hour, its virtues are supposed to be communicated to the liquor, which is then used as an infallible specific for all kinds of poison, for obstructions, fevers, and various other diseases. One species of lizard, called Lacerto Gecko, a native of Java, is peculiarly deserving of notice, for its wonderful faculty of walking, apparently in opposition to the laws of gravity, running up and down the smoothest polished Chunam walls, in pursuit of flies, and able to take so fast a hold of a smooth perpendicular surface as to carry up a weight equal to that of its own body. (See HERPETOLOGY, vol. xi. p. 29. where the mechanism is described by which this is effected.) Large crocodiles abound in the rivers and creeks, which the inhabitants, under the influence of terror, have made the objects of adoration. The great boa snake is even of greater magnitude, and a more formidable nature than these alligators. Some of them have been killed in the forests which were 30 feet in length, and capable of swallowing whole the largest hogs. The forests and mountains produce an immense variety of the feathered race, from the large cassowary to the minute humming bird. Of those which are most distinguished for the beauty of their plumage, may be mentioned the argus pheasants, fire-backed pheasants, crowned pigeons, birds of paradise, golden thrush, king's fisher, Java sparrows, or rice birds, and many of the loories and paraquets. The insect tribes are extremely numerous: snakes, scorpions, spiders, ants, musquitoes, fire-flies, and many other dangerous and disgusting vermin, swarm in the roads, houses, and even bed-chambers. A venomous spider is very common in the thickets, the body of which is nearly two inches in diameter, the fore legs or claws four inches in length, and the webs spun by it so strong as frequently to entangle and catch the smaller birds. Every object, indeed, in this country, seems impregnated with life. The bay of Batavia, swarming with myriads of living creatures, exhibits a phosphorescent light during the night-time; and a glass of water taken out of the canal, becomes in a few hours a collection of animated matter, the minute portions of which, multiplying by division and subdivision, move about with astonishing rapidity. The coasts of the island abound with excellent fish, one species of which, called the Jacob Evertzen, often weighs 400 lbs.; sharks infest the bays, and swim boldly around the ships; and many animals still unknown in natural history, are said to frequent the shores of Java.

Commerce.

The commerce of Java is very considerable, as, besides its own productions, it used to be the general depot of all the spices of the Moluccas. It is, properly speaking, however, merely an exchange trade, as all exportation of cash or bullion is expressly prohibited; and even the dollars which a merchantman may bring to the ports, are not allowed to be taken away again, but must all be expended on goods. All traders were generally farther restricted by the Dutch Company as to the nature of the cargo which they wish to export, and were required to take one-third or fourth of it in spices.

Commerce. The trade in certain articles, such as opium, camphor, benzoin, calin (a sort of Indian metal,) pewter, iron, saltpetre, gunpowder, &c. was, under the Dutch, reserved exclusively for the company, and the opportunities of gain by private trade have been gradually decreasing since the middle of last century. The principal exports from Java have been already noticed under the head of its productions; but the greater portion of the articles imported from other eastern countries, may be considered as intended more for future exportation, than for the use of the island. From Bengal are brought patnas, blue cloths, and other stuffs, drugs and opium; from different ports in Sumatra, camphor of the best quality, benzoin, calin, elephants teeth, and birds-nests;[*] from Borneo, gold-dust, diamonds, and birds-nests; from Europe, kersymeres, cloths, hats, gold-wire, silver, galloon, stationery, wine, beer, dollars; from Muscat, dollars and gum-arabic; from the Isle of France, olive-oil, wine, vinegar, hams, cheese, soap, trinkets, ebony, mercery; from the Cape of Good Hope, garden-seeds, butter, Madeira, and Constantia wines; from China, immense quantities of porcelain, and silks of every kind; from Japan, camphor, fans, articles of furniture, sabres of an excellent temper, and ingots of fine copper for common coinage to pay the troops.

Money. Money, especially of gold, is very scarce at Java; and the current coins are a mixture of Dutch and Indian pieces, of which the following Table gives the value in sterling money, at the par exchange of eleven francs per pound.

	Francs.		£	s.	d.
The old Japan gold coupang	24	0	2	3	$7\frac{1}{4}$
The new ditto . . .	14	8	1	6	$2\frac{1}{4}$
The milled Dutch ducat . .	6	12	0	12	0
The silver-milled ducatoon .	4	0	0	7	$3\frac{1}{4}$
The unmilled ditto . .	3	18	0	7	1
The Spanish dollar or piastre from	3	3	0	5	$8\frac{3}{4}$
to	3	6	0	6	0
The rix dollar	2	8	0	4	$4\frac{1}{4}$
The Batavia rupee . . .	1	10	0	2	$8\frac{3}{4}$
Other rupees about . . .	1	7	0	2	$5\frac{1}{2}$

There are likewise half-rupees, quarter rupees, and fanams, equal to one-twelfth of a rupee. There are copper coins issued by the Company, particularly the stiver, of which eighty-eight are equal to a rupee; two-penny pieces, equal to two stivers; and doits or farthings. The rix-dollar, equal to 48 stivers, is the money chiefly used in private trade; and the milled silver ducatoon, equal to 66 stivers, was the current coin of the Company through their Indian possessions. A paper currency, issued by General Daendels during the late war, and termed Porbolingo paper, was common in the island at the time of its capture by the British, but was by them tended to be gradually called in and abolished.

Weights and measures. Most merchants goods are calculated by the picol of one hundred and twenty-five pounds Amsterdam weight, which is subdivided into a hundred cattis, each weighing one pound and a quarter. Sugar is taken in canassers of three picols, or 375 pounds each; coffee, in bags of 252 pounds; and cinnamon, in bales of eighty. Rice and other grain is measured by coyangs, which must weigh, when originally purchased by the Company, 3500 pounds; but which, by deductions for dust, drying, perquisites to the warehouse keepers, and other hands through which they pass, are finally reduced, when the article reaches the consumer, to 3000 pounds. There is also a small rice measure of $13\frac{1}{2}$ lbs. called ganting.

Inhabitants. The general population of Java has been variously estimated; by Valentyn at 3,300,000; by the gentlemen of Lord Macartney's embassy in 1792, at 2,300,000; by a census, said to have been taken by General Daendels, in 1808, the returns, exclusive of the south coast, exceeded 3,000,000; and by the latest surveys of the British, there are supposed to be 5,000,000 of persons on the island. The inhabitants, especially around Batavia, are composed of various tribes; but principally of native Javanese, Malays, Chinese, and slaves.

Javanese. The Javanese live in a state of absolute slavery to the native princes, except that they are not transferred by sale from one master to another. The form of government among them is perfectly despotic, and the power of the prince in every sense uncontrouled. His will is literally the law, and is restricted by no regular institutions, either civil or religious. There are no hereditary distinctions or ranks among the people; but, by the mere authority of the monarch, the humblest may be raised to the chief dignities, and the highest degraded to the state of the meanest subject. They have no security in their property, or power to dispose of it, farther than the sovereign may permit. The land, particularly, is his exclusive property; and, in place of salaries to the officers of government, portions of ground are allotted and revoked at pleasure. Neither grant nor occupation can convey to a subject the remotest claim to permanent possession; but large tracts of territory are frequently given one day, and resumed the next; and scarcely an instance occurs of lands being held by the heirs of those who occupied them 30 years ago. The poorest peasant is not even at liberty to dispose of the fruits of his own industry at his own pleasure; but is bound to carry the whole, or a part, either to the company or the prince, at a regulated, and frequently most inadequate price. Though the unbounded prerogatives of the sovereign, and this fluctuating state of property, cannot admit a hereditary nobility, there are nevertheless a privileged class, who receive titles and extensive powers at the pleasure of their despot; and who are proportionally revered by the superstitious people as representatives of royalty. The distinction between the people and these privileged orders is extremely marked and humiliating, and extends even to the language, of which the men of rank speak one dialect, and the plebeians another. The language is even adapted to the different gradations of rank; and the sovereign particularly often makes use of one dialect, which no subject dare use, and is spoken to in another, which can be addressed only to himself. When a Javanese, in short, approaches the presence of his prince, his great object is to express the immeasurable inequality between his condition and that of the sovereign. He assumes, therefore, the most abject position of body, rather crawling than walking; shews his respect not by decency of attire, but anxiously displays his relative meanness by studied raggedness or partial nakedness; and instead of recommending himself by the elegance of his language, selects the dialect of the most ignorant slave, or mimics the barbarous idiom of a despised stranger. It is the custom to express respect, not by standing, but by sitting in the presence of a superior; and even the slaves who attend as menials, squat at the feet of their master or mistress, instead of placing themselves behind their back. The

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[*] See CHINA, Vol. VI. p. 300—Note †.

natives of Java are generally about the middle size of Europeans, straight and well made, steady and upright in their gait, affecting a superiority over the other inhabitants. Their eyes are black and prominent, the forehead broad, the nose somewhat flattened and curving downwards at the point, the upper lip rather projecting and arched, the joints of their hands and feet remarkably small, and especially in the female sex remarkably pliant, so as easily to bend backwards. The colour of their skin is a deep brown, their hair black, and kept constantly smooth and shining with cocoa-nut oil. Black is also the favourite colour of the teeth, which are all stained of the deepest hue, except the two in the front, which are covered with gold leaf. Children of both sexes go entirely naked till their eighth or ninth year; or, at most, the young females wear a belt round their loins with a broad metal plate in front. The dress of the men among the common people consists of a piece of cotton wrapt round the waist, drawn between the legs, and fastened behind, with a handkerchief or small cap upon the head. Persons of a higher class wear a wide Moorish coat of flowered cotton or other stuff, and generally turbans instead of caps. They eradicate the hair from every part of the body except the head; and rub the face, and other parts not covered by clothing, with a composition of cocoa nut oil and sandal wood dust, as a preventative against too copious a perspiration, and the bites of insects. The dress of the women nearly resembles that of the men. It consists of a piece of cotton or chints called saron, wrapt round the body as high as to cover the bosom, and hanging down to the knees or ankles. Over this they sometimes wear a short jacket, but generally the shoulders and part of the back remain uncovered. They have no covering to the head, but wear their hair bound in a fillet, and fastened behind with large pins of woods, tortoise-shell, silver or gold, according to the rank of the lady: this head-dress is frequently adorned with a variety of flowers. Both sexes are remarkably fond of bathing, especially in the morning; yet are in other respects very filthy in their persons.

The dwellings of the lower orders are rather huts than houses, constructed of bamboo, plastered with mud, and thatched with leaves of the cocoa-nut tree. There is seldom more than one apartment for the family and poultry; and the furniture generally consists only of a bedstead of bamboo, a few pots for boiling their victuals, a hollow block for pounding the rice, and a few cocoa-nut shells as drinking vessels. They are sufficiently temperate in point of diet, in consequence of their extreme poverty, yet altogether indiscriminate, and even voracious, as to the nature of their food or times of meals. Their common article of subsistence is rice, boiled with a little fish or capsicum, or salt, and the fruit of the cocoa-nut; but in the mountainous regions, where rice is not raised, they make use of a certain root called tallas, with the salt which they procure from wood ashes. Notwithstanding, in short, the fertility of the country, the oppressed inhabitants are little better than starving savages. They are continually chewing betel or pinary, or rather a composition of the areca nut, lime of shells, and seeds of long pepper, made into a paste, and rolled up in a green leaf of betel-pepper, which communicates to the tongue and lips a deep red colour, afterwards turning to a dark mahogany brown. The areca nut, especially when fresh from the tree, has a strong narcotic power, and a small portion will intoxicate those who are not accustomed to it. They are fond of opium, and indulge freely in intoxicating liquors at their religious ceremonies; but the greater part of the people stupify themselves with the less expensive articles of tobacco and bangue.

Medicine.

Though subject to few diseases, they are not long lived; seldom exceeding the age of 50, and very few attaining threescore years. Their physicians, who are frequently females, though ignorant of anatomy, are said to produce surprising cures by their knowledge of medicinal herbs, and by the use of friction with oil.

Marriages.

The Javanese are polygamists, and marry as many wives as they can maintain; besides keeping a retinue of female slaves as concubines, but the lower classes have seldom more than one wife. They are said to be extremely indifferent with regard to the chastity of their females, and to be in this respect the most depraved people in the world. Their women are more comely than the men, but become extremely ugly as they grow old. They are much attached to Europeans, and fatally jealous of losing their affections.

Amusements.

A Javanese person of rank spends most of his private hours in the society of his women, smoking his hooka in placid apathy, while they are dancing before him, or listening to their narrations of traditionary stories, or the adventures recorded in the sacred books. The principal amusement of a more active nature, is a kind of tennis-play, at which they are remarkably dexterous, striking the ball (which is about the size of a man's head) with their feet, knees, or elbows, and keeping it in continual motion like a shuttle-cock. They are also extremely fond of cock-fighting, for which they keep a particular breed of a prodigious size, nearly as large as the Norfolk bustard. Instead of spurs, they fix to the bottom of the foot a piece of sharpened iron shaped like a scythe, and about the size of the blade of a large penknife; with a single stroke of which, the bird will sometimes completely lay open the body of his antagonist.

Weapons.

The principal weapon of the Javanese, which they always carry with them, is a kind of dagger called a creese, resembling a small hunting knife, with a blade of hardened steel, of a serpentine shape, and capable, from its form, of inflicting a large and wide wound: Its point also is frequently stained with a mortal poison.

Salutations.

Their mode of salutation consists in touching the forehead with the right hand, accompanied by a slight inclination of the body.

Character.

They are described as proud and cowardly, extremely arrogant in their treatment of persons who are their inferiors, in which light they regard all foreigners; but not less cringing towards their superiors, or those from whom they have any favours to expect. They are remarkably indolent in their habits, and are with great difficulty excited to labour; a disposition, which, considering the industry of the Chinese who reside among them, may be ascribed not so much to the influence of their climate, as to the oppressive nature of their government, which renders them so uncertain of being suffered to possess the property which they may acquire, and thus takes away every motive to active exertion.

Chinese.

The Chinese inhabitants of the island are very numerous, especially around Batavia, where the poll tax paid only by the men yields 40,000 rix-dollars, where they are calculated to amount to 100,000 souls. Their appearance, dress, and character is every where the same, as in the empire of China; but in Java their extraordinary industry forms a striking contrast with the laziness of the other inhabitants. Though severely taxed by the Dutch, they generally found means to accumulate wealth. In all the towns they are the great holders of capital, and carry on a considerable trade wth their native country, and the several islands in the Eastern Archipelago, as well as around the coast of Java. They are the principal shop-keepers, the most skilful gardeners, the most ingenious artificers, on the island. They are free masters of whatever they can earn by trade or agriculture, beyond the assessments levied by the Company's government; and in the rational hope of obtaining the reward of their exertions, they readily undertake the most toilsome occupations, which the oppressed and plundered Javanese would regard and would probably experience to be lost labour. But, with all these industrious habits, they are extremely addicted to gaming; and the houses licensed for the purpose in their quarter of Batavia, are so numerous as to yield an annual tax of £ 8000. Though sufficiently pusillanimous and effeminate, they are extremely turbulent, and apt to break out into open insurrections, for which they were often punished by the Dutch in the most sanguinary and summary manner, (See BATAVIA); but, of late years, it has been the more humane policy of the Company's government to divert their attention by perpetual amusements, and to keep them in subordination by officers of their own nation.

Malays. The Malays are also a numerous class of the inhabitants of Java, but are a most worthless and ferocious race of people. They are sufficiently active, bold, and enterprising in the pursuit of plunder, and passionately addicted to every kind of gaming. They will frequently stake upon the issue of a cock-fight their last morsel of bread, their whole bodily clothing, and even their wives and children. They are treacherous in their dealings, remorseless in their enmities, and capricious in their friendships. Their rage is of the most ungovernable description, resembling a kind of mental frenzy; and their revenge is inflexible in its aim, however fatal its consequences to themselves. A blow, especially, is an indignity which they never forgive, and which makes them lose all consideration for their own existence. Under the influence of revenge or disappointment, a Malay sometimes adopts the desperate resolution of running a muck (as it is vulgarly called, from the word *amock* to kill); and, arming himself with a dagger, he sallies forth after swallowing a large dose of opium, attempting to kill every person who comes in his way. He is of consequence soon knocked on the head like a mad dog, or sometimes secured alive by means of a long pole armed with iron hooks; and, in this case, was usually put to death by torture, to deter others from imitating the example. But, since the abolition of the gambling houses by order of Lord Minto, not a single instance of these frantic bursts of despair has occurred at Batavia.

Slaves. The last class of inhabitants are the slaves, who are imported chiefly from Malabar, Celebes, Timor, Madagascar and Mosambique. They are distinguished in the towns by having their legs and feet uncovered; and are employed either in domestic services, or trained to useful trades, by which they generally earn for the use of their masters a higher interest for the money expended in their purchase and subsistence, than could be procured by employing it in any other way. The most numerous and useful are Malays, from the different islands of the Eastern Archipelago, who are extremely prompt at imitation, and expert in all handicraft trades. Those from Malabar are mild and passive, willing to be instructed, but slow of apprehension, ill adapted for hard labour, and generally used as personal attendants on their proprietors. Those from Madagascar and Mosambique are also a harmless and pliant race, tall, and athletic, but remarkable for their simplicity, and devoid of all ingenuity. The greater part of the female slaves are brought from Pulo Nias, a small island on the western side of Sumatra, and are greatly esteemed for their smooth skins, elegant shape, and lively dispositions, sometimes selling at the rate of a thousand dollars. The slaves of both sexes are well fed and lightly worked; but frequently treated with great severity. In consequence of the excess in the proportion of females, and the little care taken of their offspring, who are seldom the fruit of a connubial tie, there is required a large annual importation to keep up their number; and it is estimated, that more than a thousand are imported every year for the citizens of Batavia alone. There is little occasion, indeed, for this class of beings in a place where thousands of free Chinese, the best and most handy servants in the world, are ready to serve in every department, on the most moderate terms. Their treatment at least will now be greatly ameliorated, by the abolition of all farther trade in slaves in the British settlements, of which the good effects have already extended to the island of Java.

Language. The Jawa or Javanese language, though now supplanted by that of the Malays, on the coast, is admitted to be the most ancient, and seems to have at one time been current throughout the whole extent of the island. In the interior, not one native among ten thousand can speak the Malay language; and the two people are not in the least intelligible to each other in their speech. The Jawa is sufficiently copious, and overflows with words of pure Sanscrit. The Hindoo names for the days of the week, though now obsolete, are universally known to the learned Javanese. The alphabet of Java is nevertheless peculiar; and has no resemblance, in the order of the characters, to the Deva Nagari. The simple letters are twenty in number, besides compound characters. Each letter has an inherent vowel, as in the Bengalee, which is always pronounced like *a* in the English word ample, and is always sounded in reading, unless when a mark indicates its suppression. The other vowels are always joined to the consonants, and have generally one determinate sound. The compound characters are commonly placed beneath the simple letters; and then the inherent vowel of the upper letter is suppressed, while that of the compound one is sounded. The plural is formed, as in the Malay, by merely repeating the word; and there is no variation on account of number or person in the verbs. The orthography is extremely simple, and the construction not unlike that of the Malay.

Religion. There is satisfactory evidence, that the Javanese once professed the Hindoo religion in some form; but as there is no appearance of the grand Brahminical distinction of casts having ever prevailed among them, it is conjectured that the most prevailing system was that of Buddha. The traditions, however, of their ancient belief, the superstitious observances still extant, and the temples and idols peculiar to the Hindoo worship, with inscriptions in the sacred language of that faith, found in various parts of the island, furnish sufficient evidence, that the tenets of Brahma had also obtained a footing. Many of the penances inculcated in the Hindoo ritual are occasionally practised by the Javanese; and all who are descended of the royal blood, scrupulously abstain from using the flesh of the cow. Many idols of Brahma, Vishnu, Mahadeva, and Bhavani, both of stone and metal, have been found in the island; and that of Ganesa with his elephant head, was frequently recognised by the British officers, during their late campaigns in Java. More than 100 stones were discovered in the interior, covered with inscriptions, which Mr Marsden ascertained to be written in the Square Pali, a sacred character of the Birmans. The most extensive remains of these Hindoo structures are found at Borong Budor (the place of many idols) in the district of Cadoc, at Brambanam, and in the districts of Mataram, and Ballenbouang. In the adjoining island of Bally, the religion of Buddha still predominates; and a few idolaters are found in the eastern mountains of Java; but the prevailing religion at present is that of Mahommed, adulterated by many superstitious relics of the ancient systems. The Mahommedan faith was introduced in 1406, by Sheikh ibn Molana, or Ben Israel, an Arabian, who soon became a powerful sovereign, as well as a venerated apostle in the island. The kings of Bantam and Cheribon claim him as their ancestor; and pilgrimages are performed to his Mosque and Mausoleum, which stand near the town of Cheribon, and are ranked among the most curious antiquities of the Eastern Isles. The Javanese Mahommedans do not bury their dead in coffins, but merely wrap the bodies in a piece of white cloth before being deposited in the grave; and place two stones, one at the head and another at the feet, which they believe will serve as seats to the two angels, who are to examine after death into the conduct of every individual in this world.

History of the capture of Java by the British in 1811.

We shall now conclude this article with an account of the British expedition to Java, abridged from the detailed account published by Major Thorn, an intelligent and enterprising officer, who was himself attached to the staff of the forces employed there; and as the reduction of Java presents a series of brilliant achievements of the British arms, the splendour of which appears not to have been duly appreciated by the public, or to have been lost in the greatness of the efforts of our countrymen in the plains of Spain and Belgium, we shall present our readers with a succinct account of the operations of the army till the final subjugation of the island.

The force destined for the attack of Java amounted to upwards of 5000 Europeans, and an equal number of native troops of the East India Company's service, nearly 12,000 men in all, under the personal command of Lieutenant General Sir Samuel Achmuty, commander in chief at Madras. Of these, about 2500 were inefficient from sickness when they landed at Java. The British armament, composed of 4 line of battle ships, 14 frigates, 7 sloops of war, 8 East India Company's cruisers, 57 transports, and several gun-boats, in all about 100 sail, anchored in the bay of Batavia on Sunday the 4th of August 1811, and the debarkation of the troops took place on the same day, at Chittingching, a village about 10 miles to the eastward of Batavia. As the point of landing was left exposed by the enemy, the debarkation was effected without loss or opposition. It was the commander in chief's intention to advance direct to Cornelis, about nine or ten miles in the interior, where the enemy was posted in force, and to endeavour to penetrate by the route of Batavia, placing that city in the rear, from which he might derive supplies, and keep up the communication with the fleet. In pursuance of this plan, Colonel Gillespie, with an escort of dragoons, reconnoitred the road and country along the coast towards Batavia, to within two miles of the capital. The videttes of the enemy were observed on the other side of the Anjole river, which flowed between them and our troops, and the bridge across which was burnt down. It was a matter of surprize that the country was yielded up as far as this river without dispute, as, from its intricate and difficult nature, an active enemy might have opposed serious obstacles to an advance. The inactivity of the enemy, and the little appearance of force on the Batavia side, together with a serious conflagration in the city, induced the commander in chief to attempt the passage of the Anjole. This was effected without opposition by the advance of the army at 10 o'clock at night, on a bridge of boats provided by the navy, the enemy having contented himself with breaking down the bridges, over the different canals and rivulets, to impede the approach to the city, without risking any actual engagement.

Occupation of Batavia.

The capital being summoned on the 8th of August, the mayor made his appearance on the part of the burghers, to beg protection for them. Although little information of the enemy could be procured from this source, it was ascertained that they were assembled in force at Weltervreeden and Cornelis, the former place being about three miles distant from Batavia. The British began now to experience the consequences of being in a hostile country, the respectable inhabitants having been compelled to retire into the interior, and the water conduits having been destroyed, to cut off as much as possible a supply of water. In this state of affairs it became expedient to act with caution. A small party was pushed into the city to reconnoitre. Several of the enemy's videttes just shewed themselves, and galloped off in the direction of Weltervreeden. The party occupied the town-house, and by their presence rescued much valuable property from plunder and destruction. The town having surrendered at discretion, a royal salute was fired from the shipping, on hoisting the British flag at the crane wharf. Intelligence being received that the enemy meditated a night attack upon the detachment in the town, the men were called out at 11 o'clock at night, and ordered to lie upon their arms. Scarcely had they taken post, when the head of the enemy's column appeared, and opened a fire on the piquet stationed at the bridge leading to Weltervreeden. There was just time to raise the draw-bridge. The firing increasing all around the town, Colonel Gillespie sallied out at the head of a party to charge the enemy's advance in flank. This movement had the desired effect. The firing ceased, and the enemy were seen no more during the night. On the following evening, the town was saved from destruction by the discovery of a Malay, with a fire-brand in his hand, in the act of setting fire to magazines containing a great quantity of gunpowder.

Hitherto we have seen success attending the expedition, in consequence of the remissness of the enemy in obstructing its progress, and in making use of the means of defence within their reach. We perceive a difficult country yielded up without opposition, a river passed without contest, and the capital taken possession of without the loss of a man. General Janssens appears to have been deficient in the use of his light troops, with which he was well provided; and instead of retarding the operations of an invading army, which proves always disastrous to it, he concentrated his chief resources within a short march of the capital, and at once brought on a general engagement, the most desirable object for the British commander.

Success over the enemy at Weltervreeden.

The British force and its guns being transported across the Anjole, the advance, consisting of 1000 Europeans, and 450 Asiatics, under Colonel Gillespie, marched on the morning of the 10th of August from Batavia in pursuit of the enemy. On approaching the cantonment of Weltervreeden, they found the place abandoned by the enemy, who had retired about a mile, to a strong position, on the road to Cornelis. The enemy's right was protected by an artificial water course called the Slokan, and their left by the great Batavia river. Pepper plantations concealed their line, and an abbatis, behind which were planted four horse artillery guns, blocked up the road to Cornelis. Dispositions being made to turn their flank, the object was effected, after surmounting great obstacles; the British troops rushed forward, and charged their artillery with the bayonet. The action lasted, however, two hours, from the impediments and difficulties to be overcome in closing with the enemy. A total defeat at length ensued, with the loss of 500 men, and several officers of distinction, together with four guns. A large quantity of military stores, and 300 pieces of ordnance, were captured in the arsenal at Weltervreeden. Preparations were now made to drive the enemy from their strong position at Cornelis. Here the whole French force, exceeding, 10,000 men, was stationed under the Governor General Janssens, and General Jumel, senior military officer. The position was defended by two rivers on the east and west, both unfordable, and was shut up in a deep trench, strongly palisadoed. Seven redoubts, and many batteries of heavy cannon, occupied the most commanding ground within the lines; the fort of Cornelis was in the centre, and the works were defended by a numerous and well-organised artillery. As the season for field operations was far advanced, the heat of the climate intense, and the British force too small to admit of regular approaches, the commander in chief decided upon carrying the works by assault. Batteries of twenty 18 pounders and 8 mortars were erected to disable the principal redoubts, by the fire of which the enemy were greatly disturbed in their position, and their nearest batteries were silenced. The 26th of August was fixed for the assault. Colonel Gillespie, whom we always find at the post of honour and danger, was appointed to lead the main attack. He was supported by Colonel Gibbs at the head of another column. Colonel Wood was directed to advance against the enemy in front, and if possible open the position for the line stationed at the batteries, while other subordinate attacks were ordered to distract the enemy's attention, and to promote the main object. This object was to surprise a redoubt beyond the lines, and to cross the bridge leading into them with the fugitives, then to assault the redoubts within the lines, Colonel Gillespie attacking those to the left, and Colonel Gibbs to the right. Advancing by a detour through an intricate country, Colonel Gillespie, on approaching the works, learnt that the rear of his column had not arrived. Relying on the prompt and able assistance of Colonel Gibbs, as soon as the fire of the main attack should point out its direction, Colonel Gillespie resolved to advance. Twice he was challenged by the enemy's sentries, and answering "patrole," passed on. An officer's piquet next challenging, the word "forward" was given, and so rapidly was the command obeyed, that the piquet was demolished in an instant. The redoubt was next assaulted and carried with the bayonet, with such celerity, that not a man escaped. Passing forward to secure the passage over the bridge, the attacking column was exposed to a tremendous fire, the spot being enfiladed by all the enemy's batteries. Having succeeded in gaining this point, the key to the position, a second redoubt was warmly disputed by the enemy, and it was not carried till after severe loss on our part. At this moment Colonel Gibbs arriving, he was directed to carry another large redoubt on the right; which having effected in a most gallant style, an explosion of a gunpowder magazine took place, by which many lives were lost. The front of the position was now open, and our troops rushed in from all directions. The enemy maintained themselves in considerable force in front of fort Cornelis, but they were attacked with the bayonet, and completely overthrown. Colonel Gillespie, enfeebled by a slow fever, was overpowered by his extraordinary exertions. On receiving a contusion in the attack of the park, he fainted in the arms of Captains Dickson and Thorn. Having, however, soon recovered, and seeing the cavalry come up, he cut a horse from the enemy's guns, and immediately mounted it. The arrival of his own charger soon enabled him to head the charge in pursuit of the enemy. The route became general; and the pursuit was continued till the whole of the enemy's army was killed, taken, or dispersed. General Janssens saved himself with difficulty during the action; reaching Buitzenzorg, a distance of 30 miles, with a few cavalry, the sole remains of his army. The enemy lost an immense number in killed and wounded, and 5000 men were taken prisoners

Assault of the lines of Cornelis.

Enemy's army destroyed.

Rejection of terms by General Janssens.

After the victory at Cornelis, a verbal offer of terms was sent to General Janssens, which he refused, on the plea of still having resources. The commander-in-chief determined to follow him in person to the eastward; and learning, by intercepted letters, that he had repaired to Samarang on the sea coast, he concerted with the admiral to conduct a force there, and to compel him to abandon the position. A joint invitation was sent to surrender at discretion, in order that the horrors of war might be averted from the colonists; but this was again rejected. The fort of Samarang, which it was deemed expedient first to reduce, was discovered to be evacuated. Janssens, however, having collected a force among the native princes, still occupied a position near the town. The enemy were posted on high and rugged hills, their flanks defended by the extreme difficulty of ascent; 30 pieces of cannon on platforms covered the front, and a valley 1200 yards broad separated the two forces. Notwithstanding the formidable appearance of the position, the commander-in-chief, from imperious circumstances, determined to attack the enemy in front. Colonel Gibbs, at the head of the advance, assisted by the fire of our guns at a great elevation, rushed across the valley. The enemy, paralyzed by the unexpected attack and imposing attitude of the attacking column, made but an ineffectual use of their guns, and were already vanquished. Their guns were abandoned; but the enemy being chiefly cavalry, eluded pursuit. After this last effort, General Janssens, finding himself deserted by his men, sent in a request to the commander-in-chief for a cessation of hostilities, and an offer to submit to terms.

Enemy defeated near Samarang.

General Janssens submits to terms.

Thus, after a short but brilliant campaign, the island of Java was wrested from the dominion of France, and annexed to the number of British colonies. Lord Minto, the governor-general of India, who had accompanied the expedition, having witnessed the triumph of the British arms, and having given publicity to the merit of the army in the records of government, returned to Calcutta, and erected a monument, at his own expence, to the officers who fell in the service of their country. Sir Samuel Achmuty, having left a force deemed sufficient for the protection of the new conquest, also returned with the rest of his troops to Madras.

Dutch colonists massacred at Palimbang.

We shall now call the attention of our readers from the affairs of Java to the neighbouring island of Sumatra, an act of singular atrocity having occurred at Palimbang, in the massacre of the peaceable Dutch colonists by the command of the sultan of Palimbang. To punish this flagitious proceeding, an expedition was dispatched under the command of Colonel Gillespie. Perhaps an account of this expedition might be introduced more properly in the article of SUMATRA itself; but at the same time, regarded as an operation of part of the army of Java, we wish to present our readers, at one view, with a connected account of the military transactions of the period in this quarter. The enterprize about to be related, is of that daring character which places its author in the list of those who have signalised themselves by acts of personal intrepidity.

Account of the massacre.

British expedition to Palimbang.

Batteries at Borang seized.

Confusion at Palimbang.

A small band selected for its relief.

The sultan of Palimbang, taking advantage of the distracted state of Java, adopted the sanguinary resolution of cutting off at one blow the Dutch settlement in his dominions by a general massacre. It was rumoured that this hatred of the Dutch colonists originated in the libidinous habits of the eldest son of the sultan, who, in one of his nocturnal rambles, had been thwarted in his criminal designs upon the wife of a native by the Dutch patrole, brought to her rescue by her screams. The guard, ignorant of the rank of the culprit, pressed him so hard in pursuit, that he was compelled to seek safety in his boat, which he reached with difficulty, by plunging into the river. A thirst of revenge took full possession of the breast of the prince, who vowed to extirpate the colony in language loud enough to be heard by all his attendants. It appears that the sultan was soon prompted to second the barbarous resolution of his son, as two days only after the occurrence, and soon after the news of the success of the British in Java had reached Palimbang, a message from the former arrived to the Dutch resident, desiring him to come to the palace at Palimbang,—an invitation which, contrary to the advice of his friends, the resident imprudently accepted. Armed Malays, under various pretences, intruded themselves one by one into the fort, who overpowering the guards, bound the Europeans and natives of the garrison, and tearing them from their weeping families, hurried them on board prows, prepared for their conveyance down the river, at the mouth of which they were all murdered. They were put to death under the most horrible cruelties, and the prows which contained them were afterwards set on fire and consumed. The unfortunate victims, it is said, amounted to 24 Europeans and 63 native soldiers. But the instigator of this horrible proceeding was doomed to experience speedy vengeance. The armament destined for Palimbang, sailed on the 20th of March 1812, from Batavia, but unhappily, from detention by contrary winds and currents in the straits, ample time was afforded the guilty sultan for flight or resistance. The former measure he had resolved to adopt, having removed his women and treasure into the interior of his country, while both he and his ministers endeavoured to amuse the British commander with declarations of respect, and messages requesting to be informed of the object of the armament. Appropriate answers were returned, with the assurance that the views of the British government would only be confided by the commander of the forces to the royal ear. But the insidious policy of the sultan began fully to develope itself. A message arrived, importing that the sultan would be happy to see his friend the British commander at Palimbang, with a few attendants only, as the presence of so large a force might occasion serious alarm to his subjects. Formidable batteries in appearance, though badly constructed, were placed at Borang, 40 miles from the sea, to guard the approach to the capital. Unmolested passage up the river being demanded of the messenger by Colonel Gillespie, this was granted, and also the occupation of the batteries, which was promised as a pledge of sincerity, a person styled their commandant being left to conduct the British to the spot. The next day, the British advance, with its guns, making its appearance within half gun-shot, the batteries which the sultan had ordered his troops to defend were abandoned by the enemy. Their cannon, amounting to 102 pieces, ready loaded and primed, were taken possession of. A scene of desultory and savage hostility soon spread around. Fires in all directions were kindled, and burning rafts were prepared for the destruction of the shipping; happily the incendiary Malays were dispersed by shot from the boats of the Cornelia, before a conflagration ensued. On the morning of the 23d of April, information was received that the sultan had fled from Palimbang on learning that the batteries of Borang were seized, and that the utmost confusion prevailed in the capital, many parts of which were a prey to rapine and assassination. To put a stop to this horrible state of things, and to prevent the massacre of the wealthy Chinese, which it was rumoured the sultan's adherents meant to perpetrate on the ensuing night, and whose property was to become the prize of the assassins, Colonel Gillespie meant to interpose a prompt relief. For this object, a resolute body guard was selected, consisting of 17 grenadiers of the 59th regiment, accompanied by Captain Bowen and Lieutenant Monday of the navy, Major Butler, Major Thorn, and Lieutenant Forrest. At their head was Colonel Gillespie. The rest of the troops was ordered to follow with all expedition. It was night before they reached old Palimbang. The canoe which contained its leader outstript in sailing the other two boats, and the report of a signal gun, fired by the enemy, increased the anxiety for their coming up, as the apprehension of some treacherous design was entertained. Horrid yells and shrieks in all directions broke around, while a conflagration illuminated a tract of country, stretching for upwards of seven miles on both sides of the river. By the exertions of the crews, the other two boats were brought up to the support of their friends. A scene of horror now was displayed, which would have subdued the courage of ordinary men, but called forth the characteristic presence of mind of Colonel Gillespie. To use Major Thorn's own words, "Romance never described any thing half so hideous, nor has the invention of the imagination ever given representations equally appalling with what here struck us in reality." Undaunted by hosts of armed men, Colonel Gillespie boldly stepped on shore, at the head of his devoted band, and marched with a firm step, through a multitude of Arabs and ferocious Malays, whose weapons steeped in poison, gleamed by the light of the torches. Huge battlements with massy gates, leading from one area to another, received the party, presenting the frightful spectacle of human blood still flowing and reeking on the pavement. The gates closed on its rear, and the blood-stained court-yards through which it was conducted, appeared as the passage to a slaughter-house. A Malay who approached the colonel through the crowd, while walking by his side, had a large double-edged knife secretly conveyed to him by one of his countrymen. At the moment, a flash of lightning darting through the tempest of the night, disclosed the weapon, while the assassin was endeavouring to conceal it in his sleeve. The colonel's eye caught the object, and regardless of the crowd, he ordered the Malay to be seized, and thus frustrated by his firmness of mind the murderous design. The weapon was found, but the Malay escaped. On arriving at the palace, a more dreadful picture of devastation and outrage was displayed. Here rapine and murder had gone hand in hand. Vivid flashes of lightning and peals of thunder conspired with the glare of the conflagration to give a peculiar character of awe to the scenes which caught the sight. The flames, which devoured every thing around, in spite of the rain which fell in torrents, threatened the spot where the band had sought a temporary shelter. The crackling of bamboos, the falling in of burning roofs with tremendous crashes, and the near approach of the flames amidst a hostile multitude and desperate assassins, gave to the situation of the party a most appalling prospect. An arduous task yet remained, to secure possession of the fort; and to perform this, the party was prepared to sell their lives as dear as possible, should an attack be made before the arrival of a reinforcement. The interior of the palace being carefully examined by torch light, all the entrances but one were barricaded. At this the grenadiers were stationed, and the strictest watch maintained. Soon after midnight, the party had the satisfaction of hailing the arrival of Major Trench with 60 men of the 89th regiment; and the remainder of the force under Colonel Macleod joined the little garrison early the next morning. Thus, by an act of unparalleled intrepidity, 17 British grenadiers, and the crews of two boats, with the officers above mentioned, were put in possession of a fort and batteries, mounting 242 pieces of cannon, without the loss of a man. A position which, by any other species of attack, must have risked the safety of the armament. The celerity of the movement, and the sudden arrival of the few British, whose numbers the panic of the enemy had magnified, caused the dispersion of the sultan's adherents, the prevention of their murderous project, and the relief of the town from the horrors of pillage. An American, in charge of a Chinese junk at Palimbang, gave a dismal recital of the storm about to burst that night, and which the interposition of the British had averted. This junk was marked as the first victim of its fury. The solemn deposition of the guilty sultan, by Colonel Gillespie, took place to the great joy of the people, and his brother was proclaimed in his stead. The object of the expedition being thus happily terminated, the force, with the exception of a garrison left behind, repaired to Samarang, where a fresh field for British valour was open in the heart of Java.

Critical situation of the party.

Conflagration.

Fort and batteries secured.

Deposition of the sultan.

The sultan of Mataram or Djoejoecarta, who had been intriguing the downfal of his last masters, still continued disposed to dispute the possession of Java with the British. The new Lieut.-Governor Raffles, and Colonel Gillespie, now commander of the forces in Java, repaired to Djoejoecarta, the sultan's capital, and after trying in vain to settle matters amicably, prepared for hostilities. The residence of the sultan, or Crattan, as it is called, is about three miles in circumference, surrounded by a broad wet ditch, with draw bridges, a strong high rampart with bastions, and defended by 100 pieces of cannon. In the interior are numerous squares and courts all strong and defensible; 17,000 regular troops manned the works, and an armed population of 100,000 men occupied the country for many miles round. The Dutch fort, within 800 yards of the Crattan, was calculated for little else than a military depot, and the fire from it was only intended to amuse the enemy while the force was concentrating. At length the troops having arrived, formidable from their intrepidity, not from their numbers, they were ordered into the fort, preparatory to the attack of the enemy's strong-hold. It was determined to carry the fortifications by assault, as the most prompt way of reducing the place, and of giving security to the colonies, threatened by the irruption of armed thousands at Bantam, Cheribon, Sourabaya, and other places, on the first signal. The different attacks being arranged by Colonel Gillespie, the works were escaladed, and carried with irresistible impetuosity. The troops were animated to heroic exertion by the cry of "death or victory" resounding through the ranks. In many places the enemy were dispersed by their own guns turned upon them. The sultan was compelled to surrender himself a prisoner, the cavalry and horse artillery being posted so as to intercept the fugitives. Hostilities having now ceased, the island of Java was restored to tranquillity and order, and has, we believe, been recently given over to the king of the Netherlands. See Stockdale's *Sketches of Java;* Sir George Staunton's *Account of the Embassy to China;* Barrow's *Voyage to Cochinchina;* Thunberg's *Travels;* Hamilton's *East India Gazetteer; Baptist Missionary Periodical Accounts,* No. xxvi.; Thorn's *Account of the Capture of Java;* and Brande's *Journal of the Arts and Sciences.*

Sultan of Djoejoecarta in arms.

Djoejoecarta taken by assault.

ICE is a transparent crystallised substance formed by the congelation of water when reduced to a temperature below 32° of Fahrenheit. As ice is generally produced by a very rapid congelation, it commonly occurs in an aggregated mass of separate crystals, the axes of which are turned in different directions. Under favourable circumstances, however, where the process of congelation has been slow, and the water exposed to no agitation, perfect crystals of ice are sometimes formed. M. Hassenfratz, M. Hericaut de Thury,* and Mr Scoresby, have observed crystals of ice that had the form of regular hexahedral prisms; and Romé de Lisle, M.

Crystals of ice.

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* M. Hericaut de Thury observed the crystals of ice in the subterraneous glacier of Fondeurle, about two leagues to the east of Valence. The whole of the floor of the cavern was composed of hexahedral prisms of the most perfect transparency, of which the terminal surface presented striæ parallel to the faces of the prism, while the crystals which were found within the hollow stalactitical masses of ice, were partly triangular prisms, and partly hexahedral prisms; some of which were also striated on the terminal faces, and presented facets which replaced the terminal edges at the junction of the base and the prism. He was not able, however, to find any crystals with a complete pyramid.

D'Antic, and Mr Scoresby, have sometimes found them in the state of octohedrons, composed of two four-sided pyramids.

Optical properties of ice.

In examining the optical properties of ice, Dr Brewster found, that even large masses two or three inches thick, formed upon the surface of standing water, was as perfectly crystallized as rock crystal or calcareous spar, all the axes of the elementary crystals, corresponding with the axes of the hexahedral prisms, being exactly parallel to each other, and perpendicular to the horizontal surface.

This unexpected result was obtained by transmitting polarised light through the plate in a direction perpendicular to its surface. A series of beautiful concentric coloured rings with a dark rectangular cross passing through their centre, were thus exhibited. These rings were of the same nature as those seen along the axis of *Zircon;* for when they were combined with the rings produced by this substance, a system of rings was formed smaller than that which was produced by either singly; whereas, had they been of the opposite character, the rings produced by the combination would have been greater than one of the systems produced separately. Hence, ice belongs to the attractive class of crystals. The polarising force of ice is $\frac{1}{1111}$, that of rock crystal being $\frac{1}{180}$. Its refractive power is 1.307 less than that of water, and its specific gravity is also less than that of water. For an account of the chemical laws on which the congelation of water depends, see CHEMISTRY.

History of the polar ice.

Under the article COLD, and also under GREENLAND, some of the phenomena which accompany the formation of ice in polar regions are briefly mentioned. Their history, however, is sufficiently important to require a minute description, on account of the great scale on which congelation is effected, the variety of the appearances presented, the striking grandeur of some, and the singularity of others, together with the suggestions which some known circumstances concerning it afford for the prosecution of interesting objects.

The appearances which the ice presents in its outline, especially when existing in a detached state, are diversified; and, being of great interest to mariners who navigate the polar seas, they are designated by distinct terms with as much familiarity as the varieties of form which occur on land.

Fields of ice.

A continued sheet of ice, so extensive that its ulterior boundary cannot be seen from the mast-head of a ship, is called a *field.*

Fields are formed from ice which is in the first instance fixed. They owe their origin to a process of congelation on the surface of the ocean, to which the vicinity of land is not, as some have supposed, necessary. This process takes place both in a rough and in a smooth state of the surface, when the temperature is sufficiently low. It requires a temperature considerably inferior to the freezing point of fresh water, as the force must be sufficient to surmount the attraction of the salt for the water which holds it in solution, for more or less separation always takes place: the ice formed under these circumstances, never affords water of equally strong impregnation as the original water of the ocean.

Progress of congelation.

On a rough surface, this process begins with the formation of detached crystals, called by the sailors *sludge,* which resemble snow immersed in water without undergoing liquefaction; by the union of the crystals, and the accumulation of the sludge, the surface is rendered smooth. The continued sheet now formed is soon broken into fragments of about three inches in diameter; these again coalesce and form a continued texture of a stronger kind, which, in its turn, is broken into masses of much larger size. These are rounded at the edges by mutual attrition, and receive the name of *pancake ice.*

In sheltered situations and in still weather the congelation goes on more regularly, and to appearance more rapidly. The thin sheet formed in the first instance, receives accessions to its thickness from beneath. In twenty-four hours of keen frost it often acquires a thickness of two or three inches; and in less than two days is strong enough to bear the weight of a man. This is termed *bay ice,* from being formed in sheltered bays. That which is of older formation is distinguished into two kinds, according to its thickness, being called *light ice* when from a foot to a yard thick, and when above a yard *heavy ice.*

Some fields of ice are so smooth in their surface, so transparent in their texture, and so exactly similar to the ice formed on fresh lakes, that it has been believed scarcely possible that they should be produced by the freezing of the ocean, and they have been considered as owing their origin, at least in part, to the freezing of rain or melted snow, which had settled on a flat surface of young ice, encircled by a ledge of older ice, which retained the water like a cup.

Floes.

Loosened pieces, which are smaller than fields, but still of very large dimensions, are called *floes.* Pieces much smaller, detached from the angles of larger ones, and floating in a congregated state, are called *brash ice.*

Brash ice.

Drift ice.

Ice of any form or size, floating in a state sufficiently loose to allow a vessel to sail freely among it, is called *loose, open,* or *drift ice.*

Packs and patches.

A number of large pieces in close contact, forming a congeries which cannot be seen over from a mast head, are called a *pack.* A similar congeries, which can be seen over, is called a *patch.* When a congeries of either kind is of an oblong shape, it is called a *stream* of ice.

Hummocks.

A protuberance, considerably elevated above the common surface of flat ice, is called a *hummock.* Hummocks often attain the height of thirty feet or upwards. They are sometimes formed by fields of ice crushing each other, so that large pieces, separated from the margin, are raised on edge, or a numerous wreck is accumulated on the top of a field. Hummocks are generally near the margin, but sometimes they extend to the middle of a field, showing that their origin is sometimes different from that now described. They communicate to the ice a variety of fanciful shapes, and render the whole appearance of it highly picturesque.

Calves.

When the effect of concussions of pieces of moderate size is to accumulate such masses above a comparatively thin *floe,* that the surface of the latter is depressed beneath that of the water, this part is called a *calf.* Some of these *calves* are sufficiently deep to allow a vessel to sail over them. But it is dangerous to approach them, their depth being uncertain and unequal; and when they rub freely against the superincumbent pieces, they often become so far detached that their buoyancy raises them to the surface, and their momentum during a change of situation is sufficient to stave the timbers of a vessel, or reduce it at once to a wreck. Sometimes even a gentle heaving motion of this sort, by raising one end of a vessel, immerses the other end, to the imminent danger of precipitating it in that direction to the bottom.

Concave sinuosities in the border of a large mass of flat ice are called *bights*. They often afford a convenient refuge to ships, but sometimes they give occasion to detentions of the most inconvenient and dangerous kind.

Effects of a ground swell.

We have now to notice some changes of a grander and more terrific description, to which the ice is subjected. That powerful tendency to undulation of the surface, communicated by the agitation of the adjoining liquid surface of the ocean during a continued storm, which is denominated a *ground swell*, sometimes produces a sudden disruption of extensive fields. The ice, when thin, accommodates itself to the surface by bending; but, when several yards in thickness, it refuses to yield beyond a certain extent, and is broken into pieces with dreadful explosions. The best account that we know of the appearances presented on such occasions is given by a party of Moravian missionaries, who were engaged in a coasting expedition on the ice along the northern shore of Labradore, with sledges drawn by dogs. They narrowly escaped destruction from one of these occurrences, and were near enough to witness all its grandeur. We extract it from the recent interesting compilation of the Rev. Dr Brown, on the *History of the Propagation of Christianity*, vol. ii. p. 51. "The missionaries met a sledge with Esquimaux turning in from the sea, who threw out some hints that it might be as well for them to return. After some time, their own Esquimaux hinted that there was a ground swell under the ice. It was then scarcely perceptible, except on lying down and applying the ear close to the ice, when a hollow disagreeable grating noise was heard ascending from the abyss. As the motion of the sea under the ice had grown more perceptible, they became alarmed, and began to think it prudent to keep close to the shore. The ice also had fissures in many places, some of which formed chasms of one or two feet; but, as these are not uncommon even in its best state, and the dogs easily leap over them, they are frightful only to strangers. As the wind rose to a storm, the swell had now increased so much that its effects on the ice were extraordinary and really alarming. The sledges, instead of gliding smoothly along as on an even surface, sometimes ran with violence after the dogs, and sometimes seemed with difficulty to ascend a rising hill. Noises, too, were now distinctly heard in many directions like the report of cannon, from the bursting of the ice at a distance. Alarmed by these frightful phenomena, our travellers drove with all haste towards the shore; and, as they approached it, the prospect before them was tremendous. The ice having burst loose from the rocks, was tossed to and fro, and broken in a thousand pieces against the precipices with a dreadful noise; which, added to the raging of the sea, the roaring of the wind, and the driving of the snow, so completely overpowered them, as almost to deprive them of the use both of their eyes and ears. To make the land was now the only resource that remained, but it was with the utmost difficulty that the frightened dogs could be driven forward; and, as the whole body of the ice frequently sunk below the summits of the rocks, and then rose above them, the only time for landing was the moment it gained the level of the coast,—a circumstance which rendered the attempt extremely nice and hazardous. Both sledges, however, succeeded in gaining the shore, and were drawn up on the beach, though not without great difficulty. Scarcely had they reached it, when that part of the ice from which they had just escaped burst asunder, and the water rushing up from beneath instantly precipitated it into the ocean. In a moment, as if by a signal, the whole mass of ice for several miles along the coast, and extending as far as the eye could reach, began to break, and to be overwhelmed with the waves. The spectacle was awfully grand. The immense fields of ice rising out of the ocean, clashing against one another, and then plunging into the deep with a violence which no language can describe, and a noise like the discharge of a thousand cannon, was a sight which must have struck the most unreflecting mind with solemn awe. The Brethren were overwhelmed with amazement at their miraculous escape, and even the pagan Esquimaux expressed gratitude to God for their deliverance."

Icebergs described.

Ice in that elevated form which is called the *iceberg*, demands particular attention. This term is applied to such elevations as exist in the vallies of the frigid zones; to those which are found on the surface of fixed ice; and also to ice of enormous thickness and stupendous height in a floating state. The vallies of West Greenland are filled with icebergs to an extent never yet explored. The seven icebergs in the vallies on the west coast of Spitzbergen, were supposed by Mr Scoresby, when seen by him, to present a perpendicular front 300 feet high. Their green hue, and glistening splendour, exhibited a pleasing variety, and added a richness to the prospect by the contrast which they presented with the magnificence of the neighbouring snow-covered mountains. From these icebergs enormous overhanging masses are sometimes detached by their own weight, as from the glaciers of the Alps. This separation is aided by a softness of cohesion which they acquire in the thawing season; and it is also believed that quantities of water pent up within them exert, in the act of freezing, an expansive force, which produces disruption. Masses of this kind, in a floating state, are most plentiful in Baffin's Bay, where they are sometimes two miles long, and two-thirds of a mile broad, bristled with varied spires, rising more than 100 feet above the surface, while the base extends 150 yards beneath it. Icebergs of an even surface, elevated 30 yards above the sea, and five or six square miles in area, are very common. Those of East Greenland are of inferior size. The largest that Mr Scoresby ever saw was 1000 yards in circumference, flat on the summit, and nearly 20 feet above the level of the sea. This difference probably arises from the more sheltered situation of the large bays of West Greenland.

We have reason to believe that many icebergs are formed at a distance from any land. This appears from the account which Muller gives of an expedition made, in the year 1714, by Markoff a Cossack, after he had been foiled by drift ice in an attempt to explore the ocean to the north of Russia. This adventurous person set off with a party from the coast of Siberia at the mouth of the river Yani, in North Lat. 71°, in the month of March, to travel on the surface of the ice to the north pole in sledges drawn by dogs. He proceeded for seven days till he reached the 78th degree, when his progress was impeded by ice elevated into prodigious mountains, from the summits of which he could discern nothing but mountainous ice to the northward. He therefore returned, and, after some hardships and losses, reached the coast of Siberia on the 3d of April, having in 19 days travelled 800 miles. To what extent these masses may be detached during summer in regions nearer the pole than any that have hitherto been navigated, we cannot determine; but it is not improbable, that from this source many of the loose icebergs are derived which are found floating to the west of the islands of Spitzbergen. It is probable that many are also formed on the eastern coasts of these islands, which are more favourable to such a process. But the numbers of these enormous masses that come by Davis's Straits are by far the greatest, and the coast of Newfoundland is often crowded with them. They gradually dissolve as they move to the southward; but some have been found in Lat. 40°, 2100 miles from their source.

These lofty masses are formed partly by the accumulation of drifted snow first slightly softened by the summer heat, and acquiring an augmented solidity by a subsequent process of congelation. It is probable that their high peaks receive accessions from the falling moisture, which is more readily congealed than that which lies lower, the temperature being lowest at the highest elevations. We mentioned under the article COLD an ingenious conjecture of Professor Leslie, that they attained their great height by the deposition of hygrometric water from the air ascending from the surrounding ocean in a manner analogous to those rising peaks of ice which are formed in the congelations produced in the ingenious process for freezing water by its own evaporation, of which that philosopher is the inventor. But we may be allowed to suspend our entire acquiescence in this opinion till it is ascertained how far these formations themselves may arise from a cause totally different, viz. the elevation of moisture by the capillary attraction of the previously formed crystal. We know that this is the mode in which similar peaks are formed during the leisurely crystallization of certain neutral salts by evaporation. If a solution of muriate of ammonia is left for some days to evaporate spontaneously in a glass, appearances of the same kind are presented.

Their occa- ional uti- ty.

The shelter created by icebergs is often highly useful to the whalers, by protecting them from gales, as well as from the concussions of drift ice, as the latter moves more quickly, requiring a shorter duration of the wind in one direction to attain its utmost velocity. The ships are sometimes moored to the icebergs for security; but this situation is not without its dangers. The masses are sometimes so nicely balanced as to be easily overturned. They sometimes catch the bottom in places comparatively shallow, though still of great depth, and the effect of the concussion is to detach large pieces from them, or to cause the whole mass above water to plunge forward under the surface, and the vessel moored to them is staved and wrecked. The same effect is produced by the rising of immense calves. These occurrences sometimes happen when the ship rides at a distance of 100 yards from the emergent part. The motions are indeed of so tremendous magnitude, that a vessel is sometimes lost by the vast waves and whirls which they occasion, which overwhelm every smaller object within a considerable distance of the rolling mountain. Icebergs often prove useful by supplying the ships with fresh water, which is found collected in large wells on the surface, and is let down into the vessel by a cylindrical piece of canvas called a *hose*.

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The irregular outline of the fixed polar ice, and the changes to which it is subjected in the course of years, are highly interesting. Before the 15th century, the eastern coast of West Greenland was free from ice in summer, and could be freely approached by ships. After a considerable trade had for 400 years been carried on between Iceland and that country, which was inhabited by a large and flourishing colony, the polar ice suddenly exceeded its former limits, launched down in a direction nearly parallel to the coast as far as the southern Cape, and barricadoed the whole coast in such a manner as to render it ever since inaccessible. The fate of the colony is unknown. If the increased severity of the climate was insufficient to destroy it, this effect was inevitable from the destruction of all the resources on which it depended. The mass of ice lying between Old or West Greenland and the northern part of Russia on the east, though varying in different seasons, presents a striking uniformity in its general outline. After doubling the southern promontory of Greenland, it advances in a north-eastern direction, half enveloping Iceland in close seasons, till it reaches the small island called John Mayne's Island, which it frequently encloses. It then trends a little more to the eastward, and intersects the meridian of London in the 71st or 72d degree of latitude. Having reached the longitude of 6, 8, or 10 degrees east in the 73d or 74th degree of latitude, it suddenly stretches to the north; sometimes proceeding on one meridian to the latitude of 80°, at others forming a deep sinuosity, extending only two or three degrees northward, then south-easterly to Cherry Island; it then assumes a straight course a little south of east, till it forms a junction with the coast of Nova Zembla.

On the whole, the tendency to a fixed state of the ice is greatest on the eastern sides of land. These are rendered peculiarly cold, from the westerly winds having had their temperature reduced by blowing over the eternal snow and ice of the continents. These winds are in their origin warmer than the east, as they generally originate in southerly situations; whereas the east winds, originating in the north, are less liable to a reduction of temperature in passing over a frozen continent. Thus the eastern shores are exposed to all the original coldness of the east winds when they blow, and to an additional coldness acquired by the west winds; while the western shores are wafted by the west winds in their mild state, in which they keep up a liquefying process, a quality which they lose after traversing the land. It is well known, that south-west and north-east winds are more common in the northern hemisphere than the north-west or the south-east. Winds that blow directly from the west tend to produce a perpetual extension of the ice; but the south-west winds give that form to its boundary which we find it actually to possess, *i. e.* a line stretching to the north-east. But why, at one period, the coast should for centuries be free from ice, and at another period be perenially lined with it, is one of those phenomena in the changes of climate, for which, like many others in meteorology, we cannot account. For an illustration of the circumstances now stated, we refer to the meteorological Essays of Mr Dalton. See also our article METEOROLOGY. The form of the outline of the ice varies however according to the direction and force of storms and currents.

Whale fishing seas of Spitzbergen.

The deep bay formed by the boundary of the ice to the west of Spitzbergen, is the only track for proceeding to the fishing latitudes in the north. In close seasons, the ice at the extremity of this bay is so close, that the vessels cannot advance beyond the 75th or 76th degree; but in open seasons, they have an uninterrupted navigation along the western coast of Spitzbergen to Hackluyt's Headland, the north-western angle. An open channel extends in such seasons from 20 to 50 leagues in breadth, to the latitude of 79° or 80°, gradually approaching the coast, till it effects a junction with its northern extremity by a curvilinear head. It is only in this open part, that they can proceed sufficiently far to the north to find the whales. These animals, of stupendous size, but timid in disposition, prefer these places, as affording the most secure retreats, enabling them to dive beneath the ice out of the reach of danger, and to return to the open part to respire. It is in the 78th and 79th degrees of latitude that they occur in greatest number. At the southern part of Spitzbergen, there is, at the bottom of the bay called *the whale fisher's bight*, a barrier of compact drift ice, mixed with bay ice, stretching from the fixed ice on the west to that on the east, and from 20 to 40 leagues in breadth. This always exists in the early part even of open seasons, and to find their way across this barrier, is with mariners one principal object of anxiety and exertion. For this purpose, every advantage is taken of those openings in the ice, which are expressively called *veins of water*. When the wind is fair, they set all possible sail in order to accomplish it speedily, and yet find it necessary to be on their guard against the dangers which surround them from pieces of floating ice, dangers which of course are augmented in proportion to the velocity of a ship's motion. These difficulties occur in the month of April; but by the end of June the ice is dispersed, and a safe return afforded, which could scarcely be obtained if it continued equally prevalent, as the fogs, which obstruct the view at the end of the season, would prevent them from seeing their way through similar obstructions. In sailing to the north, it is of importance to anticipate the separation of the ice, in order to catch the best season for the fishery.

Great and unexpected changes often take place in the manner in which the drift ice is collected. It frequently happens, that a ship is completely beset, and unable to move in one direction or another, and next day, without apparent cause, the ice is completely dispersed, and an open sea presented on every side. A tendency to separation always takes place in the drift ice during a calm. The changes to which the local situation of a ship is on such occasions subjected, are not less surprising. Two ships surrounded with close ice a few furlongs apart, have sometimes been in a few days separated to a distance of several leagues, though no apparent change took place in the continuity of the pack. Bay ice sometimes proves beneficial to the whaler, by imbedding the ship, and averting that danger which arises from the unequal shock produced by the brunt of the heavy ice. But it is in other respects extremely troublesome, as it is often the means of besetment, and thus the primary cause of the greatest calamities. A sheet of it a few inches in thickness, is sufficient to render a ship immoveable. If, under these circumstances, it is too strong to be broken by a boat, recourse is had to the laborious operation of sawing it.

The general tendency of the loose ice in the neighbourhood of Spitzbergen, is to drift to the south-west, towards Iceland and Cape Farewell in West Greenland. When we consider the obstacles encountered in the navigation of the northern seas, which are not more exempt than others from stormy weather, and find that these fishing voyages are attended with so much average security, we have a striking exemplification of the adventurous spirit of man, and of the power of art in surmounting difficulties of the most threatening kind. A combination of thick weather, a stormy gale of wind, and a tempestuous sea, crowded with detached pieces of ice, each of which is enveloped in a thick spray raised by the dashing of the waves, presents one of the most terrific navigations that can be conceived.

The ice blink.

The phenomenon called the *ice-blink* is worthy of our attention. It is a lengthened stripe of lucid whiteness in the sky, bordering the visible horizon, which often affords a beautiful and perfect map of the ice, 20 or 30 miles beyond the limit of direct vision. This even serves to shew to the experienced observer the exact kind of ice, whether field or packed, which occurs in that direction.

Plan for travelling over the polar ice.

Mr Scoresby has projected a plan for surmounting the obstacles opposed by the ice in a visit to the north pole, by travelling over the surface of it in the manner already mentioned as having been put in practice by Markoff. This is detailed in an intelligent and ingenious paper, read before the Wernerian Society, which contains much information relative to the polar ice, and to which on this subject we have been principally indebted. Access to it previously to publication has been most obligingly furnished to us by Professor Jameson, the president of that Society. Of that plan it would be out of place to give any particular account. It will be inferred from the circumstances already mentioned as having occurred to Markoff, that, though not impracticable, it must be extremely precarious, and that those who engage in it, must be prepared for total disappointment after the most Herculean exertions. Yet it is worthy of remark that, if no obstruction arose from the form of the surface of the ice, an expedition undertaken from the northern coast of Spitzbergen to the north pole and back, would exceed that actually performed by Markoff only by 250 miles. Some important information, in reply to a series of queries directed to the elucidation of this subject, is given by Colonel Beaufoy, in Dr Thomson's *Annals of Philosophy* for May 1817. It was obtained from Russian fishermen who had wintered at Spitzbergen. The tendency of the accounts given by them, is to impress us with the difficulty of such an undertaking, both as arising from the great inequality of the surface of the ice, in so far as could be inferred from observations made in that part of the world, and from the storms of wind and snow, which are represented as extremely frequent. An answer to an additional query, however, is still wanted: Is there any period of the winter at which a few weeks of fair and calm weather may in general be depended on? Or are there any meteorological appearances from which such a track of weather may be occasionally predicted? One interesting practical inquiry is suggested by the degree of success obtained by Markoff. Might not an attempt be made to explore by similar means the site of the ancient colony of West Greenland?

Antarctic ice.

Of the ice of the southern hemisphere we have less particular accounts. But we know that ice extends to a much greater distance from the south pole than from the north. The 80° of north latitude is almost annually accessible at one part to navigators, and has occasionally been exceeded. The 73° or 74° may be attained in the closest summers. But the *ne plus ultra* of the antarctic hemisphere is the 72°, *i. e.* 600 miles short of that of the arctic: The nearest approach made to the South pole being 1130 miles, and to the North pole 510. Icebergs and floating ice of all forms abound in the southern seas, and present similar appearances to those found in the northern.

Ice at the bottom of the water.

We shall now take notice of one circumstance in the history of ice which is seldom particularly described, viz. that it is found forming at the bottom of water, even on a large scale, while the surface remains liquid. This seems contrary to what might be expected from the order which takes place in the successive reduction of temperature in different parts of the same portion of water, as well as from the comparative specific gravities of water and ice. The facts are well ascertained, as occurring in Germany, in Great Britain, and in North America. In Germany two kinds of ice are described as formed in that situation: one which is called *sichl-eis*, is the first that is formed at the beginning of a severe frost, and immediately rises to the surface in small grains, similar to hail. The other, from retaining its situation longer, is more commonly observed and better known. This is called in Germany *grund-eis*. In Scotland, where it is not uncommon, it is called *grund-grue*, i. e. "ground-grown." Men of science, not having attended to these phenomena, have considered them, when accidentally met with, as extraordinary. It has happened, when they were in quest of something else, that they have found at the bottom of a river a sandy mass agglutinated in a manner which they did not comprehend, till they found that the cementing medium was ice. At other times they have been struck with great surprise on finding gravel, earth, or mud, mixed with ice on the surface. But such phenomena are familiar to the fishermen and boatmen on some of the northern rivers, particularly the Elbe. They sometimes find it difficult to fix their anchors, on account of the smoothness which the ice imparts to the bottom. When taken up, the anchors are sometimes coated with ice, and at other times it forms on them in such quantities, as to raise them to the surface by its buoyancy. Ice, instead of fish, is not unfrequently brought up with the fish-hooks. The sluices and flood-gates are sometimes rendered immoveable by the ice formed at the bottom. It often acquires a great thickness before it rises, and then brings up with it not only earth and gravel, but stones of large size. We are told, on credible authority, that in the Elbe the stones to which buoys had been fixed as marks of the dangerous shallows, have been brought to the surface by the *grund-eis*, and removed to a different part of the river. On the margins of lakes numerous new fragments of rock have been found on the subsiding of frost, which had been brought up in this manner from the middle and floated to the edge. Some species of bottom are more favourable to this process than others: sand and gravel are more so than solid rock. M. Brauns, a Hanoverian, after consulting with much care the best sources of information, learned that in the northern seas, traces both of *sichl-eis* and *grund-eis* were found where the depth of the water was 108 feet. In the Baltic alone it was found at depths still greater. One reason why these phenomena are seldom observed is that ships return before the setting in of the strong winter frosts. Mr Knight, in the *London Philosophical Transactions* for 1816, thus describes the phenomena as they occurred under his own observation, and at the same time delivers his opinion of their physical cause. "I first witnessed the existence of ice in the bottom of the water in the river Teme, which passes near my residence in Herefordshire, in the last winter. In a morning which succeeded an intensely cold night, the stones in the rocky bed of the river appeared to be covered over with frozen matter, which reflected a kind of silvery whiteness, and which, upon examination, I found to consist of numerous frozen spicula crossing each other in every direction as in snow; but not having any where, except very near the shore, assumed the state of firm compact ice. The river was not at this time frozen over in any part; but the temperature of the water was obviously at the freezing point, for small pieces of ice had every where formed upon it on its more stagnant parts near the shore; and upon a mill-pond just above the shallow streams, in the bottom of which I had observed the ice, I noticed millions of little frozen spicula floating. At the end of this mill-pond numerous eddies and gyrations were occasioned, which apparently drew the spicula under water, and I found the frozen matter to accumulate more abundantly on such parts of the stones as were opposed to the current where that was not very rapid. On some large stones near the shore, of which parts were out of the water, the ice beneath the water had acquired a firmer texture, but appeared from its whiteness to have been first formed of congregated spicula, and to have subsequently frozen into a firm mass, owing to the lower temperature of the stone or rock."

Theories on the subject.

The theory here given by Mr Knight falls short in accounting for the facts which he himself observed; for, by supposing the spicula to have been formed at the surface, and afterwards precipitated by the tumbling motions of the water to the bottom, it does not contain an explanation of that congelation which must go on at the bottom itself before the spicula can adhere to the stones. On other occasions it is formed in places where the motion is far from being sufficient to send the floating crystals to the bottom. It is also to be remembered that, instead of such spicula as Mr Knight describes, smooth and compact ice is found in these situations. We would therefore observe, that water, when reduced to 32°, and then deprived of an additional portion of caloric, though it has a tendency to freeze, yet experiences in this respect different degrees of facility according to certain circumstances. One of these is the presence of certain solid points or rough surfaces. Hence water reduced to 26° without freezing, immediately freezes when a crystal is dropt into it, and the ice forms first upon the crystal itself. Agitation also seems to influence it. Water, when left quite stagnant, may remain liquid, and be immediately frozen by a gentle shaking. But a great degree of agitation while it is cooling seems to retard congelation, and always prevents it from proceeding with regularity. Now it appears to us, that in whirls and eddies, the water at the surface loses a certain portion of caloric, and receives a tendency to congelation, which however is resisted by the motion to which it is subjected, and may be promoted in another place by a slight additional aid from an external cause. The motion, indeed, while it prevents the freezing of the surface, assists that process at the bottom by accomplishing the reduction of the whole body of water to the freezing temperature. It is well known that the temperature of greatest contraction and specific gravity of water is somewhere above the freezing point, about the 40° of Fahrenheit. While higher than 40°, a reduction of the temperature at the surface, by increasing the specific gravity, produces a sinking of the superficial portion, and an intermixture with that which is beneath. But, after it has reached the 40th degree, a farther reduction of temperature, instead of contraction, produces an expansion; and the water retains its situation, unless operated on by some other force. While it is perfectly still, therefore, it remains at 40° at the bottom, while at the surface it is at 32°, and in that part the process of congelation goes on, the mere conducting power of water requiring a long time to effect an equalization of temperature. The difference of specific gravity, however, between water at 40° and at the freezing point is not great, and a very slight motion is adequate to produce a thorough intermixture, and consequent extension of the freezing temperature through the whole. When this is effected, and at the same time the congelation resisted by the motions of the surface, it is promoted by the nature of the substances at the bottom. The varieties in the qualities of different substances in this respect, as ascertained by experiment, are curious. Hair, especially boiled horse hair, wool, chaff, moss, and the bark of trees covered with lichens, are found to promote the formation of ice in a higher degree than any metals. Of the latter, copper, brass, steel, and above all tin, have ice formed on them sooner and more abundantly than iron. Polished stone and earthen-ware attract very little. On wax, resins, pitch, silk, leather, and wood deprived of its bark, it is seldom or never found. On the bottoms of boats, however, incrustations have been found, which have been evidently formed of the *sichl-eis*.

This process requires a powerful frost. Hence it appears comparatively seldom in the more temperate countries. Yet it is described by M. Desmarest as having occurred in the Rhone and the Seine. The laws by which it is regulated are worthy of a more minute experimental investigation than they have hitherto received.

See Romé de Lisle's *Crystallographie*, tom. i. p. 4. Hassenfratz *Journal de Physique*, Jan. 1785. D'Antic, *Id.* 1788, vol. xxxiii. p. 57. Hericaut de Thury, *Journal des Mines*, 1813, vol. xxxiii. p. 157. The Memoir of Mr Scoresby in the *Memoirs of the Wernerian Natural History Society of Edinburgh*, vol. ii. part 2. Col. Beaufoy in *Thomson's Annals*, May 1817. Desmarest, *Journal de Physique*, Jan. 1783; and M. Jules-Henri Pott, *Id.* July 1788. See also the articles COLD, GLACIERS, GREENLAND, HUDSON'S BAY, OPTICS, and POLARISATION. (*H. D.*)

ICELAND.

Iceland.

ICELAND, is a large island situate on the verge of the Arctic Ocean, between the 63° and 67° of north latitude, and the 12° and 25° of longitude west from Greenwich.

History.

This island was discovered about the year 860 by a Norwegian pirate, named Naddodr, who was accidentally driven upon the coast while on a voyage to the Faroe islands. A few years afterwards a Swede, *Gardar*, succeeded in circumnavigating the island, and gave it the name of Gardarsholm. Its present name was given to it by Floke, a famous pirate of those times, who remained two years, during which he explored most of the southern and western coasts. The country was colonized in the year 874, from Norway; the subjugation of which, by HAROLD the fair-haired, had produced much discontent among the petty states which he reduced. The leader of the emigration from Norway was named *Ingolf*, who, with his kinsman *Hiorleif*, went to Iceland in the year 870, and made arrangements for the settlement. It is asserted by some of the Icelandic historians, that there were actual settlements in the island before this period; but this seems improbable. The first of the Norwegian visitors found, on some parts of the coast, wooden crosses, and implements, from which it is inferred that those who had preceded them were Christians. In the *Landnama Bok*, which is among the earliest of the Icelandic historical records, it is stated, that, among other things, writings in the Irish language were found. The statements on this subject are so various, that it is impossible to form any probable conjecture on the point in question.

The colony first settled in the south-western part of the island; and the spot where the town of Reikiavik now stands was chosen, on account of the result of a superstitious observance, which guided many of the settlers in the choice of their future places of abode. When Ingolf approached the shores of Iceland, he threw into the sea the door of his former habitation in Norway, and having found it cast on the beach at Reikiavik, he there fixed his station. In the course of half a century, the coasts of this remote country were well peopled; and in the *Landnama Bok*, already mentioned, which contains minute details of the spreading of the colonies, we find several names of Scotch and Irish families who came over and settled.

At first, every body of emigrants remained under the influence of a leader, who parcelled out the land to his followers. But this feudal arrangement was soon found inconvenient, from the contests which arose for possessions claimed by the various petty chieftains. By common consent, a new system of government, which included the whole country, was settled in the year 928. The island was divided into four provinces, superintended by an hereditary governor. The southern and western provinces were subdivided into three prefectures, the northern one into four, and the eastern into two. The authorities over these were also hereditary. There were still more subdivisions, called *Hreppar*, in each of which five officers were appointed, men of property and respectability, whose care it was to keep peace and good order, and to manage the concerns of the poor in their respective districts. The proceedings of the superintendants of districts were under the cognizance of the prefect and his deputies, who met once a year; from whom there was an appeal to the provincial court; and finally, to the supreme assembly of Iceland.

This great assembly was held annually on the shores of the lake called Thingvalla, from the name of the assembly *althing*, which is derived from *al*, all, and *thing*, a court of justice. A president was chosen, with the title *Laugman*, or administrator of the laws, and was invested with all the symbols of dignity and power. It was his province to interpret the laws, and pronounce sentence; and his authority, though dependent on the will of the states, was often continued for life.

Such is an outline of a constitution settled without any contention, to which may be referred the arrangements in the government of almost every modern state in Europe. The Hreppstiores have the same jurisdiction with our justices of the peace, and the prefects of our sheriffs. The provincial assemblies resemble our quarter sessions, and the supreme assembly our parliament. For a minute account of the Icelandic commonwealth, the reader may consult the *Crymogæa* of *Arngrim Jonas.*

The code of laws adopted with this new form of government, and which were progressively amended by the assembly, is a remarkable example of the genius of the people of this age. To enter into a minute examination of it would far exceed the limits prescribed to this article, and we must refer to the works enumerated at the end. With respect to the criminal laws, corporal punishment was rarely inflicted; the atonement for almost every offence being a fine, extended according to circumstances, even to the confiscation of the whole property of the criminal. The trial by jury, though not enacted, was sometimes resorted to in particular cases.

"The constitution thus adopted by the Icelanders, (says Dr Holland, in his Introduction to Sir George Mackenzie's *Travels in Iceland,*) was preserved with little change for more than three centuries; during which period the records exist of thirty-eight laugmen, who in succession sustained the executive power. Were it allowed to apply the term to a desolate island on the confines of the Arctic circle, this might be called the Golden Age of Iceland. Secured by physical circumstances from the ambition of more powerful states, an efficient government and well directed laws provided for the people all the advantages of justice and social order. Education, literature, and even the refinements of poetical fancy, flourished among them: like the aurora borealis of their native sky, the poets and historians of Iceland not only illumined their own country, but flashed the lights of their genius through the night which then hung over the rest of Europe. Commerce was pursued by the inhabitants with ardour and success; and they partook in the maritime adventures of discovery and colonisation which gave so much merited celebrity to the Norwegians of this period. Many of their chiefs and learned men visited the courts of other countries, formed connections with the most eminent personages of the time, and, surveying the habits, institutions, and arts of different communities, returned home fraught with the treasures of collected knowledge. Nor was there among the Icelanders of this period an extinction of the elevated spirit, common to their forefathers and to the age. The Sagas, or tales of the country, afford many striking pictures of that high feeling of honour, and of those deeds of personal prowess, which were cherished by the disposition of the northern nations, and which refused not to exist even in this remote and desolate region."

Literature.

The colonization of Iceland having been undertaken by men of rank and education, literature was carefully cherished among them; and their language, the Gothic, was preserved in its utmost purity. The ancient mythology of Scandinavia afforded ample scope for poetic fiction and ornament; and the desolate region of Iceland, the gloominess of which was only interrupted by natural phenomena the most awful and tremendous, gave a range to the favourites of the muse, which imagination could scarcely exceed. The taste for poetry thus imbibed by the first inhabitants, descended to their posterity; and to this day it is no small part of the amusement of the people, during the darkness of winter, to recite the legends of former times. Nor was the fame of the Icelandic Skalds * confined to their own country. Foreign potentates cherished them in their courts, and munificently rewarded them for singing their praises.

The character of the Scandinavian poetry of this age was stamped by metaphorical obscurity. Resemblance could not be too distant, nor too fanciful, for a northern poet; and the habitual use of metaphor occasioned the adoption of phrases as familiar, which, to those unaccustomed to the style, appear extravagant and unnatural. This obscurity does not however extend through the whole of Icelandic composition, which, particularly in the relation of common events, is often exceedingly simple. Rhyme was rarely employed; and the harmony of the versification seems to have depended on alliteration, and the arrangement of particular sounds adapted to the nature of the language. Thus there was opened a broad field for the exercise of skill, as well as imagination; and the frequent contests in versification brought the Scandinavian poetry to be an art of the most refined nature. Having more leisure, the Icelandic poets excelled; and, from catalogues still preserved, we find, that of the Skalds who flourished in Sweden, Denmark, and Norway, the majority of the whole number were Icelanders.

The most celebrated and valuable remnant of northern poetry is the Edda, a work designed as a common means of education in the favourite pursuit of this extraordinary people. The Edda appears to have been composed at different times, and by different writers, about whom there has been much controversy. There are two different works which bear this title, the Edda of Sæmund, and that which bears the name of Snorro Sturlesen, to whom it is ascribed. The first or ancient Edda consists of a number of odes, of which the Voluspa, or prophetess of Vola, and the Hávámal, are the most important. The former is a short and obscure digest of the Scandinavian mythology; and the latter consists of moral precepts, supposed to have been delivered by the god Odin. They are attributed to Sæmund Sigfuson, an Icelander, who was born in the year 1056; and so eminent, as to have acquired the denomination *Frode,* or learned. The other Edda is more perfect, and better adapted to the object of instruction in the art of poetry. The first part contains a view of mythology in the form of a dialogue, in which the attributes and actions of the deities, and other events, are explained. The second part is a collection of synonymes, epithets, and prosodaical rules, in which the errors of style, and the varieties of metre, are carefully pointed out.

Sagas.

The historical writings of this age do more honour, perhaps, to Iceland, than the cultivation of poetry. Of these, the Sagas, which are of a mixed character, blending, to a certain extent, fiction with authentic narrative, are exceedingly valuable. They possess great variety, some detailing particular events relating to politics or religion, some the history of a particular family, and others the biography of eminent individuals. As might be expected, many of these narratives are tedious; but in many are to be found examples of simplicity, which carry the reader back to the times in which the actors lived, and insensibly lead him to consider himself not an indifferent spectator.

The Sagas have elucidated the history and antiquities of the north in an eminent degree; but the regu-

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* The word *skaldr*, or skalds, signifying bards, is probably derived from *skiael*, wisdom; whence the English word skill.

lar historical writings which have come to us from the Icelanders are yet more valuable. The *Annales Oddenses* of Sœmund Frode; the *Landnama Bok*; the Chronicle of the Kings of Norway, by Snorro Sturleson; and numerous other works, testify the abilities and correctness of the writers. Besides poetry and history, mathematics and mechanics were cultivated; and jurisprudence formed an important study. Travellers penetrated into Asia and Africa; and the maritime adventures of the Icelanders prove that attention was paid to astronomy and geography. Philology was not neglected, and the most celebrated Roman authors were familiar to all the learned men. The Greek language was not much cultivated.

Before the establishment of Christianity, which took place in the year 1000, the Runic was the only character in use; but more seems to have been trusted to memory than to writing. With Christianity, the Roman characters were introduced, and a new incitement was thus given to education, and every literary pursuit. The first school was established by Isleif, the first bishop of Skalholt, about the middle of the 11th century; and soon after three others were formed in different parts of the island. In these the youth were taught to read, write, and compose in their own language, and initiated in the classics and in theology, to which last particular attention was given.

Christianity established.

The establishment of Christianity was not the least remarkable event in the early history of Iceland, since it was effected in a manner which displayed, in a striking manner, the genius and government of the people. Frederic, a bishop from Saxony, began to preach the Christian doctrines in the year 981; and the number of converts gradually increased. The propagation of the new faith met with every species of opposition; but at length the contests became so frequent, while those who adopted Christianity greatly increased in number, that the national assembly, which met in the year 1000, took the matter into consideration. While the question for the establishment of the new religion was debated, a messenger hurried into the assembly, and announced that fire had burst from the earth in the southern part of the country, and was carrying destruction before it. The heathen party instantly exclaimed, that this was the vengeance of the gods against their presumption. But Snorro, who was a zealous advocate for the Christian cause, called out to them, "For what reason did your gods display their wrath, when the rock on which we stand was burning?" The place of assembly is in the midst of frightful proofs of the power of volcanic fire; and this exclamation of Snorro turned the scale in favour of the Christian faith. The decision of the assembly was solemnly pronounced by Thorgeir, the Laugman; and all religious disputes were immediately suspended. A church establishment was soon afterwards arranged, and the first bishop of Skalholt, Isleif, was ordained in the year 1057. From this period, during nearly two centuries, a pure religion was exercised by the Icelanders, undisturbed by the errors and superstitions of the Romish church.

Greenland and America discovered by Icelanders.

The discovery of Greenland, about the year 972, is another feature of this early age; and one still more remarkable was the discovery of the north-east coast of America in the year 1001 by Biorn Heriolfson, who was driven to the south while on a voyage to Greenland. A colony was established in Greenland, which subsisted till the beginning of the 15th century, when all traces of it were lost. About the same time, a material change for the worse appears to have occurred in the climate of Iceland, where, it is said, corn formerly grew. The loss of Greenland was occasioned by an unusual accumulation of ice, which has bound up the coasts ever since, and frustrated every attempt to reach the place where the once flourishing colony existed.

The part of America first seen was probably some part of the coast of Labrador. Leif, the son of Eric, the discoverer of Greenland, on hearing the report of this discovery, set out to pursue it; and passing by the coast first observed by Biorn, he came to a strait separating a large island from the mainland, probably that of Newfoundland. Thorvald, brother to Leif, went over to this new country, which, from finding wild vines growing in it, was called Vinland; after remaining two years, he was killed in a skirmish with the natives, who had not been seen till this time. A regular colony appears to have been afterwards established in Vinland. But after the early part of the 12th century, scarcely a vestige of this colony can be found, and the situation of Vinland is destined to perpetual obscurity.

Moral character at this period.

The moral character of the Icelanders, during this period of their history, seems to have kept pace with their intellectual endowments, and to have stood high. Previous, however, to the introduction of the Christian religion, some unnatural customs and superstitious usages obtained. The exposure of children, though not prohibited, was soon relinquished, after the morality inculcated by the New Testament came to be fully understood; and ceased more than a hundred years before the practice was abolished in Norway. The most singular superstition was the Beserkine. From the *Kristni Saga*, and the Ecclesiastical History of Iceland, we learn that the Beserkin were professed warriors, who, by means of magic, had rendered their bodies invulnerable. Rousing themselves by incantations into frenzy, these men committed every kind of violence, and rushed naked into battle. There is every probability that some of these were miserable and infatuated wretches, while others adopted the profession with the view of imposture.

Submision to Norway.

The independent and happy state of Iceland was not destined to be uninterrupted. The love of power produced intestine evils, which the ambition of Norway carefully fomented. The civil contests were not always trifling; for instances are recorded, in which fleets of twenty sail, and bodies of 1200 men, fought on one side. The desire of peace, and the promises of the Norwegians, now become jealous of the prosperity of Iceland, at length produced a formal proposal in the national council, that the country should be governed by a single potentate; and in the year 1261, the whole, except the eastern province, submitted to Haco, king of Norway. A few years afterwards, the submission of Iceland was completed, but under conditions which still maintained their rights and their commerce. In 1280, Magnus, the successor of Haco, gave to the island the code of laws well known by the title *Jonsbok*, which was no more than a revised copy of the ancient laws.

Transference to Denmark.

The last political change which occurs in the history of Iceland, was its transference with Norway to the crown of Denmark in the year 1380. A period of tranquillity, during which rank and property became more equalized, and trade was almost wholly transferred to other nations, succeeded; and a feeling of dependence checked enterprise, while vigour and activity were gradually lost. In the year 1482, a pestilence carried off nearly two-thirds of the population; and another broke out towards the close of the century. In addition to these calamities, the Icelanders were at this period exposed to the incursions of pirates,

Calamities at this period.

who plundered their property, committing frequent murders, and carrying off the inhabitants. "These events," says Dr Holland, "which concurred with the causes before described, in depressing the spirit of the people, and destroying the strength and prosperity of the country, are recorded in the annals of Iceland with an affecting and almost painful simplicity. No attempts are made to excite a sentiment of commiseration, beyond what humanity would of itself yield to the recital of such complicated evils. We are told that whole families were extinguished, and districts depopulated, by the virulence of the disease; that the learned, the pious, the wealthy, and the powerful, all dropt into a common grave; that the labours of industry ceased; that genius and literature disappeared; and that the wretched remnant of the Icelanders, scarcely themselves saved from destruction, sunk into a state of apathy, superstition, and ignorance. In pursuing his melancholy narrative, the historian sometimes looks back to the former celebrity and splendour of his country; but he goes no farther; and all beyond is left to the feelings and imagination of the reader."

The Introduction of Popery.

But the decline of literature, and of the national character of the Icelanders, may be traced to more remote causes. Europe began to emerge from darkness and barbarity, and the continental nations gradually rose into equality in learning. The poets and historians of Iceland were therefore received with less distinction. The errors, superstitions, and tyranny of the church of Rome, broke in upon the pure and peaceful worship of Iceland about the end of the 12th century. The levying of Peter's pence, and raising money by indulgences, were not warded off by the poverty of the people, who were oppressed even by the native bishops. From the 13th to the 16th century, the annals of Iceland present nothing of interest; being filled with records only of the depression of all mental exertion, and of physical calamities.

Of the reformed religion.

The reformation of religion, and the introduction of printing, by the establishment of a press at Hoolum about the year 1530, seemed to be the dawn of renewed life to Iceland.

The reformation was not effected without violence. John Areson, bishop of Hoolum, was the most strenuous and violent opposer of the introduction of the Lutheran doctrines. He assembled a body of armed men, and marching southward, attacked and seized Einarson, bishop of Skalholt. He was arrested himself, however, the following year, by the order of Christian III. in whose continental dominions the reformed religion had been adopted. Areson, and his two natural sons, were beheaded at Skalholt; and in 1551 the new doctrines were legally established and universally received. The schools were re-established; but so great had been the depression of learning, that it was found difficult at first to procure men of sufficient knowledge to superintend them.

Now that science began to illuminate the rest of Europe, we cannot expect to find the former condition of Iceland restored, nor even the progress of knowledge keeping pace with that of other countries. The physical evils to which Iceland is exposed operated with greater effect than before; and though we can enumerate several eminent individuals whose writings are creditable and useful, yet their literary fame has seldom stepped beyond their native island.

To the zeal of Thorlakson, bishop of Hoolum, who ushered many useful works into the world from the Icelandic press superintended by himself, the people were indebted for the first translation of the Bible into their own language. It first appeared in 1584. The friend of Thorlakson, Arngrim Jonas, published twenty-six different works in divinity, history, jurisprudence, and philology, all of which exhibited very extensive acquirements. Another eminent historical writer was Biorn de Skardsaa, who published Annals of Iceland from the year 1400 to 1645, and several other works.

Attacks of foreigners.

The 17th century is destitute of any important events. At its commencement piratical incursions of the French, English, and Algerines, were not unfrequent. Of the latter, a large body landed on various parts of the southern coast, and on the Westman islands; and besides plundering their effects, murdered nearly fifty of the inhabitants, and carried 400 of both sexes into captivity. This happened in the year 1627; and nine years afterwards, when the king of Denmark had paid a ransom, only thirty-seven survivors were found. This century also disgraces Iceland by the superstitious enormities which were practised. A belief in necromancy was so prevalent, and held in such horror, that, within the period of sixty years, twenty persons perished in the flames.

Ravages of the small-pox.

The commencement of the 18th century was marked by the destruction of 16,000 persons by the small-pox. From 1753 to 1759, the seasons were so inclement, that famine carried off 10,000 people, besides vast numbers of cattle. In 1783, the most terrible volcanic eruption on record broke out from the neighbourhood of the mountain of Skaptaa, and for more than a year showered ashes on the island, and enveloped it in a thick cloud of smoke. Cattle, sheep, and horses were destroyed, and a famine ensued. The small pox again appeared; and in a few years above 11,000 people perished.

Modern authors.

Notwithstanding the calamities incident to their situation, the Icelanders have still preserved literature from decline. In later times we have the names of Torfæus, Arnas Magnæus, and Finnur Jonson, who have greatly adorned the modern literature of their country. Arnas Magnæus was the son of an obscure priest, and by his talents he raised himself in 1694, when only thirty-one years of age, to the situation of professor of philosophy in the university of Copenhagen; and soon afterwards he was appointed professor of northern antiquities. He made a splendid collection of books and manuscripts in the Icelandic language, which was almost entirely destroyed by fire in 1728. His pupil and friend Finnur Jonson has eminently contributed to preserve the literary character of his country. He was made bishop of Skalholt in 1754, and devoted a long life to the improvement and happiness of his countrymen. His Ecclesiastical History of Iceland is an admirable work, though somewhat minute in its details; and presents a degree of patient and accurate research which has seldom been equalled. The well known exertions of Professor Thorkelin, in behalf of Iceland, are happily yet continued; but the state of war in which Europe has so long been immersed, has brought Iceland into a state of suffering from which she cannot soon be relieved.

In the present times, individuals are not wanting, who exhibit, though less successfully, all the zeal of their ancestors in the pursuit of learning. Their acquirements are such as would grace any society; and when the remoteness of their situation and the multitude of their privations are considered, the picture which Iceland presents at the commencement of the 19th century, is truly worthy of admiration. The school is not now so flourishing as it used to be; but education is systematically carried on amongst all ranks;

and the degree of information possessed by the lower orders is far from being inconsiderable.

Schools.

Two schools were founded in the 16th century, one at Hoolum, in the northern quarter of the island, and the other at Skalholt. These were united and transferred to Reikiavik, towards the end of last century; and a few years ago, it was moved to Bessestadt, the former seat of the governors of Iceland. The arrangements for conducting this school have met with a severe interruption in the war between England and Denmark, and every thing has the appearance of disrepair and approaching ruin. The establishment consists of three masters and twenty-four scholars; the funds not admitting a greater number. The head master, who has the title of Lector Theologiæ, has a salary of 600 rixdollars. He superintends all the concerns of the school; the study of theology being his particular department. One of the most accomplished men in Iceland, Steingrim Jonson, was lately removed from this situation to one of the most valuable livings in the country, that of Oddè. This, it was understood, was preparatory to his becoming Bishop of Iceland, on the demise of the present bishop. His successor in the school is of the same name, and is reputed a man of great learning and talent. The second master teaches Latin, history, geography, and arithmetic; and the third, the Greek, Danish, and Icelandic languages. The bishop examines the scholars once a-year, according to a prescribed form of proceeding. After studying at this school, some of the young men go to finish their studies at Copenhagen; but by far the greatest number return to their homes, where, secluded from the society even of their own countrymen, and while the darkness of a long winter gives them leisure, they often pursue their studies, and acquire no inconsiderable extent of knowledge.

Poetry.

Societies.

Poetry is still cultivated with surprising eagerness; and the number of manuscripts of unpublished works is very great. History is not so much cultivated; and science, strictly so called, scarcely at all. In the year 1779, a society was instituted at Copenhagen for aiding the literature of Iceland, and bettering the condition of its inhabitants. This society, which comprehended among its members, not only eminent Icelanders and Danes, but many foreigners of note, published fourteen volumes of transactions, containing essays on history, poetry, agriculture, the fisheries, and the natural history of Iceland. In 1790, a project was made for transferring the society to Iceland, which occasioned such dissensions as suspended all the proceedings, and the name only of the society now exists.

A second Icelandic society was established in the island in the year 1794, by the present chief justice Stephenson, whose exertions in behalf of the literature and general improvement of his country have been indefatigable. The number of members in this society was originally 1200, and each contributed a dollar annually. The printing establishments at Hoolum and Hrapsey having fallen into decline, were purchased by the new society, and an establishment erected at Leira. From thence have issued a considerable number of works printed for the use of the society. Various occurrences, among which the war between Denmark and Great Britain had the chief influence, have occasioned the almost total extinction of this society. It is to be wished that, as war has ceased to disturb the nations of Europe, the Icelanders will be enabled again to enjoy the only recreation which their situation admits; and that their history, political and literary, of which we have given an outline, will not cease to be interesting. A new society was established in 1816, by the exertions of a very able young man, Mr Raske, under librarian in the royal library at Copenhagen; and there can be no doubt of Icelandic literature reviving under his care in disseminating, with the assistance of this Society, the means by which the Icelanders may overtake learning in the rapid progress she has made.

Government, laws, religious establishments.

The circumstances of Iceland have required little or no alteration either in the laws, or in the form of government which was established 600 years ago. The supreme authority is entrusted to an officer, with the title of Stiftamtmand, who has a general superintendence of every department. Under the Stiftamtmand, each of the four provinces into which the island is divided, is governed by an Amtmand, or Bailiff, whose duties are the same as those of their superior within their respective jurisdictions. Each province is divided into syssels or shires, over which the sysselmen preside. These officers collect the taxes, and are paid by a rate out of the amount collected. They hold courts of law; and on the whole their duty is in almost every respect the same as that of sheriffs in Scotland.

In each parish there is an officer called Hreppstiore, whose chief business is to attend to the concerns of the poor, and to assist the sysselman in the preservation of the public peace. For the decision of petty disputes among the people, there are a certain number of persons in each parish, denominated Forlikunarmen, who may be called official arbiters.

All cases, whether civil or criminal, are first brought before the sysselman, who holds a court once a-year, or oftener if necessary. In criminal cases, and in public suits, the amptmand orders the trial, after previous examinations, on behalf of the crown. From the inferior court there is an appeal to the high court of justice, which sits six times in the year at Reikiavik. This court was established in the year 1800, at which time the assemblies at Thiugvalla were abolished. The Stiftamtmand presides, but has no voice in the proceedings. There are three judges, the first is called Justitiarius, and the other two Assessors. Evidence and pleadings being heard, the causes are determined by a majority of the three judges. From this court there is an appeal to the superior courts at Copenhagen.

Punishments.

The punishment of petty offences is fine and whipping. Sheep-stealing, which is the most common offence, is punished by imprisonment and labour, for a term of three or five years, according to circumstances. A repetition of crimes brings on the offender transportation to Denmark, where he is confined at hard labour in the work-house, for the remainder of his life. The infliction of such severe punishment is, however, very seldom required. Murder is exceedingly rare; and except in cases which subject the criminal to capital punishment, he is not confined before the time of trial.

Property.

With regard to property, no entail of land is allowed. When a proprietor dies, his lands are valued and divided into shares, of which the eldest son has the choice. The daughters receive an equivalent to half the portion of a son. A wife surviving her husband, possesses half of his estate. The rights of tenants are such as would essentially contribute to the improvement of the soil, were sufficient inducements held out to encourage it. A tenant cannot be removed, unless the proprietor can bring proof that the farm has been neglected, or that the farmer has not behaved well. Leases are not common; but letting land from year to year is a frequent practice, six months notice to quit being necessary. Although a tenant cannot be removed while he conducts himself well, and manages his land properly, he may quit his farm whenever he pleases. On every farm there is a permanent stock of cattle and sheep, which is transferred from tenant to tenant, and for which a certain fixed rent is paid. As many more cattle and sheep as the farm can maintain may be kept. Besides the rent for the stock, a land rent, landskuld, is paid according to an old valuation.

Taxes. The public taxes are so inconsiderable, that they are not sufficient to defray the expences of the civil establishment. Some of the taxes are levied on property, regulated by an annual survey made by the Hrepstiores. In ancient times, the calculation was made according to the number of ells of the cloth called *wadmal*, which each person possessed or could manufacture in a year, and the tax was levied on every hundred ells. The term hundred is now applied differently, and an Icelander is said to possess a hundred when he has two horses, a cow, a certain number of sheep, a boat and fishing materials, and forty dollars in specie. When a person possesses more than five hundreds, he pays, over and above the stated tax, twelve dried fish. This tribute is called *tuind*,* and increases in proportion to the amount of property, and is allotted equally to the public revenue, the church, and the poor. There are several other taxes of small amount. The produce of the taxes being chiefly in kind, is collected by the sysselmen, and by them paid over to the landfoged, or public treasurer, who disposes of them to the merchants. The sysselmen are paid according to what they collect; and even when they are very successful, their trouble is but ill rewarded. The landfoged is subject to the chance of gain or loss in his transactions with the merchants; and he retains a third part of the whole as his salary.

The taxes for the maintenance of the poor are much more severe on the people than those levied for the public. There is no regular establishment for the poor, if we except three small buildings in different parts of the country allotted for the reception of incurable lepers. Every farmer or householder is by law obliged to receive and support his own destitute relations; and should he have none such, orphans, and those whose age and infirmities render them incapable of supporting themselves. The expence thus incurred amounts sometimes to twenty or thirty times the amount of his public taxes, when a householder does not choose to receive paupers into his family.

The religious establishment of the country consists of a bishop, provost, and parish priests. The two sees of Skalholt and Hoolum happening to become vacant at the same time, they were united in the year 1797, in the person of Geir Vidalin, who now enjoys the title of Bishop of Iceland, and is settled at Reikiavik. The island is divided into 184 parishes, in most of which there is more than one church, on account of the scattered state of the population, the average of which for each parish may be about 260. There are nineteen provosts, each of whom, besides the general superintendance of his district, has the charge of a parish.

Ecclesiastical revenue. The revenue of the bishop amounts to 1800 dollars; that of the parishes is very unequal, some being in value nearly equal to 200 dollars, on account of the goodness of the farms attached to the livings, while others, with a greater population, are scarcely worth thirty dollars. The glebes add considerably, however, to their scanty allowances; and as every farmer is obliged to furnish the priest with a day's work, and to keep a lamb for him, his farm costs him but little labour. He also receives occasional small offerings, and perquisites for officiating at marriages, baptisms, and burials. The churches are in general neat but plain buildings, constructed of wood and turf. Some of them indeed are little better than hovels, while others are large and comfortable. At Reikiavik, there is a large church built of lava, and roofed with tiles. A more elegant one of this kind is to be seen at Bessestad. The church in the Westmann islands is reckoned the most elegant.

Young men destined for the church, after they have left the school, and been admitted as probationers, earn their livelihood by fishing and other labour, and after a certain term are examined, and received into orders, after which they await a settlement, the prospect of which is often very distant, and when obtained does not yield ease and comfort. The habitations of the priests are seldom better than those of the farmers, and are not better furnished; a bed, a table, and a few chairs, and those very indifferent, being the whole stock, in addition to a few boxes and chests, in which the clothes and chattels of the family are kept. Here, however, learning and genius are to be found; and an attention to the duties of their station is displayed by the Icelandic priests, which may well excite feelings of shame among those of other countries, who have no privations to hinder them from the proper performance of their duty. The following description of a Sabbath scene in Iceland, is not more elegant and affecting than it is correct. It is from the pen of Dr Holland, and we quote it from Sir George Mackenzie's Travels. **Sabbath scene.** "The Sabbath scene at an Icelandic church is indeed one of the most singular and interesting kind. The little edifice, constructed of wood and turf, is situated, perhaps, amid the rugged ruins of a stream of lava, or beneath mountains which are covered with never-melting snows; in a spot where the mind almost sinks under the silence and desolation of surrounding nature. Here the Icelanders assemble to perform the duties of their religion. A group of male and female peasants may be seen gathered about the church, waiting the arrival of their pastor; and all habited in their best attire, after the manner of the country; their children with them; and the horses which brought them from their respective homes grazing quietly around the little assembly. The arrival of a new comer is welcomed by every one with a kiss of salutation; and the pleasures of social intercourse, so rarely enjoyed by the Icelanders, are happily connected with the occasion which summons them to the discharge of their religious duties. The priest makes his appearance among them as a friend; he salutes individually each member of his flock, and stoops down to give his almost parental kiss to the little ones, who are to grow up under his pastoral charge. These offices of kindness performed, they all go together into the house of prayer."

Commerce. The trade of Iceland has never been managed in such a way as to be of important benefit to the natives, of whom but a small number are engaged in it. The following Tables, taken from Stephenson's *History of Iceland during the 18th Century*, will serve to give a correct idea of the state of commerce.

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* Whence, perhaps, is derived our Scottish term *Teinds*.

Table of Imports into Iceland in the Year 1806.

DISTRICTS	Rye Meal.	Rye.	Barley.	Oats.	Peas.	Pearl Barley.	Barley Groats.	Buck Wheat.	Oat Groats.	Rice.	Wheat Flour.	Rye Bread.	Biscuit.	Wheaten Bread.	Brandy.			Rum.	Wine.
															Danish.	French.	Grape.		
	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Lispd.lb.	Lispd.lb.	Sk.pd. L.lb.	Sk.pd. L.lb.	Sk.pd. L.lb.	Barrels.	Barrels.	Barrels.	Barrels.	Hhds.
Reikiavik	3502	2265	27	72	777	531	128	7	8	3 10	66 0	90 15	226 4	47 4	255	43	149	28	60
Eskefiord	563	575	. . .	4	310	145	109	. . .	4	. . .	. . .	51 12	21 4	. . .	59	98	6	4	8
Eyafiord	978	2965	32	6	856	190	80	5½	4¼	1 0	28 5	35 14	19 17	0 13	105	52	25¼	12½	6½
Isafiord	1017	701	26	2	136	161½	56⅓	2	4	30 13	16 12	53 6	3 5	2 15	150	33½	32	3	12
Total	6140	6506	85	84	2079	1027½	373⅓	14½	20¼	35 7	111 1	231 7	270 10	50 12	569	226½	212¼	47½	86½
												Barrels.	Barrels.						Pipes.
In 1630	4501	. . .	. . .	. . .	17	83	. . .	. . .	. . .	. . .	. . .	352	93	. . .	262	. . .	. . .	. . .	13¾
1743	8038	. . .	. . .	. . .	52	135	. . .	. . .	. . .	. . .	. . .	1239	684	. . .	722	14	12½	. . .	57⅕
1779	10665 Rye and Barley.	475	1138	98	133	367	. . .	. . .	. . .	. . .	. . .	986	422	. . .	1160	36⅔	. . .	18	71

DISTRICTS	Vinegar.	Mead.	Beer.	Malt.	Coffee.	Sugar.	Treacle.	Tobacco.	Paper.	Soap.	Salt.	Iron.	Tar.	Coal.	Hemp.		Fishing Lines.	Cable.	Twine.
															Hackled.	Unhackled.			
	Hhds.	Barrels.	Barrels.	Barrels.	Sk.pd. L.lb.	Sk.pd. L.lb.	Sk.pd. L.lb.	Sk.pd. L.lb.	Reams.	Firkins.	Barrels.	Sk.pd. L.lb.	Barrels.	Lasts Bar.	Sk.pd. L.lb.	Sk.pd. L.lb.	Pieces.	Pieces.	Sk.pd. L.lb.
Reikiavik	5	24	7	10	13 15	24 17	13 14	96 19	63	46	842	170 13	159	26 4½	27 0	17 6	7117	1122	4 8
Eskefiord	1	9	. . .	11	4 10	10 0	4 6	52 5	25	1	325	5 4	31	9	. . .	. . .	817	. . .	0 3
Eyafiord	2	17	34½	18	2 7	6 13	5 10	44 3	65	7	549	2 13	13	2 17	1 16	1 16	907	. . .	0 1
Isafiord	2¼	3	11	. . .	6 6	7 5	1 13	44 13	4	1	862	21 14	116	3 0	0 3	0 3	3630	23	2 0
Total	10¼	53	52½	39	26 18	48 15	25 3	238 0	157	55	2378	200 4	319	32 12½	27 4	19 5	12471	1145	6 12
In 1693	. . .	216	. . .	38	. . .	. . .	. . .	. . .	. . .	. . .	834	781 0	61	. . .	. . .	. . .	34412	. . .	9 1
1743	. . .	67	. . .	12	. . .	. . .	. . .	20 10	. . .	. . .	1864	272 0	147	. . .	. . .	. . .	. . .	. . .	. . .
1779	. . .	67	. . .	213	10 7½	27 0	. . .	256 15	218	lbs. 2054	2954	310 0	291	22 0	15 0	. . .	12890	. . .	9 5½

Iceland.

Table of Exports from Iceland in the Year 1806.

Districts.	Fish.	Dried Fish. Stock Fish.	Salted Cod in Barrels.	Salted Cod in bulk.	Oil.			Fish Liver.	Tallow.	Salted Salmon.	Wool.		Woollen Yarn.	Stockings.
					Cod.	Shark.	Seal.				White.	Mixed.		
	Sklb. L.lb.	Sklb. L.lb	Barrels.	Sklb. L.lb.	Barrels.	Barrels.	Barrels.	Barrels.	Sklb. L.lb.	Barrels.	Sklb. L.lb	Sklb. L.lb.	Sklb. L.lb.	Pairs.
Reikiavik	1606 3	1809 2	66	2 8	495½	110	10	12	149 15	28½	327 14	58 14	0 9	19,567
Eskefiord*	....	....	28	....	36	79½	...	...	151 10	....	92 12	56 4	4 3	26,186
Evafiord	30 18	....	36	....	17	561	...	...	278 6	....	166 17	11 5	24 11	79,900
Isafiord	364 5	524 16	20	7 13	259	913	14	...	19 8	....	92 5	7 18	....	56,023
Total	2001 6	2333 18	150	10 1	807½	1663½	24	12	598 19	28½	679 8	134 1	29 3	181,676
									Barrels.					
In the year 1624	843 0	5817 0	444½	....	930	...	...	...	337	5½				
1630	207 0	2823 0	142	....	1445¼	...	...	...	133¾	5				
									Sklb. L.lb.					
1743	992 0	5380 0	658	....	471	...	...	...	475 6	3	265 0			
1779	3612 0	4901 0	1905	....	1402	...	...	...	609 8	16½	23 0			

Districts.	Frocks or Jackets.	Mittens.	Wad-mal.	Lamb Skins.	Salted Sheep Skins.	Small Shark Skins.	Fox Skins.	Swan Skins.	Goat Skins.	Elder Down.	Feathers.	Iceland Moss.	Rein Deer Horns.	
		Pairs.	Pieces.							Sklb. L.lb.	Sklb. L.lb.	Barrels.		
Reikiavik	130	77,203	3	2442	190	233	63	52	....	1 11	14 12	4		
Eskefiord	345	6,737	8	642	23,516	...	32	...	....	0 19				
Eyafiord	5790	57,798	...	3723	9,091	...	15	...	115	0 19	....	....	153	
Isafiord	17	141,338	...	620	6	1335	35	3	....	3 7½	12 1	0¼		
Total	6282	283,076	11	7427	32,803	1568	145	55	115	6 16½	26 13	4¼	153	
			Ells.											
In the year 1624	....	12,232	12,251											
1630	....	13,004	4,042											
1743	1211	110,507	876											
1779	884	186,624	521	20,722	...	...	406	98	....	6 0	2 9			

A volume was published, in the year 1787, at Copenhagen, by Royal authority, entitled *Regulations for the Trade and Navigation of Iceland.* This was at the time when the trade was declared free; and the volume contains Tables of the Exports of Iceland from 1764 to 1784; but we have not had an opportunity of copying them.

* Eskefiord is situate on the same bay as Rodefiord.

Iceland.

Weights and measures.

WEIGHTS AND MEASURES USED IN THE ISLAND.

Liquid Measure.

1 pipe contains	3 ame	or	120 gallons.
1 oxhoved (hogshead)			60
1 ame	4 ankers	or	40
1 tonde	3 ankers	or	30
1 anker	5 kutting	or	10
1 kutting	4 kander	or	2
1 kande	2 potter	or	0½
1 pot	4 pæle	or	2 pints.
1 pæle		or	0½ pint.

Corn Measure.

1 tonde (barrel) = 8 skepper, or 4 English bushels.
1 skepper (½ bushel) contains 18 potter or quarts.

Cloth Measure.

1 alen or yard = 25 English inches, or two-thirds of a yard, and is divided into quarters.

Weights.

1 skippund = 20 lisepund, or 3 cwt. 22 lb. English.
1 lisepund = 16 pund, or 17 lb.
1 pund = 16 onzer, or 1 lb.

The Danish pound is 12 per cent. heavier than the English.

Farm houses.

We have already mentioned the laws respecting property, and the conditions in which a tenant holds a farm. A farm house in Iceland has the appearance of a small village; the dwelling house, all the out-houses, and the hay yard, being within a general inclosure of turf, four or five feet high, and seldom less than five or six feet thick. The doors to the different apartments are generally arranged on the south side, and each has a sort of pediment above it, surmounted by a vane. The access to the dwelling house is by a long narrow passage, into which the different rooms open. Each room is separated from the next by a thick partition of turf, and has also a separate roof, through which the light is admitted by bits of glass or skin. The principal rooms of the better sort of people have small glazed windows in front. Ventilation is not attended to, warmth being the chief object in the construction of the houses; and the consequence is, that the smell is to a stranger almost insupportable. The houses are generally built on a rising ground, and in the middle, or as near as possible to the land devoted to the hay crop. On this land, which is in general much broken into little knolls or hillocks, the manure is spread in the month of May; and about the end of July the grass is cut, when it is scarcely more than six inches long. In this operation a very short scythe is used, and the Icelanders cut with it very neatly and expeditiously. The hay is kept chiefly for the cows, though in very severe weather the sheep and horses get a small share. As soon as the crop near the house is secured, the farmer gives a feast; and when the whole is safe in the hay yard, a fat sheep is killed, and another feast takes place.

Farm-houses.

Cows.

The cows are very like the Scotch Highland sort, known in England by the name of Kyloes. No attention is paid to breeding stock; and in general we find the best stock on farms where the winter food is in greatest plenty. During the summer there is great abundance of pasturage.

Sheep.

The sheep appear to be a mixed breed, carrying long and coarse wool. The wool is removed by pulling it when it appears loose. A great quantity of mutton is salted for exportation in the northern districts.

Cheese and butter.

Very little cheese is made, butter being the chief object in the dairy. It is barrelled without salt, and is thus kept several years. The older it is the more it is prized. In this state it reaches a certain stage of rancidity, beyond which it does not pass; and it is wonderful how long it keeps.

Horses.

The horses are of a small breed, but stout, and very hardy. Those used for riding are trained to what is called pacing; and, where the ground is tolerably smooth, they go very swiftly, the motion being very easy and pleasant to the rider. The statistical information contained in the following Tables, was partly furnished to the writer of this article by Bishop Vidalin, and is partly taken from Stephenson's *Iceland in the 18th Century.*

TABLE *of the Population of Iceland in the Year* 1801.

NAMES OF DISTRICTS.	Farms.	Families.	Farmers.	Hirelings having grass.	Hirelings without grass.	Priests.	Civil Officers.	Males.	Females.	Total Inhabitants.
Southern Amt.										
East Skaptafells Syssel	53	126	88	29	—	7	2	400	511	911
West ditto	133	248	214	26	1	8	1	678	861	1539
Rangaavalle and Westmann Isles	374	664	530	104	13	14	4	1876	2311	4187
Arnes Syssel	418	709	495	153	40	21	1	2053	2572	4625
Guldbringe and Kiose Syssels .	256	704	302	132	245	13	12	1949	2066	4015
Borgarfiord Syssel	227	285	250	9	11	9	4	854	1028	1882
Western Amt.										
Myre and Hnappadals Syssels	180	235	202	13	9	9	2	694	784	1478
Snæfell Syssel	270	652	337	148	167	10	2	1627	1914	3541
Dale Syssel	181	231	208	10	4	7	3	699	893	1592
Bardestrand Syssel	203	374	332	12	21	10	2	1161	1332	2493
Western Isafiord Syssel	123	261	236	5	13	7	1	884	966	1850
Northern Isafiord Syssel	170	305	255	20	22	7	1	961	1076	2037
Strande Syssel	118	150	140	3	—	6	1	438	544	982
Northern and Eastern Amts.										
Hunavatn Syssel	375	433	405	3	6	20	2	1288	1592	2880
Skagafiord Syssel	412	492	459	9	2	20	3	1385	1756	3141
Eyafiord Syssel	448	535	499	6	13	17	3	1572	1881	3453
Norder Syssel	387	451	420	1	7	23	1	1337	1665	3002
North Mule Syssel	217	267	222	32	3	11	1	781	1981	1762
Southern Mule Syssel	211	279	231	25	18	12	—	839	998	1837
Total . . .	4761	7401	5821	735	590	231	45	21476	25731	47207

This Table, exhibiting the state of the population of Iceland in the year 1801, is taken from the register of the Bishop, to whom returns are regularly made by the priests. The original Table contains also a detailed statement of the ages of the whole population of the island, of which the following is the general result:

	Males.	*Females.*
Under 10 years of age	6231	6300
From 11 to 20	3207	3299
21 . 30	3385	4060
31 . 40	3190	3901
41 . 50	1838	2460
51 . 60	1707	2453
61 . 70	1162	1842
71 . 80	592	1096
81 . 90	158	285
91 100	6	35
Total	21476	25731

The Bishop not having made up Tables from the most recent returns, could only furnish us with the general results of the years 1804 and 1808. He said that the population was on the increase.

It appears that the excess of the female population of the island is very considerable; and that the average longevity of the women is greater than that of the men. The population has varied little during the last 100 years.

In the year 1703 it amounted to	50,444
1770	46,201
1783	47,287
1801	47,207
1804	46,349
1808	48,063

TABLE *illustrative of the Political Economy of Iceland, in the Year 1804, taken from Mr Stephenson's 18th Century.*

Names of Districts.	Population.	Working Men.	Hired Servants.	Cows.	Heifers with one Calf.	Bulls and Oxen.	Calves.	Milch Ewes.	Rams and Weathers above one year old.	Rams, Ewe-Lambs, and Weathers, of one year old.	Lambs.	Horses & Mares broken in.	Horses & Mares not broken in.	Colts and Fillies.	Boats with 8 & 10 oars.	Boats with 4 & 6 oars.	Small Boats.	Number of Gardens in use.
East Skaptafell . .	853	94	11	391	34	29	56	2241	408	1154	2024	615	97	78	—	19	—	5
West Skaptafell . .	1499	224	17	747	102	150	116	3230	371	1989	3153	1209	323	135	4	1	3	13
Westmann Islands	157	42	5	39	8	1	—	268	88	165	225	39	1	—	2	11	3	1
Rangaavalle	3854	358	48	2074	251	174	325	8079	744	3750	7479	2889	949	468	9	8	2	23
Aarnes	4398	505	105	2371	336	176	375	8550	700	2944	7050	2886	551	255	35	30	21	17
Guldbringe	2866	915	739	490	36	6	50	1022	140	500	974	745	38	30	9	225	252	139
Kiose	1088	135	37	444	31	110	109	1449	244	979	1487	469	203	94	2	16	31	13
Borgarfiord	1796	260	130	764	69	94	120	3870	426	1841	3250	900	249	125	3	25	88	9
—																		
Myre & Hnappadals	1924	276	41	701	94	55	113	3898	372	1697	2929	1112	218	105	1	19	17	9
Snæfellsnes	3541	346	598	671	55	16	56	1995	339	214	1671	670	92	27	67	118	50	8
Dale	1506	128	41	408	50	18	60	1662	218	867	1471	543	173	58	10	31	5	1
Bardestrand	2225	448	123	665	61	31	76	3374	610	1809	2443	550	45	25	4	115	90	17
Isafiord	3887	418	60	965	62	46	84	6182	1911	4048	5582	493	54	39	41	119	129	16
Strande	895	89	26	201	4	4	16	2489	35	255	942	324	7	8	—	30	67	—
—																		
Hunavatn	2873	260	79	894	87	52	86	11310	479	2620	4370	1885	294	137	—	42	3	1
Skagafiord	3080	209	29	1086	114	29	52	9598	641	2299	1322	1462	432	165	8	40	17	2
Eyafiord	3234	189	128	1012	74	22	116	9115	263	1842	6069	1241	177	109	10	56	20	9
Norder	2928	246	43	677	29	28	74	10013	616	3106	3217	945	38	32	2	68	55	—
Northern Mule . .	1845	285	30	475	28	52	75	8039	1116	3735	6549	733	71	73	1	40	11	2
Southern Mule . .	1900	365	59	520	31	39	83	5921	1082	2910	4779	663	97	79	—	55	23	8
Total	46,319	5,792	2,349	15,595	1,556	1,132	2,042	102,305	10,803	38,724	66,986	20,373	4,109	2,042	208	1,068	887	293

The population of Reikiavik in the year 1806 (including 27 prisoners in the Toght-Huus) was 446. Of this number 134 were working men. Belonging to the town there were 35 cows, 2 sheep, 92 horses, 3 large boats, 26 of a middle size, 9 small ones, and 17 gardens.

		Occupied Farms.
[*] 1703	50,444	4039
1770	46,201	3647
1783	47,287	3567
1801	47,207	4661
1804	46,349	—

	Cattle.
	35,860
	30,096
A. D.	21,457
1784 . .	[†]9,986
	20,325

	Sheep.
A. D.	279,812
1760 . . .	491,934
1770 . . .	112,809
1784 . . .	42,243
	218,818

	Horses.
A. D.	26,909
1770	32,689
1783	36,408
1784	8,395
	26,524

A. D.	1770	408	811	650	1,869	Total.
	1804	According to the above Table			2,163	

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[*] In the year 1707, the small-pox destroyed 16,000 people. Between 1753 and 1759, famine carried off 10,000, and vast numbers of cattle perished.

[†] In the year 1783, the great eruption from Skaptaa Jokul destroyed a great number of cattle; but the loss in this Table appears to be exaggerated.

Manners and customs.

The manners of the Icelanders are exceedingly simple, and respectful as well to each other as to strangers. The women, however, appear to be rather restrained, it being customary for them to wait at table, and do every little office usually committed to servants in our own country. There are but few peculiar customs, and those not of particular interest. The depressed state in which the Icelanders are kept by the wretched policy of Denmark, effectually subjugates those dispositions which, in countries where freedom teaches men to be independent, quickly display themselves in innocent and recreating amusements. The sole occupation of the Icelander is to provide food for the winter season; and when the rigour of an arctic winter confines him to his hut, and the sun scarcely sends a ray to illuminate the dreary scene around, he amuses himself with the tales of elder times, when his country stood high, and her learned men and warriors were honoured in every European court. That our lamentations are vain, that the Icelanders are condemned to misery yet greater than that they now endure, we fear is too true.

Topography.

A country less inviting to the enterprize of adventurers than Iceland can scarcely be imagined. The mountains covered with eternal snow, the plains devastated by volcanic fire, seem to present no attractions. The country in general is mountainous; but in some districts, particularly those extending from the south to the north coasts, nearly through the centre of the island, there are extensive plains, for the most part dreary wildernesses, and covered with herbage only near the sea, or where morasses have formed. The highest mountains are on the east and west sides of the island. They are in groups, seldom in chains; and those called *Jokuls*, which are covered with perpetual snow, are chiefly, if not all, volcanic. The coast, except towards the south, is much indented by arms of the sea; but with the exception of Havnefiord, on the south-west, there is scarcely a safe winter harbour.

Rivers and lakes.

There is a considerable number of lakes in different parts of the island, some of which are of great extent. The principal are those called Thingvalla Vatn, My Vatn, and Fiske Vatn. The first of these is about ten miles long, and from three to four broad. There are many large rivers in Iceland, formed by the melting of the snow on the Jokuls; and these have all a turbid appearance; some of them being so white as to resemble milk diluted with water, have received the name Huit-aa, or the White River. Several emit a fetid smell, particularly when they issue from the snow. Besides these large rivers, there are many smaller, the water of which is transparent. They rise from the lower grounds. Along almost the whole southern coast eastward from Eyarback, where the great river Elvas empties itself into the sea, there are extensive shoals, formed, no doubt, by the depositions of the rivers proceeding from the great range of Jokuls to the eastward of Mount Hekla.

The population is chiefly established near the most convenient harbours, and where fish abound. Reikiavik is the principal place, and the seat of government. It has been chosen for the convenience of the harbour, and of the gravel beach, a thing of rare occurrence in Iceland. The country around is as bleak as can well be imagined.

Volcanoes.

It is impossible to travel many miles in Iceland without meeting the frightful effects of subterraneous fire. This miserable country has been exempted from the calamities of an eruption since the year 1783, at which time the most dreadful, ever recorded, took place. On the first of June of that year, the southern districts were shaken by violent earthquakes. These continued, and were most alarming on the 8th, when smoke was seen rising among the mountains called Skapta Jokul. There appeared several eruptions from different spots, at considerable distances from each other. The showers of ashes and stones, the terrible noises, and the darkness in which the country was involved, foreboded an awful calamity. The large river Skaptaa was dried up, and the channels filled with liquid fire. Habitations were devoured, and the green pastures buried; and the wretched inhabitants had the dismal prospect of being overwhelmed by the lava, or of perishing by famine. The lava was for a time retarded by its flowing into a lake; but its progress was not stopped, when a fresh eruption took place on the 18th of June. The lava having divided, and begun to move in various directions, the scene became more and more dreadful. On the 22d fresh eruptions broke out, and continued multiplying till the 13th of July. On the 20th, the lava towards the western side of the district of Skaptaa-fell ceased to flow. To the eastward, on the 3d of August, smoke was seen to rise from the mountains towards the north; the waters of the great river Hversfliote were dried up; and on the 9th of August the lava approached by the channel of the river, overflowing in one evening an extent of four miles. This eruption continued longer than the first; and it is said that a fresh one happened in February 1784.

Mount Hekla.

Mount Hekla has been quiet for half a century. The volcanic fire appears to have been most active in the south-east and north-east districts, during the last century. Previous to the eruption of 1783, flames were seen rising from the sea, about 30 miles off Cape Reikianes, and several small islands appeared which afterwards sunk, leaving however a sunken reef, which renders the navigation round the Cape dangerous in thick weather. Similar phenomena have appeared in other parts of the world; the most recent being the eruption off St Michael's, one of the Azores, which produced the island which was called Sabrina.

Hot springs.

The greatest curiosities which Iceland presents, are the springs of hot water, many of which are justly considered as among the greatest wonders of the world. They are, we believe, greatly more abundant in this than in any other volcanic country; but the interest which the number and variety of these hot springs excites in a person who never saw any thing similar, is quickly lost in the feelings which are roused on beholding the magnificent and tremendous explosions of the Geysers. These extraordinary fountains are situate about sixteen miles north of Skalholt, on the east side of a small ridge, separated from some high mountains by a narrow swamp. Besides the principal fountains, there are a great number of boiling springs, cavities full of hot water, and several from which steam issues. There are also some places full of boiling mud, grey and red.

Great Geyser.

The silicious depositions of the water of the Great Geyser, have formed for it a bason 56 feet in diameter in one direction, and 46 in the other; a projection from one side, causing the circumference to deviate from the perfect circle. In the centre of this bason is a cylindrical pipe or pit, ten feet in diameter. Through this pit the hot water rises, gradually filling it and the bason, after which it runs over in small quantities. At intervals of some hours, when the bason is full, explosions are heard from below, like the firing of cannon at a distance; and at the same time, a tremulous motion of the ground is felt around the bason. Immediately the water rises in a mass from the pit, and sinking again, causes the water in the bason to be agitated and to overflow. Another and stronger propulsion follows, and clouds of vapour ascend; at length strong explosions take place, and large quantities of steam escaping, the water is thrown to a great height, generally from 30 to 90 feet. The steam coming in contact with the air is condensed into vapour, thick clouds of which are tossed and rolled one over another with great rapidity, the whole forming a very singular and magnificent exhibition. After continuing for some time, the explosions cease, when the bason and pipe are found empty. Bursts of steam sometimes take place when the water is rising, without any warning by subterraneous noise. These phenomena are caused evidently by the production and confinement of steam in cavities, so formed, that when the accumulation arrives at a certain point, the pressure of the water opposing its escape, is overcome, and the water is thrown out before it.

New Geyser.

The New Geyser, as it was called by Sir John Stanley, is about 130 paces from the great one. It is an irregularly shaped pit, nine feet in its greatest diameter. About 20 feet below the orifice, which is not surrounded by an accumulation of silicious matter as the other, the water is seen in great agitation. At irregular intervals, the water is tossed out of the pit to a great height, followed by a prodigious rush of steam, accompanied by a roaring noise. The force is so great that, even when there is a good deal of wind, the vapour forms a perpendicular column nearly 70 or 80 feet high; and when large stones are thrown into the pit, they are shivered to pieces, and thrown out to a height often far beyond that of the jet of vapour and water.

At the time Mr Hooker saw it, there was a greater quantity of water than when either Sir John Stanley, or Sir George Mackenzie witnessed its eruptions. Indeed, what Mr Hooker has described as a column of water, Sir George Mackenzie describes as one of vapour. When we consider the immense power of the agent which sets these grand waterworks in play, it is by no means difficult to suppose frequent alterations in their movement and appearance. The destruction of a natural valve, or a slight change in the configuration of the subterraneous pipes and cavities, might occasion variations in the phenomena from time to time.

Singular spring called Tunguhver.

The most curious of all the springs in Iceland is the *Tunguhver*, in the valley of Reikholt. Among a great number of boiling springs, are two cavities within a yard of each other, from which the water spouts alternately. While from one the water is thrown about ten feet high in a narrow jet, the other cavity is full of water boiling violently. This jet continues about four minutes, and then subsides, when the water from the other immediately rises in a thicker column to the height of three or four feet. This continues about three minutes, when it sinks, and the other rises, and so on alternately. It is difficult to imagine the structure of the cavities which occasion this irregular alternation; nor would it be easy to construct a piece of mechanism, of which steam is the prime mover, to imitate the phenomena.

In the middle of the river, which runs through the valley of Reikholt, is a small rock, from the top of which hot springs issue. At Reikholt is a bath, which was constructed 600 years ago by the famous Snorro Sturleson. It is fourteen feet in diameter, and six feet deep, being supplied with hot water from a spring about a hundred yards distant, by means of a covered conduit, which has been much damaged by an earthquake. There was also a spring of cold water brought to it, so that any desired temperature might be obtained.

On the sulphur mountains, in the district of Guldbringè, are a number of jets of steam, and natural cauldrons of black boiling mud; and there is scarcely a district in the whole island without such indications of subterraneous heat, which must occasion the most singular contrast with the winter snows and ice, through which, at that season, they rise.

At Reykum in the south, and near Husavik in the north, are hot springs, which come next to the Geysers in magnificence.

Natural history.

Quadrupeds.

The zoology of Iceland presents nothing remarkable. Of indigenous quadrupeds the number is very small, and must be limited to the fox, of which there are two varieties, the Canis lagopus, and Fuliginosus. The rein-deer, the rat, and the mouse, have all been imported; as well as the domestic animals the dog, the cat, the goat, the sheep, the ox, and the horse. Polar bears are occasional visitors, coming from the ice, which takes ground on the north and east coasts during winter. As soon as they appear, they are pursued and destroyed. The skins of the foxes, particularly those of the *Canis fuliginosus*, or blue fox, is a valuable article of commerce. The rein-deer are wild, and are derived from an original stock of three, which were all that survived of some that were sent from Norway in 1770. Instead of being serviceable, they often destroy the grass which is preserved for hay.

Fishes.

Several species of seals frequent the shores in considerable numbers; but they are not much sought after.

Whales are seldom seen on the coasts of Iceland; but that variety of Delphinus, which we mentioned in the article Faroe, named in Orkney the ca'ing whale, appears frequently in large shoals. The shark is common on the coasts, and is taken by large hooks fastened to an anchor by chains and strong lines. Of the skins, shoes are made; and they are valuable to the inhabitants of some districts for the oil which they afford, and also for their flesh.

Birds.

The cinereous eagle, or erne, is very common. The Iceland falcon, formerly so much prized, is now seldom seen, though it has not for many years been molested.

Ravens are found in great numbers near every habitation on the coast, watching for the offal of fish. They breed in the cliffs at a considerable distance from the shores.

The snow-flake, wheatear, white wagtail, golden plover, snipe, and whimbrel, together with the ptarmigan, are the other principal land birds of Iceland.

Eider ducks.

Every kind of water fowl common to northern latitudes is found on the coasts of Iceland, and on the lakes. Swans frequent the lakes and swamps in great numbers. But of all the varieties which breed in the country, the eider duck is, from its habits and usefulness, the most remarkable and valuable. Early in June, these birds collect in great numbers at every place adapted for making their nests, and where their food is in plenty. The nests are formed on the ground, generally in hollows among the grass, of straws mixed with the down which they pluck from their breasts. There is always a quantity of down round the nest, sufficient for covering the eggs when the ducks go to feed, which they do regularly during the time of low water, when they can get at the shell-fish among the seaweeds. At this time these birds lose all their wildness, and suffer the enemy, avoided by all the lower creation, man, to approach, and even to touch them, and to lift them from their nests. The drakes are not so fearless; but they frequently remain near the nests, and express their displeasure when any one touches them. As soon as the young ones have left the shells, and get to the water, the eider ducks become as wild as any other bird, and in a month or six weeks almost all of them disappear, and it is not known to what place they resort. The nests are robbed of a certain number of eggs, and of the down. The former are a great luxury to the natives, and the latter is a valuable article of export. It is part of the employment of the women during winter, to pick the straws and refuse from the down.

Fishery. It is from the sea, however, which the Icelanders derive their chief subsistence and profit. The cod is very plentiful on the coasts; and formerly the fishery of Iceland was prosecuted by the English and French with great success. The fishery commences early in February; and the inhabitants of the interior move at that time towards the different fishing stations, and travel in darkness through the snow. They engage with the owner of a boat to obey every call for fishing, and to assist in the general labour, and he receives a share of the fish in return for the use of the boat. When a sufficient quantity has been taken, the people from the country return home, leaving the care of drying the fish to the inhabitants of the fishing villages. In June, the farmers carry to the trading stations all their marketable commodities, to be exchanged for necessaries and a few luxuries, and on their return they carry home their fish to serve them during the next winter. The haddock is also taken in great plenty, and grows here to a very large size. The cod is chiefly cured for exportation, and the haddock for home consumption. The ling, skate, hollibut, flounders, and the cat-fish, are common, and are likewise dried for winter use. The skate is the least esteemed of all the other fish, and is seldom if ever eaten fresh. Herrings are taken on the north coast; but though vast shoals of them frequent the bays, this branch of the fishery is not much attended to. Sharks are an important object on the north-west coast, and a considerable quantity of oil prepared from them is exported.

Those travellers who have visited Iceland, having been there only during a short summer, and their time having been almost entirely occupied with viewing the country and its more prominent curiosities, have not pursued zoological enquiries very far. From what Mr Hooker says, the insect tribes seem to offer something new. That gentleman has furnished us with a very complete botanical catalogue, to which we refer such of our readers as desire particular information regarding the vegetable productions of this remote island. The birch is the only tree which withstands the rigours of an arctic winter; but its growth is limited, in the most favourable situations, to five or six feet.

Mineralogy. The greatest portion of Iceland is mountainous; the highest elevations appearing on the east and west sides, while extensive plains appear, with little interruption, to extend from north to south across the island. The highest mountain the height of which has been ascertained, is said to be about 5500 feet. The Sneefell Jokul, which bounds the western extremity, and has been esteemed by the natives the highest in the island, was measured trigonometrically by Sir George Mackenzie, and ascertained to be 4558 feet above an extensive beach formed near Stappen. It is probable that none of the Jokuls exceed 6000 feet. Many of them are very extensive, forming long ridges; a shape which, were it not for their characteristic covering of perpetual snow, would tend to lessen their apparent elevation to the eye. The height of the curve of congelation may be taken for Iceland, at 2829 feet, as a mean; and thus a tolerable idea of the heights of the mountains may be had, when an opportunity occurs of observing the snow line on the Jokuls. From what has been actually observed, and from the best information, it appears that all the Jokuls are of volcanic formation; in other words, that they are either active or extinct volcanoes. The greatest height of the other mountains which are not volcanic, does not much exceed 2000 feet. They are all of the trap formation; and this does not appear to reach a great height in the northern hemisphere. In Faroe, its greatest elevation appears to be somewhat above 3000 feet. As far as has yet been discovered, the formations in Iceland are limited to the flœtz trap, volcanic, and alluvial, and those of Faroe to the first and last. The flœtz trap of Greenland, that of Iceland, and of Faroe, are probably connected; and the two last may be supposed to rest on primitive rocks, as the Greenland formation has been ascertained to do.

The beds of trap are inclined for the most part at a small angle to the horizon, dipping to the eastward of the meridian; and in this respect they agree with those of Faroe.

The beds consist chiefly of amygdaloid, containing zeolite, chalcedony, opal, quartz, arragonite, and calcareous spar. The base of the amygdaloid is for the most part wacke. There are many varieties of greenstone, from the most compact to that whose component parts are of large size; felspar and augit occurring in crystalline masses of from a quarter to half an inch. Greenstone occurs also in veins, and it is in this form only that basalt has been observed in Iceland and Faroe. The veins of Iceland, and some of those in Faroe, were found to have their sides vitreous, somewhat resembling black pitchstone, and gradually passing into the character assumed by the mass of the veins. Greenstone occurs columnar. In the island of Vidöe, there are columns formed of tables several inches in thickness, and from three to five feet in diameter; and in some instances, from decomposition, easily separable from each other. Some of the tabular columns have the appearance of the tables being composed of oval concretions, rendered visible by decomposition.

Beds of tuf of large dimensions are frequent; and if they are to be denominated from the formation in which they occur, they may be called trap tuf. The resemblance which they bear to volcanic tuf is, however, in many cases remarkably strong. They occur most frequently among a class of rocks, which have been distinguished by Sir George Mackenzie by the name submarine lavas; and we shall now quote from that gentleman's account of Iceland, the description of these rocks. He has selected a particular mountain which presented a precipitous face about 2000 feet high, and which, but not without considerable difficulty and hazard, he and his fellow-travellers ascended, taking specimens from each bed, a series of which is preserved in the cabinet of the Royal Society of Edinburgh. "The mountain of Akkrefell stands perfectly detached, being separated from the mountains of Esian by the Hvalfiord, and from those towards the north by a flat swampy country extending several miles. It is bounded on the south and west partly by the Faxefiord, and partly by the Borgarfiord. On the southern side the structure of the mountain is exposed almost from top to bottom, in a precipice about 2000 feet high. From Indreholm the beds appear horizontal; but on going round the mountain we found that they dipped towards the north-east, forming a considerable angle with the horizon. From the sea at Indreholm to the foot of the mountain, there is a flat swamp extending more than a mile.

To the height of about 800 feet, the mountain of Akkrefell is composed of beds generally from ten to twenty, and sometimes extending to forty feet thick, of varieties of amygdaloid and tuffa. The latter occurred sometimes not more than a foot in thickness, and was interposed between the beds of amygdaloid. When it was so thin, it much resembled red sandstone. While scrambling among the loose stones, we had met with quantities of slags, for which we were at a loss to account, as we had been told that nothing like lava existed on or near this mountain. Its appearance indicated nothing volcanic; and our surprise on finding any undoubted productions of fire in such a place was increased, when, at the height above mentioned, we saw the under part of a bed completely slaggy, and bearing the most unequivocal marks of no slight operation of fire; and on continuing to ascend, we found every bed, excepting those of tuffa, one of which was at least forty feet thick, presenting the same appearances, and many of them having an amygdaloidal character. Our astonishment was not lessened on discovering a vein of greenstone, about four feet thick, cutting these beds, and having a vitreous coating on its sides, which seems to be common to all the veins of the country. Similar beds occur in the mountains of Esian, where the most important fact connected with them was found in a mass of slag which contained calcareous spar."

The same traveller, in a memoir concerning the Faroe Islands, printed in the 7th volume of the *Edinburgh Transactions*, thus speaks of the trap rocks of that country. "The surfaces of many lavas which I passed over in Iceland, were not unlike coils of rope, or crumpled cloth; an appearance which we should expect to be assumed by any viscid matter in motion. On our first visit to the island of Naalsoe, we observed the surface of a bed of amygdaloid, which had been exposed to a considerable extent by the removal of the bed above, exhibiting an exact picture of the lavas I had seen in Iceland. At first sight, this discovery fixed instantaneous conviction on the minds of those who were with me, some of whom had never seen lava, that heat must have caused the appearance before us. We brought away a number of specimens, which are now before the Society, and which speak a language not to be misunderstood. We afterwards discovered varied examples of this crumpled surface in different parts of the country. In the vicinity of Eyde, in Osteroe, there were many instances in which the matter appeared as if, in a viscid state of fusion, it had flowed and spread itself out." These appearances were seen in different parts of Faroe. Mr Allan, in the same volume, has described the individual minerals found in the trap of Faroe, and expressed his entire conviction of its igneous origin; while, at the same time, he appears at a loss to account for the manner in which heat had operated. Sir George Mackenzie has observed, that "while the great point, the action of heat in the formation of trap rocks, seems to be demonstrated, forming a theory of the manner in which heat has operated in particular cases, is, in a general view, perhaps not absolutely necessary in the present state of geology." Indeed, the farther we advance in the study, the farther we find ourselves from the object of our search, while we continue resolved that either heat or water shall be the sole agent. To us, the most reasonable mode for geologists to follow, appears to be, to consider both heat and water as agents which have been employed in the formation of mineral substances. And we are of opinion that a third agent ought to be added, as one which universally and continually operates, we mean gravitation. The attraction of cohesion, and electricity, may also with propriety be taken into the service; and probably to form a just theory, we should give a share to every agent which can in any degree influence the economy of the globe; the atmosphere, the motion of the earth, magnetism, &c. But at present we must refrain from entering on this subject.

A very remarkable kind of mineralized wood is found on the mountain of Drapuhlid in Iceland. In external appearance, it cannot be distinguished from a mass of charcoal; yet it is very heavy. Chalcedony is observed in some specimens filling small fissures. When the carbonaceous matter is burned, a mass remains, which, when bruised, divides into fibres finer than hair, and resembling asbestos; shewing that the silicious matter had penetrated into the most minute pores of the wood. This substance occurs in a bed of tuf lying under pearl stone. This last substance occurs of a light gray colour, and also dark green approaching to pitch stone. It was found also forming the principal ingredient in a variety of tuf not before described. "It is composed chiefly of masses of black pearlstone, imbedded in a dull blackish green matrix. It contains also masses of amygdaloid, and we found a few nodules of pyrites in it, coated with pitch coal. Pitchstone occurs at Houls, and on the west side of the mountain called Baula.

Surturbrandt.

The surturbrandt of Iceland has not been seen *in situ* by a mineralogist. It has a great resemblance to black oak found in lakes and rivers in many countries. But though capable of being shaped into tables and other articles of furniture, it is not in a condition to be cut by a plane into shavings, being somewhat brittle.

For a description of the individual minerals which occur in these regions, we must refer to the 7th volume of the *Edinburgh Transactions*, and to Sir George Mackenzie's *Travels*. The silicious depositions of the Geysers and other hot springs are very interesting, but are now well known to mineralogists.

Volcanic formation.

The volcanic formation of Iceland is perhaps the most extensive in the world, covering an extent of at least 60,000 square miles. Sir George Mackenzie distinguishes three formations, which are ascribed to the action of internal heat. The oldest is that already described as submarine lavas, which resemble trap rocks more nearly both in position and structure, than any other; and which he supposes to have flowed at the bottom of the sea. The next is a class of lavas to which he has given the name *cavernous*, from its containing numerous cavities, some of them very extensive. This is supposed to be formed of rocks which have been subjected to subterraneous heat, but not removed from their original place. Many of the appearances presented by this class seem to warrant this conclusion in regard to its mode of formation; but the conjecture is thrown out merely to attract the attention of future observers of volcanic countries. The last is the ordinary erupted lava, including ejected substances. Perhaps there is no field in which the investigation of the operations of heat could be carried on with greater facility than in Iceland, the rocks are so well exposed to view. But the shortness of the season in which travelling is practicable, presents a strong obstacle. Yet we hope that some able mineralogists will repeat and extend the observations made by Sir George Mackenzie, and avail themselves of the information afforded by that gentleman.

We understand that the celebrated traveller and mineralogist Baron Von Buch, has carefully examined the Icelandic collection in the cabinet of the Royal Society of Edinburgh, and has the intention of soon communicating to the public the result of his examination of various volcanic countries.

See *Letters on Iceland*, by Von Troil; *Voyage en Islande, fait par ordre de sa Majestè Danois*, par MM. Paulsen et Olafsen; Hooker's *Tour in Iceland*, 1809; *Travels in Iceland*, 1810, by Sir G. S. Mackenzie; *Transactions of the Royal Society of Edinburgh*, vols. iii. and vii. See also the article VOLCANO, which Baron Von Buch has promised to write for this work.

ICHTHYOLOGY.

ICHTHYOLOGY is that department of natural history which treats of FISHES, classifying them according to their forms, ascertaining their haunts, describing their manners, and specifying the uses to which they may be applied. The title of the science is a compound of two Greek words, *ιχθυς a fish*, and *λογος a discourse.*

Fishes belong to that great division of animals, characterised by having an articulated skeleton, a bony cavity containing the brain, a spinal marrow, and red blood. They are thus associated with quadrupeds, birds, and reptiles, from which, however, they may be distinguished by the following characters.

Fishes possess a heart with one auricle and one ventricle. The blood is cold. They are destitute of a windpipe and lungs, breathing by means of peculiar organs termed *gills.* They reside in water, are in general covered with scales, and swim by the assistance of fins.

The ancients regarded as fishes, all animals which seek their food in water, or which reside in that element. Hence we find whales included by older writers among fishes, constituting a subdivision, distinguished by their breathing by means of lungs. But cetaceous animals differ from fishes, not merely in their organs of respiration, but likewise in those of circulation and reproduction. Their heart consists of two auricles and two ventricles, and the blood is warm. They bring forth their young alive, and suckle them.

It is more difficult to draw the line of distinction between fishes and reptiles. The structure of the heart, and the temperature of the blood, are similar in both classes. Reptiles, however, are all furnished with lungs; and although, in a few genera, the young are possessed of gills, yet these organs disappear before the animals arrive at maturity. There are, however, two genera in which the gills are persistent, but the animals belonging to these have digitated feet, and are not likely ever to be confounded with fishes.

The study of this department of natural history is peculiarly difficult. The element in which fishes reside conceals their movements from our view, and prevents us from becoming acquainted with their instincts and habits. In the midst of lakes and rivers, in the depths of the ocean, or in pools on the less frequented shores, they perform unmolested the great operations of nature. Hence the manner of their production, the appearances exhibited by the different sexes, the changes produced by age or season, the artifices they employ to obtain their food, the migrations which they perform, and the limits of their existence, have hitherto been but imperfectly ascertained.

The rarer kinds of fishes, occasionally found on the hooks or in the nets of fishers, are rejected by them as useless, or perhaps exhibited for a few days in the neighbouring village as objects of wonder. They speedily decay, and the only memorials of their existence are preserved in the imperfect traditions of their form. It rarely happens that an intelligent naturalist is on the spot to examine their characters, or to delineate their appearance. But even should there be a person at hand capable of forming a systematic description, still their haunts and habits must remain unknown to us. Of the various species of fishes enumerated by nomenclaturists, perhaps more than the one half are known to us only by their external forms; their food, their instincts, and their functions, remaining unascertained.

The pursuits of the ichthyologist are far from possessing those charms which excite the zeal and admiration of the naturalist in other departments of zoology. It is easy, indeed, to form a collection of these objects, and to preserve their form and characters for scientific purposes; but a museum furnished with such specimens, presents little that is gay or splendid. The colours and lustre of fish fade after death, nor can any process of embalming fix and preserve them. A coating of varnish is often resorted to as a substitute for the natural slimy covering of their skins, and the brush is employed to restore the colours; but specimens prepared in this manner are disregarded by the scientific observer, and to the mere spectator a collection of fishes in wax-work would be equally acceptable. The aspect of some fishes, as the eel for example, is repulsive; while the cold moist surface of others, disgust the fastidious naturalist, or at least lessen his anxiety to examine this portion of animated nature.

These impediments to the study of ichthyology have unquestionably retarded the progress of the science; but we are confident, that the advantages which result from an attentive examination of the subject, may be placed in successful opposition. The rank which fishes hold in the scale of being, as connecting the vertebral with the molluscous animals, is alone sufficient to awaken curiosity; while a considerable degree of interest is excited, by attending to those forms and organs which fit them for residing in the waters. But this department of zoology is not occupied exclusively with matters of mere curiosity or science; the subject is of vast importance in an economical, a commercial, and a national point of view. The inhabitants of this country derive a large portion of their subsistence from the waters; nor could one half of the present population of the country be supported, were access to this great storehouse of life and nourishment cut off.

In confirmation of this assertion, we request the reader to consider the countless numbers of cod, herrings, haddocks, turbot, skate, mackrel, and pilchards, annually furnished to us by the ocean, and the salmon, pikes, perches, and trouts captured in our lakes and rivers. A part of these is consumed by ourselves, and a part exported to foreign countries. These fisheries give employment to many thousands of healthy natives, and are universally considered as the best nurseries of intrepid seamen.

Those who have paid attention to our fisheries, and the legislative enactments by which they are regulated, must be convinced that the subject is imperfectly understood, and acknowledge that many of these statutes originate in our ignorance of the habits and the haunts of the finny tribes. It must therefore appear an object of vast importance to examine the structure of fishes, and trace their manners and economy, with the view of improving the modes of fishing, ascertaining the best frequented grounds, and the periods in which they are in season. These are the objects which the ichthyologist should keep steadily in view, and to the accomplishment of these all his investigations ought to be directed. Hitherto, however, the economical department of the science has been in a great measure overlooked by the systematic inquirer. Occupied, almost exclusively, in ascertaining the position of the fins, or in counting the number of their rays, so as to form the divisions of his arrangement, the ichthyologist seldom condescends to investigate the history or discover the uses of the species. Systematic works in this branch of natural history are therefore seldom consulted by the ordinary inquirer. Disgusted with the mere enumeration of names and external appearances, of which these books consist, he retires to the hut of some old fisherman, and listens with interest to the recital of many anecdotes, illustrative of the different kinds of fish, the best frequented grounds, and the most enticing baits. In such a school he will learn much genuine natural history, mixed perhaps with a little fable.

We wish not to be understood as condemning as useless, the systematic part of ichthyology, but from the heart we condemn that want of attention to the manners of fishes, so conspicuous in the writings of naturalists; a negligence, which has brought the science into discredit, and which may be considered as the principal reason why this department of nature has obtained so few admirers. But we trust the period is at no great distance, in which the ichthyologist will be as anxious to explore the habits of those fishes, with whose specific differences he is already acquainted, as he is at present to add a new species to his list, or effect some trivial revolution in the arrangement of the genera.

In order to present the reader with a general view of the present state of ichthyological science, we propose in the following Chapters, to consider, 1st, The history of the science; 2d, The structure and functions of fishes; 3d, The condition of fishes; and lastly, Their systematic arrangement. We propose to avoid all minute details which would prove uninteresting to the ordinary observer, in order to make room for the developement of those laws which regulate this great class of animated beings.

CHAP. I.

History of Ichthyology.

History.

The history of ichthyology during the first ages of science, may gratify curiosity, but is incapable of yielding instruction. We are in a great measure ignorant of the sources from whence Aristotle obtained his information on this subject; nor do we consider as of great importance those descriptions which he has communicated. Although he treats of the manners and uses of several fishes, and divides the class into cetaceous, cartilaginous, and spinous, his labours did not contribute much to the progress of the science. The writings of Pliny were equally unproductive of advantage. He appears, however, to contemplate fishes as a distinct class of animals, without attempting to define its limits. Ovid, Elian, Athenæus, Oppian, and Ausonius, have contributed a few facts, and several entertaining descriptions. But as we are investigating the history of ichthyology as a branch of the system of nature, we must take our leave of these early writers, and examine the productions of those naturalists who flourished after the revival of letters.

Belon.

Belon, a French physician, deserves to be noticed in this place, as the first modern ichthyologist. In the year 1553, he published his great work *De Aquatilibus*; and in 1555 he produced another work, or rather the ichthyological part of the former, under the title, *La Nature et diversité des Poissons avec leurs Portraits.* Although Belon was more advantageously known as a traveller and ornithologist than as an ichthyologist, his labours in this last department were of service to the science. He did not attempt any general system, but by collecting fishes into groups, he laid the foundation of many natural families or genera. He separated the osseous from the cartilaginous flat fishes, and brought together the different species of sharks into one division. The wooden cuts which accompany the work are not destitute of merit, if we take into consideration the state of the arts at the time.

Rondelet

In the year 1554, Rondelet, a professor of physic at Montpelier, published his work *De Piscibus Marinis.* He has been rather ungraciously treated by his countrymen, for saying, that he was unable for some time to determine on the particular fish with which to begin the descriptions, and that he gave the preference to the *Gilthead,* because it was best known to the ancients and moderns, and highly prized as esculent food. In the course of his observations, he pointed out several distinguishing characters of fishes, which must have contributed to draw the attention of naturalists to their systematic arrangement. In the first four books, he treats of the differences observable among fishes, in regard to their food and haunts, their forms and functions. In the remaining books he describes the different species, in many cases forming these into natural groups. His figures of fishes are superior in execution to those of Belon.

Salvianus

The work of Salvianus, which appeared in the same year at Rome, under the title *Aquatilium Animalium Historiæ liber primus, cum eorundem formis ære excusis,* contained a description of the fishes of Italy to the amount of ninety species. The distribution of the species is destitute of arrangement; but in the description of these he follows a regular plan, treating of the name, characters, station, food, time of spawning, and method of catching of each. It is a matter of regret, that this method of communicating the history of the species has been in a great measure overlooked by succeeding ichthyologists.

Willough
and Ray.

Passing over a number of laborious compilers, who flourished in the end of the sixteenth century, we come now to consider the merits of our countryman Willoughby, and his friend Ray. "These illustrious naturalists," says the intelligent President of the Linnæan Society in his introductory discourse, "laboured together with uncommon ardour in the study of nature, and left scarcely any of her tribes unexplored. But death, which so often disappoints the fairest hopes, cut off the former in the prime of life, before he had digested the materials, to the acquisition of which he had devoted his youth; and they might all have been lost to the world, and his name have perished with them, but for the faithful friendship and truly scientific ardour of Ray. So close was the intercourse between these two naturalists, that it is not easy to assign each his due share of merit. Indeed Ray has been so partial to the fame of his departed friend, and has cherished his memory with such affectionate care, that we are in danger of attributing too much to Mr Willoughby, and too little to himself."

The work of Willoughby, as revised by Ray, was published in folio in 1686, under the title, *De Historia Piscium libri quatuor, jussu et sumptibus Societatis Regiæ Londinensis editi.* This work, the production of a laborious observer and faithful recorder, may be considered as the basis of subsequent discoveries in the physiology of fishes. It is a valuable storehouse of facts, to which the student of ichthyology should frequently resort. The systematic arrangement employed in this work, holds the first place among those systems, which appeared in the end of the seventeenth or beginning of the eighteenth centuries. The following synoptical view of this system, will enable the reader to ascertain the state of the science at the period in which he wrote. The cetaceous fishes form the subject of the second book, the classification of which, as given by our author, we purposely omit.

System of Willoughby.

III. Lib. De piscibus cartilagineis. Ova magna concipiunt.
  1. Sect. De cartilagineis longis.
  2. —— De cartilagineis planis.
  3. —— De cartilagineis oviparis.
IV. Lib. De piscibus oviparis, quorum plerique spinas in carne habent.
  1. Sect. De planis ovip. spin. qui in latus projecti natant.
  2. —— De piscibus anguilliformibus, seu lævibus, lubrices et plerumque oblongis.
  3. —— De piscibus corpore contractiore vel saltem non admodum lubrico, qui pinnis ventralibus carent.
  4. —— De spinosis dictis, quibus pinnarum dorsalium radii omnes molles et flexiles sunt.
  5. —— Pisces spinosi quibus pinnarum dorsalium radii alique aculeati.

Ray afterwards in part improved upon this system, in his *Synopsis Methodica Piscium*, which was published in the year 1713. These two works are regarded by naturalists in general, as having established the claims of ichthyology to rank as a science.

Dale.

Samuel Dale, the intelligent editor of Taylor's History of Harwich, has published a system of fishes in his *Pharmacologia*, which appeared in 1739. He has the merit of introducing several new characters, especially the position of the centre of gravity. The following synoptical view of this system may be useful.

System of Dale.

I. BRANCHIIS RESPIRANTES, CORDE UNICO VENTRICULO PRÆDITO.

Ovipari.

A. Corpore longo et lubrico, squamis quoque carente.
  a. Pinnis ad branchias obtinentes, ventralibus destituti.
  b. Pinnis utroque pari donatis; *i. e.* branchiali et ventrali.
    1. Duabus in dorso pinnis.
    2. Unica in dorso pinna.
B. Corpore contractiore vel saltem non admodum lubrico.
  a. Pinnis non aculeatis.
    1. Unica in dorso pinna.
    2. Duæ in dorso pinnæ eriguntur.
  b. Pinnis aculeatis, duabus in dorso pinnis, anteriore autem spinis radiata.

Vivipari.

A. Cartilaginei.
  a. Longi.
  b. Plani.

II. PULMONE RESPIRANTES, CORDE DUOBUS VENTRICULIS PRÆDITO.

A. Dentati.
  a. Fistulosi.
  b. Non fistulosi.
B. Edentuli.

The inferior divisions, which have been omitted, depend not only upon the position of the centre of gravity, but upon the serratures of the belly, the size of the scales, the structure of the mouth, and the places in which they reside.

Artedi.

Artedi, the friend and countryman of Linnæus, adopted the principles of classification discovered by that great reformer of science, and applied them with success in the arrangement of fishes. But a premature death prevented the completion of his plan. Linnæus collected and arranged his manuscripts, and published them in the year 1738, in two volumes, under the title *Bibliotheca Ichthyologia*, and *Philosophia Ichthyologia.* Another edition, under the same title, made its appearance in 1788 and 1789, by John J. Walbaum, a physician at Lubeck. This work of Artedi is evidently the production of an enlightened naturalist, a laborious student, and an accurate observer. In it the genuine principles of the science were for the first time clearly established. He likewise assigned the true limits of generic characters, and the method of separating species. The work abounds with judicious observations and sound criticisms, and merits an attentive perusal. The following is an outline of his system.

System of Artedi.

PISCES CAUDA PERPENDICULARI.

A. Pinnarum radiis osseis.
  a. Branchiis ossiculatis.
    1. Pinnis inermibus. *Malacopterigii.*

* Pinna dorsi unica in medio fere dorsi.	1. Syngnathus. 2. Cobitis. 3. Cyprinus. 4. Clupæa. 5. Argentina. 6. Exocætus.
** Pinna unica in medio fere dorsi et unica postica dorsi adiposa.	7. Coregonus. 8. Osmerus. 9. Salmo.
*** Pinna unica in extremo dorsi.	10. Esox. 11. Echeneis.
**** Pinna unica pluribusve per totum dorsum extensis.	12. Coryphæna. 13. Ammodytes. 14. Pleuronectes. 15. Stromateus. 16. Gadus. 17. Anarhichas.

***** Pinna unica longa vix a cauda distincta.
  18. Muræna.
  19. Ophidion.

****** Pinna exigua unica in extremo dorsi vel nulla.
  20. Anableps.
  21. Gymnotus.

2. Pinnis osseis, quarum quædam spinosæ. *Acanthopterigii.*

* Capite glabro
  22. Blennius.
  23. Gobius.
  24. Xiphias.
  25. Scomber.
  26. Mugil.
  27. Labrus.
  28. Sparus.
  29. Sciæna.

** Capite aspero
  30. Perca.
  31. Trachinus.
  32. Trigla.
  33. Scorpæna.
  34. Cottus.
  35. Zeus.
  36. Chætodon.
  37. Gasterosteus.

a. Branchiis osseis destitutis.

Branchiostegi
  38. Balistes.
  39. Ostracion.
  40. Cyclopterus.
  41. Lophius.

B. Pinnarum radiis cartilagineis vix a membrana distinctis.

Chondropterigii
  42. Petromyzon.
  43. Acipenser.
  44. Squalus.
  45. Raja.

Pisces cauda horizontali, *including the whales.*

Klein.

Klein made an attempt to classify fishes in his *Historia Piscium Naturalis.* It was published in five parts, the first appearing in the year 1740, and the last in 1749. As this naturalist appeared as the rival of Linnæus, he has too often been condemned by the admirers of the professor of Upsal without sufficient examination. It is true that in the construction of his generic and specific characters, he falls short of the excellence of Artedi or Linnæus, but in the formation of the higher divisions of his system, he exhibits an intimate acquaintance with the external characters of fishes. The following synoptical view will convey an idea of the principles of his system. We have omitted his first division, which contains the cetaceous animals.

System of Klein.

II. Pisces Branchiis occultis.

A. Ad latera.
  a. Pinnata.

1. Spiraculis quinque.
  5. Cynocephalus.
  6. Galeus.
  7. Cestracion.
  8. Rhina.

2. Spiraculo unico.
  9. Batrachus.
  10. Crayracion.
  11. Capriscus.
  12. Conger.

b. Apennia.
  1. Spiraculo unico. 13. Muræna.
  2. Spiraculis septem. 14. Petromyzon.

B. In Thorace.

1. Spiraculis constanter quinque.
  15. Narcacion.
  16. Rhinobatus.
  17. Legobatus.
  18. Dasybatus.

III. Pisces Branchiis apertis.

A. Series I. A partibus notabilibus et corpore anguilliformi.
  a. Capite et ventre notabiles 19. Silurus.
  b. Notabiliter rostrati ore vario.
    1. ore prono capite in solidum rostrum exeunte . 20. Accipenser.
    2. Ore fisso.
      * et labrace, rostro retuso dentibus horridis . 21. Lathargus.
      ** Mandibula superiore in rostrum notabile exeunte 22. Xiphias.
      *** Inferiori mandibula ultra superiorem rostratam producta 23. Mastaaccembalus.
      **** Utraque mandibula equaliter rostrata 24. Psallisostomus.
    3. Ore in rostri tubulosi extremitate 25. Solenostomos.
    4. Capite et cauda rostratus 26. Amphisilien.
  c. Notabiliter plani et oculata.
    1. In dextro latere oculati
      27. Solea.
      28. Passer.
    2. In sinistro latere oculatus 29. Rhombus.
    3. Utrinque oculati .
      30. Rhombotides.
      31. Tetragonopterus.
      32. Platiglossus.
  d. Thoracici notabiliter armati
    33. Cataphractus.
    34. Ceristion.
    35. Centriscus.
  e. Vel sterno vel capite notati instar ricini omnibus corporibus sibique invicem adhærentes
    36. Ocontion.
    37. Echeneis.
  f. Corpore teretiusculo anguillæ adspectum habentes 38. Enchelyopus.

B. Series II. Corpore spisso vel lati, vel carinati et castigati.
  a. Tripterus . . . 39. Callarias.
  b. Pseudotripterus . . 40. Pelamys.
  c. Dipterus.
    1. Pinna secunda cutacea vel adiposa 41. Trutta.
    2. Pinnis ambabus radiatis
      42. Mullus.
      43. Cestreus.
      44. Labrax.
      45. Sphyræna.
      46. Gobio.
      47. Asperulus.
      48. Trichidion.
  d. Pseudodipterus.
    1. Pro prima pinna dorsali aculeis discretes 49. Glaucus.
    2. Præter pinnam longam, processibus in capite quasi cristatus 50. Blennus.
  e. Monopterus.
    1. Pinna longa unica.
      * Interrupta . . . 51. Perca.
      ** Sinuosa . . . 52. Percis.
      *** Coæquata.
        α. Dentibus acutis
          53. Maenas.
          54. Cicla.
          55. Synagris.
          56. Hippurus.
        β. Dentibus latis et obtusis 57. Sargus.

System of Klein.

γ. Edentuli . .	58. Cyprinus. 59. Prochilus.
2. Pinna brevi.	
* Ad medium dorsi.	
α. Corpore lato spisso	60. Brama.
β. Corpore castigato.	
† Barbatus . .	61. Mystus.
†† Imberbes .	62. Leuciscus. 63. Harengus.
** Caudæ proxima .	64. Lucius.
f. Pseumonopterus . . .	65. Pseudopterus.

Linnæus.

We come now to consider the system of the celebrated Linnæus. At first this eminent naturalist adopted the views and arrangements of his friend Artedi. By degrees, however, he unfolded the principles of a new method, which appeared in its most perfect form in the 12th edition of the *Systema Naturæ*, 1766, as follows.

System of Linnæus.

I. Apodes.

Pinnæ ventrales nullæ.

Apertura branchiarum ad latera thoracis	1. Muræna.
Dorsum apterygium . . .	2. Gymnotus.
Cauda aptera	3. Trichiurus.
Dentes rotundati	4. Anarhichas.
Caput corpore angustius . .	5. Ammodytes.
Corpus ensiforme . . .	6. Ophidium.
Corpus ovatum . . .	7. Stromateus.
Rostrum ensiferum . . .	8. Xiphias.

II. Jugulares.

Aperturæ branchiarum ad nucham	9. Callionymus.
Os simum	10. Uranoscopus.
Anus prope pectus . . .	11. Trachinus.
Pinnæ pectorales elongatæ in acumen	12. Gadus.
Pinnæ ventrales didactylæ muticæ	13. Blennius.

III. Thoracici.

Os simum, corpus ensiforme	14. Cepola.
Capitis dorsum planum transversim sulcatum	15. Echeneis.
Caput antice truncato-obtusum	16. Coryphæna.
Pinnæ ventrales coadunatæ inpinnam ovatam	17. Gobius.
Caput corpore latius . .	18. Cottus.
Caput cirris adspersum . .	19. Scorpæna.
Labium superius membrana transversa fornicatum . . .	20. Zeus.
Oculi ambo in latere altero capitis	21. Pleuronectes.
Dentes setacei confertissimi, flexiles	22. Chætodon.
Dentes validi incisores s. molares	23. Sparus.
Pinna dorsalis ramento post spinas notata	24. Labrus.
Pinna dorsalis in fossula recondenda	25. Sciæna.
Opercula branchiarum serrata	26. Perca.
Cauda lateribus carinata; spinæ dorsales distinctæ . .	27. Gasterosteus.
Cauda lateribus carinata: Pinnulæ spuriæ plures . . .	28. Scomber.
Squamæ, etiam capitis, laxæ .	29. Mullus.
Digiti distincti juxta pinnas pectorales	30. Trigla.

IV. Abdominales.

Corpus vix ad caudam angustatam	31. Cobitis.
Caput nudum, osseum scabrum	32. Amia.
Radius 1. pinnæ dorsalis pectoraliumque dentatus . .	33. Silurus.
Caput antice truncatum . .	34. Teuthis.
Corpus cataphractum . . .	35. Loricaria.
Pinna dorsalis postica adiposa	36. Salmo.
Rostrum cylindricum operculo clausile	37. Fistularia.
Mandibula inferior longior, punctata	38. Esox.
Mem. branch. duplex, exteriore minore	39. Elops.
Anus caudæ vicinus . . .	40. Argentina.
Fascia lateralis longitudinalis argentea	41. Atherina.
Mandibula inferior intus carinata	42. Mugil.
Apertura branch. linearis absque operculis . . .	43. Mormyrus.
Pinnæ pectorales longitudine corporis	44. Exocœtus.
Digiti distincti juxta pinnas pectorales	45. Polynemus.
Abdomen carinatum serratum	46. Clupea.
Membrana branchiostega triradiata	47. Cyprinus.

The most remarkable change which we witness in this system, is the removal of the cetacei and cartilaginei of Ray from the class of fishes. The former he has inserted in the class Mammalia, while he has placed the latter among the Amphibia, under the order Nantes. He was induced to assign to these last such a position in his system, in consequence of trusting to the inaccurate observations of Dr Garden of South Carolina, who, from a dissection of the fish called *diodon*, concluded that it possessed both lungs and branchiæ. Subsequent systematic writers have in general restored them to their true place among fishes.

The ichthyologists who preceded Linnæus, invariably endeavoured to employ those characters in the formation of their primary divisions, which indicate some peculiarity of organization, connected with the vital functions. In other words, they attempted to discover a natural method in ichthyology. Linnæus assumed, as the foundation of his system, the relation of the ventral to the pectoral fins, without attempting to point out the influence exercised on the animal economy, by a change of position in these organs. Hence his Orders are all arbitrary and artificial. In the construction of his Genera, he was singularly happy in the choice which he made of characters. Those which are *essential* have been given in the Table; the *natural* character was employed in the system itself. He introduced the use of trivial names, and corrected the specific characters. His terms were classical and expressive, and the whole system bears the stamp of a mighty genius. His genera, it is true, have been divided, in order to form new ones; but how few have equalled this naturalist in the luminous brevity of his characters.

Gronovius.

Gronovius, the cotemporary and friend of Linnæus, published his *Museum Ichthyologicum*, in 2 vols. folio, in the year 1754-6. In this work he attempted the following systematic arrangements.

System of Gronovius.

I. Cauda Horizontali.

Whales.

II. Cauda Perpendiculari.

A. Radiis pinnarum cartilagineis.

Chondropterygii. α. Pinnis ventralibus præsentibus	5. Acipenser. 6. Callorynchus. 7. Squalus. 8. Raja.

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System of Gronovius.

b. Pinnis ventralibus nullis 9. Petromyzon.

B. Radiis pinnarum osseis.

1. Branchiarum aperturis, foramine exiguo tantum apertis.

Branchiostegi.

a. Pinnis ventralibus nullis
10. Muræna.
11. Gymnotus.
12. Syngnathus.
13. Ostracion.

b. Pinnis ventralibus spuriis
14. Balistes.
15. Cyclopterus.
16. Cyclogaster.

c. Pinnis ventralibus veris præsentibus
17. Gonorynchus.
18. Cobitis.
19. Uranoscopus.
20. Lophius.

2. Branchiarum aperturis subter atque in lateribus laxe apertis.

Branchiales.

a Pinnis ventralibus in pectore sub pectoralibus.

* Pinna dorsi solitaria
21. Sciæna.
22. Cynædus.
23. Sparus.
24. Holocentrus.
25. Coracinus.
26. Scarus.
27. Chætodon.
28. Labrus.
29. Callyodon.
30. Pleuronectes.
31. Echeneis.
32. Blennius.
33. Erichelyopus.
34. Pholis.

** Pinna dorsi una pluribus
35. Cottus.
36. Amia.
37. Trachinus.
38. Gobius.
39. Eleotris.
40. Trigla.
41. Mullus.
42. Perca.
43. Scomber.
44. Zeus.
45. Gadus.

b Pinnis ventralibus inter pinnas pectorales et analem sitis.

* Pinna dorsi solitaria
46. Clarius.
47. Silurus.
48. Aspredo.
49. Albula.
50. Cyprinus.
51. Clupea.
52. Argentina.
53. Synodus.
54. Hepatus.
55. Erythrinus.
56. Umbra.
57. Cataphractus.
58. Exocætus.
59. Anableps.
60. Esox.
61. Solenostomus.
62. Belone.

** Pinnis dorsalibus duobus, posteriore spuria seu adiposa
63. Salmo.
64. Anostomes.
65. Charax.
66. Mystus.

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System of Gronovius.

*** Pinnis dorsalibus veris seu radiatis
67. Callichthys.
68. Plecostomus.
69. Centriscus.
70. Mugil.
71. Polynemus.
72. Atherina.

c Pinnis ventralibus veris nullis.
73. Anarhichas.
74. Ophidion.
75. Mastacembalus.
76. Ammodytes.
77. Gasterosteus.
78. Channa.
79. Gasteropelecus.
80. Xiphias.
81. Leptocephalus.
82. Gynogaster.

In this system Gronovius has brought back the cetaceous and cartilaginous divisions of Ray. His primary characters are similar to those employed by that illustrious zoologist. Those of a subordinate rank are in part derived from the same source, and from Artedi and Linnæus. As a system, it is inferior to that of Linnæus, since the subordinate characters are liable to exceptions. Like that naturalist, he employs the number of the fins, as a character subordinate to those furnished by their position.

Brunich.

Brunich attempted another system of fishes, which he published in his *Zoologiæ Fundamenta*, (Hafniæ, 1771). It is an attempt to unite the natural method of Ray and his numerous followers, with the artificial system of Linnæus. It appeared at the time when the professor of Upsal was in the meridian of his glory, and was treated with neglect by the admirers of that great man. To us, whose opinions on the merits of these systems are not likely to be influenced by party feelings, the method of Brunich appears equally simple as that of Linnæus, and, in the first tribes, is certainly superior. We add it here, that the reader may judge for himself.

TRIBUS I.

System of Brunich.

Branchiis incompletis. Spiraculis thoracis lateralibus. Aurium foraminibus pone oculos. Pinnis cartilagineis.—CHONDROPTERIGII.

1. Petromyzon.
2. Raja.
3. Squalus.
4. Chimæra.
5. Acipenser.

TRIBUS. II.

Branchiis incompletis. Apertura thoracis linearis. Pinnis membranaceis radiatis. Corpore sæpius cataphracto vel muricato. BRANCHIOSTEGI.

A. Pinnis ventralibus nullis.
6. Syngnathus.
7. Ostracion.
8. Balistes.
9. Tetrodon.
10. Diodon.

B. Pinnis ventralibus presentibus.
11. Lophius.
12. Cyclopterus.
13. Centriscus.
14. Pegasus.

TRIBUS III.

Branchiis completis. Apertura thoracis hiante, Pinnis membranaceis radiatis; ventralibus nullis; corpore sepius alepedoto.—APODES.

System of Brunich.

15. Xiphias.
16. Anarhichas.
17. Ammodytes.
18. Trichiurus.
19. Stromateus.
20. Muræna.
21. Ophidion.
22. Gymnotus.

TRIBUS IV.

Branchiis completis. Apertura thoracis hiante; pinnis membranaceis radiatis; ventralibus sub jugulo; corpore squamis minutis tecto vel nudo. JUGULARES.

23. Lepadogaster.
24. Blennius.
25. Gadus.
26. Uranoscopus.
27. Callionymus.
28. Trachinus.

TRIBUS V.

Branchiis completis. Apertura thoracis hiante; pinnis membranaceis radiatis; ventralibus in thorace; corpore sepius squamoso quam alepidoto.—THORACICI.

- A. Malacopterigii.
  - 29. Cepola.
  - 30. Coryphæna.
  - 31. Pleuronectes.
  - 32. Echeneis.
- B. Acanthopterigii.
  - 33. Gobius.
  - 34. Sparus.
  - 35. Labrus.
  - 36. Mullus.
  - 37. Scomber.
  - 38. Trigla.
  - 39. Chætodon.
  - 40. Perca.
  - 41. Gasterosteus.
  - 42. Scorpæna.
  - 43. Cottus.
  - 44. Zeus.

TRIBUS VI.

Branchiis completis. Apertura thoracis hiante; pinnis membranaceis radiatis, ventralibus in abdomine; corpore squamato loricato vel alepidoto.—ABDOMINALES.

- A. Malacopterigii.
  - 45. Salmo.
  - 46. Argentina.
  - 47. Amia.
  - 48. Fistularia.
  - 49. Esox.
  - 50. Cobitis.
  - 51. Cyprinus.
  - 52. Exocætus.
  - 53. Clupea.
  - 54 Mormyrus.
  - 55. Atherina.
- B. Acanthopterigii.
  - 56. Silurus.
  - 57. Loricaria.
  - 58. Theutis.
  - 59. Elops.
  - 60. Polynemus.
  - 61. Mugil.

The four last tribes of this system are obviously those of Linnæus, with the introduction of a subordinate character from Ray. We must, however, observe, that among fishes whose fins have soft articulated rays, or are malacopterigious, several species have been inserted by ichthyologists, which were entitled to a place among those with spinous rays, termed Acanthopterigious. Thus many species of the genus Pleuronectes (but not all of them) have a strong spine in front of the anal fin; and in the genus Cyprinus, both the carpio and barbus have one serrated spinous ray in the dorsal fin. The species of these two genera are still retained among the malacopterigious fishes, and could not be far removed from their present situation, without destroying the natural links of the species. Such inconsistencies will be found in all systems, where characters are employed which exercise but a feeble influence on the animal functions.

Gouan.

Professor Gouan of Montpellier, made another attempt on the classification of fishes, in his *Histoire des Poissons*. It is essentially the same as that of Brunich, with some slight alterations in the genera in the branchiostigous divisions.

Scopoli.

Scopoli in his *Introductio ad Historiam Naturalem*, (1777,) attempted a new system, founded on the position of the anus. Linnæus had previously employed the same character in the formation of two genera in his system, namely Trachinus and Argentina. But Scopoli elevated it to the rank of a primary character, and divided fishes into the three following classes. 1. Ano inferiore sive caudæ plus minus approximato. 2. Ano superiore, capite plus, minus approximato. 3. Ano medio. The subordinate characters are those which had been employed by former authors. The efforts of these two naturalists to produce systems, were never treated with much attention.

Bloch.

In the year 1785, the splendid work of Bloch on fishes, made its appearance both in German and French. The system is professedly that of Linnæus, with additions to the number of genera warranted by the researches of the author. The descriptions and figures, which are in general of the real size, are from nature, and the economical history of the species is given in detail. Walbaum with propriety styles this work, *Opus sine pari*.

Bonnaterre.

The ichthyological department of the *Encyclopedie Methodique* was undertaken by Bonnaterre, and published in the year 1788. This author, in the systematic part of the subject, followed the method of Linnæus. His introductory matter, however, is more valuable than the systematic part. He has collected with care, the principal facts respecting the anatomy and functions of fishes, and has arranged and defined the characters which he employs. He has added a number of good figures of fishes, chiefly copies from other works.

Cuvier.

In the year 1800, the "Lectures on Comparative Anatomy," by Cuvier made their appearance. Independent of the important contributions to the physiology of fishes, this author has attempted a classification of those animals, which merits the consideration of naturalists. The following outline, in which the genera are omitted for want of room, may be acceptable to the systematic enquirer.

System of Cuvier.

History.

System of Cuvier.

CARTILAGINOUS FISHES . . .	Fixed Branchiæ, Chondropterigii .	Round mouth at the end of the nose or snout.	
		Transverse mouth under the snout.	
	Free Branchiæ, Branchiostegi . . .	Transverse mouth under the snout; teeth.	
		——— no teeth.	
		Mouth at the end of the nose; no teeth.	
		——— teeth.	
		The bones of the jaws answering instead of teeth.	
		Mouth very wide; a number of small teeth.	
OSSEOUS FISHES	Apodes	Mouth at the end of the nose.	
		Mouth under the nose.	
	Jugulares	Head unarmed.	
		Head armed.	
	Thoracici	Dorsal fins partly spinous; head armed.	
		Dorsal fins partly spinous; head unarmed	Two dorsal fins.
			One dorsal fin.
		Bones of the jaws naked, and answering instead of teeth.	
		Two eyes on the same side.	
		The body very long.	
		A furrowed discus on the head.	
	Abdominales	No operculum to the branchiæ.	
		No teeth.	
		Sharp teeth; no cirri.	
		Head depressed; cirri.	
		Spines free on the back.	
		Mouth at the end of the nose.	

Several natural families are formed by this author, and we hope he will add to the number in the second edition of his work.

De la Cepede.

In the year 1803, De la Cepede completed his *Histoire Naturelle des Poissons,* in five volumes. The opportunities of investigating the subject of ichthyology enjoyed by this author were valuable, and he has availed himself of these with very great diligence and success. He had access to the best furnished museum in Europe, formed from the spoils of the collections of those countries which France had subjugated. Before giving our opinion of the execution of the systematic part of the author's plan, we shall lay a sketch of it before our readers.

System of De la Cepede.

System of De la Cepede.

Le sang rouge, des vertèbres, des branchies au lieu de poumons.

SOUS-CLASSES.		DIVISIONS.		ORDRES.
POISSONS CARTILAGINEAUX. 1. L'épine dorsale composée de vertèbres cartilagineuses	1.	1. Point d'opercule, ne de membrane branchiale	1.	1. Apodes.
			2.	2. Jugulaires. 0
			3.	3. Thoracins. 0
			4.	4. Abdominaux.
	2.	2. Point d'opercule, une membrane branchiale	5.	1. Apodes. 0
			6.	2. Jugulaires.
			7.	3. Thoracins.
			8.	4. Abdominaux.
	3.	3. Un opercule, point de membrane branchiale	9.	1. Apodes. 0
			10.	2. Jugulaires. 0
			11.	3. Thoracins. 0
			12.	4. Abdominaux.
	4.	4. Un opercule, et une membrane branchiale	13.	1. Apodes.
			14.	2. Jugulaires. 0
			15.	3. Thoracins.
			16.	4. Abdominaux.
POISSONS OSSEUX. 2. L'épine dorsale composée de vertèbres osseuses	5.	1. Un opercule, et une membrane branchiale	17.	1. Apodes.
			18.	2. Jugulaires.
			19.	3. Thoracins.
			20.	4. Abdominaux.
	6.	2. Un opercule, point de membrane branchiale	21.	1. Apodes.
			22.	2. Jugulaires. 0
			23.	3. Thoracins. 0
			24.	4. Abdominaux. 0
	7.	3. Point d'opercule, une membrane branchiale	25.	1. Apodes.
			26.	2. Jugulaires. 0
			27.	3. Thoracins. 0
			28.	4. Abdominaux. 0
	8.	4. Point d'opercule, ni de membrane branchiale	29.	1. Apodes.
			30.	2. Jugulaires. 0
			31.	3. Thoracins. 0
			32.	4. Abdominaux. 0

The reader will perceive, that the primary characters are those of Ray. The secondary characters, depending on the structure of the appendages of the gills, may be considered as in a great measure his own; while those of a third rank belong to the Linnæan system. It may perhaps surprise an English reader to be informed, that of the thirty orders which are here constituted, only seventeen can be employed at present, the remaining fifteen having no examples in nature. To these last orders, I have added a cypher in the synoptical view.

Every ichthyologist will allow that many fishes must exist in nature which have never come under the inspection of the naturalist; many links in the chain are still wanting; so that our systems, for the present, must be imperfect. But we can assign no other motive, in thus constructing orders which have no ascertained existence, than a desire to anticipate discovery, and to exhibit a confident reliance on the perfection of the systematic principles employed.

The characters which he uses in the construction of his genera, are derived from various sources. Thus, his genus Prionotus, is separated from that of Trigla, by the serrated spines between the dorsal fins of the former. Serrasalmus, is separated from Salmo, in consequence of a serrated abdomen. The number of the dorsal fins separates Lutanus from Centropomus. The size of the dorsal fins forms the distinction between Bodianus and Tænianotus. It is rather singular that this author takes no notice of the number of rays in the gill flap as a generic character, while the presence of that organ furnishes him with one of his primary characters.

The names of his genera are in many instances exceptionable, and appear to have been constructed in open violation of the acknowledged rules of the science of zoology. The following maxim of Artedi, *Nomina generica, ex uno nomine generico fracto et altero integro composita exulent,* is overlooked in the following examples of hybrid names, among many which might be produced: Gobiesox, Scomberesox, and Murænoblenna. The propriety of adhering to this rule of Artedi, must appear evident, when we consider, that such names indicate ambiguity or doubt with respect to their characters, "innuunt enim ambiguitatem quandam, ut incertum sit ad quodnam genus piscis proprie pertinat." Another rule in ichthyology, "*Nomina generica desinientia in* oides *non probari debent,*" is equally despised, although Artedi justifies its value by saying, "quia aliud genus innuunt vel aliud alludunt, cui hoc in *oides* desinens, simile erit, et nullam ulteriorem originem vel causam suæ denominationis habent." Thus, Lacepede has the following genera: Mugil Mugiloides, Gobius Gobioides, Coryphæna Coryphænoides, Scomber Scomberoides, Muræna Murænoides. There is a third rule given by Artedi, and equally entitled to the attention of the ichthyologist, which La Cepede likewise overlooks.—"*Nomina generica, quæ non sunt originis Latinæ vel Græcæ proscribantur.*" Thus we have the following barbarous names, *Misgurnus,* formed from Misgurne, the Bavarian provincial name of Cobitis fossilis of Linnæus, and the only known species of the genus Makaira, the name of a fish known at Rochelle. There is likewise a genus *Ompok,* a name attached to a dried fish in the Dutch collection, and provincial. The similarity in the sound, between many of the genera of this author, will inevitably lead to confusion. Thus we have Holocentrus and Holocanthus, Pomacentrus and Pomacanthus, Callionymus and Calliomorus, Acanthurus and Acanthopodus, and a host of other genera with names so nearly alike, that we might be led to suppose the author formed them purposely to perplex. We cannot close our observations on the genera of this author, without adding, that all generic names taken from objects in the other classes of nature, ought to have been rejected; such, for example, as Eques, Gallus, Hydrargirus.

In the construction of his species, there is perhaps too strong a desire to increase their number, in the absence of all prominent characters. This, we fear, has been the case in the genus Salmo, Labrus, and some others, where the limits of the species are ill defined. He has been too liberal in employing the names of individuals, as trivial names to his species. Thus we have three different species in the system named in honour of his wife, who does not appear to have been particularly attached to any branch of natural history. We can have no objections to an author dedicating his work to his wife, as La Cepede has done; but we object to the naming of species, ascertained by the labours of others, in honour of any female friend. In France, an author may gain credit for his sensibility and love, by so doing, but to our colder temperament, it seems to be affectation. In many instances, our author changes the received trivial names, bestowing upon them new ones of his own, without even assigning any reason for doing so. This takes place in almost every extensive genus of the system, and merits the severest censure. The French naturalists, it is true, have not scrupled to violate established maxims in science, in order to form a *French system.* This seems to have been the reason why La Cepede abandoned the principles of Artedi in the construction of his genera, and disregarded the dogmas of the Linnæan school. But the French systems, like all others, must submit to the test of sound principles; and when tried by these, whoever shall attempt to restore to its Linnæan purity this department of zoology, must cancel multitudes of the names of La Cepede. We may add, that the descriptions are often swelled by vague analogies, and are in too many instances destitute of precision.

These remarks have extended perhaps too far; but as the system is at present the most popular in Europe, we have judged it expedient to state our undisguised sentiments as to its merits. It abounds in faults, but it is not destitute of excellence. A vast mass of facts is collected, many species are for the first time described, many new characters are unfolded, and the work upon the whole is the most complete view of ichthyology extant. Figures of the new or rarer species are given. These, however, are inferior in every respect to those of Bloch.

Shaw.

The ichthyological part of the *General Zoology* by Dr Shaw, appeared in two volumes, in the years 1803-4. We sincerely regret that it is not in our power to bestow any praise on this work. The text is a very meagre compilation, chiefly from the writings of Bloch and La Cepede; and the figures which accompany the work, are principally copied from the same sources.

In the preceding historical review of ichthyological writers, in which we have endeavoured to mark the progress of the science, the reader must have perceived the great difference of opinion, with respect to the value of the characters employed in classification. The organs of motion are regarded by some as holding the first rank, while those of respiration are preferred by others.

These circumstances indicate the infant state of the science, and point out the propriety of an anatomical investigation of the whole tribe.

We are still in want of accurate representations of many species of fishes. The figures which we meet with, often bear but a remote resemblance to the objects themselves. When a painter, ignorant of natural history, is employed to delineate a fish, (or any other animal), he is apt to overlook the most important characters, unless these are very obvious. He rests satisfied if he produces a general resemblance. Hence the peculiar shape of the fins is often sacrificed to the desire of avoiding sharp angles, and spots, punctures, or streaks, are omitted as useless, or as spoiling the beauty of the drawing. These figures, in passing afterwards through the hands of the engraver, are still farther altered to suit professional taste, so that the figures in works on natural history are often imperfect representations. Hence naturalists should study the art of drawing, and carefully inspect the strokes of the engraver, if fidelity in representation be the object in view.

Writers on British ichthyology.

Before closing these short notices of the principal writers on fishes, we propose to add a few observations on the labours of those who have contributed to the advancement of British ichthyology. This branch of natural history has never been very popular in Britain, and at present is in a great measure neglected. Merret, in his *Pinax rerum Naturalium Britannicarum*, London, 1667, is the first who arranged systematically our native fishes. He distributed them into the following classes: I. Pisces pelagii squamosi. II. Pelagii læves. III. Marini saxatiles. IV. Squamosi in mari et in fluminibus. V. Fluviatiles squamosi. VI. Fluviatiles læves. He has enumerated about 76 species. He acknowledges the assistance which he derived from Turner in his letter to Gesner. His references are chiefly to the works of Gesner and Aldrovandus; and he has added a number of provincial names. Taking all circumstances into consideration, this little work deserves great praise.

The labours of Willoughby and Ray, which we have already mentioned with respect, contributed to advance the science of ichthyology in this country, by the introduction of a more determinate nomenclature, and a more accurate definition of species.

From the days of Ray until the appearance of Pennant, no systematic British ichthyologist had appeared. In the year 1776, that naturalist published his British Zoology. The third volume of this work treats of our native fishes, amounting to one hundred and fifty-two species, exclusive of the cetacea. The system which he follows is the Linnæan, with the addition of the cartilaginei of Ray. He does not confine himself to mere descriptions; he notices the habits and uses of the particular species. The figures are upon the whole respectable. This work contributed to diffuse a taste for the study of zoology in this country, and still continues to maintain that reputation which its general accuracy, and pleasing style, deservedly procured. A second edition made its appearance two years ago, edited by a son of the author's. It contains a few additions, compiled from authentic sources.

The *Synopsis of the Natural History of Great Britain and Ireland*, by Berkenhout, merits a place in this catalogue. The first edition appeared in the year 1769, and the second in the year 1795. In the first volume the British fishes are enumerated, amounting to 157 species, and arranged according to the Linnæan method. The specific characters are short, but judiciously selected.

In the year 1802, Mr Stewart of Edinburgh published his *Elements of Natural History*, in which he enumerates the British species of fishes. This work has lately been revised by the author, and several new species have been added to his list.

Mr Donovan completed, in 1808, five volumes of his *Natural History of British Fishes*. This work contains coloured representations of 119 species. The figures are faithful representations, and the descriptions abound in sound criticisms and important illustrations. He is perhaps deficient in his account of the external characters of the species. This production is a valuable book of reference, and ought to be frequently consulted by the student. We may add that he has swelled the list of British fishes by the discovery of many new and curious species.

The *British Fauna*, by Turton, was published in 1807, previous to the completion of the preceding work. In this small volume 168 species are described. It is a very useful compilation, chiefly on account of its convenient size for the pocket.

Besides these systematic writers on British ichthyology, several naturalists, by describing the fishes of particular districts, have rendered important service to the science.

In the work of T. Caius *De Canibus Britannicis*, (Lond. 1570,) contains notices respecting a few species of British fishes, such as the xiphias, the trachurus, the acus, and a few others.

In 1684, Sir Robert Sibbald published his *Prodromus Historiæ Naturalis, sive Scotia Illustrata.* In this work the fishes of Scotland are described and enumerated; and, considering the state of the science at the time, the catalogue is an extensive one. The same author enlarges on the fishes of the Frith of Forth in his *History of Fife and Kinross.*

The topographical labours of Plott merit respectful mention; and in his *Histories of Oxfordshire and Staffordshire*, he has not overlooked the fishes of these districts. The history of the former county appeared in 1676, and that of the latter in 1686.

In 1698, Martin published his *Description of the Western Islands of Scotland*, in which he notices the ichthyological productions of those seas, but in a very cursory manner.

Wallace, in 1700, published his *Account of the Orkney Islands*, in which he noticed a few of the more common fishes of that country.

The British student of zoology must be familiar with the name of Borlase. His *Natural History of Cornwall*, published in 1758, is generally quoted as a book of reference, and contributed to advance our knowledge of British fishes. Several new species were published for the first time from the drawings of the Rev. Mr Iago, minister of Loo.

Several remarks, illustrative of Irish ichthyology, appear in Rutty's *Natural History of the County of Dublin*, 1772. Smith, in his county histories of Kerry, Waterford, Cork, and Down, had communicated previously a few imperfect notices regarding the fishes of those districts.

In the year 1811, the first volume of the *Memoirs of the Wernerian Natural History Society of Edinburgh* appeared before the public, containing two papers illustrative of British ichthyology. The first is the production of the late eminent zoologist Montagu, in which he gives an account of five rare species of British fishes, to be afterwards taken notice of. The second paper is from the pen of the secretary, Mr Neill. It contains a list of the fishes of the Forth, and the lakes and rivers in the neighbourhood of Edinburgh, which have been observed by the author. The species amount to 76 in number, and among these there is one new British species.

The last author whom we shall mention as having contributed to extend our knowledge of the distribution of British fishes, is the late Rev. George Low, minister of Birsa and Hara. The *Fauna Orcadensis,* which he left behind him in MS. was published in the year 1813, and contains an extensive list of the fishes which the author observed in the seas around the islands of Orkney.

CHAP. II.

Structure and Functions of Fishes.

Structure and functions.

As fishes are destined to live in water, we may expect to find all their organs constructed in such a manner, as to accommodate themselves to the properties of that element. We propose to examine these organs in succession, and to bestow attention at the same time to the functions which they perform. By treating the subject in this manner, repetitions will be avoided, and the general reader assisted in comprehending the economy of this important class of animated beings.

Sect. I. *Organs of Support.*

Organs of support.

The bones of fishes vary in form, proportion, and number, according to the species. The skeleton is more complicated than that of man, and is difficult to prepare and preserve. Hence the osteology of fishes is a subject but little attended to by naturalists. Avoiding all minute details, we propose to consider the skeleton, as consisting of a cranium, spine, and ribs.

As the *cranium* of fishes is covered with skin only, its form is easily ascertained, and it exhibits remarkable differences in shape according to the species. In all the species it is large in proportion to the size of the body. The cranium of osseous fishes consists of a great number of separate pieces. These amount to eighty in the perch. But as these bones are soon ossified together, it becomes very difficult to trace the original lines of separation in aged individuals. The occiput appears like a vertical truncation of the cranium, and is united to the spine by a single tubercle placed below the foramen. The motion of the head is very limited in every direction. In some of the cartilaginous fishes, the head is joined to the vertebral column by two condyles; but this articulation is equally incapable of extensive motion as the former.

The *vertebral column* is either cylindrical, angular, or compressed. The vertebræ may readily be distinguished from those belonging to the higher classes, by the peculiar form which they exhibit. The body of the vertebra is of a cylindrical figure, with a funnel-shaped depression at each end. It consists of concentric rings, which are supposed by some to increase in number with the age of the animal. The vertebræ are destitute of articular processes, and when in union, form throughout the whole column cavities composed of two cones, joined at the base. These cones contain a cartilaginous substance formed of concentric fibres, of which those next the centre are the softest. By means of this cartilage the vertebræ are united, and upon it they perform all their movements. In the cartilaginous fishes all the vertebræ are consolidated together, so that the spinous processes can only be distinguished.

The vertebræ may be divided into the cervical, dorsal, and caudal. In osseous fishes, the *cervical vertebræ* are in general wanting, although in some cases they exist, as in the herring, to the number of four. In the cartilaginous kinds, they are ossified into one piece. The *dorsal vertebræ* are easily recognised, by wanting processes on the inferior part. These have generally on the sides transverse processes, to which the ribs are attached. The *caudal vertebræ* are possessed of spinous processes, both on the superior and inferior surfaces. In those fish which are flat these are very long, as in the flounders. The first caudal vertebra is in general of a peculiar shape. The cavity of the trunk is terminated by its inferior process. In the flounders it is large, round in the fore part, and terminated below by a sort of spine. The last caudal vertebra is however more remarkable than the first. It is almost always of a triangular form, flat, and placed vertically. Upon its posterior extremity it bears articular impressions, which correspond to the small and delicate bones of the fin of the tail.

The number of the bones of the vertebral column in different species being exceedingly various, suggested to Artedi the use of this character in the separation of nearly allied species. Among the species of the genus Cyprinus, for example, a difference in the number of vertebræ has been observed to the amount of fourteen. In ascertaining this character, Artedi recommends the greatest circumspection. The fish should be boiled, the fleshy parts separated, and the vertebræ detached from one another, and these counted two or three times in succession to prevent mistakes. This character is of great use, as it is not liable to variation, individuals of the same species exhibiting the same number of vertebræ in all the stages of their growth.

The number and size of the *ribs* are likewise extremely various. The cartilaginous fishes may be considered as destitute of true ribs. Where they exist, as in the osseous fishes, they are articulated to the body of the vertebræ, or to the spinous processes. They are forked in some fishes, and in others double; that is, two ribs proceed from each side of every vertebra. In the genus Cyprinus they are of a compressed shape; in the cod they are round; and in the herring like bristles.

The number of the ribs likewise furnishes a character in the discrimination of species, which may be safely relied on in the absence of more obvious characters.

Besides these bones which we have enumerated, there are many more osseous spiculæ, which serve to support the fins, and to strengthen the muscles. Indeed the existence of numerous bones, unconnected with the skeleton, is a distinguishing character of the osteology of fishes, and these we shall afterwards consider in our account of the different purposes to which they are subservient.

The composition of the bones of fishes has never been investigated with sufficient care. It is well known, that they never acquire so great a degree of hardness and rigidity as the bones of the mammalia or birds: hence we may safely conclude from the facts connected with the process of ossification in other animals, that the bones of fishes abound in gelatinous and cartilaginous matter, while the portion of earthy or saline matter is small. The earthy salts are phosphate and carbonate of lime, and the phosphate of magnesia, the former predominating in quantity. In one division of fishes, termed the *cartilaginous*, the proportion of earthy matter is so small, that the bones never become indurated, but continue in all the periods of the life of the fish soft and flexible. These animals are therefore supposed to grow during the whole course of their existence.

When the bones of some fishes are boiled in water, they undergo a change of colour. This circumstance is well illustrated in the case of the gar-fish, or sea pike, (*Esox belone*,) whose bones by boiling become of a grass green colour; and in the bones of the viviparous blenny, which experience a similar change. This alteration of colour has fostered some of the prejudices of the vulgar, but has failed to arrest the attention of the chemist.

The bones of fishes when reduced to powder, are mixed up with farinaceous substances, and used instead of bread by some of the northern nations. In Norway, and even in some of the remote districts of our own country, fish bones are given as food for cows, and are greedily devoured by them.

Sect. II. *Organs of Protection.*

Organs of protection.

Under this head, it is our intention to consider the skin, the scales, and the spines of fishes. The *skin* of fishes consists, as in the other vertebral animals, of a true skin, a rete mucosum, and a cuticle. The *cutis*, or true skin of fishes, is remarkably thick in those species which have small scales; while in those which have large scales, it frequently assumes the appearance of a thin membrane. It is much more closely attached to the muscles in this tribe than in any of the other vertebral animals. This organ in the *gadi*, for example, consists almost entirely of gelatine, and hence is much esteemed as an article of food, and is used also in fining, as a substitute for isinglass. Eel skins are likewise used in the manufacture of size, in consequence of the gelatine which they contain.

In the higher classes of vertebral animals, there is an organ termed the *corpus papillare*, or the villous surface of the skin, in which the sense of touch is supposed more particularly to reside. Fishes, however, are destitute of this organ; and hence anatomists have concluded, that these animals are possessed of this sense in a very imperfect degree.

Intermediate between the true skin and the cuticle, is situated the *rete mucosum*. It consists of a mucous layer, in which the colouring matter of the skin resides. In the animals which we are now considering, this layer is remarkable for the brilliant tints which it exhibits, communicating to the scales all their metallic lustre.

The *cuticle*, or external layer of the skin, appears in fishes in a soft state, and, in many instances, is a simple mucous substance enveloping the body. It is detached at certain seasons of the year in large pieces.

The *scales* are implanted in the cuticle, and in their position and use resemble the hairs on the bodies of quadrupeds. They cover the body of fishes like tiles on the roof of a house, pointing backwards. The posterior edge, which in general is free, is usually crescent-shaped, fringed in some species, and smooth in others. By means of a lens, longitudinal ribs may be perceived finely decussated by transverse striæ. These ribs sometimes radiate from the centre, and the crossing striæ are concentric. When macerated in weak acids, they are found to consist of alternate layers of membrane and phosphate of lime, and hence are supposed to increase in every direction by the addition of new layers.

Instead of imbricated scales, some fishes are protected by *osseous plates*, covered, like the scales, by the cuticle, and presenting an even surface. Among some of the sharks, as the *Squalus acanthias*, instead of scales there are flat bent bristly laminæ; and in the remora there are hard rough tubercles. These osseous plates in the sturgeon, resemble in shape the shell of a limpet.

These scales may be considered as the ordinary armature of fishes. They guard their bodies from external injury, and, when rubbed off by accident, they are reproduced.

The naturalist employs the appearances exhibited by the scales, as a character in the discrimination of nearly allied species. The form, the surface, and the size of the scales, are chiefly used for this purpose, although the disposition of the longitudinal and the transverse rays, together with the condition of the margin, would furnish more permanent marks. The scales in the description of a fish, are likewise considered in regard to their adhesion to the skin. Thus some scales, which adhere but slightly, are said to be deciduous; while others, which cannot be rubbed off but with difficulty, are termed tenacious or adhesive.

Besides the scales, many fishes are furnished with spinous processes. These sometimes accompany the fins; while in other instances they appear as the armature of the head and cheeks. They appear to be of the same consistence and composition as horn. Those found on the head are in general fixed; but those connected with the fins are moved by peculiar muscles. These organs may be considered as defensive weapons, and act, in some instances, not merely by their form and consistence, but by some *venomous* secretion by which they are covered. Thus the common weever (*Trachinus draco*) inflicts a wound with the spines of the first dorsal fin, often followed by violent burning pains, inflammation, and swellings; so that the fishermen are in the practice of cutting off the offensive organ before they bring the fish to market. The spines of the *Squalus acanthias*, or piked dog-fish, is likewise considered by fishermen as capable of inflicting a dangerous wound.

The fishes furnished with spinous rays in the fins, were, at a very early period, separated from those with soft rays. They were termed *Acanthopterygii* by Artedi. The fishes furnished with spines on the head or cheeks, have been subdivided by La Cepede into several genera, from the characters furnished by these organs.

Sect. III. *Organs of Sensation.*

Organs of sensation.

In attending to the organs of sensation in fishes, the condition of the *brain* demands our first consideration. We have already stated, that the head is large in proportion to the size of the body; but with regard to the brain, the reverse of this appears to be the case. It does not completely fill the cavity of the cranium destined for its reception, the surrounding space being occupied by a salt fluid. It bears a much smaller proportion to the size of the body, than we find in the higher classes of animals. The following Table of these proportions in a few fishes is given by Cuvier.

White shark (*Squalus carcharias*)	$\frac{1}{2495}$
Great dog-fish (*Squalus canicula*)	$\frac{1}{1344}$
Tunny	$\frac{1}{37440}$
Pike	$\frac{1}{1305}$
Carp	$\frac{1}{560}$
Silurus glanis	$\frac{1}{1887}$

The brain of fishes is of a less compact texture than that of the superior animals, and in some species is almost fluid. In structure, however, it is nearly the same, although characterised by a few constant marks. The subdivisions of the brain and cerebellum, or their tubercles and lobes, are more numerous than in the mammalia and birds. In one genus of fishes, the Gadus, Dr Monro (*Structure and Physiology of Fishes*, Edin. 1785, p. 44.) found spheroidal bodies between the dura and pia mater, and covering the greater part of their nerves, like a coat of mail, in their course towards the organs to which they are destined. He was unable to ascertain their use.

The *spinal marrow* in fishes, instead of being conveyed in a vertebral canal, as in the mammalia, passes through the space formed by the superior processes of the vertebra. Like the other nerves of fishes, the size of the spinal marrow is in proportion to the size of the body, not to the brain from which it proceeds.

Having offered these few observations on the brain, we now proceed to consider the organs of the five senses, adverting to their structure, their functions, and their importance in the classification of fishes.

Smelling.

1. *Organs of smell.* The external organs of smell present several remarkable differences, according to the species, varying in number, shape, and position. In many fishes the nostrils are single, while in others they are divided at the surface by a transverse membrane, and thus exhibit the appearance of being double on each side. They likewise vary in shape, being round in the cod-fish, oval in the conger-eel, and oblong in others. They are placed in the snout in many fishes, near the eyes in some, and between the eyes and the snout in others. Where the openings are double on each side, these are either placed contiguous to each other, as in the carp, or at a little distance, as in the perch. The nostrils in some instances appear like short tubes.

The nasal openings are furnished with a few muscular fibres, which are capable of executing a limited contractile motion. This motion, however, in living fishes, can seldom be perceived.

Proceeding to the examination of the inside of the nostril, we may observe, that in the sharks and skates the nasal laminæ are placed parallel to each other on both sides of a large lamina, which extends from one end of the fossa to the other, and consist of folds of the pituitary membrane. In the other fishes, whether cartilaginous or osseous, the laminæ proceed like radii from an elevated and round tubercle. The pituitary membrane in some fishes, as in the pike, is furnished with reticular ramifications of black vessels, but in the greater number of fishes these vessels are red. Between these are situated some small papillæ, which pour out a thick mucilage.

The *olfactory nerves*, at their origin, form swellings or knots, so large as frequently to have been mistaken for the real brain. These tubercles in skates and sharks are united into one homogeneous medullary mass, from each of the lateral parts of which the olfactory nerves arise. In the species of the genera Pleuronectes, Clupea, Esox, Perca, and Salmo, there are two pair of tubercles, the anterior of which is smaller than the other.

In the cartilaginous fishes, as the skate and shark, the olfactory nerve is very soft. It is, in them, a bulb which passes obliquely forward towards the nares, which are at a greater or less distance from the brain according to the species. The spinous fishes have the olfactory nerve very long and slender. In those which have the snout elongated, this nerve is received into a cartilaginous tube. In those with short snouts, the nerve is surrounded by a fine membrane only, which appears to be the same as that which contains the fat or oily humour that covers the brain. In the haddock, and some other fishes, the olfactory nerve, in its course from the brain to the nose, passes through a cineritious ball, which resembles the cineritious matter connected in our body to the olfactory nerve within the cranium.

When the olfactory nerve arrives behind the folded membrane which we have described, it is dilated to be applied to the whole of its internal and convex surface. In some fishes no previous enlargement takes place, while in others the nerve swells into a real ganglion. When expanded, it has been compared to the retina, but the filaments of which it is composed are more distinct.

The sense of smell in fishes is supposed by many to furnish them with the most delicate tests, for searching after and distinguishing their food. Dr Shaw (*General Zoology*, vol. iii. p. 9.) states, that "if you throw a fresh worm into the water, a fish shall distinguish it at a considerable distance; and that this is not done by the eye is plain from observing, that after the same worm has been a considerable time in the water, and lost its smell, no fishes will come near it; but if you take out the bait, and make several little incisions into it, so as to let out more of the odoriferous effluvia, it shall have the same effect as formerly. Now it is certain, that had the animals discovered this bait with their eyes, they would have come equally to it in both cases. In consequence of their smell being the principal means they have of discovering their food, we may frequently observe them allowing themselves to be carried down with the stream, that they may ascend again leisurely against the current of the water; thus the odoriferous particles swimming in that medium, being applied more forcibly to their organs of smell, produce a stronger sensation." We do not presume to dispute the accuracy of these observations, but we may observe, that the well known voraciousness of fishes, the eagerness with which they will seize a metal button, or any glittering object, the whole art of artificial bait and fly-fishing, all seem to point out the organ of sight as the principal instrument by which they discover their food. Besides, the organs of smelling are by no means favourably situated for receiving quickly the impressions new objects are calculated to produce. In the chondropterygii the nares communicate by a groove with the angles of the mouth, but in general the organs of smell have no communication with those of mastication or respiration; and as the external openings are narrow, and but ill supplied with muscles, we are at a loss to conceive in what manner the water impregnated with odoriferous particles is thus rapidly applied to the extremities of the olfactory nerve. Alternate absorption and ejection of the water have never been observed. The same water we know must pass through the mouth, and be spread over the extended surface of the gills; so that we may presume, until farther light be thrown on the subject, that these latter organs may likewise contribute to warn the fish of the presence or absence of salutary or noxious impregnations.

The organs of smell furnish the ichthyologist with some important characters in the description of the species. These have hitherto been too much neglected, as they have the advantage of being permanent.

Seeing.

2. *Organs of sight.* The eyes of fishes, like all other red-blooded animals, are two in number. They vary greatly in position, both being, in some species, on the

same side of the head, as in flounders, while in others they are nearly vertical. In general, however, they are placed one on each side of the head. The eyes of fishes are larger in proportion to the size of their bodies than in quadrupeds, as we find the eye of the cod-fish equal in size to that of an ox.

Fishes in general are destitute of *eye-lids*, and are seldom even furnished with projections in place of eyebrows. In the moon-fish, (Tetraodon mola) however, the eye may be entirely covered with an eye-lid, perforated circularly. In the greater number of fishes, the skin passes directly over the eye without forming any fold, and in some cases it does not adhere very closely to the eye. Thus the common eel may be skinned without producing any hole in the situation of the eye, the skin only exhibits at that place a round transparent spot. In the trunk-fish, (Ostracion,) the conjunctiva, or external covering of the eye, is so similar to the rest of the skin, that we observe lines upon it, which form the same compartments as on the body of the fish. Some fishes may be considered as blind, as the Gastrobranchus cœcus, in consequence of the uniform opacity of the skin in passing over the eye.

The form of the eye in this tribe of animals is nearly that of a hemisphere, the plane part of which is directed forward, and the convex backward. In the Ray, the superior part is also flattened, so that the vertical diameter is to the transverse as 1 to 2. This flatness of the anterior part of the eye is compensated by the spherical form of the *crystalline lens.* This body is more dense in fishes than in land animals. Monro found the crystalline lens of an ox to be 1104, while that of a cod was 1165, water being reckoned at 1000. The crystalline lens projects through the pupil, and leaves scarce any space for the aqueous humour. The *vitreous humour* is proportionally small. The portion of the axis occupied by each of the three humours of the eye, in the herring, for instance, may be expressed in fractions as follows: aqueous humour $\frac{1}{7}$, crystalline lens $\frac{3}{7}$, and the vitreous humour $\frac{1}{7}$. The spherical form of the crystalline lens has been already stated; but the following Table, from the observations of Petit and Cuvier, will exhibit more clearly the proportion between the axis and the diameter in a few species.

The axis is to the diameter in the

Salmon as	9 to 10
Sword-fish	25 : 26
Shad	10 : 11
Pike	14 : 15
Barbel	11 : 12
Carp	14 : 15
Mackrel	12 : 13
Whiting	14 : 15
Shark	21 : 22
Ray	21 : 22
Herring	10 : 11
Tench	7 : 8
Eel	11 : 12
Conger	9 : 10

The *sclerotic coat* of the eye of fishes is more firm and dense than in the higher animals. It is here cartilaginous, semitransparent, and elastic, and sufficiently solid to preserve its form of itself. In the salmon it is of the thickness of a line posteriorly, and of an almost bony hardness before. This is frequently the case in other fishes, especially near its junction with the cornea, where it sometimes appears like an osseous ring. The outer layer of the *choroid coat* is either white, silvery, or gold-coloured, and is very thin and little vascular. The inner coat, to which the term *membrana Ruyschiana* has been applied, is in general black, and covered everywhere by mucous substance. In the ray, however, it is transparent. Between these two membranes of the choroid coat there is a body of a brilliant red colour. Its form is usually that of a thin cylinder, formed like a ring round the optic nerve; the ring, however, is not complete, a segment of a certain length being always wanting. Sometimes, as in the *Perca labrax*, it consists of two pieces, one on each side the optic nerve. It is considered by some as muscular, and enabling the eye to accommodate its figure to the distance of the objects; while others regard it as glandular, and destined to secrete some of the humours of the eye. This gland, we may add, does not exist in the *Chondropterygii*, as the rays and sharks.

The *iris* is in general distinguished by its golden and silvery brilliancy. This arises from its transparency, allowing the natural colour of the choroid coat to be discerned. The pupil is different in form in the different species, but in general it approaches to circular or oval; in some genera, as the salmon, it projects into an acute angle at the anterior part. In the *Gobitis anableps* of Linnæus, the cornea is divided into two portions, and there is a double pupil with a single lens. In the ray, the superior edge of its pupil is prolonged into several narrow stripes disposed in radii, gilded externally, and black internally. In their ordinary state they are folded between the superior edge of the pupil and the vitreous humours: but when we press the superior part of the eye with the finger, they unfold themselves, and cover the pupil like a window-blind. In the torpedo, the pupil can be completely closed by means of this veil. No other fishes possess any thing similar to this conformation, although in most osseous fishes, there is at each corner of the orbit a vertical veil which covers a small part of the eye.

In general, the eyes of fishes are placed in a conical cup, and repose on a mass of gelatinous matter contained in a loose cellular substance. This trembling elastic mass affords the eye a point of support in all its motions. In the *Chondropterygii*, however, as the rays and sharks, the eye is joined to the extremity of a cartilaginous stalk, which is itself articulated in the bottom of the orbit. In this manner the muscles act on a long lever, and have therefore great power in moving the eye.

The *optic nerves* arise under the cerebrum, and are very large. They are composed either of distinct filaments, or of a single flat band, which is sometimes folded longitudinally on itself, and contracted into the figure of a cord. They cross each other without being confounded, and we plainly see that the nerve of the left side proceeds to the right eye, and that of the right side to the left eye. This crossing is less apparent in the cartilaginous fishes, although in the ray the right nerve passes through an opening in the left. These nerves pass directly through the membranes of the eye by a round hole. Internally they form a tubercle, which is papillated in the ray, sharks, and carps. The radiating fibres which arise from the edges of these tubercles to form the retina, are very obvious. In other genera the retina is formed from the edges of two long white caudæ, in the same manner as it arises in birds from the single white line.

The eye is one of the most important organs which fishes are known to possess. It enables them to perceive the approach of their foes, and it is the principal instrument by which they obtain their food. The amateur in artificial fly-fishing often tempts the fish with one kind of fly, but in vain; and upon substituting another in its place of a different form or colour, he succeeds in the capture. These motions of the fish are all regulated by the eye; hence some fish will bite as readily at a bit of red cloth as at a piece of flesh.

As this organ exercises a very powerful influence on the habits of fishes, it should be carefully attended to by the systematic ichthyologist. The characters which are furnished by its form and position are not liable to variations, and they are sufficiently obvious. Those furnished by the colours of the different parts hold a secondary rank. They are not very liable to vary, but they experience great changes after death, and should be used with very great caution.

Hearing.

3. *Organs of hearing.* It was long known to naturalists, that fishes possessed some means of distinguishing the vibrations of sonorous bodies. Trouts and carp have been taught to come to a particular place of the pond for food upon a bell being rung; and a drum has sometimes been employed to drive fishes into a net. In general, however, it was supposed that the vibrations communicated to the water, became sensible to the fish, through the medium of the organs of touch.

The Abbé Nollet (in the *Hist. de l'Acad. R. des Sciences*, 1743, p. 26.) ascertained by conclusive experiments, that the human ear was susceptible to the impressions of sound, even when immersed in water. This discovery excited the attention of anatomists to the structure of the organs of hearing, and Camper, Geoffroi, and Vicq d'Azyr, succeeded in pointing out the nature of the different parts. Our illustrious countryman Dr Monro, in his work on the structure and physiology of fishes, contributed to enlarge our knowledge of the organs of hearing by numerous accurate dissections.

In the osseous fishes, no external ear has hitherto been detected, and the same remark is applicable to those cartilaginous fishes which have free branchiæ. But in the cartilaginous fishes with fixed branchiæ, small apertures have been discovered leading to auditory organs. These were first observed by Monro in the skate and the angel shark. In the former fish they occur in the back part of the occiput, near the joining of the head with the spine. They are two in number, not larger than to admit the head of a small pin; and in a large fish are found at the distance of an inch from each other.

In fishes that have free branchiæ, the internal organs of hearing are situated in the sides of the cavity of the cranium, and fixed there by a cellular tissue, consisting of vessels, and osseous or cartilaginous frœna. In the fishes with fixed branchiæ, those organs are inclosed in a particular cavity formed in the substance of the cranium. This cavity is situated on the side and posterior part of that which contains the brain, with which it does not communicate, except by the holes that afford passages for the nerves. The sac exhibits many differences as to size and form in the different species. Besides the ordinary viscid fluid, there are some small cretaceous bodies suspended by a beautiful plexus of nerves. These, in the osseous fishes, are three in number, and are hard and white like porcelain. In the cartilaginous fishes with free branchiæ, these bodies are in general fewer in number, and of a softer consistence, being seldom harder than moistened starch. It is supposed that these bodies assist in communicating to the nerves the vibrations produced in the water by sound. With the sac are connected three semicircular canals, filled with a viscid fluid similar to that in the large sac. The *auditory nerves* arise so near to the origin of the fifth pair, that they have been considered as the same. In the genus Raja these pass into the cavity of the ear by a particular foramen; in the osseous fishes, they are distributed directly into that organ.

As the ear of fishes is much less complicated in its structure than in the higher orders of animals, we may conclude that the sense of hearing is weak in proportion. Indeed the difficulty of detecting any natural movements of fishes, occasioned by sound, led the ancients to conclude that they did not enjoy this sense. We have, however, demonstrated its existence, but we are unable to ascertain the advantages which these animals derive from it, or the influence which it exerts on their habits and economy. In systematic ichthyology, the characters of the organs of hearing are too minute and difficult of detection, ever to be employed. They vary in different species, it is true, and may be resorted to in cases of difficulty; but for their investigation they require a dexterous hand and an experienced eye.

Tasting.

4. *Organs of Taste.* As the tongue of fishes (the organ in which the sense of taste resides in the higher orders of animals) is but imperfectly developed, naturalists are in general disposed to conclude, that the sense of taste can scarcely be said to belong to this class of beings. It presents no visible distinct papillæ, and its skin is analogous to the common integuments of the mouth. The nerves which supply it, are branches of the same nerves which proceed to the branchiæ. In the present state of our knowledge it is impossible for us to assign the precise influence which the sense of taste exercises on the economy of fishes. If noxious ingredients exist in the water, it appears probable, that some warning will be given the animal of their presence, either by the nerves of the mouth during the passage of the water to the gills, or by the latter organs. It does not appear that this sense is ever used in the discrimination of food, and does not furnish any characters, as such, to the systematic ichthyologist.

5. *Organs of Touch.* We have already observed that the skin of fishes is destitute of the corpus papillare, and hence anatomists have concluded, that they possess the sense of touch in a very limited degree. Besides, few nerves have hitherto been traced to the skin; and as its surface is in general coated with scales, it appears but ill adapted for receiving very delicate impressions. In some species, such as the common trout, (*Salmo fario,*) the sense of touch is well displayed, if, under a stone or bank, the hand be moved gently towards it, and its sides titillated. It will exhibit the pleasure it derives by leaning on the hand, and if the operation be performed with care, every part of the body may be gently stroked, and the fearless fish in part raised above the water.

From these observations on the organs of sensation, the reader will readily perceive that fishes hold a much lower place in the chain of being than quadrupeds or birds. The organs of smell and sight, appear to be more completely developed than those of hearing, taste, or touch, and therefore claim the attentive consideration of the student in his enquiries after a natural method in ichthyology.

Fishes possess no voice by which they can communicate their sensations to others. Some species utter sounds when raised above the water, by expelling the air through the gill opening when the flap is nearly closed.

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While others, even under water, as the salmon, utter certain sounds while in the act of depositing their spawn; but for what purpose these sounds are uttered, or by what organs they are produced, we are still ignorant.

Sect. IV. *Organs of Motion.*

Organs of motion.

If we attend to the vast variety of forms, exhibited by different kinds of fish, we shall be disposed to conclude that *shape* exercises but little influence on their movements. While some are cylindrical and lengthened, others are nearly globular: some are depressed, while others are compressed. The general form, however, approaches to ovate, the body being thickest at the thorax, and tapering a little towards the head and tail.

The *fins* of fishes, correspond with the wings of birds, the former being calculated to give the motion to the body in the water, the latter in the air. These organs vary in number, size, situation, and structure, in different species.

The *number* of fins varies according to the genera, and even according to the species. It is difficult to fix on those fins which exercise the greatest influence on the habits of the animal, as there is not any one fin common to all fishes, although all fishes have at least one of these organs. The *size* of the fins is equally various in the different species, as it bears no constant proportion to the figure or magnitude of the fish, nor to its habits or instincts.

The *situation* of the fins furnishes the ichthyologist with some of the most obvious and useful characters. Those fins which are situated on the back are termed *dorsal*, and vary greatly in number and shape. The fin which surrounds the extremity of the tail, is termed the *caudal* fin, and is always placed perpendicularly. It is forked in some, even, or rounded in others. Between the caudal fin and the anus are situated the anal fins, which vary in number and shape according to the species. Between the anus and throat are placed the ventral fins. When they do exist, they never exceed two in number, and are parallel to each other. The *pectoral fins* are usually two in number, and are placed on each side, a short way behind the gill opening. By Linnæus and others, the ventral fins are considered as analogous to the feet of quadrupeds, and the characters furnished by their position are employed as the basis of his classification. Those fishes which are destitute of ventral fins, are termed, in his system, *apodal*; those which have the ventral fins placed nearer to the anterior extremity than the pectoral fins, are termed *jugular;* those having the ventral fins beneath the pectoral, he calls *thoracic*, and when the ventral fins are placed behind the pectoral fins they are termed *abdominal*. These distinctions are of great importance in an artificial system, and may be employed with success in the inferior divisions of a natural one.

The *structure* of the fins of fishes has long occupied the attention of naturalists. In general these organs consist of numerous jointed rays, which are subdivided at their extremities. These are covered on each side by the common integuments, which form in some instances soft fibres projecting beyond the rays. These fins, with articulated rays, were considered by the older ichthyologists as furnishing characters for arrangement of great importance. Fishes possessing these were termed *malacopterygii*. Besides these articulated rays, there exist in the fins of some fishes, one or more rays made up of a single bony piece, enveloped like the former by a common membrane. Some fishes have one or more fins consisting entirely of these bony rays. Fishes with such rays are termed *acanthopterygii*. In a few genera the posterior dorsal fin is destitute of rays, and has obtained the name of *pinna adiposa* or flesh-fin.

As these rays serve to support the fins, and are capable of approaching or separating like the sticks of a fan, we may conclude that they move upon some more solid body as a fulcrum. Accordingly we find in the sharks, for example, that the rays of the pectoral fins are connected by a cartilage to the spine. In the osseous fishes the pectoral fins are attached to an osseous girdle which surrounds the body behind the branchiæ, and which supports the posterior edge of their aperture. This osseous girdle is formed of one bone from each side, articulated at the posterior superior angle of the cranium, and descending under the neck, where it unites with the corresponding bone. Between the rays of the fin and this bone, which resembles the scapula, there is a range of small flat bones separated by cartilaginous intervals, which may be compared to the bones of the carpus. The rays of the ventral fins are articulated to bones which correspond to the pelvis in the higher classes of animals. The pelvis is never articulated with the spine, nor does it ever form an osseous girdle round the abdomen. In the jugular and thoracic fishes it is articulated to the base of the osseous girdle which supports the pectoral fins. In the abdominal fishes, the bones of the pelvis are never articulated to the osseous girdle, and are seldom connected with each other. They are preserved in their situation by means of certain ligaments. The rays of the caudal fin are articulated with the last of the caudal vertebræ, which is in general of a triangular form and flat. The rays of the dorsal fin are supported by little bones, which have the same direction as the spinous processes, and to which they are attached by ligaments.

As connected with the fins, we may here take notice of those organs which are termed cirri or tentacula, according as they are placed about the mouth, or on the upper part of the head. They are in general soft, but often contain one jointed ray. They do not differ in structure from the fins, and are so closely connected with them, that it is difficult to point out their use. It is not probable that they are organs of touch, but rather peculiar modifications of fins.

The muscles which move the fins, and all the other organs of the body, are of a paler colour than in the animals of a higher order. They are also more uniform in their substance, being in general destitute of tendinous fibres. In the greater number of fishes there are no muscles peculiar to the head. The sides are furnished with the most powerful ones, to execute the lateral movements of the animal. These muscles are disposed in layers or arches, with the convexity towards the head. The different muscles are strengthened by small detached spines, imbedded among the fibres of the muscle, and giving them additional strength. Between the layers there is in general a quantity of viscid albuminous matter interposed. After death this fluid speedily undergoes a change, and can seldom be observed in fishes which have been kept a few days. But in recent fish, when boiled, the albumen appears coagulated in the form of white curd between the layers of the lateral muscles.

The motions of a fish are performed by means of its fins. The caudal fin is the principal organ of progres-

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sive motion. By means of its various flexures and extensions, it strikes the water in different directions, but all having a tendency to push the fish forward; the action resembling, in its manner and effects, the well known operation of the sailor termed *skulling*. The ventral and pectoral fins assist the fish in correcting the errors of its progressive motions, and in maintaining the body steady in its position. Borelli cut off with a pair of scissars both the pectoral and ventral fins of fishes, and found, in consequence, that all its motions were unsteady, that it reeled from right to left, and up and down, in a very irregular manner. The dorsal and anal fins serve to maintain the body in its vertical position. But from the circumstance of some of these fins being wanting, and others evidently too small to produce the desired effects, those fins which do exist appear to be capable of executing all the movements for which the others, when present, are designed.

The medium in which fishes reside prevent us from making any accurate observations on the velocity of heir motion. Mackrel, and some other marine fishes, will seize a bait moving at the rate of six or eight miles an hour; and some of the voracious sharks will keep up with a vessel in her voyage across the Atlantic. The darting of a salmon or trout in the water resembles the rapidity of an arrow, but such motion cannot be kept up for any length of time. This the angler is well aware of, who, with his hook fixed on very slender gut, will kill by fatigue the strongest salmon in the course of an hour or two, and a large trout in the course of two or three minutes. These facts seem to indicate, that however numerous and powerful the muscles of a fish may be, they are incapable of supporting a continued exertion.

Besides the action of swimming, fishes are likewise capable of *leaping*. They accomplish this by a violent effort of the caudal fin, or, according to some, by bending the body strongly, and afterwards unbending it with an elastic spring.

A few species are capable of sustaining themselves in the air for a short interval, and are termed *Flying-fish*. Such fish have the air bag, an organ to be noticed hereafter, of uncommonly large dimensions; hence the body has great buoyancy. The pectoral fins are likewise of an extraordinary size. Having by a leap raised themselves above the surface of the water, they continue in the air and move forwards, seldom farther than a hundred yards, by the action of their pectoral fins. The continuance of their flight is interrupted by the drying of the membrane of these fins, when they again fall into the water.

There is one species of fish (Perca scandens of *Lin. Trans.* vol. iii. p. 62.) which appears capable of *climbing*. By this motion, according to Lieutenant Daldorff of Tranquebar, it sometimes raises itself five feet above the surface of the water, mounting up the crevices of trees. The spines of its gill-cover retain it in its position; and when the body is bent to one side, the spines of the anal fin fix themselves in the bark; and when the body is then brought back to its ordinary shape, the head has reached a higher elevation. The spines of the expanded gill-covers again keep a firm hold, and a similar twisting of the body takes place in another direction. The spines of the dorsal fin contribute likewise to this extraordinary progression. The flying-fish leave the water to escape from other fishes which prey upon them; but the object to be gained by these movements of this fish has not been ascertained, nor has even a conjecture been offered on the subject.

The organs of motion, we have already hinted, are extensively employed by the systematic ichthyologist in the formation of his divisions. It does not appear, however, that naturalists have determined the exact value of the characters which they furnish, either for generic or specific distinctions. La Cepede, in some instances, has formed genera from a difference in the number of the dorsal fins; while into the genus Gadus, species with one, two, and even three fins, are admitted. As the number of the fins is invariably the same in the same species, and as these organs may be supposed to exercise considerable influence on the habits of fishes, the character thus exhibited may be safely employed in generic distinctions. The characters furnished by the structure of the fins have not been overlooked, especially the rays. The circumstance of being bony or jointed, is often noticed in specific distinctions, although well entitled to regulate divisions of a higher kind, as the character furnished is permanent. Those characters furnished by the fins, which are employed exclusively in the construction of species, are derived from their form, and the number of their rays. But as these characters are liable to vary in different individuals of the same species, they should be employed with great caution. In many fishes there are numerous rays on each side the different fins so concealed under the skin, that it is impossible to count them, while others do not reach the extremity of the organ. Hence the number of rays must vary with the mode of enumerating, and perhaps with the age of the animal. The extent of variation occasioned by the last cause has not been satisfactorily determined.

SECT. V. *Organ of Adhesion.*

Organ of adhesion.

THE organ here referred to, generally termed *sucker*, is only found on a few fishes. In some of these it is situated on the upper part of the head, while in others it is placed on the thorax. In the celebrated fish called the Remora, it is of an oval form, and consists of transverse rows of cartilaginous plates, connected by one edge to the surface of the head, and in the other edge free, and finely pectinated. A longitudinal partition divides the plates in the middle of the head. In the spaces between the plates, and on each side of the partition, a row of fleshy tubercles may be observed. In the cyclopteri this organ is of a circular form, and consists of numerous soft papillæ. It is situated on the thorax. Instead of a separate organ of adhesion, the ventral fins in the goby are united, and are capable of adhering to rocks and stones, while in the lampry the mouth contracts and acts as a sucker.

The existence of a sucker is equally common to some cartilaginous and osseous fishes. Its use to the fish is difficult to ascertain. When, by means of this organ, the fish attaches itself to the sides of other fishes, or to the bottom of ships, it is carried forward without any exertion of its own; and, during storms, adhesion to rocks by means of it, may save a weak fish from being tossed about by the fury of the waves; but there may perhaps be other purposes to which it is subservient, which still remain to be discovered.

The sucker furnishes to the ichthyologist characters for the discrimination of the species which are obvious and permanent; but these have seldom been described with accuracy or minuteness.

SECT. VI. *Organs of Respiration.*

Organs of respiration.

As the organs of respiration appear in fishes under a new form, very different from the lungs of the higher order of animals, they demand our attentive consideration. Many quadrupeds, birds, and reptiles, reside in water, but are obliged to come to the surface frequently in order to respire. But as fishes live immersed in the water, they are furnished with certain organs called Gills, instead of lungs, to enable them to exercise the functions of respiration in the fluid in which they reside. In many of the inferior animals, respiration is performed by the same apparatus; but as it appears in its most perfect form in fishes, its examination will be the more interesting.

These organs of respiration in fishes consist of four parts, a gill-lid, a gill-flap, the gill-opening, and the gills themselves. The two last are always present, but one, and sometimes both, of the two first are wanting. We propose to examine these parts in succession, beginning with those which are exterior.

Gill-lid.

1. *Gill-lid.* The gill-lid, or as it is also termed, *operculum*, is situated behind the eye on each side. It is scaly, membranaceous, or bony, and is articulated to the bones of the head. It consists sometimes of one piece, or of two or more, and is therefore termed monophyllous, diphyllous, or triphyllous. The surface in some is smooth, in others rough, or tuberculated, or striated, or spinous. Its use is to give support to the gill-flap, and act as a cover to the opening of the gills. It is absent in fishes which have fixed branchiæ, and in a few with free branchiæ. When it does exist, the characters which it exhibits in its structure are subject to little variation, and have been employed by La Cepede in the construction of his orders.

Gill-flap.

2. *Gill-flap.* This is the *membrana branchiostega* of Linnæus, and was considered by him as a true fin. It consists of a definite number of curved bones or cartilages, with a membrane. Its posterior edge is generally free, and its anterior edge or base is united with the gill-lid. It is capable of extension and contraction, and when at rest it is generally folded up under the gill-lid. It is wanting in the chondropterygii, and likewise in a few genera of osseous fishes. When present, it appears to assist the mouth in promoting the current of water through the gills, or perhaps forms a current over the gills when the mouth is occupied in seizing prey.

The gill-flap furnishes to the systematic ichthyologist some of his most useful characters. He seldom pays attention to its form, but its rays are eagerly counted, as he finds that they are not subject to vary. Species of the same genus have, in general, the same number of rays, and many of the Linnæan genera depend on this circumstance for their character. Artedi, on this subject, draws the following conclusion: "Quod numerus ossiculorum in membrana branchiostega primum et præcipuum characterem in distinguendis generibus piscium catheturorum et osteopterygiorum suppeditet." But in counting their number, care must be taken to examine the structure of the gill-lid at the same time, as the student sometimes enumerates among the rays of the gill-flap the posterior divisions of that organ, when present, and hence finds his observations at variance with the descriptions of authors.

Gill-opening.

3. *Gill-opening.* This division of the organs of respiration presents many remarkable differences. In the osseous fishes, and among the branchiostegi, this opening is a simple aperture behind the gills on each. It is sometimes round, or semi-lunar, and in relative position it differs according to the species or genera. In the cartilaginous fishes, the opening on each side is subdivided into as many apertures as there are gills, the gills in this tribe being fixed to the membranes which act as partitions in the opening. In such fishes, these openings are on the summit, at the sides, or underneath, according to the genera.

Gills.

4. *Gills.* In the fishes with gills or branchiæ, these organs are in general eight in number, four on each side. Each gill consists of three parts, a cartilaginous or bony support, and its convex and concave sides. The support of each gill consists of a crooked bone or cartilage, in general furnished with a joint. At its base, it is united with the bones of the tongue, and above with those of the head. At both extremities it is moveable, and throughout is flexible like a rib. Its position is nearly vertical. From its exterior or convex side, issue a multitude of fleshy leaves, or fringed vascular fibrils, resembling plumes, and closely connected at the base. These are of a red colour in almost all fishes in a healthy state. The internal or convex side of the support next the mouth exhibits many singular differences. It is always more or less furnished with tubercles. These in the genus Cyprinus are smooth—in the Cottus rough. They are lengthened into slender spines in the herring and smelt, but in the former these are serrated, while in the latter they are smooth. This concave part of the gill is of a white colour, and forms a striking contrast with the colour of the convex side.

In some osseous fishes, the number of gills exceeds four on each. In the herring, for example, there is a small imperfect gill on each side attached to the inner side of the gill-lid, on which all its motions depend. It has no bony arch nor concave side. At the entrance to the gullet, there is a cartilage on each side, studded with tubercles, resembling in appearance the concave side of the last gill. In the *plaise*, a similar gill may be observed on the inside of the gill-lid, but no distinct appearance of a sixth gill at the entrance to the œsophagus.

In the chondropterygii, the gills are far from being so perfect. They are fixed to partitions which serve the purposes of the bony arches in the osseous fishes. These partitions extend from the mouth to the gill-opening, and vary in number according to the genera. They are destitute of the inner or concave white side, but the fleshy leaflets are of the same structure with those on the convex part of the gills in osseous fishes.

We are indebted to that acute anatomist, Sir Everard Home, for some important observations on the respiratory organs of the lamprey and myxine, the apodal chonropterygious fishes, and the least perfect in the system. "In the lamprey, (he says), the organs of respiration have seven external openings on each side of the animal; these lead into the same number of separate oval bags, placed horizontally, the inner membrane of which is constructed like that of the gills in fishes. There is an equal number of internal openings leading into a tube, the lower end of which is closed, and the upper terminates by a fringed edge in the œsophagus. These bags are contained in separate cavities, and enclosed in a thorax resembling that of land animals, only composed of cartilages instead of ribs, and the pericardium, which is also cartilaginous, is fitted to its lower extremity like a diaphragm." In the myxine,

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the external openings are two in number, but there are six lateral bags on each side, placed perpendicularly, to which there are six tubes from each of the openings, and close to the left external opening, there is one which passes directly into the œsophagus. (*Phil. Trans.* 1815, Part II. p. 256.)

The characters furnished by the gills are of the first importance in arranging the species. They are easily examined, and the distinctions are obvious. But by some strange conceit, ichthyologists seldom look into the gills, or point out to us the peculiarities which they exhibit. Indeed the characters furnished by the organs of respiration should be regarded as occupying the highest rank. Without the aid of any other characters, fishes might be classified with ease, and even species might be determined with certainty.

SECT. VII. *Organs of Circulation.*

Organs of circulation.

THE organs of circulation are not so obvious as those which we have been considering, and are seldom attended to by the mere ichthyologist. Without entering into the minute details of comparative anatomy, we trust the following observations may not prove uninteresting to the general reader. The *heart* of fishes is situated in the forepart of the body, in a cavity between the gills and a little behind. The pericardium or membrane which lines this cavity, is similar to the covering of the cavity of the abdomen, and like it, is often spotted or silvery. In the skate, Dr Monro found the bottom of the pericardium lengthened into the shape of a funnel, which divides into two branches. These are tied closely to the lower part of the œsophagus, and open into the cavity of the abdomen. Into this cavity there is secreted a liquor, afterwards to be taken notice of. The heart itself is small in proportion to the body of the animal, and varies greatly in figure in the different species. It is quadrilateral in some, and semicircular in others. It consists, as we have already mentioned, of a single auricle and a single ventricle, corresponding to the right side of the heart of warm-blooded animals. The auricle is in general larger than the ventricle, and of a thinner texture in its coats. It receives the blood from the body, and transmits it to the ventricle. This last division of the heart has walls of considerable thickness. It sends forth an artery, which, at its separation from the heart, forms a bulb varying in shape according to the species. This artery subdivides and proceeds directly to the gills, over whose leaves it is spread in the most minute ramifications.

The blood, in passing through the gills of fishes, undergoes similar changes as the blood of quadrupeds in passing through their lungs. It is likewise now well established, that the atmospheric air contained in the water furnishes to the blood those materials which are necessary for its purification, and a continuance of the life of the animal.

The water for this purpose is taken in at the mouth, and sent to the gills, where, after being in a great measure deprived of the oxygen of its atmospheric air, the water is ejected through the gill opening.

"In the lamprey," according to Home, "the water is received by the lateral openings of the animal into the bags which perform the office of gills, and passes out by the same opening; the form of the cavities being fitted to allow the water to go in at one side, pass round the projecting parts, and out at the other. A part of the water escapes into the middle tube, and from thence either passes into the other bags, or out at the upper end into the œsophagus. There is a common opinion that the water is thrown out of the nostril: this, however, is unfounded, as the nostril has no communication with the mouth."—"In the myxine, the elasticity of the two tubes, and the bags into which they open, admits of the water being received; and the pressure produced by the action of the external muscles forces it into the œsophagus, from whence it is thrown out by the opening at the lower end of that tube."

If the ejection of the water from the gills of a fish be prevented, by the gill cover being tied down with a string, it soon expires in convulsions. Similar fatal consequences follow, when fish are placed in water previously deprived of its atmospheric air by boiling or freezing: and when fish are kept in a small pond, whose surface is frozen over, and where the water in that case cannot obtain a fresh supply of air, they speedily perish. If a small opening be made in the ice, before it be too late, the fishes will come near it for a fresh supply. In this manner, fishes are frequently taken during winter in ponds and lakes.

The extent of surface presented by the gills of a fish, to enable the blood to come in contact with the air in the water, is much greater than one would, without attentive consideration, be led to suppose. Dr Monro calculated, that the whole gills of a large skate presented a surface equal to 2250 square inches, or equal to the whole external surface of the human body.

The process of respiration for the supply of the gills is carried on even during sleep. The number of respirations in a minute is seldom above thirty, or below twenty. In the same individual it is liable to considerable variation, depending on the will of the animal.

The blood, after being renovated in the gills, is reabsorbed by a multitude of minute vessels, which unite together; but, instead of returning the blood to the heart again, to be afterwards distributed through the body, this aorta exercises that function, and descends along the inferior side of the spine, in a canal fitted for its reception, giving off arteries, during its course, to the adjacent parts. The blood is absorbed again by veins, which have extremely thin coats. These are much larger in their course than in their termination; and besides form, in different parts of their course, considerable receptacles for blood.

Any injury received by the gills of fishes is attended with much pain, and a considerable effusion of blood. Some fishermen seem to be well aware of this last circumstance, and cut the gills with a knife as soon as the fish is taken. A copious bleeding takes place; and they find that a fish so killed will keep much longer in a fresh state, than one on whom this operation of bleeding has not been performed.

SECT. VIII. *Organs of Nourishment.*

Organs of nourishment.

IN attending to the organs of nutrition, it will be necessary to consider the structure of the mouth, and afterwards the gullet, stomach, and intestines.

Mouth.

The *mouth* of fishes exhibits many remarkable differences, according to the species, in regard to position, figure, and size. In general, it is situated at the extremity of the head, and is then said to be terminal. In some species, and even genera, it is placed beneath a snout, or on the under side of the head. Wherever situated, it is always transverse with respect to the body, unless in the genus Pleuronectes, in which it occupies an oblique position. When the mouth is opened, it is in general of an oblong or oval shape. In some fishes, its capacity is less than the size of the head; but, in general, it is capable of opening to a great width, sometimes superior to the thickness of the body.

Lips.

The *lips* of fishes are seldom regularly formed. In a few species, however, these surround the mouth, and are of a firm, fleshy consistence. In other instances, the lips are of an osseous texture, divided into plates which fold over one another. Such kind of lips give to the mouth increased dimensions, as they are capable of being exserted or folded up at the pleasure of the animal.

Jaws.

The *jaws* are moveable, and both are attached to the bones of the palate. They are seldom equal, the one exceeding the other in length. They furnish, by their position and mode of union, many important characters in the classification of fishes. These characters have been lately investigated by Cuvier with his usual success; and he is of opinion, that the maxillary and intermaxillary bones will furnish characters not for genera merely, but likewise for orders.

Teeth.

The *teeth* of fishes exhibit remarkable differences, with regard to number, situation, and structure. In the higher orders of animals, the number of teeth in the mouth is almost always constant in the same genera and species. But among fish, the teeth are often so numerous that it is difficult to count them, especially as they occupy so many different positions. The jaws are not exclusively employed to support these organs, as in quadrupeds; the tongue, the palate, the throat, being often furnished with them. In the saw-fish, the teeth are inserted on each side of its flattened and projecting snout. In the genus Sparus, the front teeth resemble those of the human species. They are provided with fangs, which are contained in alveoli. In many fishes, the teeth are formed of processes of the jaw bones covered with enamel. Those of the shark tribe adhere merely to the gums, or at least to a firm cartilaginous substance which covers the jaw. They are not formed, as in the mammalia, by the addition of new layers, one within the other, but apparently in a manner resembling the formation of bone. They are at first soft and cartilaginous, and pass, by successive gradations, into a state of hardness and density not inferior to that of ivory. In the skate, the teeth consist of an assemblage of tubes, covered externally by enamel, and connected to the jaw by a softer substance, which probably sends processes or vessels into those bony tubes.

The teeth of fishes are in general bent inwards, to enable them to retain their prey. As few fishes masticate, they have seldom any teeth which resemble grinders, although those which live on the harder shell-fish have teeth fitted for triturating these.

In the classification of fishes, the teeth furnish several important characters, which are little liable to variation. In the genus Squalus, in particular, the teeth exhibit many remarkable differences in form, sufficient, in the absence of other characters, for the discrimination of the species.

Gullet.

The *gullet* or œsophagus, on account of the absence of a neck, is in fishes remarkably short. In some, indeed, the stomach seems to open directly into the mouth. Where it exists, it exhibits few peculiarities of structure. In some of the branchiostegi it is beset with tufts of hair resembling a fine net-work. It is in general capable of great dilation, and when the stomach is unable to hold the whole of the prey which has been seized, a part remains in the gullet until the inferior portion gives way.

Stomach.

The *stomach* of fishes is in general thin and membranaceous, differing little in its structure and appearance from the gullet. It frequently contains the remains of crustaceous animals, still retaining their form, but greatly altered in consistency. Hence naturalists have concluded, that the food is reduced by solution, and not by trituration. But in some fishes, particularly those which subsist principally on shell-fish, the stomach has thick muscular coats. Its shape is considerably different in the different species, but the characters furnished by this organ are seldom regarded.

Intestines.

The *intestines* exhibit many remarkable peculiarities. Sometimes they proceed directly from the stomach to the anus in nearly a straight line. In other instances, they form in their course one or more flexures. In some instances, the gut is widest towards the stomach, and gradually becomes smaller as it approaches the anus, while in others the reverse of this is the case. It is furnished internally in some species with spiral valves, in others with lozen-shaped hollows, while in a few it has numerous fringed laminæ. Between the great and small intestines, in the chondropterygii, there is a kind of cœcum or appendix vermiformis; but in osseous fishes, there is no appearance of any such organ. In the last division, however, there are bodies which have been termed *Appendices*, or Intestinula-cœca. These are situated at the origin of the gut, in a double or single row. They vary in number, shape, or size, according to the species; but continue the same in all the individuals of the same species. In place of these in the chondropterygii, there is a glandular body, which has been compared to the pancreas of warm-blooded animals. The character for the discrimination of the species furnished by the appendages is of importance, as being easily investigated and permanent.

These intestines, and the rest of the viscera situated in the cavity of the abdomen, are contained in a membranaceous sac or peritonæum. This is silvery in some fishes, black or spotted in others. We are informed by Willoughby, that this sac opens externally near the anus by means of two small holes. These openings were afterwards examined by Monro, who found in each of these passages a semilunar membrane or valve, so placed as to allow liquors to get out from the abdomen readily, but to resist somewhat their entry into it.

The anus in fishes, occupies many different positions according to the species. This circumstance was seized upon by Scopoli, in the system which we have noticed above, and was raised to the dignity of a primary character in his system. This orifice is not merely the opening whence issue the fæces, but in general the spawn also.

Sect. IX. *Organs of Absorption.*

Organs of absorption.

The vessels of the absorbent system of fishes are analogous to those of quadrupeds. They are, however, destitute of valves, unless at their termination in the red veins, and do not appear to possess conglobate glands. Dr Monro, to whom we are indebted for the first illustration of this class of vessels, gives the following view of their arrangement in the cod and the salmon. " The chief branches," he says, " of the lacteal vessels of the great and small intestines, and which are smaller in proportion to the blood vessels than in the nantes pinnati of Linnæus, run upwards in the mesentery, almost parallel to each other, and near the mesenteric arteries. In their whole course, they communicate by a vast number of small transverse canals. At the top of the abdomen near the gall bladder, the lacteals of the stomach, and lymphatics of the spleen, liver, and intestinula cœca are added. The chyle, mixed with the lymph of the assistant chylopoietic viscera, passes upwards and towards the right side into a large receptacle contiguous to the gall bladder, and between it and the right side and back part of the lower end of the œsophagus. From the receptacle of the chyle, large canals pass upwards to the right and left, receiving in this course the lymph from the organs of urine and generation. Those on the left side are chiefly behind the œsophagus.

The chyle, mixed with the abdominal lymph, having ascended above the bones, which resemble our clavicles, is poured into large cellular receptacles, situated chiefly between the clavicles and the undermost of the gills, and which also receive the lymph from all the other parts of the body.

Four lymphatic vessels, which terminate in these receptacles, and which have their extremities contracted by a doubling of their internal membranes, chiefly merit attention. The first conveys the lymph from the middle of the belly, from the ventral and pectoral fins, and from the heart. The second runs up the side of the fish, parallel to the great mucous duct, and brings the lymph from the principal muscles of the tail and body. The third is deep seated, and conveys the lymph from the spine, spinal marrow, and upper part of the head. The fourth lymphatic vessel, or rather plexus of vessels, brings the lymph from the brain and organs of the senses, and from the mouth, jaws, and gills.

These receptacles may therefore be called the common receptacles of the chyle and lymph. The right receptacle communicates freely with the left by large canals, which pass chiefly behind the heart and œsophagus.

From each of these receptacles in the salmon, a canal runs downwards and inwards, and opens into the upper end of its corresponding vena cava inferior, contiguous to, and on the fore and outer side of the internal jugular vein. The termination of these canals are contracted, and their internal membranes are doubled, so as to serve the purpose of valves, in preventing the passage of the blood from the venæ cavæ into the receptacles. In the cod kind, the receptacles are proportionally larger than in the salmon; and, besides transmitting the muscles of the gills, and their several nerves, contain the upper cornua of the air bladder." (Monro, *Struct. and Phys. of Fishes*, p. 31.)

The termination of the lymphatic veins in the skin, may be readily ascertained in this class. Coloured liquors injected into them, are discharged by numerous pores, chiefly situated on the upper parts of the body. These orifices are placed at regular intervals. As Dr Monro did not observe any appearance of extravasation in the cellular substance, he considered that these orifices were the natural beginnings of the lymphatic veins.

Sect. X. *Organs of Secretion.*

Organs of secretion.

In considering the organs of this class, we propose to examine the structure of the liver, pancreas, kidneys, air, and mucous ducts.

Liver.

1. *Liver.* This organ in fishes, is remarkable on account of its size in proportion to the rest of the body. It commonly lies almost wholly on the left side. Its colour exhibits various shades of brown frequently mixed with yellow. It is entire in some fishes, as the lamprey, flounder, and salmon; or divided into two or more lobes, as in the perch and carp. These varieties of form are constant in all the individuals of the same species, but frequently differ somewhat in the species of the same genus.

The *gall bladder* is present in the greater number of fishes; but in a few species, as the lamprey, its presence has not been detected. The *bile* varies greatly in colour according to the species. In the thornback and salmon it is yellowish white, and, when evaporated, leaves a matter which has a very sweet and slightly acrid taste, containing no resin. The bile of the carp and eel is very green and very bitter, contains little or no albumen, but yields soda, resin, and a sweet acrid matter similar to that which may be obtained from salmon bile. The biliary ducts open separately into the intestine.

The liver appears to be the only organ of the body of fishes which contains oil in abundance, or is sought after on that account. This oil is lodged in cells, and cannot be completely obtained by the boiling of the liver. To accomplish the extraction of the whole oil, fishermen in general allow the livers to putrefy a little, and in this manner the cells are ruptured, and a greater quantity of oil obtained. But gelatinous matter and bile are likewise among the products, and as these afterwards putrefy, they communicate a fœtid smell to the oil. This disagreeable smell is common to all kinds of fish oil thus prepared; but it may be removed by various processes. Perhaps the best are those which were communicated to the Society for the encouragement of arts, manufactures, and commerce in the year 1761, and published in the twentieth volume of their Transactions, to which we refer the reader. The liver of the cod, cut into small pieces, boiled in the stomach of the same animal, and eaten with vinegar and pepper, is a favourite dish in the northern islands of Scotland.

Pancreas.

2 *Pancreas.* In the chondropterygii, there is a pancreas resembling that in the higher classes of animals, of an irregular form, and placed at the origin of the intestines. The substance appears compact, but gelatinous when cut. In the osseous fishes, the intestinula cœca already described, appear to serve instead of a pancreas. They send two large canals into the intestines; and when these are wanting, as is the case in the carp, the walls of the intestines discharge abundance of humour from glands placed upon their inner surface. In the sturgeon, an organ is found, in its internal structure similar to these intestinula; but in its outward form resembling the pancreas of the skate. It is inclosed in a muscle, evidently intended to express its contents. It opens into the intestine by three large orifices, and has internally a singular reticular appearance, as exhibited by Monro in the work on fishes so often referred to, page 84. tab. ix.

Spleen.

3. *Spleen.* This organ varies greatly in its form and position in the animals of this class. In some it is nearly triangular, while in others it approaches to a spherical figure. It is in general entire; in some instances, however, it is divided into lobes, which adhere by very slender filaments. In the sturgeon, these lobes are seven in number. It is placed in some species on the stomach, or to the first part of the intestines; in others between the stomach and liver; and in a great number it is under the air bag, and above the other bowels. It is always of a darker colour than the liver.

Kidneys.

4. *Kidneys.* It was the opinion of Rondeletius and others, that fishes were destitute of kidneys and the

bladder of urine; but the observations of Willoughby and others have demonstrated their existence. The kidneys of fishes are uniform in their substance, and of a reddish brown colour. They are in general long and narrow, and apparently united into one mass. The peritoneum covers their under surface, and they are placed longitudinally under the spine. The ureters begin by numerous roots, and run along the under surface of the kidney. They terminate either in a vesica urinaria, or a cloaca; or unite together to form a dilation, which supplies the place of a bladder of urine.

In the chondropterygii, the ureters terminate in the cloaca, but in the other cartilaginous fishes the bladder of urine is present, although very small and thin in its coats. The urethra in most fishes is short, and commonly opens behind the anus by an orifice which also gives issue to the sexual evacuations. Renal glands are wanting in this class.

Air-bag.

5. *Air-bag.* This organ is called by some the swimming bladder, by others the air bladder. It is the vesica natatoria of Willoughby, and the vesica aerea of Artedi. In this country it is called the *sound.* When present, it is situated in the anterior part of the abdominal cavity, and adheres to the spine. It is wanting in the chondropterygii, and even in some of the osseous fishes, as the flounder and mackrel.

It is very different in shape according to the species. In the herring and some other fishes it is oblong and pointed at both ends. In the salmon it is obtuse at both ends. In the burbot it is obtuse in the lower end, and bifid at its superior extremity. In the carp it is divided transversely, and in the silurus longitudinally, into two lobes.

In general there is a duct (*ductus pneumaticus*), by means of which this air bag communicates with the œsophagus, or the stomach. In the sturgeon there is a round hole, nearly one inch in diameter, in the upper and back part of the stomach, communicating with the air bag. The hole is surrounded by thin muscular fibres placed between the membranes of the stomach and air bag, which decussate at opposite sides of the hole. These are considered by Monro as having the effect of a sphincter muscle. In the salmon, the last quoted author found a hole so large as to admit readily the largest sized goose quill, leading directly through the coats of the œsophagus into the air bag. The œsophagus in this fish has a thick muscular coat, but the fibres of that coat do not seem to form a distinct sphincter around the hole. In other fishes the duct of communication is of considerable length. In the common herring the under part of the stomach has the shape of a funnel; and from the bottom of the funnel a small duct is produced, which runs between the two milts, or the two roes, to its termination in the middle of the air bag. In some fishes, as the cod and haddock, Monro could not perceive any ductus pneumaticus, or opening into any of the abdominal viscera. The air bag was not enlarged by blowing into the alimentary canal, nor could he empty the air bag without bursting it.

In the air bag of the cod and haddock, the same acute observer examined the red coloured organ noticed by Willoughby, and considered by him as a muscle, the surface of which is very extensive, as it is composed of a vast number of leaves or membranes doubled. In those fishes, however, in which the air bag communicates with the alimentary canal, this red body is either very small and simple in its structure, as in the conger eel, or entirely wanting, as in the sturgeon, salmon, herring, and carp.

Naturalists, in general, are disposed to regard the air bag as accessory to the organs of motion. Having observed that flat fish, which reside always at the bottom, are in general destitute of this organ, they have assigned to it the office of accommodating the specific gravity of fishes to the density of the surrounding element, and thus enabling them to suspend themselves at any depth. A very simple experiment has likewise countenanced the opinion. When the air bag of a fish is punctured, the animal immediately falls to the bottom, nor is it able, by any exertion of its fins, to elevate itself again. When in a sound state, the external skin of the air bag (regarded as possessing strong muscular power) is supposed capable of contraction, so as to condense the air, and enable the animal to sink, or of extension, so as to allow the air to expand, and aid the animal in rising in the water.

The air bag of some fishes soon loses its muscular power, in consequence of the air being expanded by the action of the sun, when the fish has remained too long at the surface. In this situation the fish continues at the surface. When some fish are suddenly brought up from deep water, the diminished pressure occasions the expansion of the air contained in the bag. The organ sometimes bursts in such cases, and the contents, rushing into the abdomen, push the gullet sometimes out of the mouth of the fish. We have witnessed this effect produced in the cod fish.

The above theory fails in explaining all the phenomena. The eel, which resides always at the bottom, is yet possessed of an air bag; while the sharks, which roam about in all depths, and the mackrel, which pursues its prey at the surface, are destitute of this reputed organ of equilibrium.

Various opinions have been advanced with regard to the manner in which this air bag is filled. By some it has been supposed, that a portion of the air, which fishes are capable of abstracting from the water, is transmitted through the gullet and stomach into the air bag when necessary, and expelled and renewed at the pleasure of the animal. Needham long ago considered that the air, or, as he termed it, a vaporous exhalation contained in the air bag, was generated in the blood, secreted into this organ, to be afterwards thrown into the stomach or intestines, to promote the digestion of the food.

The nature of the air contained in the air-bag, was never investigated until pneumatic chemistry had opened up new fields of discovery. In 1774, Dr Priestley turned his attention for a short time to the subject; and in the air-bag of the roach he found azote in one instance unmixed, and in another in company with oxygen. Fourcroy afterwards examined the gaseous contents of the air-bag of the carp, and found them to consist of almost pure azote.

The most accurate and extended experiments on this subject are those of M. Biot, published in the *Mem. d'Arcueil,* i. 252. and ii. 8. He found the proportion between the oxygen and the azote (for he was unable to detect the presence of hydrogen, or any sensible quantity of carbonic acid) to vary according to the species, as may be seen in the following table.

Names of the Fish.	Proportion of Oxygen.
Mugil cephalus	quantity insensible.
Ditto	ditto.
Murænophis helena	very little.
Sparus annularis, female	0.09
Ditto, male	0.08

Names of the Fish.	Proportion of Oxygen.
Sparus sargus, female	0.09
Ditto, male	0.20
Holocentrus marinus	0.12
Labrus turdus	0.16
Sparus melanurus	0.20
Labrus turdus var.	0.24
Sciæna nigra, female	0.27
——— male	0.25
Labrus turdus, female	0.24
——— male	0.28
Sparus dentex, female	0.40
Sphyræna spet (Esox sphyræna, Lin.)	0.44
Sparus argenteus	0.50
Holocentrus gigas	0.69
Gadus merluccius	0.79
Trigla lyra	0.87

The depth at which the fishes had been caught increases from the beginning to the end of the table, and the proportion of oxygen observes the same rule. This last circumstance induced Biot and his friend De Laroche to endeavour to ascertain the proportion of oxygen contained in sea water at different depths. They were unable to perceive any difference. M. Configliachi has more lately repeated these experiments, and found that the proportion of oxygen in sea water bore no relation to the depth from which the water had been obtained.

These experiments lead to the conclusion, that the air contained in this sac is a secretion of the organ; that in fishes which live near the surface azote is secreted; but in fishes which live at great depths, the quantity of oxygen is proportionally increased. The purposes accomplished by this arrangement have never been explained in a satisfactory manner. The red organ which we have already taken notice of as existing in some fishes, is now generally considered as the part which separates this air from the blood. But as this organ is not always present when there is an air-bag, we are still left in doubt on the subject.

To the systematic ichthyologist, the characters furnished by the air-bag are of considerable importance, although seldom sufficiently attended to. They are easily traced, and they are not subject to variation.

To the economist, the air-bag or sound is considered as an article of value. This organ in the cod or ling, when salted, forms a nourishing and palatable article of food, held in high estimation in the northern islands of this country. But it is chiefly in the manufacture of the substance called ISINGLASS that the sounds of fishes are extensively employed. The sounds of various kinds of sturgeon are chiefly made use of for this purpose. The external membrane is removed, and the remaining part is cut lengthwise, and formed into rolls, and then dried in the open air. The sounds of cod and ling are frequently employed as a substitute for those of the sturgeon. They require some dexterity to separate them from the back-bone. But when the membranes are well scraped on both sides, steeped for a few minutes in lime water to absorb the oil, and then washed in clean water and dried, they form an isinglass of considerable value.

Isinglass consists almost entirely of gelatine, and is used either as food, or for the purpose of fining liquors. 500 grains of it yielded to Hatchet by incineration 1.5 grains of phosphat of soda, mixed with a little phosphat of lime. An inferior kind is manufactured from the bones, fins, and useless parts of fishes. These materials are boiled in water, the fluid skimmed and filtered, and afterwards concentrated, until it readily gelatinizes on cooling. This kind is much used in various manufactures, and might be obtained in considerable quantity at all the fishing stations in this country where the materials abound, but which are at present left as a nuisance on the adjoining beach.

Mucous ducts.

6. MUCOUS DUCTS. The surface of the skin of fishes is almost always covered with a slimy fluid, to protect them from the penetrating influence of the surrounding element. This mucus is poured out from small pores, situated under the scales in every part of the body of some fishes, while in others these excretory ducts are arranged in a determinate order. These ducts were first observed and described by Steno, in his works, " *De Musculis et Glandulis*, p. 42. and *Elementorum Myologiæ Specimen*, 1669, 8vo. p. 72. The subject was afterwards investigated by Perrault, Lorenzini, and Revinus, and more recently by Monro. To this last author we are indebted for many excellent observations and sketches. " In the skate," (he says, *Struct. and Phys.* p. 21.) " numerous orifices, placed pretty regularly over the surface, have been observed by Steno to discharge this slimy matter. With respect to these last, I have remarked some memorable circumstances. First, I have discovered one very elegant serpentine canal between the skin and muscles, at the sides of the five apertures into the gills. Farther forwards it surrounds the nostrils; then it passes from the under to the upper part of the upper jaw, where it runs backwards as far as the eyes. From the principal part of this duct, in the under side or belly of the fish, there are not above six or eight outlets; but from the upper part near the eyes there are upwards of thirty small ducts sent off, which open upon the surface of the skin. The liquor discharged from these has nearly the same degree of viscidity as the synovia in man. But besides the very picturesque duct I have been describing, I have remarked on each side of the fish, a little farther forwards than the five breathing holes, a central part from which a prodigious number of ducts issues, to terminate on almost the whole surface of the skin, excepting only the snout or upper jaw. At these centres all the ducts are shut; and in their course they have no communication with each other. In these two central parts, or on the beginning of the mucous ducts, a pair of nerves nearly as large as the optic, terminate; and, which is a curious circumstance with respect to them, they are white and opake in their course, between the brain and their ducts; but when they divide, they become suddenly so pellucid, that it is impossible to trace them farther, or to distinguish them from the coats of the ducts."

Lateral line.

In the osseous fishes, the openings of the mucous ducts are chiefly observable in the fore part of the head, and in the *lateral line*. This line extends from the head to the tail, along each side of the fish, and exhibits several striking peculiarities. It is not observable in the lampry; in general it is single, but in the sandeel it has the appearance of being double. It is usually of a different colour from that of the sides, and varies according to the species in position and direction. After death it sometimes disappears, and hence some difficulties have arisen with regard to the discriminating marks which it furnishes.

The mucus which is poured out upon the skin by these ducts, in some cases appears to be the liquid known by chemists under that name, while in other instances it appears to be of the nature of albumen. Chemists, however, have not turned their attention to the subject.

Besides this liquid, secreted on the external surface of the body, many physiologists have detected liquors in the cavity of the brain, the pericardium, and the abdomen, which we may take notice of in this place. Dr Monro found the liquor surrounding the brain of a skate to be of a saltish taste; and his friend Dr Rutherford found that it contained one sixty-fifth part of its weight of sea salt dissolved in it. The liquor in the cavity of the abdomen contained only one seventy-eighth part.

SECT. XI. *Organs of Reproduction.*

Organs of reproduction.

The reproduction of fishes is a subject involved in great obscurity. The element in which they reside conceals from us the actions which they perform, and hence we are unable to point out with certainty the uses of the different organs, or the functions which they exercise. Even in the days of Aristotle the difference in the mode of reproduction between the cartilaginous and the osseous fishes had been observed; and although many accurate observations have been made by modern zootomists, much still remains to be done both in the field of observation and dissection.

In the general view which we propose to give of this subject, fishes may be divided into two classes, distinguished by their reproductive organs. Thus, some have the sexes distinct, while in others they are united. Those with the sexes distinct may be subdivided into the oviparous and the false viviparous, or ovoviviparous.

Sexes distinct. Oviparous.

1. *Oviparous fishes, with the sexes distinct.* The fishes included under this division are by far the most numerous. They have all free branchiæ. Some of them possess a cartilaginous skeleton, while others belong to the division termed osseous. In all, the egg is impregnated externally, and arrives at maturity without the aid of the mother.

In the *males* of this division, the testes, known by the name of *milts*, are two in number, of a white colour, and lengthened form. The surface is usually irregularly tuberculated. They are situated on each side of the abdomen, and consist of glandulous sacs destined for the preparation of the impregnating fluid. Through the middle of each milt there passes a ductus deferens, uniting with each other at the posterior part of the abdomen, and forming a kind of vesicula seminalis. The external opening for the issue of the semen is in some in the cloaca, while in others there is a small orifice situated behind the anus, which gives vent to the sexual evacuations.

In some of the oviparous abdominal fishes, there are two cartilaginous fins situated between the ventral fins, and supposed by La Cepede to be the external openings of the sexual organs. They are termed by him *Appendices genitals.*

We possess few accurate experiments on the chemical composition of the seminal fluid of fishes. Fourcroy published in the *Annales de Chim.* vol. lxiv. p. 3. some experiments on the milt of the carp. It was neither acid nor alkaline. It appears to consist of albumen, gelatine, phosphorus, phosphat of lime, phosphat of magnesia, and muriat of ammonia. More recently, Dr John subjected the milt of a tench to a chemical analysis, and obtained the following ingredients: water, insoluble albumen, gelatine, phosphat of ammonia, phosphat of lime, phosphat of magnesia, and alkaline phosphat. He could not detect the presence of any phosphorus, which had been given as a constituent by Fourcroy and Vauquelin. In all these examples, however, the seminal fluid was mixed with the substance of the testes.

In the *females* of this division, the ovary, usually termed the *roe*, is double in the greater number of fishes, but in a few it appears to be single. It occupies nearly the same position as the milt in the males. It consists of a thin delicate membrane inclosing the ova. These are generally disposed in transverse layers, connected by means of blood vessels. There is no distinct oviduct. The external openings are similar to those in the male.

Previous to the deposition or ejection of the roe or eggs by the female, a union has been formed with a male. But this connection is merely temporary, and is dissolved immediately after the impregnation of the egg has taken place. In the Cyclopterus lumpus, however, it is stated that this connection is of longer duration, that they continue to watch over the eggs with tender solicitude, and defend them from the rapacity of other fishes. The pleasure derived from the belief in this singular example of parental care, is in a great measure destroyed by the hint which has been thrown out, that they defend the eggs from the attack of other fishes, that they may appropriate them as a feast to themselves.

The ova are first deposited by the female, and then the male pours upon them the impregnating semen. In many instances, they form a hole in the sand, by their mutual assistance, and place therein the roe; in other instances, the roe is deposited in the crevices of rocks, or on sea weeds or aquatic plants. But it would be endless to detail the various ways (even were we better acquainted with them than we profess to be) in which fishes perform this curious function of their nature.

The eggs of fishes are very various with respect to colour, but agree in being of a spherical form. The integument is more or less firm according to the species. The yolk, instead of occupying the centre, as in the eggs of birds, is placed laterally, and is surrounded by the glaire or albuminous matter. Between the yolk and the glaire, is situated the germ or embyro. The germ becomes ready for exclusion at very different periods, according to the species. Thus the egg of the carp is said to be perfected in the course of three weeks, while that of the salmon requires as many months. But in the eggs of the same species, a great deal depends on the temperature to which they are exposed. In the same pond, those eggs are soonest hatched which have been deposited in the shallowest water.

As the embryo is developed, the heart first appears, afterwards the spine, eyes, and tail. The organs of motion are evolved in the following order. The pectoral fins first make their appearance, and afterwards those of the tail; the dorsal fins follow, and then the ventral and anal fins.

Sexes distinct. Ovoviviparous.

2. *Ovoviviparous fishes, with the sexes distinct.* In this division are included the chondropterygii, and likewise a few osseous fishes. Sexual intercourse takes place, and the eggs are hatched in the uterus, and excluded along with the fry.

In the *males* of this division, at least in those of the chondropterygii, the testes are two in number, flat, of great extent, and situated between the spine and the stomach and intestines. Each is divided into two portions; the first resembles the soft milt of oviparous fishes, and the second consists of small spherical glandular bodies. From these an epididymis is produced, chiefly composed of convoluted tubes, which terminate in a vas deferens; the underpart of which is greatly dilated, and forms, as in birds, a considerable receptacle, or vesicula seminalis. Contiguous to the outer side of the dilated end of the vas deferens, there is a bag of considerable size, filled with a green liquor, which is discharged into the same funnel with the semen, and probably at the same time with it. By some, this is considered as a vesicula seminalis, while by others it is regarded as supplying the place of a prostate gland. The funnel through which the seminal fluid is poured, opens near the cloaca.

In the males of the chondropterygii, there are certain organs situated near the anus, consisting of bone, cartilage, and muscles. These were long regarded as the external organs of reproduction. But Rondeletius was of opinion that these were only accessory organs, and enabled the males to retain the females more closely during coition. The celebrated ichthyologist Bloch, from dissections, arrived at the same conclusion.

The late Mr Montagu has observed some peculiarities in the sexes of the skate, which deserve to be noticed. These are enumerated in the *Memoirs of the Wernerian Natural History Society*, vol. ii. p. 414. After speaking of the appendages at the base of the tail, he says, " Accompanying this truly masculine distinction, are series of large reclined hooked spines, never to be found on the other sex, and which begin to shew themselves early in all the species hitherto examined; these are placed in four distinct series, one on each shoulder or fore-part of the wing, or pectoral fin, and one on each angle of the wing. These spines are complete hooks resembling those used for fishing, and lie with their points reclined inwards in two or three, and sometimes four parallel lines, but the number of rows, and number in each row, depends on age; for in very young specimens, I have noticed only four or five spines in a single row. For what purpose this formidable armoury is given exclusively to the males, is not known, but as the hooks are extremely sharp, and lie partly concealed, with their points a trifle reflected, the fishermen's hands are frequently lacerated by incautiously handling the fish. These formidable spines, peculiar to the masculine gender, have occasionally been fixed on as a specific character; and as it does not appear to be generally known that it is only a sexual distinction, it has been thought proper to notice it for the advantage of others who may be pursuing the same track. There is another circumstance, which perhaps, in the discrimination of species, requires more attention than usual; that is, the teeth of both sexes of each species. The necessity of this is particularly evinced by the great difference observable in the teeth of the two sexes of the thornback, *Raia clavata*.

" In search of both sexes of this species, I was naturally led by the usually described essential character of the teeth being blunt, and I was not a little surprised when, amongst several hundreds examined, not one male could be found; but I noticed a ray, not unfrequently taken with the thornback, that was in every other respect similar, except that the wings were generally not so rough, and sometimes quite smooth about the middle. A variety also of this fish had an oblong dusky spot, surrounded with white, in the middle of each wing. The teeth of these fishes were not above half the size of those of the female thornback, and, except a few of the outer series on the lips, were sharp-pointed. For a long time I was puzzled to discover to what species of Raia these belonged, till, after an examination of a great number, I began to be as much surprised at not finding a female amongst such a quantity of these, as I was at not finding a male amongst those with blunt teeth. These circumstances naturally induced me to conclude, that the sexes of *clavata* had not been accurately defined, and that the leading character of blunt teeth might have been drawn from the female only. The fishermen had not noticed the distinction of the teeth in these fishes, and had considered all of them to be thornbacks. After much attention to the subject, and after having offered a premium for a male thornback with blunt teeth, an intelligent fisherman assured me, he had examined a vast number since I pointed out the distinction of the teeth, and that he could not find one instance of a male with blunt teeth, nor a female with sharp teeth. It may therefore be fairly inferred, that the sexes of the thornback actually differ in this particular, and that the male has probably been described as a different species, but under what title it is difficult to ascertain, unless it be Raja fullonica of some authors."

The male organs of the sharks and rays are such as we have now described; but few accurate observations have been made on the male organs of those ovoviviparous fishes, which belong to the branchiostegous and osseous tribes, such as the syngnathus, blennius, and muræna.

In the *females* of the sharks and rays, the ovaria, two in number, are situated at the sides of the spine, and contain ova of different sizes. From each of these proceeds an oviduct, the anterior extremities of which are united to the diaphragm and spine. Internally, these ducts are covered with glandular papillæ, and pass through a large glandular body. After passing this body, they dilate into a large sac, which is the uterus.

When the ova pass into the oviduct, they are carried to this glandular body, which is supposed to secrete the glaire or albuminous part, and afterwards conveyed to the uterus, where they receive the shell. At what period the egg becomes impregnated, or in what manner the operation is performed, are questions to which no satisfactory answers can be returned.

The eggs are of a quadrangular form, with processes at the four corners. By some they are called sea-mice, but by our fishermen they are known by the name of *skate* or *shark-purses*. The shell has a horny consistence, and may often be observed, at certain seasons, among the rejectamenta of the sea.

When the young fish have been perfected in the uterus, where they derive their nourishment exclusively from the egg, and not from the mother, they are ejected through the openings of each uterus, at the sides of the cloaca; and upon escaping from the shell, enjoy immediately an independent existence, and begin to search after new nourishment.

Hermaphrodites.

3. *Oviparous fishes which are hermaphrodite.* Instances of hermaphroditism among fishes, were for a long period considered rare, and always as accidental. Baster detected such an arrangement in the whiting, and Duhamel observed the same in the carp. But it was reserved for that able anatomist, Sir Everard Home, to point out a particular tribe of fishes in which the organs of both sexes are always present in the same individual.

Having been unsuccessful in obtaining any male lamprys, although he got what were considered as females in abundance, Sir Everard began to suspect that the individuals of the species were hermaphrodites, and his observation on these fish at different periods justified his conjectures.

“I found, (says he, *Phil. Trans.* A.D. 1815, Part II. p. 266), upon examination, that the two glandular bodies projecting into the belly, one on each side of the ovarium, which have always been supposed to be the kidneys, varied very much in size and appearance at the beginning and end of the season. When the ova are so small that the animal is reputed to be a male, these glandular bodies, and the black substance upon which they lie, appear to form one mass, and the duct upon the anterior part is thin and almost transparent, containing a fluid equally so; but in the end of May, when the ova increase in size, these glandular bodies become larger, more turgid, and have a distinct line of separation between them and the black substance behind; their structure is more developed, being evidently composed of tubuli running in a transverse direction, and the ducts leading from them are thicker in their coats, and larger in size.

“On the 5th of June, the ova were found to be of the full size; and a small transparent speck, not before to be observed, was seen in each; at this time the tubular structure had an increased breadth, and the duct going from it contained a ropy fluid, which, when examined in the field of the microscope, was found to be composed of small globules in a transparent fluid. On the 9th of June, neither the ova nor the tubular structure had undergone any change. On the 11th of June, the ova were of the same size, but the slightest force detached them from the ovarium; the tubular structure had increased still more in size, the fluid in the ducts was thicker, more ropy, and when water was added to it in the field of the microscope, it coagulated, and what was before made up of globules, had now the appearance of flakes. The ova do not pass out at an excretory duct as in fishes, but drop from the cells in the ovarium in which they were formed, into the cavity of the abdomen, and escape by two small apertures at the lower part of that cavity, into a tube common to them and to the semen in which they are impregnated.” In the lampern or pride, and in the gastrobranchus cœcus, a similar structure is observable.”

Although these observations leave little room to doubt that the animals in question are hermaphrodites, still it remains to be determined at what precise period, or in what position, the eggs are impregnated.

Castration.

Although the sexual organs of fishes had been long known, it was not until the middle of the 18th century that any experiments were performed to ascertain the effect of their abstraction. Tully appears to have been the first person who performed the operation, and an account of his experiments has been published in the *Gent. Mag.* vol. xxv. p. 416, and in *Phil. Trans.* vol. xlviii. When the abdomen of the fish is laid open, and the milt or roe carefully separated, and the wound sewed up again, the fish appears to experience but little pain, and the wound heals in a few weeks. These experiments have frequently been performed on the carp, and they are attended with little risk. The fish grows to a larger size, and its flesh is said to have a more delicate flavour. But castration has never come into general use among the proprietors of fish ponds, being seldom performed but from motives of curiosity or science.

Hybrid fishes.

We have already stated, that the impregnation of the egg takes place without the body of the female, and the experiments which have been conducted to establish this point, have likewise made us acquainted with the existence of *hybrid fishes*. Even in a common fish pond, where carp and trout are permitted to live in company, the carp sometimes impregnates the eggs of the trout, or the trout those of the carp. The limits, however, within which this irregularity is confined, have never been investigated with care.

Number of eggs.

Fishes exhibit very remarkable differences in regard to the *number of eggs* which they produce. The rays and sharks seem to prepare but a very limited number. Rondeletius states the number in the Squalus acanthias at six; other observers have found in other species 26 and even 30. But the number of eggs in other kinds of oviparous fish, exceeds almost our powers of reckoning. The following Table (*Phil. Trans.* 1767), may convey to the general reader some idea of their prolific powers.

Fish.	Weight.		Weight of spawn.	Number of eggs.	Season.
	Oz.	Dr.	Grains.		
Carp	25	5	2571	203109	April 4.
Cod-fish . . .	0	0	12540	3686760	Dec. 23.
Flounder . .	24	4	2200	1357400	March 14.
Herring . . .	5	10	480	36960	October 25.
Mackrel . . .	18	0	1223½	546681	June 18.
Perch	8	9	765½	28323	April 5.
Pike	56	4	5100½	49304	—— 25.
Roach	10	6½	361	81586	May 2.
Smelt	2	0	149½	38278	March 21.
Sole	14	8	542½	100362	June 13.
Tench	40	0	—	383252	May 28.

It appears evident, from this Table, that there is no regular proportion between the weight of the fish and the weight or number of eggs produced. Nor is there any estimated proportion between the number of eggs deposited, and the number of fish which arrive at maturity. The eggs are eagerly sought after by other fishes, by aquatic birds and reptiles. In the young state, they are pursued even by their own species, as well as by beings belonging to other classes. But for the numbers of eggs thus produced, the very race of fishes would soon be extinguished by enemies while young; and we may add, that the diminution of the number of eggs would cut off a large supply of food, and destroy that dependence which we observe in the polity of nature, of the different races of animals on one another.

The season in which fish deposit their eggs varies according to the species, and even the habit of the individual. It is well known that among salmon, even in the same river, a difference of some months is observable, and we believe that the same remark is applicable to all other kinds of fish. In general, before spawning, fish forsake the deep water, and approach the shore, that the roe being placed in shallow water, the influence of the solar rays may vivify it. At that season, some fish forsake the salt water, and ascend rivers, and after spawning, retreat again to the ocean.

The eggs of various species of fish belonging to the oviparous order, with distinct sexes, are used as articles of food. Where circumstances permit, they are consumed while in a recent state. In other situations they are salted, and form the well-known article of trade *caviar*.

The characters which the organs of reproduction furnish, in the discrimination of species, have been hitherto too much neglected. Connected as they are with the existence of the animal, and exercising a powerful controul over its habits, they ought to be examined with care, and their appearances recorded in detail.

SECT. XII. *Organs of Electricity.*

Organs of electricity.

FROM the remotest periods, the benumbing powers of the torpedo have been the subject of popular admiration. In the days of Aristotle and Pliny, some of its curious properties were ascertained; but it was not until the year 1772, that any accurate observations were made on the animal, conducted on scientific principles.

The resemblance between the sensation produced by the torpedo, and that occasioned by the discharge of a jar charged with electricity, was first pointed out by John Walsh, Esq. who determined, at the same time, many of the phenomena which accompany this action of the animal. Nearly about the same time, and in consequence of examples furnished by Walsh, Mr Hunter dissected this animal with care, observed the appearances of its electrical organs, and pointed out their relation to one another. Previous to these observations of Walsh and Hunter, Borrelli, Lorenzini, and Reaumur, had each of them examined the fish, and arrived at some accurate general conclusions. Since that time the subject has attracted the attention of other investigators, and may now be considered as having received more ample illustration than any other branch of the physiology of fishes.

The structure of the electrical organs of the torpedo and the other fishes which possess them, has been already fully explained under the article ELECTRICITY, to which we refer our readers. Since the publication of that article, Mr Tod (*Phil. Trans.* 1816, Part I. p. 120,) has investigated the influence of the nerves in the production of the electricity which these organs exhibit, and added some new facts to those which had been given to the public by preceding writers. He observes that the columns, when separate and uninfluenced by external pressure, appear to be of the form of cylinders, as is shown as nearly as possible by suspending them by one of their extremities. The different forms which they exhibit in a horizontal section of the whole organ, are produced by their unequal attachment to one another, by the intermediate reticulate substance. He adds, that the electrical organs are so placed within the curvature of the semilunar cartilages of the large lateral fins, as to be entirely under the influence of the muscles, which are inserted into these organs.

In order to ascertain the share which the nerves have in producing the phenomena, he made an incision on each side of the cranium and gills of a lively torpedo, and pushed aside the electrical organs so as to expose and divide their nerves. The animal was then placed in a bucket of sea water. On examining it in about two hours afterwards, he found it impossible to elicit shocks from it by any irritation; but it seemed to possess as much activity and liveliness as before, and lived as long as those animals from which shocks had not been received, and which had not undergone this change. Two of these animals being procured, the nerves of the electrical organs of one of them were divided after the manner above described. They were placed each in separate buckets of sea water, and allowed to remain undisturbed. This was performed in the morning, and when examined in the evening, it was impossible to distinguish between the liveliness or activity of either. Of other two of these animals, the nerves of the electrical organs of one of them were divided. Being placed each in separate buckets of sea water, they were both irritated as nearly alike as possible. From the perfect animal, shocks were received; after frequent repetition, it became weak and incapable of discharging the shock, and soon died. The last shocks were not perceptible above the second joint of the thumb, and so weak as to require much attention to observe them. From the other, no shocks could be received; it appeared as vivacious as before, and lived until the second day. This experiment was frequently repeated with nearly the same results. The nerves of one electric organ only being divided in a lively torpedo, from which shocks had been previously received, on irritating the animal, it was still found capable of communicating the shock. Whether there was any difference in the degree of intensity could not be distinctly observed. One electrical organ being altogether removed, the animal still continued capable of discharging the electric shock, and the same circumstance took place when only one of the nerves of each electrical organ was divided. When a wire was introduced through the cranium of a torpedo, which had been communicating shocks very freely, all motion immediately ceased, and no irritation could excite the electrical shock.

The shock is communicated through the same conductors as common electricity, and intercepted by the same non-conductors. The sensation may be communicated to several persons at the same instant; and it is of no consequence whether the animal be insulated or not. The shock, however, is much stronger in air than in water; in summer than in winter; when the animal is in vigour, than when in an exhausted state. The shocks generally follow simple contact or irritation; but, in some instances, when caught by the hand, no shock is discharged until muscular energy has been exerted in vain to extricate itself.

This electrical discharge is in general accompanied by an evident muscular action. There appears a swelling of the superior surface of the electrical organs, particularly towards the anterior part opposite to the cranium. The eyes also appear at the time somewhat retracted. If this action of the fish be too much excited, the animal becomes debilitated, and soon expires.

Spallanzani, while prosecuting his experiments on this subject, ascertained, that the young fish as well as the old possessed this power; and, what appears still more surprizing, even those still in the egg in the uterus were able to communicate a sensible shock.

Besides the torpedo, there are other fish which possess the same apparatus, and exhibit the same singular phenomena. One of these, the *gymnotus electricus*, has been carefully examined by Hunter; and the result of his observations, communicated in the 65th volume of the *Phil. Trans.* A third fish, the Silurus electricus, possesses the same property; and probably many more with which we are as yet unacquainted; although to this list there can only be added at present the *Trichiurus Indicus* and *Tetraodon electricus.*

The use of this singular faculty has often been pointed out both by ancient and modern naturalists. As an instrument of defence, the exercise of such a power will protect the fish from many of its foes; and when used in the offensive, it will be equally formidable. Such animals may be able to benumb their smaller and defenceless prey, and employ their electrical energies in procuring food.

The characters furnished by the organs of electricity were for a long time overlooked, and were not even permitted to constitute a generic distinction. The torpedo was long classed with the rays; and in many systems fishes with electrical organs, and such as are destitute of them, still belong to the same genus.

CHAP. III.

Condition of Fishes.

Condition of fishes.

The subjects which we propose to discuss in this Chapter are rather of a miscellaneous nature, and embrace a variety of circumstances connected with the natural and economical history of fishes. We shall divide the whole into eight sections, and in these treat of the distribution, migrations, education, naturalization, dietetical uses, and diseases of fish; and conclude with some observations on the geological data which they furnish, and the various methods which have been employed to preserve them in a museum.

Sect. I. *Distribution of Fishes.*

Distribution of fishes.

We have already stated, that fishes naturally reside in the water; but as this element is found to differ in its constitution and temperature according to its situation, we may expect to find the finny tribes that dwell in it influenced by these circumstances. At a very early period, the diversity in the distribution of fishes attracted the attention of observers. Rondeletius at last attempted a division of this class of animals, from the different situations in which they are found, into marine, fluviatile, lake, and pond fish. It will be more suitable to our present purpose, to consider them as inhabitants of the sea or of fresh water.

Salt water fishes.

The salt-water fishes are much more numerous than those which reside in fresh water. They cannot be distinguished from fresh water fishes by any peculiarity of structure, or external form. They are always found in the greatest numbers in tideways, and on those banks which are formed at the junction of opposite currents. They in general resort to a certain kind of bottom, in which we may suppose they find a plentiful supply of food. Some are always found near rocky shores, while others prefer the sandy bays. Some are found only in the open ocean, and are termed *pelagic*; others keep within a short distance of the coast, and are termed *littoral*. M. Risso, in the introduction to his *Ichthyologie de Nice*, (8vo. Paris 1810, p. xiv.) has the following interesting notices respecting the distribution of the fishes of the Mediterranean, which we shall give in his own words. "Ces grandes profondeurs sont hérissées de rochers et ne sont fréquentées que par les *Squales*, les *Balistes*, les *Chimères*, les *Ziphias*, les *Gades*, les *Caranx*, les *Centronotes*, les *Lepidolèptres*, les *Trigles*, les *Centropomes*, les *Holocentres*, les *Bodians*, les *Tetragonures*, les *Pomatomes*. A cent mètres des profondeur, en avançant vers la terre, les fond de la mer est recouvert de fange et de limon, séjour impur de *Raies*, des *Lophies*, des *Cepoles*, des *Zees*, des *Pleuronectes*, des *Oligopodes*, enfin de tous les poissons a chair molle et baveuse. En continuant de s'élever á cent cinquante mètres de profondeur, a peu pres, la végétation se manifeste: les algues, les caulinies, les ulves, les conferves, les varecs, et les zoophytes qui tapissent ce séjour, y appellent les *Ophidies*, les *Stromatées*, les *Murènes*, les *Uranoscopes*, les *Vives*, les *Scorpènès*, les *Peristedions*, les *Labres*, les *Spares*, les *Lutjans*, les *Esoces*, les *Murénophis*, &c. Viennent ensuite les rochers du rivage, ou les *Syngnathes*, les *Centresques*, les *Blennies*, les *Batrachoides*, les *Gobies*, les *Notoptères* font leur demure accoutomée. Enfin les belles plaines de galets et de sable ou se nourrissent les *Lépadogastères*, les *Ammodytes*, les *Callionymes*, les *Lepidopes*, les *Gymnètras*, les *Osmères*, les *Scombrésoces*, les *Argentines*, les *Atherines*, les *Stolephores*, les *Mugil*, les *Clupées*, et les *Serpes*."

These different depths at which fishes reside in the sea, may be regulated by the presence of suitable food in those places. When fishes live at a great depth, the air-bag secretes more oxygen than when residing near the surface; but this is a circumstance over which the fish perhaps can exercise controul; and although the pressure upon the body must increase with the depth in the water, we are ignorant of the effect produced on the sensations of the animal by the change. Even many pelagic fish become littoral during the breeding season, and the littoral fish retreat to the deep on the approach of a storm.

Fresh water fishes.

The fresh-water fishes are not so important, in an economical point of view, as those which inhabit the ocean. Some species frequent rivers, and seem to require, for the preservation of their health, a continued current of water. Others live in lakes, and seem contented to spend their days where the water is still. Like salt-water fishes, they appear to prefer particular altitudes; and in ascending mountains, we may observe that the fish in the lakes and rivers have their boundaries, as well as the vegetables which cover their surface. Thus Wahlenberg found, that the pike and perch disappeared from the rivers of the Lapland Alps along with the spruce fir, and when 3200 feet below the line of perpetual snow. Ascending 200 feet higher, the gwiniad and the grayling are no longer to be found in the lakes. Higher up still, or about 2000 feet below the line of perpetual snow, the char disappears; and beyond this boundary all fishing ceases.

When a salt water fish is put into fresh water, its motions speedily become irregular, its respiration appears to be affected, and unless released it soon dies. The same consequences follow when a fresh water fish is suddenly immersed in salt water. In what manner they are influenced by the change, has never been satisfactorily determined.

There are not a few fish which may be said to be *amphibious*, or capable of living either in fresh or salt water at pleasure. Such fish, in an economical point of view, are extremely valuable, as they furnish to the inhabitants of this and other countries an immense supply of food. The salmon may be given as an instance in this country, where, from one river, (Tay) 50,000 head of full sized fish have been obtained. To the Greenlanders, their Angmarsæt, or Salmo arcticus, is perhaps more valuable, as it is formed into bread, as well as consumed in a fresh or salted state.

All these fishes seem to reside chiefly in the sea. There they grow and fatten; but when the time of spawning approaches, they forsake the salt water, and return to rivers and lakes. But this desertion of the ocean is only temporary, and regulated by the circumstances connected with reproduction. The instant the spawning is finished, they repair with equal rapidity to the ocean, to repair their exhausted strength, and fit them for obeying again the laws of their existence. Some of these fishes appear to be capable of living exclusively in fresh water, when confined in a lake or river. We are informed in the statistical account of the parish of Lismore, when speaking of the fresh water lakes of that island, (*Stat. Acc.* vol. i. p. 485.) "That, about 50 or 60 years ago, there were some sea trouts carried to these lakes, the breed of which preserve their distinction perfectly clear to this day. They retain their shining silver scales, though they have no communication with the sea; their flesh is as red as any salmon, and their taste is totally different from that of the yellow trouts."

The circumstance of some fish being capable of living either in fresh or salt water, has suggested the idea of attempting to modify the constitution of salt water fishes, so as to enable them to subsist in fresh water. If the change is attempted to be produced in young fish by degrees, and with caution, the experiment may prove successful, especially with those fish that reside chiefly near the sea shore. But in the case of fishes which live in deep water, a change not only in the respiratory organs must be produced, but likewise in those of digestion, as they must subsist on a new kind of food. We regard such experiments as curious, but can scarcely bring ourselves to believe, that they will be productive of advantage to society. In attempting to improve our fisheries, we should prefer the prudent advice of Virgil to the dreams of the theorist—*et quid quæque ferat regio, et quid quæque recuset.*

We possess but few accurate observations on the distribution of fishes, with respect to *temperature*. Living in an element subject to little variation from the change of the seasons, fishes, like sea-weeds, have an extensive range of latitude as well as longitude through which they roam. But they appear to abound in the greatest variety of species in the equatorial regions, and to diminish in numbers with regard to species as we approach the poles. In this country we may observe a certain arrangement of some of the species with respect to latitude. Thus the fresh water fishes of England are much more numerous than those in Scotland. In the sea at the south of England, the pilchard is found in abundance, while it is rare in Scotland. In the seas in the north of Scotland, the tusk (*Gadus brosme*) abounds, in the south of Scotland it is very rare, and in England it is unknown.

While some fishes living in the northern seas, or in alpine lakes, seem to prefer cold water, there are fish which appear to dwell even in the waters of tepid springs. La Cepède informs us that Desfontaines found the *Sparus Desfontaines* in the warm waters of the two fountains which supply the town of Cassa in the kingdom of Tunis. The waters raised Reaumur's thermometer 30° above the freezing point, or about 100° of Fahrenheit. The waters contained no mineral impregnations, and when cooled, were used by the inhabitants.

Sect. II. *Migration of Fishes.*

Migration of fishes.

Those fishes which enter rivers for the purpose of spawning, perform their migrations annually, but do not appear at any very precise period. Their motions appear to be regulated by the condition of their generative organs, and these are in their turn controuled by the temperature of the water in which the fishes remain, or the supply of food. In rivers where salmon spawn, it is observed that these fish continue entering the river for the space of seven or eight months. Those marine fishes, such as the herring, pilchard, and many others which leave the deep water, and approach the shores for the purposes of spawning, are equally irregular with respect to their periods of appearing and disappearing.

Besides these movements, which depend on the generative impulse, many marine fishes appear to migrate from one shore to another, influenced by laws which have never been satisfactorily explained. Thus haddocks have been known to visit a coast for many years in succession, and then suddenly to disappear, and at the same time all those predaceous fish which fed upon them. Perhaps these movements may depend upon the supply of food, and be regulated by circumstances over which we can exercise no controul. Accurate observations, however, would probably ascertain the limits of these migrations, and enable us to derive advantage from motions which at present we regard as calamitous.

In the summer season, all the fresh water fish are active and lively; but during the winter, many species bury themselves in the mud, and, in a state of quiescence similar to natural sleep, outlive the vicissitudes of that variable season. While active they require a copious supply of food; but in this state of hybernation they continue fasting, and without inconvenience.

Sect. III. *Education of Fishes.*

Education of fishes.

The element in which fishes reside, removes them so far from our influence and observation, that it is difficult to estimate the amount, or the qualities of the immaterial principle which they possess. We witness them fly from danger, obey the impulse of appetite, and provide a suitable place for the eggs of their future offspring. These, however, are in general regarded as the lowest marks of mind, or as mere blind instinctive motions.

Fishes, we have seen, possess in a greater or less degree of perfection all those external senses, by means of which the other animals acquire a knowledge of external objects. Hence we find that they speedily become acquainted with the hand that feeds them, and know the face of a stranger. They may be taught to come to the edge of a pond when called by their usual name, or to assemble at the sound of a bell. Baster even informs us of a trout, which had been kept fourteen years and seven months, which would come and repose on the hand of its master while he removed the water of the vessel in which it was kept.

That they possess some powers of deliberation, appears evident from the artifices which they employ to escape from the nets in which they have been inclosed, or from the hook which they have incautiously swallowed. Salmon have been known to lie close on the ground in some hollow place, to permit the net to pass over them, or by a sudden spring to leap out of the net. The fishing frog, or angler, as it is also called, (*Lophius piscatorius*,) has two long tentacula on the head, resembling in appearance small worms. Having buried its body in the sand, leaving only these tentacula exposed, it moves them backwards and forwards, until the eye of some young fish is attracted by the deceitful appearance, and falls a prey to its lurking foe.

With regard to their social instincts, fishes present very remarkable differences. Some are gregarious at all seasons, while others are solitary unless during the breeding season. The sexual union is merely temporary, and no feelings of affection subsist between the parent and the offspring. Indeed the life of a fish is one continued scene of suspicion and fear, no leisure being left for the improvement of its faculties. Hence we are disposed to rank fish as the lowest link of the chain of vertebral animals,—to regard the powers of their immaterial principle, as controuled by the dangers to which they are exposed, and as almost exclusively occupied in supplying the wants which are connected with the first laws of existence.

Sect. IV. *Naturalization of Fishes.*

Naturalization of fishes.

In tracing the history of those attempts which have been made to subject this portion of the creation to our controul, we trace at the same time the progress of civilization and luxury. In Egypt, they had their sluices and their fish ponds in the days of Isaiah, (chap.xix. 10,) and from this early seat of the arts and sciences the Romans probably acquired the knowledge of rearing and feeding fish. During the more prosperous days of that refined people, almost every wealthy citizen had his fish ponds. In modern times, the Chinese bestow more attention on the cultivation of fish than perhaps any other nation. And in Europe, the importance of the subject has been duly appreciated by the Swedes, Prussians, and Germans. In the latter countries, a considerable part of the revenue from property is derived from the carp ponds.

Fresh water fish.

In general, the rearing of fresh water fish in artificial ponds has hitherto been chiefly attempted, few trials having been made to rear the salt water fish in confinement. In the construction of a pond for fresh water fish, care should be taken to have a regular supply of water free from mineral impregnations, to cover the deepest parts of the pond at least six feet. The more extensive the shallow ground at the sides is, especially if it be covered with marsh plants, so much more abundant is the supply of those minute animals, on which many fish chiefly subsist. Care should likewise be taken to introduce those small fish, which, by multiplying, may furnish a constant supply of food.

When fish ponds are formed, it is in general the wish of the proprietor to have a certain number of his stock in good condition, that he may have a regular supply for his table. For the accomplishment of this object, there is usually one pond set apart for the purpose, into which are introduced those full grown fish which he wishes to feed. During the winter season little food is required, but along with the heat of spring, fishes acquire a keen appetite, and at that period a constant supply of food should be given them. They should be fed morning and evening at a stated time, and always at the same place in the pond. The food should consist of any kind of corn, boiled or steeped in water for some time until it swells. Malt is esteemed a very fattening food, and the crumbs of bread steeped in ale; but peas are considered as little inferior to either. Pikes must have an abundant supply of eels, otherwise they require a long time to fatten. Some recommend the laying of dead carrion upon stakes in the middle of the water, that it may breed maggots, which falling into the water, furnish an abundant supply of very acceptable food.

In the construction and management of fish ponds, there are many circumstances of a local nature which it is impossible to specify. The methods employed to stock these ponds are at present more deserving of our attention. The first, and certainly the most obvious method, is to obtain living fish from similar situations. In catching these, the utmost care should be taken not to bruise them, or to rub off their scales, and to keep them as short a time out of the water as possible. The vessels in which they are to be carried should be full of water, as when the barrel is not entirely full, the fish are liable to be driven by the currents against the lid or sides. This transportation should take place only in cold weather, and in the winter season, (as fishes can bear cold better than heat,) and should be performed with as much expedition as circumstances will permit.

The second method of stocking fish ponds, is in some respects preferable to the preceding, especially when the waters are at a distance from which the supply is to be obtained. This consists in ascertaining those places in which the spawn of the wished for species is deposited, and conveying the impregnated eggs to a similar situation in the new ponds. In this manner a vast number of individuals may be obtained at once, and with great certainty of success, provided they are supplied during the journey with fresh water, and but little agitated. The impregnated eggs may be known by a small aperture, which may be detected on one side by means of a good microscope, and which is scarcely perceptible previous to impregnation. By means of this method, however, a much longer period must elapse ere fish are obtained for the table than by the former, although this objection is in a great measure obviated, by obtaining from the eggs a race of fish with constitutions accommodated to your waters.

The last method, which has been rather absurdly termed *artificial fecundation,* we owe to the ingenuity of M. Jacobi, (*Mem. de l'Acad. de Berlin.* 1764, *p.* 55.) It is founded on a knowledge of the mode of reproduction in oviparous fishes, and in its turn serves to illustrate the function of generation in fishes. In those places where the fish are easily procured, a female is obtained, whose roe is nearly ready for exclusion and having prepared a proper box with water, the fish is held by the head, with its tail downwards, and gently squeezed on the belly. The eggs which are perfect, readily run out into the vessel. A male fish is next obtained, and being held in a similar situation, the milt is poured upon the eggs. The eggs thus impregnated are conveyed to a proper situation as in the second method, and protected from those enemies which we have already enumerated.

The advantages which result from the translation and feeding of fishes have been felt and appreciated in other countries, but in our kingdom they have been in a great measure overlooked. In Scotland and Ireland, and we may likewise include England, there are multitudes of ponds and lakes, which are at present mere useless wastes, but which, if properly stocked with fish, would greatly contribute to the prosperity of the country, by furnishing an additional supply of food. To our forefathers we owe the introduction of two useful species of fish into the country, namely, the *carp,* which was translated (probably from France or Spain) into England about the year 1496, and the *pike,* which was naturalized about the beginning of the fifteenth century. The gold and silver fishes of China have likewise been naturalized in England, as objects of beauty. We wish this catalogue had been more extensive; we fondly hope that it will soon increase.

Salt water fish.

The formation of ponds for salt water fish, has often been the subject of speculation, but in few instances has it ever been reduced to practice. Indeed the motives for constructing such a pond must originate chiefly in curiosity, as those who are situated on a sea-coast, where such ponds can only be constructed, have access to that great storehouse of life, and may at all seasons derive from it an inexhaustible supply. Besides, there are few situations favourable for the construction of such a pond, and even where most favourable, an expensive barrier must be constructed to separate it from the sea. Some ponds of this kind have been constructed in Scotland. These are well described in the Scots Magazine for June 1816, p. 412.

" A good many years ago, a small fish pond, into which sea-water could be easily introduced, was constructed by an enterprising individual at Peterhead, in Aberdeenshire, (Mr Arbuthnot). A few sea fish were occasionally kept in it; but it soon fell into disuse, and it has of late been neglected. This however was, as far as we know, the first attempt of the kind in this country.

Since that time two sea-fish ponds, of greater dimensions, have been formed by private gentlemen in Scotland, for the conveniency of supplying their families. One of these is at Valleyfield, the seat of Sir Robert Preston, Bart. on the shore of the Frith of Forth; the other is situated in Wigton-shire, in an inlet called Portnessock, on the peninsular ridge of country called the Rins of Galloway, nine or ten miles south from Portpatrick, and is the property of Mr Macdowall of Logan.

At the spot where it is formed, there had originally been a small natural basin, communicating with the sea by means of a narrow sinuous fissure, or perhaps an empty vein in the rock. This basin has been enlarged and deepened, by working away the solid rock, which is grey wacke slate. At flood-tide, the water covers, to the depth of two or three feet, a ledge or walk which passes round an interior or deeper pond, and, at this time, allows tolerably ample space for the rapid motions of the fish.

The pond is replenished with fishes by the keeper, whose house is hard by. In easy weather, this man rows out in his fishing coble, to the mouth of Logan Bay, in which the inlet of Portnessock is situated. For catching the fish, he uses the common hand line, and the usual baits. He is provided with a wide tub, into which he puts a convenient quantity of sea water: to this tub he immediately commits such part of his capture as happen to be little hurt by the hook. He finds it necessary, during summer, to cover the tub with a cloth; and in sultry weather he experiences difficulty in keeping the fishes alive in the tub till he reach the shore. This, it seems evident, cannot be ascribed either to mere heat, or to the exhausting of the air contained in the water, by the respiration of the fishes. In all probability, it depends on the influence of the electric fluid of the atmosphere. De la Cepede, in his essay on the culture of fresh-water fishes, particularly mentions the powerful effect of this fluid on them, when confined in small portions of water, in the course of their transference from one place to another.

As might naturally be supposed, the fisherman prefers for the pond young fish, or at most those of middle size to those of large growth. In selecting cod-fish, for example, he rejects all that exceed 6lb. giving the preference to what he styles *lumps*, or young cod-fish, weighing 4lb. or 5lb. In the pond, the fish are not only preserved alive till wanted for use, but, being regularly fed, are found to be fattened. They are taken for use, however, merely by the line and hook; and it is probable, that the fish in best condition will not always be the first to catch at the bait.

The fishes we observed in the pond were the following:

1. Cod (*Gadus morhua*). They were lively, and caught greedily at shell-fish, which we threw into the pond. They kept chiefly, however, in the deep water, and, after approaching with a circular sweep, and making a snatch at the prey, descended out of sight to devour it. It has often been doubted, whether the red ware codling of Scotland was the young merely of the common cod, or a distinct species, *Gadus callarias*. Here one would think the question might easily be decided. Upon describing this red ware codling, we were assured that it occurs on the coast of Galloway, and that it had sometimes been caught and placed in the pond; but that, after a year, it became as large and as pale in colour as a common grey cod. This accords with our own observations, made in less favourable circumstances.

2. Hadock (*G. æglefinus*). These, contrary to expectations, we found to be the tamest fishes in the pond. At ebb tide, they come to the inner margin, and eat limpets from the hand of a little boy, the son of the keeper. They appeared white, and rather sickly. One was diseased about the eyes.

3. Coalfish (*G. carbonarius*). Some of these were of a large size, exceeding in dimensions the largest cod in the pond. No fish has received so many different names as the coalfish. When young, it is called at Edinburgh, podley; in the northern islands, sillock; in Galloway, blochan. When a year old, it is styled cooth, or piltock, in the north; and glasson in the south-west of Scotland. When full grown, it is named sethe in the north; and stenlock in the south-west. Accordingly we were now told, that " these stenlocks were mere blochans when they were put in." They were become of a fine dark purple colour. They were bold and familiar, floating about slowly and majestically, till some food was thrown to them: this they seized voraciously, whether it consisted of shell-fish, or ship biscuit. We were informed, that they too occasionally approach the margin, and take their food from the keeper's hand.

4. Whiting (*G. merlangus*). These were scarce in the pond, and very shy.

5. Pollack (*G. pollachius*). This was pretty common, and has been found to answer very well as a pond fish. It is generally called layde or lythe.

Besides these five species of gadus, we were told that the ling (*G. molva*) had occasionally been kept in the pond.

6. Salmon (*Salmo salar*). This was the wildest and the quickest in its motions of all the inhabitants. When a mussel or limpet, freed from the shell, was thrown on the surface of the water, the salmon very often darted forward and took the prey from all competitors, disappearing with a sudden jerk and turn of the body. I suspected this to be the salmon-trout (*S. trutta*); but was assured that it was the real salmon, which is occasionally taken in the bay.

7. Flat-fish, or flounders, of two sorts, were also in the pond; but they naturally kept at the bottom, and we did not see them. From the description given by the people, we concluded that they were dab and young plaise.

The food given to the fishes consists chiefly of sand-eels and of shell-fish, particularly limpets and mussels. In the herring-fishery season, they cut herrings in pieces for this purpose.

It is remarkable, that all the kinds of sea-fish above enumerated, seem to agree very well together. No fighting had ever been observed by the keeper, and seldom any chasing of one species by another.

None of the fish have ever bred: indeed, no opportunity of breeding is afforded to them. A warm and shallow retreat, laid with sand and gravel, would have to be prepared for some species; and large stones, with sea-weed growing on them, would have to be transferred to the pond, and placed so as to be constantly immersed in the water for the use of others. The dimensions of the present pond, however, are too circumscribed to admit of its being used as a breeding place. An addition for this purpose might, without much difficulty, be formed, and here some curious observations might be made. The spawn of various sea-fishes is frequently accidentally dredged up by fishermen, and could therefore no doubt be procured by using a dredge: its degree of transparency indicates whether it will prove prolific. This might be placed in a protected corner of the breeding pond, and its progress watched. On this branch of the natural history of sea fishes, little is known."

SECT. V. *Dietetical Uses.*

Dietetical uses.

FISH, considered as an article of food, is regarded as light, and easily digested, and therefore well suited for the young, the weak, and the sedentary. But for the same reason it is unsuitable food for those engaged in laborious occupations. Among the Romans, he who fed on fish was regarded as effeminate. It has often been considered, though perhaps without cause, as promoting the fertility of the human species; and the immense population of China has been ascribed to the abundant use of this kind of nourishment. Its tendency to encourage diseases of the skin appear to be universally acknowledged, and is indeed very evident in the remote islands of this country, of Faroe, of Iceland, and of Norway, where fish forms so great a proportion of the food of the inhabitants.

Previous to using fish as food, they have frequently to undergo some sort of preparation, varying according to the situation, the necessities, or the taste of the consumers. Where circumstances permit, they are in general used in a *fresh* state; and even in large cities, where the supply must be brought from a distance, various expedients are resorted to, to prevent the progress of putrefaction. By far the best contrivance for this purpose is the well-boat, in which fish may be brought to the place of sale even in a living state. Placing the fish in boxes, and packing them with ice, is another method, and has been extensively employed, particularly in the supply of the capital with salmon.

In many maritime districts, where fish can be got in abundance, a species of refinement in taste, at least a departure from the simplicity of nature, prevails, to gratify which, the fish are kept for some days, until they begin to putrefy. When used in this state, they are far from being disagreeable, unless to the organs of smell. Such fish are termed by the Zetlanders *blawn-fish.*

Where fish are to be found only at certain seasons of the year, various methods have been devised, in order to preserve them during the periods of scarcity. The simplest of these processes is to *dry* them in the sun. They are then used either raw or boiled, and not unfrequently in some of the poorer districts of the north of Europe, they are ground into powder, to be afterwards formed into bread.

But by far the most successful method of preserving fish, and the one in daily use, is by means of salt. For this purpose they are packed with salt in barrels, as soon after being taken as possible. When boiling them for the table, if the water be repeatedly changed, a great portion of the salt will be abstracted, and the fish rendered more palatable. In this manner are preserved herrings, pilchards, cod, salmon, and many other kinds of esculent fish.

In many instances, after the fish have been salted in vessels constructed for the purpose, they are exposed to the air on a gravelly beach, or in a house, and dried. Cod, ling, and tusk, so prepared, are termed in Scotland *salt-fish.* Salmon in this state is called *kipper,* and haddocks are called by the name of the place where they have been cured.

After being steeped in salt, herrings are in many places hung up in houses made for the purpose, and dried with the smoke of wood. In this state they are sent to market, under the name of *red-herrings.*

Although salt is in general employed in the preservation of fish, whether intended to be kept moist or to be dried, vinegar in certain cases is added. This is practised in this country, at least chiefly with the salmon sent from the remote districts to the London market. It can only be employed in the preservation of those fish, to which this acid is served as a sauce.

The flesh of fish is always in the highest perfection, or *in season* as it is called, during the period of the ripening of the milt and the roe. After the fish have deposited their spawn, the flesh becomes soft, and loses a great deal of its peculiar flavour. This is owing to the disappearance of the oil or fat from the flesh, it having been expended in the function of reproduction. When in season, the thick muscular part of the back, as it contains the smallest quantity of oil, is inferior in flavour, or richness, to the thinner parts about the belly, which are esteemed by epicures as the most savoury morsels.

There are some kinds of fishes, especially those which inhabit the shores of warmer countries, which are reputed *poisonous.* These are, the Tetraodon ocellatus, sceleratus, and lineatus, and the Sparus pagurus, and a few more. It is generally supposed, and with some probability, that the poisonous quality of these fish proceeds from the food on which they have subsisted. This conjecture is supported by the history of the mussel and the oyster, which owe their occasional noxious qualities to the zoophytes on which they feed. Perhaps the poisonous quality of these fishes might be considerably diminished, if not entirely removed, were the intestines carefully taken away, and the fish placed for a short time in salt brine.

SECT. VI. *Diseases of Fishes.*

Diseases of fish.

FISHES, in a domesticated state, are subject to various diseases, the cause and cure of which are not satisfactorily ascertained. Trouts, carps, and perches, are subject to various cutaneous diseases. During severe winters, when the surface of the ponds in which they are kept are frozen over, the various kind of fish seem to contract diseases, and, in such cases, great mortality often prevails. This seems to arise from want of air in the water, and can only be prevented by removing the fish to a deeper pond, through which there is a constant current. In some rigorous seasons, the extent of this mortality is most alarming, as, between 1788 and 1789, in some districts of France the inhabitants lost nearly all their stock of carp, pike, and tench. *Journal de Physique,* November 1789.

In the very same year, an epidemic distemper affect-

Condition of Fishes.

ed even those fish which live in the sea, as the following fact, communicated by the late Mr Creech of Edinburgh, in the Appendix to the sixth volume of the *Statistical Account of Scotland*, satisfactorily proves: "On Friday, 4th December 1789, the Ship Brothers, Captain Stewart, arrived at Leith from Archangel. The captain reported, that on the coast of Lapland and Norway he sailed many leagues through immense quantities of dead haddocks floating in the sea. He spoke several English ships, who reported the same fact."

Fishes are greatly tormented with intestinal worms. The common stickeback may be quoted as a remarkable instance. Its death is often occasioned by the increase of the *Tænia solida* of Gmelin; and it is even supposed, that the extinction of its existence by this parasite follows the function of reproduction with regularity. *Annals of Philosophy*, February 1816.

Fishes exhibit remarkable differences with respect to their *vivaciousness*. Thus some fishes expire almost the instant they are taken out of the water, as the herring, the smelt, &c. Others are capable of surviving hours and even days, when removed from their native element, as the eel, carp, and some others. It sometimes happens that vivacious fishes are conveyed to a distance by birds, and left, without being killed, on rocks or fields. This has given rise to many of the absurd stories which have been told of showers of fishes. Rondeletius observes with propriety, that those fishes whose gill openings are but imperfectly covered expire soonest when taken from the water; and those fish whose branchiæ are protected by a gill-lid which shuts close, or by a narrow opening, are most vivacious. The air soon dries the fine plumes of the branchiæ, and obstructs the process of respiration and of circulation.

Few accurate observations have been made to determine the *age* of fishes. The element in which they reside is supposed to preserve them from the pernicious influence of sudden changes of temperature; the slowness of the process of ossification; the coldness of their blood; and the tardiness of all their primary movements, are considered as indicating a lengthened existence. Accordingly we find, the age of the carp has been known to reach to 200 years, and the pike to 260.

The marks by which the age of fishes may be determined, have never been pointed out in a satisfactory manner. As the age of trees may be guessed at by the number of concentric circles in the wood, so it has been supposed that the age of fishes may be ascertained by the number of concentric circles in the scales or in the vertebræ. Such analogical reasonings are hurtful to science, as they occupy the place of observation. They have done so in this instance at least.

It is seldom that a fish is permitted to die a natural death, from old age. During every period of its existence it is surrounded by foes; and when no longer able to exercise its wonted watchfulness, or exert its powers of defence, it falls an easy prey to its more powerful adversaries. In a domesticated state, previous to death, the dorsal fins lose the power of maintaining the body in a vertical position, the levity of the belly, and the extraordinary distension of the air bag, reverse the natural position, so that the back becomes undermost, and the animal floats on the surface. Similar appearances present themselves, when the waters are contaminated by noxious mineral or vegetable impregnations.

SECT. VII. *Fossil Fish.*

Fossil fish.

The investigation of those changes which have taken place in the race of fishes since the formation of the globe, is attended with peculiar difficulty. The external form, on which in general the specific distinction is founded, is destroyed by pressure. All distinct traces of the softer parts have disappeared, and the geognost is left to draw his conclusions from the form of the teeth, or the outline and structure of the skeleton. Hence the conclusions which have been drawn respecting the particular species should be received with caution. In the newer rock formations, which have been termed *local*, such as the strata at Eningen, the remains of fishes have been observed, belonging to existing races, and still natives of the neighbouring lakes. But in the rocks of those formations which are called *universal*, the skeletons of fishes which have been found, in all probability belong to species now extinct. In examining the organic remains which we consider of this sort, it would appear that the teeth of unknown sharks are more numerous than those of any other description of fish. They are found in all the floetz limestones of this country, in company with the ancient camerated shells. Vertebræ of osseous fishes are chiefly found in the strata connected with the chalk formation, seldom in those of an older date.

Before concluding this chapter, it may not be unacceptable to the reader to be presented with a few observations on the *preservation of fishes for a museum*.

Method of preserving fishes for a museum.

The simplest method consists in dividing the fish vertically and longitudinally, taking care to preserve attached to one side the anal, dorsal, and caudal fins. From this side the flesh is then to be scraped off, the bones of the head reduced in size, the base of the fins made thinner, and the specimen then stretched out on pasteboard and dried. By this means a lateral view of the fish is preserved, and if the fins and gill-flap are cautiously spread out, the specimen will furnish sufficient marks for recognising the species. A collection of such fishes may be kept in a portfolio, similar to an herbarium.

Many species may be well preserved, by extracting the contents of the body at the mouth, or skinning the fish with the skin entire from the mouth towards the tail, in the same way as eels are prepared for cooking. Let it then be restored to its former position, fill the whole with fine sand, and having spread out the fins, let it be dried with care. Almost all wide-mouthed cylindrical or tapering fishes may be preserved in this manner. Some recommend filling the skin with plaster of Paris, while others employ cotton. Preserved fishes are usually covered with a coat of varnish, to restore in part the original lustre. But no means of this sort can retain many of the brilliant colours which the animals of this class possess; and even the form of some of the soft parts cannot be preserved. Hence fishes are in general preserved in bottles of spirits of wine. In this way, it is true, they take up much room, but they can be subjected to examination at pleasure, and all their characters satisfactorily exhibited.

CHAP. IV.

CLASSIFICATION OF FISHES.

Classification of fishes.

IN the last chapter, when treating of the structure and function of fishes, we endeavoured to point out the relative value of those characters which systematic ichthyologists have hitherto employed. We there gave it as our opinion, that the organs of respiration furnish characters which are obvious, permanent, and natural. By means of these characters, fishes may be divided into two great classes, viz. those with *fixed* and those with *free* gills; and the inferior divisions might depend on circumstances connected with the number, position, and structure of the accessory organs. But instead of attempting, in this place, to give a new system of ichthyology, we propose to lay before our readers a condensed view of the genera according to the system of La Cepede, the outlines of which have been already given in the historical part of this article. We propose to add occasional observations on the characters of these genera, and on the history of rare or useful species. In the account of species it is necessary to be concise, as an enumeration of all the known species of fishes, amounting to upwards of 1470, would swell the article to an inconvenient length.

SUB-CLASS I. CARTILAGINOUS FISHES.

Cartilaginous fishes.

In the fishes belonging to this sub-class, the skeleton never becomes so much indurated as to deserve the name of bone, but continues in the form of cartilage more or less compact. As this internal character cannot be discovered without the use of the dissecting knife, its employment in the formation of the primary divisions of a systematic arrangement has been justly condemned by many naturalists, and ought to be relinquished. The genera which are included under this division, exhibit great differences in the structure of their organs of respiration and reproduction.

DIVISION I.

The cartilaginous fishes of this division are destitute of a gill lid and gill flap. The gills are likewise fixed.

ORDER I. APODAL. *No ventral Fins.*

The structure of the animals of this very natural order has been ably investigated by Sir Everard Home, as we have already pointed out, while describing the organs of respiration and reproduction. They constitute the last link in the chain of fishes, and form the transition to the molluscous animals.

GENUS I. PETROMYZON. *Lamprey.*

Lamprey.

Seven gill-openings on each side of the neck, and an aperture on the top of the head.

The species of this genus possess an organ of adhesion on the lips, by which they attach themselves to stones; hence the name Petromyzon, from *πετρος*, *lapis*, and *μυζαω*, *sugo*. Lacepede enumerates nine species, three of which are British. They are distinguished by characters drawn from the form of the dorsal and caudal fins. All the species are vivacious, and may be kept in life for a considerable time when out of the water. The P. Planeri, found in the rivulets of Thuringia, when plunged into diluted alcohol, will survive upwards of a quarter of an hour; but it indicates, by its convulsive movements, the painful effects produced by the fluid on its organs of respiration. Some of the species are used as food, but principally for baits.

GENUS II. GASTROBRANCHUS. *Hag.*

Hag.

Gill-openings, two in number, situated under the belly.

This genus was formed by Bloch from the Myxine glutinosa of Linnæus. This last author placed it among his Vermes intestina; and the former, upon restoring it to its proper place among fishes, bestowed upon it a new name. Only two species are known.

ORDER IV. ABDOMINAL.

This is a very natural order. The species are ovoviviparous, and are distributed by Lacepede into three genera.

GENUS III. RAIA. *Ray.*

Ray.

Body depressed, five gill-openings on each side placed beneath, mouth under the snout.

This is a very extensive genus, including, according to La Cepede, thirty-six species. Some naturalists however, are disposed to regard a few of these as hybrid animals. Several new genera have been separated from it, particularly the genus CEPHALOPTERUS, which includes those species with a divided snout, and the torpedo, the characters of which we shall shortly notice. The species have been divided into several sections, from the form of the teeth, and the spines on the body; but the observations of Montagu appear to indicate these characters, as pointing out the differences of the sexes, not as sure marks by which the species may be distinguished. His remarks on this subject we have already stated under the head of *reproduction.* Many of the animals of this genus grow to a large size. They furnish a wholesome and palatable food, and are used either when fresh, salted, or dried. The spines of some are considered by the fishermen as venomous. One species, the R. Sephen of La Cepede furnishes, according to this author, the well known article of commerce termed shark's skin, or shagreen. This skin is covered with round hard tubercles, and, when dressed, is used to cover boxes or cases. The squalus canicula furnishes an inferior sort of skin, which is often used as a substitute, but the tubercles are smaller, and not so regular in shape.

GENUS IV. TORPEDO. *Cramp-Fish.*

Cramp-fish.

Body smooth, depressed, and obtuse before; five gill-openings on each side, placed beneath; electrical organs single on each side.

This genus, which has been lately revived, contains at present four species according to Risso; but the characters which separate them are far from being determinate. The best known species is the Raia torpedo of Linnæus, whose electrical organs have been already described under the article ELECTRICITY of this work.

GENUS V. SQUALUS. *Shark.*

Sharks.

Body round, tapering; gill openings from five to seven on each side of the neck.

This genus contains upwards of thirty species, whose characters and organs have not been described with sufficient attention. They exhibit very obvious differences in the structure of their organs of respiration, and on that account ought to be separated into several genera. The characters furnished by the organs of motion should be employed in forming the genera into sections.

The sharks are voracious and formidable; they possess great strength, and swim with considerable velocity. The smaller species are salted and dried, and used as food. The liver yields a considerable quantity of oil, and the skin of some species is used, on account of its roughness, to polish wood, brass, or ivory. It is likewise employed to make thongs and tackle for carriages. The teeth are employed by savages to point their arrows, and as a substitute instead of knives.

The species are all inhabitants of the sea, and are very widely distributed. Their teeth are found imbedded in limestone rocks of different ages, and seem to indicate that the sharks of the first ages were of a much larger size than those which now exist.

GENUS VI. PRISTES. *Saw-Fish.*

Saw-fish.

Snout produced, depressed, and furnished with a row of teeth on each side.

This genus, which Latham (*Lin. Trans.* ii. p. 273.) separated from Squalus, in imitation of the older naturalists, contains five species, distinguishable from one another by the appearances of the teeth in the snout. The most remarkable species is the Squalus pristes of Linnæus, now the P. antiquorum: the snout is frequent in collections. This animal grows to the length of fifteen feet. It is a native of the seas of both hemispheres. By means of its formidable snout, it attacks with success various kinds of whales, which it lacerates in a dreadful manner with its lateral teeth.

GENUS VII. SQUATINA. *Angel-Fish.*

Angel fish.

Body depressed, snout rounded, mouth terminal.

This genus was long recognised by naturalists. Linnæus united it to Squalus, and recently it has been revived. It contains only one species, the Squalus squatina of Linnæus. This is the *mermaid-fish* of Artedi, which, according to some naturalists, has given rise to those stories which we read and hear concerning mermaids. It is, however, more probable that there is a fish, not yet described by naturalists, of an amphibious nature, which has been occasionally seen on our coasts, and whose appearance, at a distance, bears some resemblance to the human form. For a description of one seen on the coast of Caithness, see the *Scots Magazine* for the year 1809, p. 734.

GENUS VIII. AODON.

Gill-openings, five on each side; mouth destitute of teeth.

La Cepede separated this genus from Squalus. It contains three species, whose characters have been but imperfectly described. Two of these were observed by Forskael in the Red Sea, and the third was observed by Brunich at Marseilles.

Sea snake.

At the conclusion of this account of the cartilaginous fishes with fixed branchiæ, we deem it expedient to direct the attention of the reader to the sea snake which was cast ashore on Stronsa, one of the islands of Orkney, in September 1808. The anatomical characters, furnished by the mutilated fragments which were sent to the Wernerian Society, seem to point out a connection with the genus Squalus. But the articulated fins on the sides, the form of the dorsal fin, and the lengthened neck, clearly prove the propriety of the new genus constituted for its reception, and termed HALSYDRUS, or sea snake. *Scots Mag.* 1809, p. 7.

The structure of the vertebræ of this animal has been explained with great precision by that celebrated anatomist Dr Barclay, and figures of some of the parts have been published from the accurate drawings of Mr Syme. These and the various descriptions of the animal sent from Orkney, have been given to the world in the first volume of the *Memoirs of the Wernerian Natural History Society of Edinburgh.*

DIVISION II.

Cartilaginous fishes, destitute of a gill-lid, but furnished with a gill-flap.

ORDER VI. JUGULAR.

GENUS IX. LOPHIUS. *Angler.*

Angler.

One gill opening on each side; mouth large and terminal.

This genus contains about eight species. Some naturalists appear disposed to leave in this genus those species in which the mouth is somewhat contracted, and to form another genus (Batrachus) of the wide-mouthed species. The L. histrio might in that case be considered as the type of the former, and the common fishing frog (L. piscatorius) as the representative of the latter. The flesh of the different species is soft, and seldom used as an article of food. Pliny remarks of the common angler, "that it puts forth the slender horns it has beneath its eyes, enticing by that means the little fish to play round, till they come within reach, when it springs on them." The skin of this animal, rendered transparent by oil, is sometimes used as a mask, with a candle burning in it, to represent the devil.

ORDER VII. THORACIC.

GENUS X. BALISTES. *File-Fish.*

File-fish.

Head and body compressed; about eight teeth in each jaw; gill-openings narrow.

In this genus La Cepede enumerates twenty-nine species. They chiefly inhabit the seas of warm countries. They are remarkable for the brilliancy of their colours, which are often gracefully disposed. The flesh is considered as poisonous.

ORDER VIII. ABDOMINAL.

GENUS XI. CHIMERA. *Sea-Monster.*

Sea-monster.

One gill-opening on each side of the neck; tail produced, and ending in a filament.

This genus consists of two species, a southern and a northern. The last of these has been repeatedly found in our seas.

DIVISION III.

Cartilaginous fishes, with a gill lid, but destitute of a gill flap.

ORDER XII. ABDOMINAL.

GENUS XII. POLYODON.

Teeth in the jaws and palate.

We owe this genus to La Cepede. It contains only one species, found preserved in spirits in the Parisian museum.

GENUS XIII. ACIPENSER. *Sturgeon.*

Sturgeon.

Mouth bearded before, without teeth, retractile, and placed under the head.

This genus contains only four species, but these are of considerable importance in an economical point of view; the sounds furnish isinglass and the roe caviar. They live in the sea, and at times ascend the rivers in troops. Their flesh is excellent and highly prized.

Classification of Fishes.

DIVISION IV.

Cartilaginous fishes, furnished with a gill-lid and gill-flap.

ORDER XIII. APODAL.

GENUS XIV. OSTRACION.

Body covered with an osseous coat of mail; cutting teeth in each jaw.

This genus contains fifteen species. They are easily recognised by the body being covered with an osseous plate, somewhat resembling a tortoise. They are all natives of the seas of warm countries. They feed upon the crustaceous animals, and some of the testaceous mollusca. The flesh is excellent, but small in quantity. La Cepede recommends the *O. triqueter* as a fish which he thinks might easily be naturalized in our seas. The *O cubicus,* a native of the Indian seas and the Isle of France, is often kept in pools, where it soon becomes so familiar as to come to the surface and eat from the hand. Its flesh is esteemed a great delicacy.

GENUS XV. TETRODON. *Sun-Fish.*

Sun-fish.

Jaws bony, extending, divided at the tip into two teeth; gill-opening linear; body round.

The fishes of this genus, have obtained their present name from the double teeth with which their jaws are furnished. La Cepede describes nineteen species, some of which are natives with us. They have the singular power of inflating their abdominal cavity at pleasure. The inflation is produced by air sent from the gills, into a sac formed of a duplicature of the peritoneum, and from thence into the abdomen. The inflation aids the animal in rising in the water, and as the abdomen is in some species covered with spines, it brings these organs of defence into a more favourable position for resistance.

GENUS XVI. OVOIDES.

Jaws bony, extended, divided at the tip into two teeth, destitute of dorsal, anal or caudal fins.

The single species, for the reception of which Lacepede formed this genus, was found described among the manuscripts of Commerson. It is an inhabitant of the Indian seas.

GENUS XVII. DIODON. *Globe-Fish.*

Globe-fish.

Jaws bony, extended, undivided.

The globe fish are but few in number, La Cepede having described only six species. They are natives of warmer seas. They are covered with long and formidable spines, like a hedgehog, and often exhibit a rich variety of colours. The *D. atinga,* a native of the tropical seas, is one of those fish considered by navigators as noxious. According to Pison, the gall is so virulent as to produce nearly instantaneous death in those that eat the parts of the fish where any of it has been spilt. The sound of the same fish, however, produces an isinglass, equal in quality to that which is obtained from the Acipenser huso.

GENUS XVIII. SPHEROIDES.

Body globular, four teeth or more in the upper jaw, no dorsal, anal or caudal fins.

La Cepede formed this genus for the reception of a species drawn by Plumier, and supposed to live in the sea on the east coast of America.

Classification of Fishes.

GENUS XIX. SYNGNATHUS. *Pipe-Fish.*

Pipe-fish.

Head produced, mouth small and terminal, furnished with a lid, no teeth; gill-openings on the neck.

The species of this genus have never been determined in a satisfactory manner. Even the British species are in confusion. There are eight species described, and some varieties; but it is probable that the characters of the sexes have been hastily considered as marks of distinct species.

It appears from the observations of naturalists, that the species of this genus belong to the ovoviviparous division of fishes, or those which hatch their eggs internally. Their bodies are covered with osseous plates like a coat of mail.

ORDER XV. THORACIC.

GENUS XX. CYCLOPTERUS. *Sucker.*

Sucker.

Mouth furnished with sharp teeth; ventral fins united; between these there is an organ of adhesion.

There are upwards of twelve species of this genus known. They may be distributed into sections from the union or separation of the caudal, dorsal and anal fins. They inhabit the sea, but are occasionally found in the mouths of large rivers. Their flesh is soft and oily, and eagerly sought after by seals. Some of the species, in a few hours after death, dissolve into a homogeneous gelatinous mass.

GENUS XXI. LEPADOGASTER.

Tentacula four before the eyes; organs of adhesion double.

We are indebted to Gouan for a knowledge of the only species of the genus, which he found in the Mediterranean. It has since been observed, in other seas, by many naturalists.

ORDER XVI. ABDOMINAL.

GENUS XXII. MACRORINCHUS.

Snout produced; jaws furnished with teeth; scales on the body small.

This genus was formed by La Cepede, and contains one species discovered by Osbeck in his voyage to China, and described by him.

GENUS XXIII. PEGASUS.

Snout produced; jaws furnished with teeth; body covered with large osseous plates.

The first notice of this genus was given by Ruyschius. It now contains three species. These have the pectoral fins uncommonly large, and are capable of supporting themselves for some time in the atmosphere. They are all of a diminutive size, and live in the seas of warm climates.

GENUS XXIV. CENTRISCUS. *Trumpet-Fish.*

Trumpet-fish.

Jaws without teeth, snout produced; body compressed; ventral fins united.

La Cepede describes three species belonging to this genus, viz. C. scutatus, velitaris, and scolopax.

SUB-CLASS II. OSSEOUS FISHES.

Osseous fishes.

All the osseous fishes have free branchiæ. With a few exceptions, they are oviparous. They appear to

Classification of Fishes.

be the most numerous as well as the most perfect of those animals which breathe by means of gills.

Division V.

Osseous fishes furnished with a gill-lid and a gill-flap.

Order XVII. APODAL.

Genus XXV. Cæcilia.

No fins; opening of the gills under the neck.

This genus was instituted by La Cepede, for the reception of the Muræna cæca of Gmelin. It is destitute of eyes on the exterior, and its true place in the system has not been satisfactorily determined. It is probable that it has fixed branchiæ, and is nearly related to the Gastrobranchus.

Genus XXVI. Monopterus.

A caudal fin, but destitute of all others; gill openings situated between the eyes.

The only species of this genus, is described by La Cepede from the manuscripts of Commerson. It is a native of the Indian seas.

Genus XXVII. Leptocephalus.

Anal and dorsal fins, but no pectoral or caudal ones; head small, body greatly compressed.

This genus was instituted by Gronovius, from an example sent to him by Pennant. This last author obtained it from Holyhead, through the kindness of Mr Morris. Donovan seems disposed to consider this as a spurious genus, and to conclude that the Leptocephalus morrisii is nothing more than a young and mutilated example of the Blennius gunnellus. But the late additions which have been made to the history of the L. morrisii in the new edition of the British Zoology, and by Montagu in the Memoirs of the Wernerian Society, vol. ii. p. 437, have removed all doubts on the subject. M. Risso is inclined to add another species to this genus, termed L. Spallanzani; but the shape of the body is so dissimilar, being cylindrical, that we fear it does not belong to this genus.

Genus XXVIII. Gymnotus.

Destitute of dorsal and caudal fins, but furnished with pectoral and anal fins.

This genus includes six species, the most remarkable of which is the G. electricus, which possesses the same benumbing power as the torpedo, and whose history has been given in detail under the article Electricity, vol. viii. p. 472.

Genus XXIX. Trichiurus. *Blade-Fish.*

Blade-fish.

No caudal fin; body compressed; gill lids placed near the eyes.

This genus contains two species. The first, T. electricus, is distinguished by its electrical properties. It is a native of the Indian seas, and was first described by Willoughby under the title Anguilla Indica. The second species, T. lepturus, inhabits the fresh waters, and probably ought to be separated from the former, as it is destitute of electrical organs.

Genus XXX. Notopterus.

Pectoral, anal, and dorsal fins present, no caudal fin; body very short.

The two known species which constitute this genus, were formerly included among the Gymnoti; but the presence of pectoral fins is a sufficiently obvious line of distinction. The first species, N. kapirat, of La Cepede, is a native of the seas at Amboyna. It is there named Pengay, or Kapirat. This last has been employed as the trivial name in the system, in defiance of the established maxims of the science. The second species is the N. squamosus, a native likewise of the Indian seas.

Genus XXXI. Ophisurus.

No caudal fin; body and tail cylindrical, and long in proportion to the thickness; head small; nostrils tubular.

The three species of this genus have been called by fishermen sea serpents, from their form and motions. They twist themselves in various directions with astonishing facility, and, when swimming, perform all their evolutions like the serpents. The O. ophis is a native of the European seas. The second, O. serpens, is found in greatest abundance in the Mediterranean.

Genus XXXII. Triurus.

Snout extended like a tube; one tooth in each jaw; caudal fin very short.

The only known species of this genus was found by Commerson in the south seas, and termed by La Cepede, T. Bougainvillianus. In its general aspect and size it bears a considerable resemblance to the common herring. He first observed them in the stomach of other fishes of the genus Scomber, which he had opened immediately upon being caught. We mention this fact, for the purpose of informing the inexperienced ichthyologist, that in such situations he may often meet with some of the rarest objects of his pursuit, and in a condition still fit for a minute examination.

Genus XXXIII. Apteronotus.

Jaws fixed; no dorsal fin; possessing a caudal fin.

La Cepede formed this genus for the reception of the Gymnotus albefrons of Gmelin, whose trivial name he has changed for that of Passan, by which it was designated by Daubenton. It presents some peculiarities of structure, which merit an attentive examination. From the upper part of the body, between the dorsal fin and the head, there issues a fleshy filament, which, after diminishing somewhat in size, and describing an arch, becomes again united with the body near the organ of the caudal fin. The filament is convex above and concave below, and is connected throughout its whole length by twelve short oblique filaments to the subjacent furrow into which it is received.

This curious species was first described by the celebrated Pallas, from a specimen in the collection of the Petersburgh Academy. Afterwards La Cepede added to its history, having had an opportunity of examining a more perfect specimen in the museum at Paris.

Genus XXXIV. Regalecus.

With pectoral, dorsal, and caudal fins; no anal fin, nor spines in place of it; body and tail lengthened.

There are two species belonging to this genus. The one inhabits the northern seas, and in Norway is called King of Herrings. It was first particularly described by Ascanius. It is very nearly related to the genera Ophisurus and Trichiurus. The other species, R. lanceolatus, has been described from a Chinese drawing of a fish in the Dutch collection.

GENUS XXXV. ODONTAGNATHUS.

On each side of the upper jaw a long curved jagged plate. This genus contains only one species, the O. mucronatus. It was obtained from Cayenne, where it is known under the name of Sardine. It lives in salt water, and is considered as good food.

GENUS XXXVI. MURÆNA. *Eel.*

Eel.

Body furnished with pectoral, dorsal, caudal, and anal fins; nostrils tubular; eyes covered with the common integuments; body serpentine and viscous.

It is a matter of regret, that the history of the species of this genus should still be involved in obscurity. The common eel is considered by some as oviparous, by others as ovoviviparous, and the opinion of ichthyologists is equally divided with regard to the reproductive organs of the conger. The species are very extensively distributed, being found in various parts of the new and old world. Their flesh is used as food, but is considered as difficult to digest. The skins are employed in place of ropes.

GENUS XXXVII. AMMODYTES. *Launce.*

Launce.

Head slender; caudal fin distinct from the dorsal and anal ones; upper lip doubled in.

This genus contains only one species, which is a native of the European seas. Its trivial name tobianus has been changed by La Cepede into *alliciens,* from its being a tempting bait, we presume, to other fishes. We cannot censure too severely such unnecessary innovations, as they perplex the student, and encumber the science with a load of useless synonymes.

GENUS XXXVIII. OPHIDIUM.

Head covered with large scales; body and tail compressed and covered with small scales; gill-flap very large; dorsal, anal, and caudal fins united.

According to La Cepede, there are three species belonging to this genus, two of which are natives, and the third was found by Fabricius in Greenland. He distributes them into two sections. In the first is placed the *O. barbatum,* having a beard; and, in the second, the *O. imberbe* and *unernak,* which are destitute of a beard. Risso, in his *Ichthyologie de Nice,* has described a fourth species which belongs to the first section, which he terms O. vassali. It differs from the O. barbatum in the four filaments of the beard being equal.

GENUS XXXIX. MACROGNATHUS.

Upper jaw produced; body and tail compressed; caudal fin distinct from the dorsal and anal fins.

La Cepede instituted this genus for the reception of the Pentophthalmus of Ray, and another fish which was found in the Dutch collection. The name of Ray ought to have been employed from its claims to priority. The M. aculeatus is found in the Indian seas, and its flesh is considered good.

GENUS XL. ZIPHIAS. *Sword-Fish.*

Sword-fish.

Upper jaw produced; blade-shaped; equal at least to one-third of the length of the body.

There are two species described by La Cepede as belonging to this genus, viz. *Z. gladius* and *ensis.* Some circumstances appear to favour the supposition that a third species exists, which has been confounded with the gladius. After having, however, examined the figures and descriptions of several authors, in connection with this subject, we feel ourselves at a loss to offer a decided opinion. The reader will find some judicious remarks on the subject in the *Scots Magazine for July* 1811, and in the *Memoirs of the Wernerian Society,* vol. ii. p. 58. In the last work, there is a figure of what is considered as the new species, which will, we hope, create the curiosity of naturalists to examine the subject.

GENUS XLI. MAKAIRA.

Snout produced; two osseous lanceolate shields on each side of the extremity of the tail.

La Cepede formed this genus for the reception of a fish thrown ashore at Rochelle. The fishermen called it Makaira.

GENUS XLII. ANARCHICAS. *Wolf-Fish.*

Wolf-fish.

Head rounded; upwards of five conic fore-teeth in each jaw; grinders flat and round; one long dorsal fin.

Three species of this genus are known to naturalists. They inhabit chiefly the boreal regions, and furnish a palatable food to the inhabitants.

GENUS XLIII. COMEPHORUS.

Body long and compressed; head and mouth large; rays of the second dorsal fin furnished with long filaments.

The only known species of this genus was found by the celebrated Pallas in the Lake Baikal.

GENUS XLIV. STROMATEUS.

Body greatly compressed and oval.

This genus contains five species, some of which are found in the Mediterranean, and others in the equatorial seas. The S. fiatola is the one which has been longest known, and is remarkable for the agreeable brilliancy of its colours. It inhabits the Mediterranean and Red Seas. The *S. paru,* which is frequent on the coast of Tranquebar, is esteemed delicate food, its flesh being white and tender.

GENUS XLV. RHOMBUS.

Body compressed and short; each side of the animal appears like a rhomboid; rays of the dorsal and anal fins not articulated.

The only known species of this genus was brought to Linnæus from Carolina by Dr Garden, and by him inserted in the genus chætodon. The skin appears to the naked eye to be entirely destitute of scales.

ORDER XVIII. JUGULAR.

GENUS XLVI. MURÆNOIDES.

Ventral fins consisting of one ray; gill-flap of three rays; body lengthened and compressed.

This genus was formed by La Cepede for the reception of the Blennius murænoides of Gmelin. It forms a sort of connecting link between the apodal and the jugular fishes of this division.

GENUS XLVII. CALLIONYMUS. *Dragonet.*

Dragonet.

Head larger than the body; eyes near each other; gill openings on the neck; ventral fins distant; scales minute.

There are five species of dragonets described by naturalists; but it is probable that this number will be reduced when the sexual differences are better known. Mr Neill, to whose ichthyological labours we have already alluded, has ascertained that the Linnæan Cal. Dracunculus is merely the female of the Cal. Lyra. "In the course," says he, "of dissecting and preserving some of each, (viz. the sordid and gemmeous dragonet), it struck me, as remarkable, that the gemmeous dragonets were all males, and the sordid dragonets all females. I now considered it as a fortunate circumstance that numbers were brought to me, presuming that if I should find the gemmeous dragonets to be uniformly *milters*, and the sordid dragonets to be uniformly *spawners*, I might be permitted to conclude that they are only male and female of one and the same species. I accordingly opened every specimen which I received to the amount of some dozens, and the result entirely supported that opinion. Both sorts were brought to me nearly in equal numbers; and from the fishermen I learned that they were taken promiscuously on the same lines." *Memoirs of the Wernerian Natural History Society*, vol. i. p. 530.

GENUS XLVIII. CALLIOMORUS.

Gill-openings on the sides; head larger than the body; ventral fins distant; scales minute.

The Callionymus Indicus of Gmelin is the only known species of the genus. It is a native of Asia.

GENUS XLIX. URANOSCOPUS. *Star-Gazer.*

Star-gazer. Head depressed; eyes on the head contiguous; edges of the gill-lid ciliated.

The position of the eyes in the fishes of this genus is very remarkable, and has procured for them the generic names which are prefixed. There are two species. The first species, *U. mus* of La Cepede, the *U. scaber* of Gmelin, is an inhabitant of the Mediterranean. It lives near the shore, and, concealing itself in the mud, moves the filaments of the beard, so as to imitate the motions of a worm, and in this manner entices the small fish to their destruction. Its flesh is white, but dry and disagreeable. Its bile was considered by the ancients as useful to heal wounds. The U. Japonicus, first described by Houttuyn, is found in the seas near Japan.

GENUS L. TRACHINUS. *Weever.*

Weever. Head compressed and spinous; gill covers spinous; anus near the breast.

This genus contains three species, two of which are found in the British seas. The spines of the dorsal fin of the common weever are supposed by our fishermen to contain a venemous fluid, as the wounds occasioned by them are exceedingly painful, and attended with a considerable degree of inflammation.

GENUS LI. GADUS. *Cod.*

Cod. Head smooth, compressed; gill lid, of many pieces, margined with a smooth border; ventral fins slender, and ending in a point.

This is the most important genus, in an economical point of view, in the whole system. All the species are esculent and palatable, and furnish to the human race a valuable supply of nourishment. Besides the flesh, the liver is used to extract the oil which it contains; the roes are salted as a kind of caviar; and the air-bladder yields isinglass. They are gregarious, and are chiefly to be met with in the temperate and cold climates. The species exceed twenty in number, and exhibit such remarkable differences in the number and form of their organs of motion, that we are surprised at still finding them included in the same category.

GENUS LII. BATRACHOIDES.

Head depressed and large; opening of the mouth wide; around and below the under jaw, a beard.

This genus was formed by Lacepede, for the reception of two species from the genera Gadus and Blennius. The first is the Gadus tau of Gmelin. It is found in the Atlantic ocean, and was first accurately described by Bloch. The second is the Blennius raninus of Gmelin, the Gadus raninus of Muller.

GENUS LIII. BLENNIUS. *Blenny.*

Body and tail lengthened and compressed; head blunt and steep: ventral fins consisting of from two to four united rays. Blenny.

This genus contains, according to La Cepede, twenty-three species. Some of the species at least are ovoviviparous, or hatch the eggs internally, and exclude them along with the young fish, while others appear to be simply oviparous. The genus formed by Artedi was named from Βλεννα, mucus, to indicate the slimy nature of their skin. La Cepede distributes them into sections, according to the number of the dorsal fins and the condition of the head. Into his last section, or those with one dorsal fin and no tentacula, he has inserted the Gadus brorme under the title Blennius Torsk, although he had previously given the species under the cod genus.

GENUS LIV. OLIGOPODUS. *Spotted Blenny.*

One dorsal fin extending from the head to the tail; one ray in each ventral fin. Spotted Blenny.

This genus contains the *Coryphæna velifera* of Gmelin, a fish first described by Pallas. It is a native of the Indian seas.

GENUS LV. KURTUS.

Body greatly compressed, and carinated above and below; back arched.

We are indebted to Bloch for the formation of this genus, which contains only one species, termed by him *K. indicus.* La Cepede has changed the trivial name into *Blochianus.* It is a native of the Indian seas, and feeds on crustaceous and testaceous animals.

GENUS LVI. CHRYSOSTROMUS.

Body and tail arched; compressed; one dorsal fin.

Rondeletius described the only species of this genus known to naturalists, under the name Fiatola.

ORDER XIX. THORACIC.

GENUS LVII. LEPIDOPUS.

Body lengthened, blade-shaped; ventral and anal fins consisting of one ray.

Gouan of Montpellier, formed this genus, and described for the first time the only known species.—L. argenteus. Shaw in his General Zoology, without being aware of the previous labours of Gouan, formed his genus *Vandellius* for the reception of a species differing in some respects from the fish of Gouan, but of the same genus. Montagu, inattentive equally to the labours of Gouan and Shaw, formed his genus *Ziphotheca* for the reception of a species of Lepedopus, similar to the one which Shaw describes. He had considered his fish as belonging to the apodal order, not supposing that the pair of ventral scales, though destitute of motion, were regarded as the rudiments of ventral fins. We are disposed to consider this genus as consisting, at present, of four species. The L. argenteus of Gouan, termed Gouanianus by La Cepede—L. tetradens, the Ziphotheca tetradens of Montagu, and the Vandellius argenteus, caudafurcata of Shaw.—L. Peronii and L. pellucidus of Risso.

GENUS LVIII. HIATULA.

No anal fin.

The H. Gardeniana of La Cepede, and the only known species, is the Labrus hiatula of Linnæus. It was observed by Dr Garden in South Carolina.

GENUS LIX. CEPOLA. *Band-Fish.*

Band-fish.

An anal fin; more than one ray in each ventral fin; body long and blade-shaped; belly scarcely the length of the head.

This genus was first characterised by Bloch. It contains three species, whose specific differences are far from being distinctly marked. The C. tenea and rubescens (whose trivial name La Cepede, with his usual fondness for innovation, has changed into serpentenformis,) are found in the Mediterranean, while the third species, *trachyptera*, has been hitherto observed only in the Adriatic gulf.

GENUS LX. TÆNIOIDES.

An anal fin; pectoral fins disc-shaped; body long, blade-shaped; belly scarcely the length of the head: eyes indistinct; no caudal fin.

The genus contains one species, the T. Hermannii, of whose habits or station nothing is at present known. The trivial name which La Cepede has bestowed upon it, is in honour of Professor Hermann of Strasburgh. The eyes are so very small that they can scarcely be distinguished. They appear like black points.

GENUS LXI. GOBIUS. *Goby.*

Goby.

Ventral fins united; two dorsal fins.

La Cepede distributes the twenty-two species of which the genus consists into two sections, from circumstances connected with the attachment of the pectoral fins. All the species are diminutive in point of size, and have failed to attract the notice of the epicure. A few species, however, are used as food. The G. *lanceolatus* is said to have a very pleasant taste. It lives in the rivers and streams in Martinique.

GENUS LXII. GOBIOIDES.

Ventral fins united; one dorsal fin; head small; the gill-lid attached nearly throughout its margin.

La Cepede has constructed this genus from species which formerly belonged to the genus gobius. The first species which he describes is the gobius anguillaris of Gmelin, a native of the Equatorial seas.

GENUS LXIII. GOBIOMORUS.

Ventral fins distinct; two dorsal fins; head small, eyes approaching; gill-lid attached nearly throughout its margin.

The genus contains four species. The first has been long known to naturalists, and is the Gobius gronovii of Gmelin.

GENUS LXIV. GOBIOMOROIDES.

Ventral fins distinct; one dorsal fin; head small; the gill-lid attached nearly throughout its margin.

The Gobius Pisonis of Gmelin is the only known species of the genus. It was first described by Piso in his Natural History of Brasil.

GENUS LXV. GOBIESOX.

Ventral fins distinct; one dorsal fin, short, and placed on the tail near the caudal fin; head larger than the body.

The G. cephalus, of which the genus consists, is a native of the American rivers, and was first described by Plumier.

GENUS LXVI. SCOMBER. *Mackrel.*

Mackrel.

Two dorsal fins; spurious fins in front of the tail above and below; sides of the tail carinated on the ends of the lateral line.

This important genus contains fourteen species, two of which are natives of our seas. Many of the species exhibit the greatest variety and beauty of colour, and almost all furnish wholesome food. The flesh of the common mackrel is somewhat greasy; and from it the Romans expressed a *garum* or pickle, which was esteemed not only as an agreeable seasoning, but as a valuable medicine.

The Scomber germo of La Cepede, which is found in great abundance in the Pacific ocean, proves extremely palatable and wholesome to sailors. Commerson observed that the shoals of this species did not approach indiscriminately all the vessels of the fleet, but chiefly those which had been long at sea, and whose bottoms were foul. The same observer supposes that fishes often approach ships in the equatorial seas, enticed by their shadow in the water, which screens them from the direct influence of the sun beams.

GENUS LXVII. SCOMBEROIDES.

One dorsal fin, with spines in front; spurious fins above and below in front of the caudal fin.

La Cepede, who formed this genus, has described three species. The *S. Noelii* has ten spurious fins above, and fourteen beneath. The *S. Commersonianus* has twelve spurious fins above and beneath, while the S. saltator has only seven above and eight beneath. The second species is from the shores of Madagascar; but the habitation of the others is unknown.

GENUS LXVIII. CARANX. *Scad.*

Scad.

Two dorsal fins; no spurious fins; sides of the tail carinated.

This was instituted by Commerson, and so named from *καρα*, *caput*, in reference to the size, the power, and the lustre of that part of the body, and the dominion exercised by the species of this genus over their weaker neighbours. The genus contains twenty species, which La Cepede has distributed into two sections. In the first are placed those which have no spines between the dorsal fins; and in the second, such as are furnished with spines in that place. Many of the species are from the Red sea, and present few particulars worthy of being mentioned.

GENUS LXIX. TRACHINOTUS.

Two dorsal fins, with spines concealed in the front of these under the skin.

This genus was formed by La Cepede from *τραχινος*, *asper*, in reference to its dorsal spines. It contains only one species, the T. falcatus, first described by Forskael in his Fauna Arabica. Commerson likewise observed it on the shores of Madagascar.

GENUS LXX. CARANXOMORUS.

One dorsal fin; no spurious fins; upper lip fixed.

This genus is nearly allied to the preceding, and contains 4 species, formerly included in the genus Scomber.

GENUS LXXI. CÆSIO.

One dorsal fin; upper lip extensile.

The species contained in this genus are two in number; and might with propriety have been united with those in the preceding genus. The first is termed C. cærulescens, and is a native of the Molucca isles; and the second, C. equulus, was described by Forskael.

GENUS LXXII. CÆSIOMORUS.

One dorsal fin; no lateral ridge; separate spines in front of the dorsal fin.

This genus is nearly allied to the preceding, and contains 2 species described from the MSS. of Commerson.

GENUS LXXIII. CORIS.

Covering of the head entire; one dorsal fin; the 1st or 2d rays of the ventral fins twice as long as the others.

Naturalists are indebted to Commerson for a knowledge of the two species which compose this genus. These he termed C. aygula and C. angulatus.

GENUS LXXIV. GOMPHOSIS.

Snout produced, in form of a nail; head destitute of scales like those of the back.

Commerson likewise instituted this genus, consisting of two species—the G. cæruleus and G. varius.

GENUS LXXV. NASO.

A horn or protuberance on the snout; two plates or shields on each side of the extremity of the tail; skin shagreened.

Commerson formed this genus, which contains two species, one of which is the Chætodon unicornis of Gmelin, found in the Red Sea by Forskael, and at the Isle of France by Commerson.

GENUS LXXVI. KYPHOSUS.

Back elevated; a hunch on the shoulder; gill lid with scales like the body.

This Commersonian genus contains one species, the K. bigibbus.

GENUS LXXVII. OSPHRONEMUS.

Ventral fins, each of five or six rays, the first spinous, and the second terminated by a long filament.

This genus contains two species. The first of these, O. goramy, is an inhabitant of the fresh waters of Hindostan and China. It has been naturalized in the Isle of France, and ought to be translated to Europe. As food, it is said to be of exquisite flavour. The second is the O. gallus, the Scaurus gallus of Forskael. It frequents the coasts of Arabia, and is considered by the inhabitants as a noxious species.

GENUS LXXVIII. TRICHOPODUS.

Ventral fins with one ray longer than the body; one dorsal fin.

The genus contains two species. One of these is the Labrus trichopterus of Gmelin, a native of the Indian seas. The other is T. mentum, described from a drawing by Commerson.

GENUS LXXIX. MONODACTYLUS.

Ventral fins of one short ray. One dorsal fin.

The M. falciformis was first observed by Commerson, and is the only species of the genus.

GENUS LXXX. PLECTRORINCHUS.

Lips plaited and marginated; one or more of the plaits of the gill-lid denticulated.

La Cepede instituted this genus. The name is from πλεκτρον, *pecten*, and ρυγχος, *rostrum*. There is but one species observed by him in the Dutch collection.

GENUS LXXXI. POGONIAS.

One dorsal fin; chin bearded.

This genus, from πωγων, *barba*, was instituted by La Cepede for the reception of one species, the P. fasciatus, in the collection of the Stadtholder at the Hague.

GENUS LXXXII. BOSTRYCHUS.

Body long; serpentine; two dorsal fins; two tentacula on the upper jaw.

The two species of which the genus consists are but imperfectly known. They rest on the authority of Chinese drawings.

GENUS LXXXIII. BOSTRYCHOIDES.

One dorsal fin. In other respects like the preceding.

A Chinese drawing of the only species of this genus was found in the Dutch collection.

GENUS LXXXIV. ECHENEIS. *Sucking Fish.*

Sucking fish.

Head depressed, and furnished with an organ of adhesion, consisting of an oval plate with transverse folds.

The name of the genus is derived from εχω, *habeo*, and ναυς, *navis*; because the best known species was supposed to have the property of sticking to ships, and retarding their motions. It is the *remora* of the ancients.

GENUS LXXXV. MACROURUS.

Two dorsal fins; tail twice as long as the body.

This genus was instituted by Bloch for the reception of the Coryphæna rupestris of Linnæus, which is found on the coasts of Greenland and Iceland. To the inhabitants of these countries it furnishes a plentiful supply of nourishing food. In some of the districts where it is found it is called berg-lax, or rock salmon. It is the *ingminniset* of the Greenlanders.

GENUS LXXXVI. CORYPHÆNA.

Head truncated, or very obtuse; one dorsal fin, nearly as long as the body and tail.

This genus contains sixteen species, which La Cepede has distributed into sections, from the shape of the tail. The first species which La Cepede describes is the C. *hippurus*, which is found both in the Atlantic and Pacific ocean. Its flesh is very agreeable; and being a voracious fish, easily taken, and fond of following vessels, often furnishes the sailor with a grateful repast. When taken out of the water, the beautiful combinations of colours fade as the fish expires, and the dying coryphene is contemplated by sailors with as much delight as the ancient Romans are said to have exhibited on viewing similar changes in the expiring mullet, when brought to the table before the feast began.

GENUS LXXXVII. HEMIPTERONOTUS.

Head truncated; one dorsal fin, about half the length of body and tail.

La Cepede formed this genus from two species formerly included in the genus Coryphæna. The H. *quinque-maculatus* of La Cepede, the *Coryphæna pentadactyla* of other writers, inhabits the rivers of China, the Molucca isles, and other places in the Indian Archipelago. It is gregarious, appearing in vast shoals, and is eagerly sought after as an article of food. It is dried or salted, and forms an article of trade in those countries similar to the cod fishery of our northern districts.

GENUS LXXXVIII. CORYPHENOIDES.

Head truncated, or very obtuse; one dorsal fin; gill opening a simple transverse slit.

This genus contains only one species, the C. branchiostega. It inhabits the seas of Asia, and differs from the genus Coryphæna principally in the form of the gill opening.

GENUS LXXXIX. ASPIDOPHORUS. *Pogge.*

Pogge.

Body and tail covered with a scaly coat of mail; two fins on the back.

This genus was first instituted by Scopoli, and afterwards adopted by La Cepede for the reception of two species included in the genus Cottus. The first is the *Cottus cataphractus* of Linnæus, common in the European seas; and the second is the C. *japonicus* of Gmelin, which was first described by Pallas as a native of the seas about the Kurile islands. It is destitute of the cirri or beard under the throat, and from that circumstance ought perhaps to be referred to another genus.

GENUS XC. ASPIDOPHOROIDES.

Body and tail armed with a coat of mail; one dorsal fin; rays of the ventral fins fewer than four.

This genus bears a very close resemblance to the preceding, from which it is principally distinguished by the union of the two dorsal fins. The only species it contains is the Cottus monopterygius of Gmelin, a fish which inhabits the coast of Tranquebar.

GENUS XCI. COTTUS. *Bull head.*

Bull-head.

Head larger than the body; form approaching conical; two dorsal fins; spines and tubercles on the head or gill lid; ventral fins with more than three rays.

La Cepede describes nine species, some of which are used as food.

The grunting bull-head, Cottus gruniens, a native of the American and Indian seas, is considered as esculent food. The liver, however, is said to possess noxious qualities. When first taken from the water, this fish utters a sound, in some degree resembling the grunting of a pig, and produced by the sudden expulsion of air from the internal cavities through the gill covers and mouth.

The Cottus insidiator, a native of the Arabian seas, is said to bury itself in the sand, and wait the approach of its prey. When the small fish have approached sufficiently near, it then darts out upon them with considerable velocity. The C. scorpius, which in this country is despised, is eagerly sought after as food by the inhabitants of Greenland. From the liver they likewise extract an oil. This animal is very vivacious. It can close the gill opening so closely, by means of the lid, as to prevent the atmosphere from drying the gills, and consequently obstructing respiration.

GENUS XCII. SCORPÆNA.

Head covered with spines or protuberances; destitute of small scales; one dorsal fin.

The species of this genus, sixteen in number, are distributed into two sections from circumstances connected with the beard. They have all a very uncouth appearance, and they are armed with formidable spines. The S. horrida, says Shaw, resembles rather some imaginary monster of deformity than any regular production of nature. The head is very large, perfectly abrupt in front, and marked by numerous tubercles, depressions, and spines. On the top is a semilunar cavity; the mouth opens from the upper part, and is large, and of a shape resembling a horse shoe. It is a native of the Indian seas. The S. porcus is the most common European species. It is found plentifully in the Mediterranean, where it lurks among the sea weeds, and, as opportunity offers, darts upon its prey. When seized by any stronger animal, it twists itself violently, and, erecting its strong spines, makes a vigorous resistance. Wine, in which this fish was suffered to die, was esteemed by the ancients as a salutary medicine. The S. scrofa, which is found in the Atlantic and Mediterranean, is said to prey not only on the smaller fishes, but on the aquatic birds as they swim on the surface. The S. antennata, remarkable for two long tentacula, surrounded by several fibrous brown bars seated immediately above the eyes, is a native of Amboyna, and its flesh is said to be exquisite. In the S. volitans, the pectoral fins are so large, that the fish can fly for a short distance. It is the Gasterosteus volitans of Linnæus.

GENUS XCIII. SCOMBEROMORUS.

One dorsal fin; spurious fins above and below, in front of the caudal fin; no separate spines in front of the dorsal fin.

The S. plumierii is the only species of the genus, and is a native of Martinique. It was described by La Cepede from the drawings of Plumier.

GENUS XCIV. GASTEROSTEUS. *Stickle-back.*

Stickleback.

One dorsal fin; separate spines in front of the dorsal fin; tail carinated laterally; one or more spinous rays to each ventral fin.

The species of this genus are natives of Europe. The G. aculeatus is common in rivers. It is sometimes found in such plenty as to be employed as manure, an oil excellent for burning may be expressed from the body. The other species are natives of the seas. They are armed with sharp spines on the back, so that few fish venture to seize them.

GENUS XCV. CENTROPODUS.

Two dorsal fins; ventral fins with one spine, and five or six small articulated rays.

This genus, from Κεντϱον, *aculeus*, and πȣς, *pes*, was created by La Cepede for the reception of one species, C. rhombeus, observed by Forskael in the Red Sea.

GENUS XCVI. CENTROGASTER.

Ventral fins with four spines and six articulated rays.

This genus contains two species which inhabit the sea of Japan. They were first described by Houttuyn in the *Act. Haerl.* vol. xx. 2. p. 334. No. 22.

GENUS XCVII. CENTRONOTUS.

One dorsal fin; ventral fins with at least four rays; a longitudinal crest on each side of the tail, and two spines in front of the anal fin.

This genus, formed from Κεντϱον, *aculeus*, and νωτος, *dorsum*, contains eleven species. They are all of a small size. The most remarkable among these is the pilot fish of Willoughby, the C. conductor of La Cepede, which has often excited the astonishment of observers. It follows vessels to feed on the substances thrown overboard; and is generally seen in company with the shark, which in the opinion of some it conducts to its prey.

Pilot fish.

GENUS XCVIII. LEPISACANTHUS.

Scales of the back large, ciliated, and terminated by a spine; the gill lid denticulated behind.

This genus, from Λεπις, *squama*, and ακανθα, *spina*, was instituted by La Cepede. It contains only one species from Japan, first described by Houttuyn.

GENUS XCIX. CEPHALACANTHUS.

Two long denticulated spines on each side of the head behind.

This genus, formed from Κεφαλη, *caput*, and ακανθα, *spina*, was instituted by La Cepede. It contains only one species, the Gasterosteus spinarella of other naturalists. It differs from the Sticklebacks in wanting the spines on the back. It is a small fish, and a native of India.

GENUS C. DACTYLOPTERUS.

One small fin, consisting of rays connected by a membrane near each pectoral fin.

La Cepede formed this genus from δακτυλος, *digitus*, and πτερον, *pinna*, for the reception of two species of fishes formerly included in the genus Trigla. The D. priapoda is one of those fishes capable of flying for a short distance in the atmosphere. Hence it has been termed the sea-swallow, by sailors. It is found principally near the tropics, but is also met with in the Mediterranean. The other species, D. Japonicus, was first described by Houttuyn. It is the Trigla alata of Gmelin.

GENUS CI. PRIONOTUS.

Soft rays near each pectoral fin separate; serrated spines between the dorsal fins.

There is but one species belonging to this genus, a native of the American seas. It is the Trigla volitans minor of Brown. Jamaica, 453. tab. 47. fig. 3.

GENUS CII. TRIGLA. *Gurnard.*

Gurnard.

Soft separate rays near each pectoral fin; no spines in the interval between the dorsal fins.

The name of the genus is from τριγονος, *terpariens*, in reference to the fecundity of the fish. Many of the species have the power of raising themselves into the air, when the sea does not afford them a safe asylum. Their flesh is white and insipid; and is seldom sought after when other fish can be obtained.

GENUS CIII. PERISTEDION.

Soft separate rays near each pectoral fin; one dorsal fin; one or more bony plates on the under side of the body.

This genus was formed by Lacepede, and contains two species. They are readily distinguished from the species of the genus Trigla by the osseous plates, which form a coat of mail on their under side. The P. malarmat of Lacepede, the Trigla cataphracta of Gmelin, is found in the European and Indian seas. It is sought after as food, although its flesh is said to be dry and insipid. It swims with great rapidity, and is very active in all its movements. The P. chabrontera is found in the Mediterranean, and was first described by Osbeck.

GENUS CIV. ISTIOPHORUS.

Two dorsal fins, the first very long elevated and rounded; two rays to each ventral fin.

The T. gladifer is the only known species. It is an inhabitant of the tropical seas, and its appearance is considered by sailors as the presage of a storm. It resembles in many respects the sword-fish. It grows to a great size, swims with great velocity, and possesses undaunted courage. It often strikes its snout against vessels with such force as to break it; and, in consequence of its boldness, proves a dangerous enemy to fishes equal to itself in size. When young, its flesh is considered as agreeable to the taste; but when old, it is oily and indigestible.

GENUS CV. GYMNETRUS.

No anal fin; one dorsal fin; the rays of the ventral fins elongated.

This genus contains only one species, which was instituted by Bloch, the G. Hawkenii, a native of the Indian seas, and occasionally in those of Europe.

GENUS CVI. MULLUS. *Surmullet.*

Surmullet.

Scales large, and easily detached; summit of the head bluntly elevated; under jaw with a beard.

There are fourteen known species in the genus. The most remarkable of these is the Red Surmullet, Mullus barbatus of Linnæus. This fish, when alive, presents some of the most brilliant colours exhibited in nature, and the changes which they experience as the fish expires are singularly various. The luxurious Romans brought this fish alive to table in a glass vessel, and, suffering the fish to expire, contemplated with delight the successive changes of colour. After pleasing the eye by this fine display, the fish was removed and dressed for the feast.

GENUS CVII. APOGON.

Scales large and deciduous; head bluntly raised; no beard on the under jaw.

The generic name is from απωγων, imberbis. The only known species is the A. ruber of La Cepede, the Mullus imberbis of Willoughby. It is found chiefly on the rocky coast of Malta, and differs from the surmullets in wanting the beard or cirrus on the lower lip. It is of a fine red colour; the opening of the mouth is large, and the palate and jaws very rough.

GENUS CVIII. LONCHURUS.

Pectoral and caudal fins equal at least to a fourth of the whole length of the body: dorsal fin long and indented.

Bloch instituted this genus for the reception of a fish brought from Surinam, which he termed L. barbatus. La Cepede changed the trivial name into dianema, instigated apparently by no other feeling than the love of change. The nose or upper lip is produced into an obtuse short snout, so as to cause the mouth to appear as if placed somewhat beneath. The head is covered with scales like those on the back, and the jaws are furnished with small sharp teeth.

GENUS CIX. MACROPODUS.

Ventral fins the length of the body, caudal fin forked, its length equal to a third part of the body: head and gill lid covered with scales similar to the back; opening of the mouth very small.

This genus from μακρος, *longus*, and πους, *pes*, contains only one species, M. viridiauratus, an inhabitant of the fresh water lakes of China, but whose history is little known.

GENUS CX. LABRUS. *Wrasse.*

Wrasse.

Lips thick; upper lip protrusile; no teeth in the form of grinders or incisors; rays of the dorsal fin terminated by a filament.

The name of the genus is expressive of the thick lips with which the species are furnished, and is a term used by Ovid. La Cepede describes 130 species. Some of these, however, rest on very doubtful authority, and a few may be considered as varieties. The characters by which they are separated depend, in a great measure, on the number of the rays of the fins. They are all remarkable for the brilliancy of their colours, the size of their scales, and the strength of their teeth, and we may add, for their extensive distribution. In all the seas of the globe some species belonging to this genus have been found. Few of the species are esteemed as food, and although some are reputed poisonous, the evidence on which the belief rests is unsatisfactory. Many of the species are solitary, while a few appear to be gregarious. The Labrus julis is said to live in vast troops; and, if we may credit Ælian, will attack and bite men bathing in the water. The flesh of the Labrus cinædus is soft, tender, and easy of digestion, and suitable for the young and weak.

GENUS CXI. CHEILINUS.

Lips thick; rays of the dorsal fin terminating in a filament: large scales, with appendages at the base of the caudal fin.

This genus of La Cepede contains two species, viz. C. scarus and C. trilobatus. The first appears to be the true Scarus of the ancients. It inhabits the shores of the Mediterranean, and has been often examined. It is of a whitish colour mixed with red. The scales are large and transparent. This species lives in shoals, and such is the attachment which is said to prevail among them, that according to Appian, when one has taken the bait, another will come to its assistance, and bite the cord to enable it to escape. This fish was eagerly sought after by the luxurious Romans, who preferred the liver, and even the intestines without being emptied. Its food consists of marine plants. The second species is described by La Cepede from the manuscripts of Commerson, and is a native of the Indian seas.

GENUS CXII. CHEILODIPTERUS.

Upper lip extensile, two dorsal fins; no cutting or grinding teeth: gill-lid destitute of spines or processes.

This genus contains ten species, divided into two sections, from the form of the tail. Little more is known of their history than their systematic characters. They were formerly included in the genera Sciæna and Labrus.

GENUS CXIII. OPHICEPHALUS.

Scales of the head polygonal, larger than those of the back; all the rays of the fins jointed.

The name of this genus, from *οφις*, *serpens*, and *κεφαλη*, *caput*, is sufficiently expressive of the distinguishing character of the species. These are two in number, which were described by Bloch, and come from the coast of Coromandel. The scales of these fishes, where exposed, are tuberculated, and feel rough to the touch. They inhabit fresh water lakes and rivers, and feed on aquatic plants. Their flesh is esteemed agreeable and salubrious.

GENUS CXIV. HOLOGYMNOSUS.

Scales invisible; ventral fins resembling a fleshy beard; tail as if formed of two truncated cones, united by their summits.

La Cepede formed this genus, from *ὅλος*, *totus*, and *γυμνος*, *nudus*, for the reception of the H. fasciatus, a native of the equatorial seas, where it was first observed by Commerson.

GENUS CXV. SCARUS.

One dorsal fin; jaws osseous, prominent, occupying the place of teeth.

This genus was instituted by Forskael, and contains at present nineteen species. They are remarkable for the brilliancy of their colours, and the armature of their fins. The mouth in the species of this genus is constructed rather in imitation of some of the cartilaginous fishes, as the Diodon, than of any of the osseous fishes. The jaws are bony, entire in some species, and divided in others, and destitute of true teeth, but often tuberculated or crenulated. They feed on crustaceous and testaceous animals, and likewise on sea weeds. The flesh of the Scarus rivulatus is pleasant to the taste, but the wounds made by the spines of its fins being difficult to heal, it has been considered as venomous. It frequents the coasts of Arabia.

GENUS CXVI. OSTORINCHUS.

Two dorsal fins; osseous jaws prominent, and occupying the place of teeth.

This genus was instituted by La Cepede, and the only species of which it consists (discovered by Commerson) has been named by him in honour of M. Fleurieu. It is a native of the Equatorial seas.

GENUS CXVII. SPARUS. *Gilt-head.*

Gilt-head.

Cutting or grinding teeth in several rows; the height of the body nearly equal to its length.

Forskael formed this genus, deriving the name from *σπαιρειν*, *palpitare*, on account of the rapid motions of the fish when taken from the water. It is a very numerous genus. About a hundred species have been described by ichthyologists. They are distributed into three sections, from characters furnished by the form of the tail. The lunulated gilt-head, Sparus aurata, was well known to the ancients, and by them dedicated to the goddess Venus. In spring, this species frequents the shores, and even enters the mouths of rivers. Its flesh is said to improve in fresh water, and hence Duhamel and others have recommended its being translated into lakes and rivers. As food, it was much prized by the ancients, and valuable medical qualities were ascribed to it. Where common, as in the Mediterranean, it is often salted, and sent inland as an article of trade. Several species have a remarkable phosphorescent property. Willoughby first observed this in the S. pagrus, but it is more remarkable in the S. chrysurus. This last fish inhabits the seas of Brazil, and when a few of them are swimming in company, they emit so much light, that in the darkest night a person might see to read by means of it. This property enables the fish to pursue its prey with more certainty; but, on the other hand, it gives information to its foes. Its flesh is esteemed excellent, and much sought after.

GENUS CXVIII. DIPTERODON.

Two dorsal fins; mouth with several rows of teeth.

This genus contains six species. The D. asper inhabits the rivers of France and Germany; and, being very vivacious, might easily be translated into this country, in the more temperate seasons of the year. Its flesh is esteemed excellent, and in our rivers and lakes would prove a valuable addition to our stock of food. As this fish searches for its food in the mud, in which there are occasionally small pieces of gold, and as these have sometimes been found in its stomach, the fishermen have concluded that its food was gold. The flesh of the D. zingel is equally white, firm, and palatable, and is found in the same situations. It is so bold and vigorous, and so well protected by means of scales, that few fishes will venture to attack it. Hence it multiplies very rapidly.

GENUS CXIX. LUTJANUS.

One dorsal fin; a process to one or more of the pieces of the gill-lid; no spines on these pieces.

This genus contains, according to La Cepede, seventy-four species. The L. anthias is the *ἱερος ἰχθὺς* of the Greeks, who fancied that no dangerous fish could reside in the waters in which it lived, and that divers might descend with safety, if they knew that this fish was an inhabitant of the place. It feeds on small fishes, and is very common in the Mediterranean. The L. johnii, so named by Bloch in honour of his missionary friend John, is found on the coast of Tranquebar. Its flesh is white and palatable. The L. plumierii of La Cepede, the Anthias striatus of Bloch, found in the Atlantic ocean, is also esteemed safe and agreeable food. The Lutjanus scandens, first described in the Linnean Transactions, vol. iii. is remarkable for its power of creeping up the stems of trees, by means of the spinous processes of its fins and gill-lid.

GENUS CXX. CENTROPOMUS. *Basse.*

Basse.

Two dorsal fins; one or more processes to each piece of the gill-lid; no spines on these parts.

La Cepede instituted this genus, which contains twenty-one species. The name is derived from *κεντρον*, *aculeus*, and *πωμα*, *operculum*. The Centropomus sandat of La Cepede, the Perca lucioperca of Linnæus, inhabits the fresh waters of all the countries of the north of Europe It grows to a great size, and its flesh is white, tender, and pleasant to the taste. In the form of its head, and the size of its teeth, it bears a near resemblance to the pike; while, in the structure of its gill-lid, the number and situation of its dorsal fins, and the hardness of its scales, it approaches in appearance the perch. Hence, almost all naturalists have termed it lucioperca. It is a matter of regret that this fish dies so quickly upon being taken out of the water: hence it cannot be transported alive to any distance. But as it is one of those fishes which, if translated into our lakes and rivers, would prove a valuable addition, the fecundated eggs might be employed with ease. In this department of rural economy, how much remains to be done

GENUS CXXI. BODIANUS.

No processes on the gill-lid; plates of the gill-lid spinous; one dorsal fin.

The genus contains twenty-four species. The most remarkable species is the B. palpebratus, first accurately described by Pallas. It has a moveable membranaceous plate above each eye, supposed to assist the animal in regulating the admission of light to that organ. It is a native of Amboyna. The B. pentacanthus, whose trivial name La Cepede, with his wonted love of barbarisms, has changed into jaguar, is a native of the coast of the Brazils. It prefers the mouths of large rivers, near which it grows very fat, and its flesh acquires an increased degree of delicacy and flavour. It is there termed jaguar. The B. aya frequents the lakes of Brazil, and is there salted or dried in the sun as an article of trade. It multiplies very rapidly, and might probably, with little difficulty, be translated to the fresh water lakes of Europe. Its flesh is esteemed good. The B. guttatus of Bloch, changed by La Cepede into B. jacob-evertsen, the name of a Dutch sailor, is found at St Helena, the East Indies, and Japan. It becomes very fat, and is eagerly sought after by Europeans. The B. apua is another of the Brazilian species used as food. Its flesh is oily, and of exquisite flavour.

GENUS CXXII. TŒNIANOTUS.

One or more spines on the gill-lid; dorsal fin very long.

This genus, from *ταινια*, *tenia*, and *νωτος*, *dorsum*, contains only two species, remarkable for their lengthened shape. The first species, T. latovittatus, was observed by Commerson in the Isle of France. He found in its stomach the fragments of corals and of shells. Its teeth are very small, and its tongue and palate destitute of asperities; yet the hardness of its jaws, the number of its teeth, and the continuance of its efforts, enables it to triturate those hard bodies, for the performance of which, in other fishes, more powerful grinders are provided. The second species, T. triacanthus, has the tail rounded, while in the former it is forked. Its habitat is unknown, as it was found preserved in spirits in the Dutch collection, during its captivity in Paris.

GENUS CXXIII. SCIÆNA.

Gill-lid furnished with spines, but destitute of processes; two dorsal fins.

This genus contains eleven species, distributed into sections from the form of the tail. They differ from the genus Bodianus chiefly in the number of the dorsal fins. The *Sciæna coro* is a native of the Brazils, and is taken at all seasons, although its flesh is said to be dry and insipid. The Sciæna umbra, the coracinus of the ancients, is the most important species of the genus, and has been long known. It inhabits the Mediterranean and Adriatic seas, and is found peculiarly abundant in the Nile. It lives in troops, and feeds on crustaceous and testaceous animals. It is esteemed excellent food when in season. Those which are found in fresh water are reckoned preferable to those taken in the sea, and the young are considered as more palatable than the old. The ancients attributed to this fish the most extraordinary medical virtues.

GENUS CXXIV. MICROPTERUS.

Rays of the second dorsal fin short.

This genus contains one species, which La Cepede has named in honour of Dolomieu. We are ignorant of the discoverer and the locality of this species: it was found in the museum at Paris.

GENUS CXXV. HOLOCENTRUS.

One dorsal fin; one or more spines, and a process on each gill-lid.

Bloch formed this genus from species chiefly belonging to the Perca of Linnæus. At present, it contains sixty-five species, divided into sections from characters furnished by the caudal fin. The H. schratzer is found abundantly in the Danube and its tributary streams. Its flesh is white, firm, and salutary, and of a pleasant taste. It feeds on small insects and worms, and spawns in the spring. So valuable a fish ought to be translated to other countries. Although it soon dies when taken from the water, yet with care it may be conveyed to a distance, or the spawn may be used as a substitute.

GENUS CXXVI. PERCA. *Perch.*

Perch.

Two dorsal fins; one or more spines, and a process to the gill-lid; with or without a beard.

This genus, as it now stands, contains fourteen species. The common perch of our lakes may be regarded as the most important species of the genus in an economical point of view. The *P. umbra*, the umbra of the ancients, another valuable species, chiefly resides in the Mediterranean. Its head is compressed and covered with small scales, and it has a thick short cirrus on the lower jaw. Its flesh is firm, but easy to digest, and its head was esteemed a favourite morsel by the ancient Romans. It feeds on sea weeds and small worms. From the skins of some of the species an isinglass is prepared, little inferior to that which is obtained from the air-bag of the sturgeon.

GENUS CXXVII. HARPE.

Many large strong teeth in each jaw: in the upper jaw small compressed teeth in the intervals between the larger ones; dorsal, ventral, and anal fins large and falcated.

This genus was instituted by La Cepede, and contains only one species, H. cæruleo-aureus, of which little is known. It is described from the drawings of Plumier.

GENUS CXXVIII. PIMELEPTERUS.

The whole, or a great part of the dorsal, anal, and caudal fins adipose.

This genus, from *πιμελη*, *pinquedo*, and *πτερον*, *pinna*, contains one species, viz. P. Bosquii, named in honour of M. Bosc, the discoverer. It is found in the Atlantic Ocean, and follows vessels, picking up the fragments of food thrown overboard. It keeps in the eddy at the rudder. It is very difficult to catch, as, with considerable dexterity, it bites off the bait without swallowing the hook. According to Bosc, it is sought after as food by the French, but neglected by the English. In its manners it bears a near resemblance to the pilot fish.

GENUS CXXIX. CHEILIO.

Snout depressed; head and gill-lid destitute of small scales; gill-lid carved; under jaw pendant; dorsal fin low and long, ventral fins small.

This genus, from *χειλος*, *labrum*, contains two species, first observed by Commerson at the Mauritius. The first is termed C. auratus, on account of its golden yellow colour. The lateral line is spotted with black points. The flesh is white, and of a pleasant taste, but disregarded, as it is very common. The second species is termed C. fuscus. The colour is brown, having the ventral fins white, and the dorsal and anal fins spotted with white.

Genus CXXX. Pomatomus.

Gill-lid notched at its upper posterior margin, and covered with scales like those on the back; anal fin adipose.

The P. skib of La Cepede is the only known species. It inhabits the bays and mouths of rivers in Carolina, and is there called skibjack. It performs its motions in a remarkably rapid manner, darting suddenly to a considerable distance. Its flesh is reckoned good. It was observed by Bosc during his residence in the United States.

Genus CXXXI. Leiostomus.

Jaws without teeth, and entirely covered with the lips; the mouth under the snout.

Bosc is the discoverer of L. xanthurus, the only known species, termed in Carolina *yellow-tail*. La Cepede formed the genus from λειος, *lævis*, and στομα, *os*. It differs from the perches in the absence of a process to the gill-lid, and in wanting teeth.

Genus CXXXII. Centrolophus.

A longitudinal crest, and row of distant spines, in part concealed in the skin, above the nape; one dorsal fin.

This genus was instituted by La Cepede to include a fish sent him from Fechamp by M. Noel of Rouen. It was called by the fishermen Le Negre, and hence he has termed the species C. niger. It is of a black colour. The eyes are large, and in front of the dorsal fin there are three spines placed vertically, or pointing forwards.

Genus CXXXIII. Eques.

Two dorsal fins; the rays of the first ending in long filaments; teeth numerous, rigid, and fixed.

The E. Americanus is the only known species of the genus, and has hitherto been found only in the seas of the new continent. It is the Chætodon lanceolatus of Gmelin. In point of brilliancy, and variety, and disposition of colours, this fish has few rivals. The head is small and compressed; the snout rounded. The genus was formed by Bloch.

Genus CXXXIV. Leiognathus.

Jaws without teeth; a strong curved spine on both sides of each of the soft rays of the dorsal fin; a long flattened scaly appendage near each ventral fin; gill-lid carved, and destitute of small scales.

This genus (from λειος, *lævis*, and γναθος, *maxilla*) contains only one species, viz. L. *argenteus*, a native of Tranquebar. It was first described by Bloch under the title Scomber edentulus, but it differs from the mackrel in being destitute of teeth. The head, body, and tail are also compressed, and the opening of the mouth is very small. Its flesh is fat and agreeable to the taste; and being found at all seasons, is of great use to the inhabitants of those shores which it frequents.

Genus CXXXV. Chætodon.

One dorsal fin; gill-lid destitute of processes; teeth small, flexible, and moveable; opening of the mouth small.

This genus has obtained its present name from χαιτη, *seta*, and ὀδους, *dens*. La Cepede has enumerated forty-two species. They chiefly inhabit tropical seas. Their flesh is excellent food, and they are much sought after by sailors. They are remarkable for their form and the brilliancy and variety of their colours. The limits by which the different species are separated are ill defined, so that much confusion prevails in their nomenclature. They all inhabit the seas of tropical countries, and were unknown or disregarded by the ancients. The skeletons of some species have been found along with other ruins of the animal kingdom, in the strata at Mount Bolca. La Cepede particularly mentions the remains of the Chætodon vespertilio and teira. The Ch. marginatus appears to prefer the mouths of rivers, is very common at the Antilles, and its flesh is good. The flesh of the Ch. macrolepidotus, a native of the East Indies, is said, in point of delicacy, to resemble the sole. But the most extraordinary species is the Ch. rostratus, a native of the fresh waters of India. Dr Shaw, after informing us that its prey consists of the smaller kinds of insects, says, "When it observes one of these, either hovering over the water, or seated on some aquatic plant, it shoots against it from its tubular snout a drop of water, with so sure an aim as generally to lay it dead, or at least stupified on the surface. In shooting at a sitting insect, it is commonly observed to approach within the distance of from six to four feet before it explodes the water. When kept in a state of confinement in a large vessel of water, it is said to afford high entertainment by its dexterity in this exercise; since, if a fly, or other insect, be fastened to the edge of the vessel, the fish immediately perceives it, and continues to shoot at it with such admirable skill as very rarely to miss the mark."

Genus CXXXVI. Acanthinion.

One dorsal fin; teeth small, flexible, and moveable; two or more naked spines in front of the dorsal fins.

The three species, of which this genus consists, were formerly included in the genus Chætodon; but the spines, placed behind the head, form a sufficient mark of distinction, and is expressed in the name of the genus from ακανθα, *spina*, and ινιον, *occiput*. The first species, A. rhomboides, is a native of the American seas, as is also the A. glaucus. The flesh of the last species is white and nourishing, and sought after as food. It sometimes grows to the length of 18 inches. The third species inhabits the rocky shores of Arabia, where it was observed by Forskael. It has something of the habit of a flounder, and seldom exceeds a foot in length.

Genus CXXXVII. Chætodipterus.

Body and tail compressed; two dorsal fins; teeth small, flexible and moveable; gill-lid destitute of processes and spines.

La Cepede instituted this genus for the reception of C. Plumierii. This species is nearly as deep as it is long, and its sides are lozenge shaped. The general colour is green, mixed with yellow, crossed by six narrow bands of deep green. It was observed in the West Indies by Plumier; and prefers a stony bottom.

Genus CXXXVIII. Pomacentrus.

One dorsal fin; gill-lid furnished with a process, but destitute of long spines; teeth small, flexible and moveable.

This genus contains seven species. They inhabit the seas of warmer countries, and in general exhibit a fine display of colours. One species has indeed obtained the name of Peacock, (P. pavo,) from the variety and lustre of its colours. It is a native of the Indian seas, and was first described by Bloch.

Genus CXXXIX. Pomadysis.

Two dorsal fins; teeth small, flexible and moveable; gill-lid furnished with a process.

Forskael discovered, in the Arabian sea, the only species of the genus termed P. argenteus, with whose habits we are still unacquainted.

Genus CXL. Pomacanthus.

One dorsal fin; teeth small, flexible, and moveable; gill lid furnished with long spines, but no process.

The seven species included under this head, were formerly arranged in the genus Chætodon. The Pe. canescens, a native of Arabia, and first described by

Forskael, is sought after as food, and its flesh is agreeable. The P. paru, a native of the American seas, is likewise much sought after as food, and is taken by the hook.

GENUS CXLI. HOLACANTHUS.

One dorsal fin; teeth small, flexible, and moveable; gill lid with a process and spines.

This genus contains thirteen species. They inhabit the tropical seas, and are elegantly ornamented with curved coloured bands. The species are divided into sections from circumstances connected with the tail. The Holacanthus imperator is not only remarkable on account of the brightness and distribution of its colours, but of its excellence as food. It is an inhabitant of the Indian ocean, and its flesh is remarkably fat and palatable, reckoned equal in point of flavour and richness to the salmon. It is considered as superior to any other fish known in that vast ocean. It grows to about a foot in length, and is of an oval shape.

GENUS CXLII. ENOPLOSUS.

Two dorsal fins, teeth small, flexible, and moveable; a process and one or more spines on the gill lid.

This genus, from ενοπλος, *armatus*, was instituted by La Cepede, and includes only one species, named Whitii in honour of the discoverer. See White's *Tour, New South Wales*, p. 254. tab. 39. It was at first termed Chætodon albescens. Its colour is white, tinged with blue, and silvery.

GENUS CXLIII. GLYPHISODON.

One dorsal fin; body and tail compressed; teeth indented or carved.

This genus, formed from γλυφις, *incisura*, and οδους, *a tooth*, contains two species. The G. moucharra of La Cepede, Chætodon saxatilis of Bloch, is found on the coast of Arabia, as well as on the shores of the Brasils. It remains always in deep water, among corals, on the polypi of which it subsists. Although its flesh is white, yet it is dry and insipid. The flesh of the other species G. kakaitul of La Cepede, the Chætodon maculatus of Bloch, a native of the fresh waters of Surinam and Coromandel, is so full of bones, that none but the negroes make use of it.

GENUS CXLIV. ACANTHURUS.

One dorsal fin; body and tail compressed; one or more spines on each side of the tail.

The name of the genus is derived from ακανθα, *spina*, and ουρα, *cauda*. There are six species, the most remarkable of which is the A. chirurgus or Lancet fish, so called from the wounds which it inflicts with its caudal spines, being deep, and accompanied with a flow of blood. It is found in the sea at the Antilles, where it is much sought after for dietetical uses. The A. nigricans is found in the warmer seas of both continents. It feeds on small crabs and shells, and its flesh is firm and palatable.

GENUS CXLV. ASPISURUS.

One dorsal fin; body and tail compressed; a hard shield-like plate on each side of the tail.

This genus, from ασπις, *clypeus*, and ουρα, *cauda*, contains only one species, vis. A. sohar. It was first described by Forskael, who found it in the Arabian gulf. It lives on the remains of organised bodies, and resides near the shore.

GENUS CXLVI. ACANTHOPODUS.

One dorsal fin; one or two spines in the place of each ventral fin.

This genus contains the chætodon argenteus and Bodaertii of Gmelin, of whose history little is known.

GENUS CXLVII. SELENE.

Two dorsal fins, with spines in the space between them.

This genus, from σεληνη, *luna*, contains two species, natives of the West Indies and America. The first termed S. argentea, was described by La Cepede from the drawings of Plumier; and from its shape is termed by the natives moonfish. The second S. quadrangulatus, is the Faber marinus fere quadratus of Sloane, and placed in the genus zeus by many naturalists. In shape it is almost square.

GENUS CXLVIII. ARGYREIOSUS.

One dorsal fin, with spines in front.

The zeus vomer of Linnæus is the only species of this genus. It is common to the coast of Norway and the Brazils. This is a very remarkable circumstance, indicating a constitution capable of supporting opposite extremes of temperature. In whatever situation it is found, it presents the same form, and exhibits the same beauty of colouring. It arrives at the same size in the seas of both continents, and in both its flesh is esteemed as excellent. The name of the genus is derived from αργυρεος, *argenteus*.

GENUS CXLIX. ZEUS. *Doree.*

Doree.

One dorsal fin, without spines in front, the rays terminating in long filaments.

This genus, as now restricted, contains only three species. The first of these is the Z. ciliaris, so named from a few of the last rays of the dorsal and anal fins extending like hairs far beyond the connecting membrane, and even farther than the tail itself. La Cepede, in the absence of observation, hazards the conjecture, that the animal may use these long filaments to entice its prey to approach, as a few fishes are known to do, who possess long filaments. He even supposes, that by means of these, twisted round aquatic plants, the fish maintains itself stationary for particular purposes. These conjectures are supposed to be rendered probable from the facts which are established with regard to the cunning of another species, the Z. insidiator, which like the chætodon rostratus, ejects water through its tubular mouth on flies that alight on aquatic plants, and thus stupifies and secures them; but the analogy is here very remote, as the points of resemblance are so few. The flesh of this last species is rich and agreeable; a hook baited with a fly is employed in taking it. Both species are natives of the Indian seas. The third species is the Z. faber, or common doree. It is a native of the Northern Atlantic and Mediterranean seas, and was well known to the ancients.

GENUS CL. GALLUS.

Two dorsal fins, without spines between them.

La Cepede formed this genus for the reception of the Zeus gallus of other writers. This species is very widely distributed, being common to Greenland, the Mediterranean, South America, and the East and West Indies. Its flesh is esteemed good. It feeds on small worms and fishes.

GENUS CLI. CHRYSOTOSUS. *Opah.*

Opah.

One dorsal fin; jaws destitute of teeth; body and tail compressed; height equal to the length.

The generic name is from χρυσωτης, *aurator*. The Zeus luna of Linnæus is the only species. It is found in the Northern and Atlantic seas, and from the inspection of drawings in the Museum at Paris, Lacepede is disposed to consider that it likewise inhabits the Chinese seas. Dr Mortimer says, that the Prince of Anamaboe, on the coast of Africa, recognised, in an English specimen, a fish which he said was common on his own shores, and very good to eat.

GENUS CLII. CAPROS.

Body and tail compressed; jaws destitute of teeth; two dorsal fins.

This genus, from *καπρος*, *aper*, was instituted by La Cepede, and so named from the resemblance the only known species bears to a wild boar. It is the Zeus aper of Linnæus, and has long been known as an inhabitant of the Mediterranean. It is scarcely three inches in length, and is of a reddish colour; the snout is somewhat produced and sharpish, and protrudes in the act of opening like the common Doree. Its flesh is said to be very coarse, and of a rank flavour.

GENUS CLIII. PLEURONECTES. *Flounder.*

Flounder.

With pectoral fins; both eyes on the same side of the head.

This extensive and important genus, containing upwards of forty species, derives its name from *πλευρον*, *latus*, and *νηκτης*, *natator*. The genus is divided into two sections, from the position of the eyes, both of which are always placed on one side of the head. In the first division are placed those having the eyes on the right side, and in the second those having the eyes on the left. It sometimes happens, however, that a species with eyes in general on the right side, has been found having its eyes on the left, all the other characters of a species remaining fixed. This circumstance points out the propriety of being cautious in relying on the character furnished by the position of the eyes.

The genus contains at present upwards of thirty species, but a more attentive examination of their characters, than has hitherto taken place, would perhaps point out the propriety of suppressing a few as varieties, and some as hybrids. Their flesh is white, pleasant, and easily digested; and as the species are of considerable size, they are much sought after as food. Several species delight to reside at the mouths of rivers, and even to live in the fresh water. By a little attention these might be translated into lakes and ponds, and thus not only the quantity, but the variety of food furnished might be increased. All the species prefer a sandy bottom, and they are much more numerous in cold than in hot countries.

GENUS CLIV. ACHIRUS.

Both eyes on the same side of the head; no pectoral fins.

This genus, from *α* privative and *χειρ*, *manus*, was formed for the reception of those species which have no pectoral fins, formerly included in the genus pleuronectes. There are six species known. The A. marmoratus inhabits the sea at the Isle of France, where it was observed by Commerson. Its flesh is esteemed excellent. We may observe, that Commerson observed a row of pores at the base of the dorsal and anal fins, equal in number to the rays in those fins, which upon being pressed poured out a milky mucus.

ORDER XX. ABDOMINAL.

GENUS CLV. CIRRHITUS.

Gill-flap of seven rays, the last remote; beards united by a membrane, and placed near the pectoral fins.

This genus contains only one species described from the MSS. of Commerson. It bears a close resemblance to the species of the genus Holocentrus and Perca. The seven filaments of the beard are long, and united by a membrane, resembling a second pectoral fin. There is no mention made of the place where it was found.

GENUS CLVI. CHEILODACTYLUS.

Body and tail compressed; upper lip double and extensile; head abrupt.

There is only one species belonging to this genus, from the East Indies; and described from a specimen in the Dutch collection.

GENUS CLVII. COBITIS. *Loche.*

Loche.

Head, body, and tail cylindrical; eyes near the summit of the head; no teeth; bearded; one dorsal fin; scales minute.

This genus contains three species, two of which have been long known to naturalists. The first, *G. barbatula*, or common Loch, is common in the waters of the southern and middle districts of Europe. It prefers rivers which have a gentle current, to those which are either rapid or dormant. Its flesh, during autumn and spring, is esteemed a great delicacy, superior indeed to all other fresh water fish, especially when it is killed in wine or in milk. It has been translated into some of the northern countries of Europe. It soon expires when removed from the water, and even when placed in water in a state of rest. The *G. tænia* differs in external character from the last, chiefly in having a double spine on each side of the head, a little before the eyes. When taken from the water, it emits a grunting sound like the gurnard, and is more vivacious than the last. Its flesh is dry and insipid. The G. *Tricirrhata* was observed by M. Noel in the rivulets near Rouen. Its beard consists of three filaments.

GENUS CLVIII. MISGURNUS.

Body and tail cylindrical; one short dorsal fin; jaws with teeth.

The *Cobitis fossilis* of Linnæus is the only known species of the genus. It inhabits marshes and lakes with a muddy bottom. It is remarkably vivacious, and is capable of surviving among mud, provided it be moist. This is a wise provision of nature, by which this animal is fitted for those situations in which it resides. When the pools or ditches in which it lives dry up, this animal buries itself in the mud, and lives securely until the rain replenishes its pond. As it is frequently dug up in this situation, it has been supposed to search for its food in the ground like an earth-worm. It will remain alive under ice, provided there is a small portion of unfrozen water around it. It appears to be extremely sensible to the changes in the state of the atmosphere. During calm weather, it remains at rest on the mud in the bottom of the ditch; but, at the approach of a storm, or change of weather, it rises to the surface of the water, and moves about with seeming uneasiness. Hence it is often kept in vessels within doors by the curious, for the purpose of predicting the changes in the weather. In winter, it buries itself in the mud, and issues forth in spring when it spawns. It is found in the marshes and lakes of the midland parts of Europe. Its flesh is soft, and but little sought after.

GENUS CLIX. ANABLEPS.

Pupil of the eye double.

The A. surinamensis, the only known species, was the cobitis anableps of Linnæus. It is a native of the rivers of Surinam, near the sea coasts. We have already adverted to the extraordinary structure of the eyes in this fish, which appear as if furnished with two pupils. The anal fin in the male is composed of nine rays, the last three or four only being distinct. The preceding ones, are in part united with a hollow conical appendix covered with scales, and open at the apex. This opening communicates with the milt and the blad-

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der of urine, and is the passage through which they escape. The species is ovoviviparous.

Genus CLX. Fundulus.

Body and tail nearly cylindrical; jaws with teeth; no beard; one dorsal fin.

There are two species in this genus; the first of these is the *cobitis heteroclita* of Linnæus, whose trivial name is now changed by La Cepede into *F. mud-fish!* It was observed in Carolina by Dr Garden, and was there named mud-fish. The other species inhabits Japan, and was first described by Houttuyn in Act. Haarl. xx. 2. p. 337. n. 26. In the former species there are six rays in each of the ventral fins; in the latter, eight rays.

Genus CLXI. Colubrina.

Head lengthened; above covered with scales, like those of a serpent; no dorsal fin.

This genus has been constructed for the reception of a species whose existence rests on the authority of a Chinese drawing in the Dutch collection. La Cepede has termed it C. Chinensis.

Genus CLXII. Amia.

Head covered with plates, divided by sutures; teeth in the jaws and palate; beard on the upper jaw.

The A. calva, the only known species, is a native of Carolina. It is a fresh water fish, and was originally described by Linnæus from specimens sent him by Dr Garden. It does not appear to have fallen under the inspection of any other ichthyologist.

Genus CLXIII. Butyrinus.

Head without scales, and one fourth of the whole length of the animal; one dorsal fin.

The B. bananus is the only species, of which little satisfactory has been ascertained. It is described by La Cepede from the MS. of Commerson. The tail is forked; on each side of the back there are four longitudinal waved lines, and the lateral line is nearly straight.

Genus CLXIV. Tripteronotus.

Three dorsal fins, and one anal fin.

The hautin of Rondeletius; the T. hautin of La Cepede is the only known species. It is the only fish of this order which possesses three dorsal fins; and, what is more extraordinary, when the number of the dorsal fins is considered, it has only one anal fin.

Genus CLXV. Ompok.

Jaws with a beard and teeth; no dorsal fin; anal fin long.

The only known species of this genus is the O. siluroides. A specimen of this fish was found in the Dutch collection, having the provincial name *Ompok* attached to it.

Genus CLXVI. Silurus.

Head large, depressed; mouth terminal, bearded; one short dorsal fin.

This genus, formerly very extensive, contains at present only eleven species. They are distributed into two sections, from the form of the tail. The *S. glanis*, or common silure, is one of the largest of the inhabitants of the fresh waters. It grows sometimes to the length of 15 feet, and to the weight of 300 pounds. The head is depressed; the snout rounded in front; the lower jaw is longest. There are two filaments on the upper jaw, and four on the under. The general colour is green mixed with black. The eyes are remarkably small. It inhabits the larger rivers of Europe, Asia, and Africa, and is seldom found in the open sea. Its motions are all slow. It lurks under some root with its body sunk in part in the mud; and, by moving the filaments of its beard, it entices the small fishes to approach, when it seizes them. The flesh is white, fat, and pleasant to the taste, but very difficult to digest. The air-bag furnishes isinglass, which is considered excellent. The skin dried and rubbed with oil, is sometimes used as a substitute for glass. This species might be translated with ease into this country; and there appears to be several favourable situations for its growth. The *S. fossilis*, which is a native of the East Indies, is sometimes dug out of the mud like the Misgurnus, which it appears to resemble in habit.

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Genus CLXVII. Macropteronotus.

Dorsal fin very long.

The species of this genus, four in number, were separated by La Cepede from the Siluri, from which they differ in the greater length of the dorsal fin. If such a character be admitted as sufficient to constitute a genus, we fear that the science of ichthyology will speedily revert to that state of confusion and uncertainty which prevailed in the days of Aristotle and Pliny. The first species is the *Silurus anguillaris* of Linnæus, which La Cepede now names M. charmuth. Geofroy, according to La Cepede, has discovered a cavity connected with the gills, which the animal has the power of closing. In this cavity there is a flat cartilaginous substance, divided into many branches, having the surface covered with numerous ramifications of blood-vessels. This organ he considers as a supplementary gill, and is disposed to believe that the circulating system is performed by means of three separate ventricles. But from the details which we have seen, it is impossible to form any distinct conception of such an arrangement. This species is common in the Nile. The *M. batrachus* is a native of Asia and Africa. The skin is so transparent on the sides, that the divisions of the muscles can be perceived like so many transverse lines. The remaining species of the genus, viz. M. fuscus and hexacicinnus are described on the authority of Chinese drawings in the Library of the Museum at Paris.

Genus CLXVIII. Malapterurus.

Dorsal fin adipose, and placed near the tail; furnished with electrical organs.

The Silurus electricus of Linnæus is the only known species of the genus. It has been long known as possessing those benumbing qualities which are so remarkable in the Torpedo. It is found in many of the African rivers. See the article Electricity.

Genus CLXIX. Pimelodes.

Two dorsal fins; the second adipose.

This genus contains twenty-four species, formerly included in the genus Silurus. They are divided into two sections from the form of the tail. The P. bagre is a native of the great rivers on the American continent. There are four filaments in the beard, two orifices to each of the nostrils, and a lengthened cavity on the head. The flesh is held in little estimation. The P. ascita exhibits one of the most remarkable examples of reproduction in the whole system. The eggs, while still in the uterus, gradually increase in size, and distend the skin of the belly until it burst longitudinally. To this slit, the farthest advanced egg approaches, and its integuments give way, opposite to the head of the animal. The embryo is left, resting on the yolk, and attached to it by a cord of vessels. When all the yolk is absorbed, the remains of the egg pass through the slit, and the animal, separated from its mother, begins to enjoy an independent existence. Other eggs come forward to the same position; and when all have been excluded, the edges of the opening meet, and speedily grow together, when a fresh rupture takes place in the following season. This is a curious instance of the ovoviviparous mode of reproduction. This species is found both in the East and West Indies.

Genus CLXX. Doras.

Two dorsal fins; the second adipose; longitudinal rows of large hard plates on the sides of the body.

Two species; viz. D. carinatus and costatus belong to this genus. They were formerly considered as Siluri. The first of these is a native of Surinam; the second is common to America and India. Its flesh is said to have a very unpleasant taste; and the formidable spines with which it is armed, are considered by the fishermen as venomous. For the purpose of curing the wounds which they receive by accident from this fish, they anoint them with the oil which they obtain from its liver, a balm which they frequently carry about with them.

Genus CLXXI. Pogonathus.

Dorsal fins two in number, supported by rays; body with lateral plates.

This genus differs from the former, in the second dorsal fin being radiated. It contains two species, first observed by Commerson. The first named *P. courbina*, a native of Plate river, has twenty-four filaments in the beard of the under jaw. It grows to the length of more than two feet, and weighs upwards of six pounds, but its flesh is soft and insipid. The *P. auratus* has only one filament in the beard on the under jaw.

Genus CLXXII. Cataphractus.

Two dorsal fins; the second with one ray; body with lateral plates.

We owe this genus to Bloch. It contains three species. The first of these, named C. callichthys, is found both in the East and West Indies. It lives in limpid running fresh water, and is said to creep out of the water to a considerable distance from the rivers, and to dig holes in the ground, in which it conceals itself. It seldom exceeds a foot in length. Its flesh is said to be palatable. It has four filaments in the beard, and the tail is rounded. The C. *Americanus* has six filaments in the beard, and has hitherto been observed only in Carolina. The C. *punctatus* has four filaments in the beard, and the tail is in the form of a crescent. It is found in the rivers of Surinam.

Genus CLXXIII. Plotosus.

Two dorsal fins; the second of these, and the anal fin, united with the caudal.

The P. *anguillaris* is the only known species, and is a native of the Indian seas. It was inserted by Bloch in his genus *Platystachus*.

Genus CLXXIV. Ageneiosus.

Two dorsal fins; the second adipose; chin beardless.

The two species, A. armatus and inermis, are natives of the Indian and South American seas, and were formerly included among the Siluri. The first of these has a remarkable long serrated bony process on each side of the head near the nostrils.

Genus CLXXV. Macromphosus.

Mouth beardless; first ray of the first dorsal fin lengthened; strong and notched; second dorsal fin supported by rays.

The Silurus cornutus of Gmelin, is the only known species of the genus. It was first described by Forskael. The snout is about half the length of the body, compressed, and a little recurved at the top. The first ray of the first dorsal fin is serrated beneath for about half its length, and extends nearly to the tail. This fin contains nine rays, the second dorsal fin contains only six.

Genus CLXXVI. Cenrtanodon.

Head depressed, and covered with large hard plates; mouth at the extremity of the snout, without teeth or beard; one or more spines on each gill lid.

This genus contains only one species, formerly termed Silurus imberbis. It was first described by Houttuyn, and is a native of Japan. The body and tail are lengthened, and covered with distinct scales. The eyes are large and approaching.

Genus CLXXVII. Loricaria.

Body covered with a coat of mail; mouth inferior; lips extensile; one dorsal fin.

The genus contains two species, viz. L. setifera, and maculata, natives of the American seas. The mouth of the first is surrounded by a number of small filaments, which are not observable on the latter. These fish bear a very close resemblance to the sturgeon in the armature of the body, the position of the mouth, and the great size to which they attain.

Genus CLXXVIII. Hypostomus.

Body covered with a coat of mail; mouth inferior; lips extensile; two dorsal fins.

The presence of the second dorsal fin, is the character by which this genus is distinguished from the preceding. The only known species is the H. guacari of Lacepede, a native of the American rivers. It is the Loricaria plecostomus of Linnæus. The flesh is said to be good.

Genus CLXXIX. Corydoras.

Body and tail covered on the sides with large plates; mouth terminal; no beard: two dorsal fins, with more than one ray in each.

A specimen of the C. Geoffroy, the only known species, was found in the Dutch collection. Its native country is unknown. In the first dorsal fin, there are two spinous and nine articulated rays. The tail is forked.

Genus CLXXX. Tachysurus.

Mouth terminal, bearded; the first ray of the dorsal and pectoral fins strong; dorsal fins two, radiated.

The existence of the T. sinensis, the only known species, rests on the authority of a Chinese drawing in the Dutch collection.

Genus CLXXXI. Salmo. *Salmon.*

Salmon.

Mouth terminal; head compressd; second dorsal fin adipose; first dorsal fin as near the head as the ventral fins; upwards of four rays in the gill-flap; teeth strong and numerous.

The characters of the twenty-nine species which compose this important and extensive genus, have not been satisfactorily determined. Naturalists, in general, attending to the characters furnished by colour and by the number of rays in the fins, have, we fear, multiplied the species unnecessarily. At present, indeed, it is difficult from the characters in ordinary use, to determine the young animals as of the same species with the old. Recourse must be had to the characters furnished by the organs of respiration, and the intestines; and under the guidance of the marks which they furnish, the species may be satisfactorily determined.

All the species of this genus are elegant in their form, finely variegated in colour, and rapid in their movements. Their flesh is excellent. This in some changes to a fine red upon boiling, in others it continues white.

GENUS CLXXXII. OSMERUS. *Smelt.*

Smelt.

First dorsal fin farther removed from the head than the ventral fins.

The character by which this genus is distinguished from the preceding is so unimportant, that we are at a loss to account for the older naturalists being disposed to separate them. The genus contains six species. The O. eperlanus, or common smelt, is well known. The other species are natives of warmer countries.

GENUS CLXXXIII. COREGONUS.

Teeth in the jaws none, or very small.

Twenty species are described by La Cepede. They were included by Linnæus in the genus Salmo. The C. *lavaretus*, or gwiniad, is sought after on account of its flesh, which is white and tender. They die very soon after they are taken, and hence it is very difficult to translate them. The C. thymallus, or grayling, is likewise another species sought after as food. Its flesh is firm, white, and pleasant to the taste, but considered as difficult to digest. The eggs, or spawn of the C. migratorius, are eaten in Siberia, its native country. The C. Wartmanni, a native of the Swedish lakes, is either eaten in a fresh state, when it is considered as excellent, or salted and carried to a distance. At the age of three years, it is sometimes seized with a distemper which gives it a red colour.

GENUS CLXXXIV. CHARACINUS.

Gill-flap consisting of four rays, or more.

Generic characters, so vague and trivial as those by which the three preceding genera are distinguished, indicate the imperfect state of the science. Sixteen species are described by La Cepede. The first of these is the C piabucu, so named from its provincial name in Brazil, although termed by Gmelin and others argentinus. It is a native of the middle parts of America, inhabiting rivers. It is easily taken with a hook. Its flesh is white and palatable The C. bimaculatus, found in the rivers of Amboyna and Surinam, is likewise remarkable for the whiteness and delicacy of its flesh. All the species indeed bear so close a resemblance to the salmon, that they might have continued under the same genus, and in a separate section, with advantage to the student.

GENUS CLXXXV. SERRASALMUS.

Under part of the belly carinated, and notched like a saw.

The S. rhombeus is the only known species. It is a native of the rivers of Surinam, and was first described by Pallas. It is said to attain to a considerable size. In shape it bears some resemblance to the Chætodons. It is said to be very voracious, and that it will attack ducks which happen to be swimming on the water Its flesh is white, firm, and fat, and held in great estimation. The fish is of a reddish tinge with black points; the sides are silvery, and the fins grey.

GENUS CLXXXVI. ELOPS.

Gill flap of thirty rays or more; eyes approaching; one dorsal fin; a scaly appendage near each ventral fin.

The Saurus maximus of Sloane, now Elops saurus, is the only known species. It is found in Jamaica, where it is called the Sein Fish, or Sea Gally Wasp. In its general appearance, it approaches the common pike. The tail is much forked, and armed both above and below by a strong spine, forming a first or spiny ray on each side of the tail. In the specimen examined by Bloch, no spinous ray in the caudal fin could be perceived. Dr Shaw, however, observed it in a fine specimen preserved in the British Museum.

GENUS CLXXXVII. MEGALOPS.

Eyes large; gill-flap of at least twenty-four rays.

The M. *filamentosus*, brought from Madagascar by Commerson, is the only species yet discovered. The rays in the gill-flap are singularly numerous. The last ray of the dorsal fin extends backwards in the form of a long filament. The species bears a near resemblance to the preceding.

GENUS CLXXXVIII. NOTACANTHUS.

Body and tail lengthened; the nape raised, and anal and caudal fins united; spines in place of a dorsal fin.

The Acanthonotus of Bloch, is the only known species. It grows to nearly three feet in length. It is a native of the East Indies, and is said to be remarkably active in all its motions, and exceedingly voracious.

GENUS CLXXXIX. ESOX PIKE.

Pike.

Opening of the mouth large; jaws with strong teeth; snout depressed; dorsal and anal fins short, nearly equidistant from the head.

This genus contains nine species, which are divided according to the form of the tail into two sections. The common pike, E. lucius, now common in the lakes and rivers of Europe, is a strong active voracious fish, and is not unfrequently compared to a shark. It preys indiscriminately on young fish, serpents, frogs, and the young of aquatic birds. Its flesh is held in some estimation, and is used either fresh, salted, or smoked. The eggs or spawn are formed into a sort of caviar, which is not considered as wholesome. When castrated, pikes are said to become speedily fat. The *E. belone*, or gar-fish, is an inhabitant of the sea, and approaches the shore to spawn. It is considered as the forerunner of the mackrel. The bones become green on being boiled. The flesh is dry and insipid. The E. gladius, which is common to the shores of Asia and America, furnishes a pleasant and wholesome food, and is easily obtained. It multiplies very rapidly.

GENUS CXC. SYNODUS.

Dorsal and ventral fins nearly equidistant from the head; body and tail lengthened and compressed.

This genus contains five species, distributed into two sections, from the form of the tail. The only species of importance in an economical point of view, is the S. Malabaricus. It was inserted in the genus Esox by Bloch. It lives in the rivers on the coast of Malabar. Its flesh is white and palatable.

GENUS CXCI. SPHYRÆNA.

Two dorsal fins; opening of the mouth large.

The number of the dorsal fins furnishes a very obvious character, by which this genus may be distinguished from Esox, with which it was formerly united. Five species are described by La Cepede. The first of these, termed by him *S. spet*, the *Esox sphyræna* of Linnæus, has been known to naturalists since the days of Aristotle. It is found in the Mediterranean sea, and likewise in the Atlantic ocean. The flesh is white, easy to digest, and resembles in flavour the cod. It grows to upwards of two feet in length. The remaining species are new, and described from the drawings of Plumier.

GENUS CXCII. LEPISOSTEUS. *Garfish.*

Garfish.

Body covered with osseous scales; one dorsal fin, more distant from the head than the ventral fins.

The armature of the species of this genus resembles a coat of mail, so hard are the scales, and so closely attached to the body. The L. gavial of La Cepede is the *Esox osseus* of Linnæus. It is a native of the lakes and rivers of Europe, Asia, and America, but in the former country it is rare. The flesh is firm, white, and well flavoured, and much sought after.

Genus CXLIII. Polypterus.

Gill-flap of one ray; two blow holes; dorsal fins numerous.

The P. bichir, the only known species, exhibits many singular peculiarities of structure. It is found in the Nile, and was described for the first time by Geoffroy, in the *Bulletin des Sciences*, No. 61. The body is nearly cylindrical, long, and serpentiniform; in the anal fin are fifteen rays; the tail is rounded. It is known to the Egyptians by the name of *bichir*, and is considered as a very rare animal. It is supposed in general to inhabit the depths of the Nile, remaining among the soft mud, which it is thought to quit only at some particular seasons, and is sometimes taken in the fishermen's nets at the time of the decrease of the river. It is said to be one of the best of the Nilotic fishes, having a white or savoury flesh; and as it is hardly possible to open the skin with a knife, the fish is first boiled, and the skin afterwards drawn off whole.

Genus CXCIV. Scomberesox. *Saury.*

Saury.

Jaws long; dorsal fin immediately above the anal fin; between the caudal fin and the dorsal and anal fins a number of spurious fins, as in the mackrel.

This genus, instituted by La Cepede, contains only one species, with whose history he seems to be very imperfectly acquainted. It is the Saury pike of the British Zoology.

Genus CXCV. Fistularia.

Jaws long, tubular; mouth terminal; one dorsal fin.

The F. petimba of La Cepede is the only known species. It is the F. tabacaria of Linnæus. It was first described by Marcgrave in his history of the Brazils, under the name of Petimbuaba. The tail is perhaps of the most singular construction of any species in the system. It is deeply forked, and from the middle of the furcature springs a very long and thickish bristle or process of a substance resembling that of whalebone, and gradually tapering to a fine point. A variety has been observed by Dr Bloch, in which this part was double, and the snout serrated on each side. This species inhabits the equatorial seas, lives chiefly on the smaller fishes, and its flesh is poor, and unpleasant to the taste.

Genus CXCVI. Aulostomus.

Jaws long, tubular; mouth terminal; longitudinal row of spines instead of the first dorsal fin.

The Fistularia chinensis of Gmelin is the only known species. It is a native of the equatorial sea. It feeds on small worms, and the spawn of fishes. Its flesh is said to be dry and insipid. M. Gazola supposes, that he has observed the remains of this fish in the strata of Mount Bolca.

Genus CXCVII. Solenostomus.

Jaws long and tubular; mouth terminal; two dorsal fins.

The Fistularia paradoxa of Pallas, is the only known species. It is a native of Amboyna, and in its general form appears to bear a close resemblance to the Syngnathi, or Pipe-fish.

Genus CXCVIII. Argentina. *Argentine.*

Fewer than thirty rays to the gill membrane; more than nine rays in each ventral fin; one dorsal fin; colour silvery.

Argentine.

La Cepede describes four species. The first of these, A. sphyræna, or Pearly argentine, is found in the Mediterranean Sea, and in the Atlantic Ocean. The skin of the air bag of this little fish is covered with a silvery powder, or rather shining silvery scales. These are carefully collected and introduced into small globules of glass, to the inside of which they are fastened with gum. These beads are termed artificial pearls, and are used as articles of dress. The A. glossodonta of Gmelin, changed by La Cepede into A. *bonuk*, was first described by Forskael as a native of the Red Sea, where he likewise found the A. *machnata*. The A. *Carolina*, so named from the country in which it has been found, is about the size of a small herring, and lives in the fresh waters.

Genus CXCIX. Atherina. *Atherine.*

Atherine.

Gill flap and ventral fins, with fewer than eight rays; no teeth in the palate; two dorsal fins; a longitudinal silvery band on each side.

There are four species of Atherine described by naturalists. The A. hepsetus, or European Atherine, is by far the most common, being found in the North Sea, the Atlantic, and the Mediterranean. In general appearance, it much resembles the smelt. Its flesh is considered as uncommonly delicious. About the Greek Islands, according to Sonini, where it is seen in vast shoals, it is easily taken by trailing in the water a horse's tail, or a piece of black cloth fastened to the end of a pole; the fishes following all its motions, and suffering themselves to be drawn into some deep cavity formed by the rocks, are readily secured by means of a net.

Genus CC. Hydrargira.

Gill flap and ventral fins with fewer than eight rays; no teeth in the palate; one dorsal fin; lateral silvery band.

Bosc discovered in Carolina the only known species of the genus, named H. *swampina*, because it is found in the swamps or lagunes. The head is depressed, the lips are extensile, the under jaw longest. This species inhabits the fresh water marshes, and as these are sometimes nearly dried up, it is compelled to shift its haunts to deeper water, which it accomplishes by a series of leaps. The flesh is unsavoury, and little sought after, but it furnishes a grateful repast to the aquatic birds which frequent its haunts.

Genus CCI. Stolephorus.

Fewer than nine rays in the ventral fins and gill flap; one dorsal fin; no teeth; lateral silvery band.

La Cepede describes two species, viz. S. Japonicus and S. Commersonii. The former of these was first described by Houttuyn. It has five rays in the dorsal fin, while the latter species has fifteen.

Genus CCII. Mugil. *Mullet.*

Mullet.

Lower jaw carinate within; scales striated; two fins on the back.

There are seven species belonging to this genus. The most common is the M. cephalus, or common mullet, a fish well known to the ancients. It is to be found in almost all seas. This ascends rivers, like the salmon, to spawn; and at that time they congregate in vast shoals. At this time the fishermen endeavour to surround them with the net. They are said to grow very fat in rivers and lakes with a sandy bottom. They are esteemed excellent food when fresh, and are likewise often used salted. The spawn salted and dried forms a kind of caviar named botargo, which is used in Italy and the midland districts of France. The M. albula, a native of the American seas, is likewise esteemed an excellent dish for the table. In the M. crenilabis, a native of the Red Sea, both lips are curiously crenulated on the edges. The M. tang, whose flesh is fat and savoury, inhabits the rivers of Guinea. The history of the remaining species requires farther elucidation.

Genus CCIII. Mugiloides.

Lower jaw carinate within; scales striated; one dorsal fin.

The only known species, M. Chilensis, was found by Molini at Chili. It inhabits the fresh water rivers, and grows to about a foot in length.

Genus CCIV. Chanos.

Lower jaw carinate within; no teeth; scales striated; one dorsal fin; a membranaceous wing on each side the tail.

The C. Arabicus was first described by Forskael, and is the only species known. It is a native of the sea of Arabia, and was formerly inserted in the genus Mugil. The scales are large and rounded, and of a brilliant silvery colour; the head is more narrow than the body, destitute of scales, and of a green colour mixed with blue; the upper lip is grooved, and longer than the lower; the latter line is curved at its commencement, and then proceeds in a straight line to the tail. Its ordinary length is about four feet, but one variety, named *Anged*, grows to nearly twelve feet.

Genus CCV. Mugilomorus.

Lower jaw carinated within; no teeth, but protuberances in their stead; more than thirty rays in the gill flap; one dorsal fin, with an appendage to the rays.

The only known species of this genus is the Mugil appendiculatus of Bosc, the description of which was communicated by that naturalist to La Cepede. The trivial name imposed by the discoverer, was changed by the last author into Anna-carolina, in honour of his own wife.

Genus CCVI. Exocætus. *Flying Fish.*

Flying fish.

Head entirely covered with small scales; pectoral fins very large, reaching to the caudal fin; gill-flap of ten rays; one dorsal fin situated above the anal fin.

The species of this genus, which are four in number, have the power of leaping out of the water, and flying for a short distance, by the aid of their long pectoral fins. The first species is the *E. volitans*, or common flying fish, and has been long known to naturalists. It is very extensively distributed, being found in the European, American, and Indian seas. In the dorsal and anal fins there are fourteen rays; fifteen or sixteen in each of the pectoral fins; ventrals small, and placed nearer the head than the middle of the whole length of the fish. The stomach can scarcely be distinguished from the intestinal canal, and the air bag is uncommonly large. According to the observations of Plumier, as quoted by Bloch, the spawn of this species (found near the Antilles) corrodes the skin of the palate or tongue. The second species, *E. mesogaster*, has twelve rays on the dorsal and anal fins; thirteen in the pectoral fins; ventral fins placed near the middle of the animal. This species was observed by Plumier in the sea near the Antilles. The E. exiliens; the dorsal fin has eleven or twelve rays; the anal fins twelve; eighteen in each of the pectoral fins; the ventral fins long, reaching to the extremity of the dorsal fin, and situated a little beyond the middle of the body towards the tail. This species frequents the same seas as the E. volitans. It is likewise found in the Mediterranean, sometimes single, sometimes in small shoals. In shape it greatly resembles a herring; its flesh is fat and delicate. The last species, *E. comersonii*, has twelve rays in the dorsal fin, ten in the anal, and thirteen in each of the ventral fins. These last are sufficiently long to reach to the middle of the dorsal fin, and are situated beyond the middle of the body towards the anal fin. The dorsal fin is marked on the part nearest the tail with a large blue spot. It is a native of the Indian seas, where it was first found by Commerson.

Genus CCVII. Polynemus.

Free rays near each ventral fin; head covered with small scales; two dorsal fins.

La Cepede describes six species, all of which were known to former naturalists. He divides them into sections, from the form of the tail. They are chiefly the inhabitants of warmer countries. The *P. plebeius* of Broussonet is termed *P. emoi* by La Cepede; the trivial name here adopted being the appellation by which this fish is known to the natives of Otaheite. It is a native of the American, Indian, and Southern seas. The flesh is considered excellent, and hence in India this species is known by the name of *royal fish*. The inhabitants of the coast of Malabar prefer the head of the fish as a delicious morsel. In these countries it is salted and dried. M. Gazola supposes that he has found the remains of this fish in the strata of Mount Bolca. The P. paradisus, or Mango fish, is reckoned one of the best esculent fishes found at Calcutta. It is known to the natives by the name of *tupsee mutchey*. It feeds on young fishes and the crustacea.

Genus CCVIII. Polydactylus.

Free rays near each pectoral fin; head without scales; two dorsal fins.

The P. plumierii is the only known species. It bears a close resemblance to the species of the preceding genus. It is of a silvery colour; the nose is protuberant and long; the upper jaw longer than the under; the six free rays which are near the pectoral fins, resemble long threads; the second dorsal fin and the anal fin are of equal extent, placed opposite, and falcated.

Genus CCIX. Buro.

A double process between the ventral fins; one long dorsal fin; scales small and difficult to perceive; five rays in the gill flap.

The B. brunneus is the only known species, and was described by La Cepede from the MSS. of Commerson. Over the surface, there are numerous scattered small spots of a white colour; the iris is golden and silvery; head small; nose a little pointed; upper jaw moveable, and, together with the lower jaw, furnished with one row of small pointed teeth; the back and belly are carinated, and the body and tail are compressed.

Genus CCX. Clupea. *Herring.*

Herring.

Jaws furnished with teeth; more than three rays in the gill flap; one dorsal fin; belly carinated, and notched or very sharp.

La Cepede describes seventeen species of herrings, which he distributes into two sections from the shape of the tail. The most common species, C. harengus, is one of the most important to the human race in an economical and a commercial point of view. This fish is an inhabitant of the northern seas. In Europe it is seldom found farther south than the fiftieth degree of latitude, nor farther north than the sixtieth. On the coasts of America, however, it reaches farther south. The migrations of this fish have long attracted the attention of naturalists; lengthened descriptions have been given of their marvellous journies from the arctic regions, of the course which they pursue, and the obstructions which they meet with. But these descriptions have been given from a very imperfect acquaintance with the habits of the animal It is now clearly established, that the herrings, like all the other fishes that reside in deep water, approach the neighbouring shore at the season when they are ready to spawn, and return to their favourite haunts when the process of reproduction is finished The food of the herring consists of the smaller *crustacea* of young fishes, even those of their own species. At the season when they are ready to spawn, their stomachs are found empty. This fish is salted as an article of trade, the process (it is said) being first tried by William Beukelen of Biervlet near Sluys. The smoking of herrings, according to La Cepede, was first practised by the inhabitants of Dieppe. In some of the northern countries, when the herrings are in abundance, they boil them in large cauldrons, and obtain oil for their lamps; the refuse they employ as manure to the ground. The sprat, *C. sprattus*, differs from the herring in having nine rays in each ventral fin, while the herring has only six; and according to Mr Neill, "if a straight line be dropped from the fore part of the dorsal fin perpendicularly downwards, it will, in the true herring, fall a little in front of the ventral fins, but in the garvie (sprat) it will fall a little behind the same fins." This species is found in the northern countries, and also in the Mediterranean. It is used for all the purposes to which the herring is applied, and is prepared after the same manner. The *C. alosa* or *shad*, termed also from its size, mother of herrings, migrates from the sea into the fresh water rivers, like the salmon. The fry are called *white bait.* The flesh has rather a disagreeable taste. The C. encrassicolus, or anchovy, is another species of this genus held in high estimation. It inhabits the sea, and, like the herring, it approaches the shores for the purpose of spawning. The Romans expressed a pickle from this fish, which they termed a *garum.* The moderns pickle them, and as the bones dissolve entirely in boiling, the sauce is of equal value. The remaining species are chiefly the inhabitants of the seas of warmer countries. They are esculent, and possess in a greater or less degree the peculiar flavour of the herring.

Genus CCXI. Mystus.

More than three rays in the gill flap; belly carinated; anal fin very long, and united with the caudal fin. One dorsal fin.

The Clupea mystus of Osbeck is the only known species. It is a native of the Indian seas. In its general form it resembles the blade of a sword, the body and tail being greatly compressed. Upper jaw longer than the under, and furnished on each side with a flat narrow denticulated bone, which reaches to the ventral fins.

Genus CCXII. Clupanodon. *Pilchard.*

Pilchard.

More than three rays in the gill flap; belly carinated; anal and caudal fins separate; one dorsal fin; jaws without teeth.

The absence of teeth in the jaws of the Pilchard, is the mark by which, as a genus, it is distinguished from Clupea. Six species are known. The *C. pilchardus*, or common pilchard, is the most important species of the genus. It is found in great abundance on the shores of Cornwall. The flesh is considered excellent, and is eaten either fresh or salted. It contains a great deal of oil, which is extracted from it in considerable quantities by the Cornish fishermen. The C. thrissa is a native of the Indian and American seas, and ascends the fresh water rivers to spawn. The flesh is considered as fat and agreeable, but in certain circumstances it has been found to be hurtful. The C. sinensis frequents the shores and rivers of Asia and America, where it is taken in such quantities that the inhabitants manure their fields of rice with them.

Genus CCXIII. Gasteropelecus.

Head, body, and tail, compressed; belly carinated and semicircular; two dorsal fins; ventral fins very small.

This genus was instituted by Gronovius, and afterwards adopted by Bloch, for the reception of the Clupea simia of Linnæus. It has been inserted by Gmelin and some others in the genus Salmo. The two dorsal fins separate it from the herring, while the circumstance of the second dorsal fin being radiated, indicate its want of connection with the salmon. It is a native of the equatorial seas, and is said to swim very ill, on account of the peculiar shape of its body, which renders it difficult to maintain its vertical position.

Genus CCXIV. Mene.

Head, body, and tail, compressed; belly carinated and semicircular; back elevated; one low, lengthened dorsal fin; ventral fins narrow and produced.

The only species which has been taken notice of, rests on the authority of a Chinese drawing in the Dutch collection, and is termed by La Cepede, M. Anna-carolina, in honour of his wife Anne Caroline Hubert Jube La Cepede.

The generic name is indicative of its moon-shaped form.

Genus CCXV. Dorsuarius.

The anterior part of the back furnished with a compressed hunch, terminated above by a thin edge; one dorsal fin.

This genus contains at present only one species, termed *D. nigricans.* It is described by La Cepede from the manuscripts of Commerson. It was found near fort Dauphin, in Madagascar.

Genus CCXVI. Xyster.

Head, body, and tail, compressed; belly carrinated and semicircular; back elevated; gill flap of seven rays; a depression below each ventral fin.

Xyster *fuscus*, the only species which has been described, was observed by Commerson. It is of a uniform brown colour. The two jaws are rounded, and nearly of equal length; the caudal, dorsal, and anal fins, have small scales at the base; the tongue is short, large, and semicartilaginous. The nostrils have two openings each.

Genus CCXVII. Cyprinodon.

Head, body, and tail, of an ovate form; three rays in the gill flap; jaws with teeth.

The C. variegatus is from Carolina, and was first observed by Bosc. The opening of the mouth is very small; the under jaw is longest; the teeth are short; the gill lids rounded; the lateral line indistinct; iris of a golden colour. It scarcely reaches the length of four inches.

Genus CCXVIII. Cyprinus Carp.

Gill flap with four rays or more; jaws without teeth; one dorsal fin.

This very extensive genus, containing seventy species, has been subdivided into sections, from the presence or absence of the beard, and the form of the tail. These sections, we may add, are distinguished by characters more obvious and important than many of those employed by La Cepede in the construction of genera, so that we are surprised to find them still remaining in company, after witnessing so many other genera dismembered. The species are esteemed excellent food, and much sought after. The carp, which stands at the head of fresh water fishes, is well known in this country as a valuable and useful pond fish, but it is more particularly esteemed on the continent. The breeding and feeding of this fish, is there to many a source of very considerable profit. The flesh of the Barbel, *C. barbus*, is white and good, but the spawn is considered by many as hurtful. Bloch, however, is disposed to call the truth of this opinion in question, and states, that he has eaten the eggs, with all his family, without suffering any inconvenience. The scales of the C. alburnus, or bleak, are employed similar to those of the atherine, in the formation of artificial pearls. For this purpose the scales are carefully removed, and frequently rubbed against one another in water. The silvery-looking substance is then introduced, along with a solution of isinglass, into glass balls prepared for the purpose. Almost all the species may be kept in ponds, where they increase rapidly in size. They soon become acquainted with the person who feeds them, and will readily eat meat from his hand. They likewise, by habit, obey the call of a bell. When in this naturalized or domesticated state, their fins sometimes change in form and even structure, as may frequently be observed in the gold and silver fishes of China.

Division VI.

Osseous fishes with a gill-lid, but destitute of a gill-flap.

Order XXI. APODAL.

Genus CCXIX. Sternoptyx.

Body and tail compressed; under part of the body carinated and transparent; one dorsal fin.

The *S. diaphana*, an inhabitant of the West Indies, is the only known species. La Cepede has changed the trivial name into Hermann, in honour of Professor Hermann of Paris, who first described the species. The skin is apparently destitute of scales, and there is no lateral line. There are nine rays in the dorsal fin, of which one is spinous. It is a native of the island of Jamaica.

Division VII.

Osseous fishes with a gill-flap, but destitute of a gill-lid.

Order XXV. APODAL.

Genus CCXX. Stylephorus.

Eyes peduculated; snout produced, looking upwards; between which and the head there is a flexible leathery duplicature; mouth terminal; gills three on each side; pectoral fins small; dorsal fin extending from the head to the tail; caudal fin short, radiated with spines; body long, compressed.

This genus was instituted by Dr. Shaw for the reception of the S. chordatus from the West Indies. See *Lin. Trans.* vol. i. p. 90. Tab. 6. La Cepede has changed the trivial name imposed upon it by Shaw, and has substituted *argenteus* in its place.

Order XXVIII. ABDOMINAL.

Genus CCXX. Mormyrus.

Snout produced; mouth terminal; jaws with teeth; one dorsal fin.

La Cepede has described nine species of Mormyri, principally from the notes and observations of Geoffroy. They are chiefly inhabitants of the Nile.

Division VIII.

Osseous fishes destitute of a gill-lid and gill-flap.

Order XX. APODAL.

Genus CCXXI. Murænophis.

No pectoral fins; one gill opening on each side; body and tail nearly cylindrical; dorsal, caudal, and anal fins united.

This genus, the *gymothorax* of Bloch, contains twelve species. They were included by Linnæus in the genus Muræna. The first species described La Cepede is the M. helena. This is the *Muræna* of the ancients. It is found in the seas of the temperate and warmer regions of the earth. It lives with equal comfort in fresh water. The Romans constructed ponds for feeding fishes of this kind, and esteemed them as an excellent dish for the table. The memory of one Vedius Pollio is transmitted to posterity by Pliny as execrable, since he was in the practice of feeding his Murænæ with his condemned slaves. In ponds they become very familiar, and will eat food from the hand. They are cunning, and when they have swallowed the hook, make the utmost exertions to bite the line.

Genus CCXXII. Gymnomuræna.

No pectoral fins; one gill opening on each side; body and tail nearly cylindrical; no distinct dorsal or anal fin.

There are two species described by La Cepede; the G. *doliata* and *marmorata*, from the notes of Commerson. In the former, the anus is situated nearer the head than the middle of the fish; in the latter, it is nearer the tail than the head.

Genus CCXXIII. Muræno-blenna.

No distinct fins; body and tail nearly cylindrical; surface viscous.

The M. Olivacea, the only species, was found by Commerson in the Straits of Magellan. Its body is more completely enveloped in mucus than any other fish. An individual of this species, kept in alcohol for two months, was found nearly reduced to a mucilaginous oily pulp.

Genus CCXXIV. Sphagebranchus.

Destitute of fins; gill-openings two, under the neck; body and tail nearly cylindrical.

The S. *rostratus* of Bloch, and the only species of the genus, is a native of the East Indies. It has four gills on each side; the mouth is furnished with teeth; the skin has no visible scales; the snout terminates in a point; the upper jaw is longest.

Genus CCXXV. Unibranchapertura.

No pectoral fins; body and tail serpentine; one gill-opening under the neck; dorsal, anal, and caudal fins united.

This genus, the last in the system of La Cepede, contains five species. It was termed Symbranche by Bloch. The U. marmorata is a native of the fresh waters of Surinam. Its flesh is fat, but unpleasant to the taste.

Such is an outline of the system of ichthyology as given by La Cepede. In our descriptions of the genera, we have stated the more essential characters only, as we wished to prevent the article from swelling to an inconvenient length. The reader will readily perceive that the number of genera has been greatly increased

Classification of Fishes.

since the days of Linnæus. The Swedish naturalist included all the species known to him in sixty-one genera; we have enumerated two-hundred and twenty-five. We are persuaded, however, that the characters employed in the formation of not a few of the modern genera, ought to have been confined to the definition of species merely. Many of the names employed to designate the genera and species by former authors, have been suppressed by La Cepede, and new terms employed in their place, in many cases without any apology for the change being offered. We would earnestly recommend to those who cultivate this branch of Zoology, to respect and follow the excellent and judicious rules laid down by Artedi; otherwise ichthyology will continue a mere heap of rubbish, destitute of fixed principles, and a determinate nomenclature.

The reader, in perusing our account of the genera, must have been struck with the occurrence of the same genera in the same relation to other genera, in the systems of Linnæus and La Cepede, although the principles employed in the construction of the primary divisions of these two systems differ widely from each other.

BRITISH FISHES.

British fishes.

As many of our readers are probably anxious to become acquainted with the number of fishes which are natives of the seas, lakes, and rivers of the British isles, we subjoin a synoptical view of the present state of our native ichthyology. The addition of the characters by which the species are distinguished, would have augmented the list to an inconvenient length, so that we have confined our short observations, annexed to each species, to a notice of the more common provincial names and places of residence. The reader who wishes more extensive information on the subject may consult those works already enumerated in the historical part of this article, which treat of British fishes.

CARTILAGINOUS FISHES.

GENUS I. PETROMYZON. *Lamprey.*

Lamprey.

1. *P. marinus.* Sea Lamprey.

The Lamprey is common in the greater rivers of the three kingdoms, into which it enters for the purpose of spawning. In Scotland it is called *lamper eel.*

2. *P. fluviatilis.* Lesser lamprey.

Equally common with the preceding species in the same situations. It is however found in the lesser streams and rivulets into which the sea lamprey does not enter. It is the *nine eyed eel* of the Scotch.

3. *P. branchialis.* Pride or lampern.

This species is not so common as the two which we have noticed. It is found, however, in several of the English rivers.

GENUS II. GASTROBRANCHUS. *Hag.*

Hag.

4. *G. glutinosus.* Glutinous hag.

The hag is perhaps no where common on our coasts, although it has been met with at various places.

GENUS III. RAIA. *Ray or Skate.*

Ray.

5. *R. batis.* Skate or Flaire.

Common on all parts of the coast. Mr Neill informs us, that in the Firth of Forth it is called *blue skate, grey skate,* or *Dinnen skate.*

6. *R. oxyrinchus.* Sharp-nosed ray.

This is equally common as the skate, and sometimes confounded with it. In the Forth it is called *white skate, friar skate, May skate,* or *mavis skate.*

7. *R. clavata.* Thornback.

Very common on all parts of the coast. Montagu considered the R. fullonica of some authors as the male thornback. The teeth in the males of this species are sharp, and in the females blunt.

8. *R. Aspera.* Rough ray of Pennant.

This species was found by Pennant in Loch Broom. Montagu is inclined to consider it as a variety of the thornback, while Donovan regards it as the same with his R. rubus. The description left us by Pennant, would lead us to consider it as different from any of these species.

9. *R. tuberculata.* Shagreen ray.

This species was first observed by Pennant at Scarborough. It has since occurred to Montagu on the Devon coast, where it is called *dun-cow.*

10. *R. rubus.* Land ray, or French ray.

Montagu, to whom we are indebted for much valuable information with regard to the species of rays, considers the R. rubus and miraletus of Donovan as synomous, and females, while he regards the Fuller's ray of Pennant as the male. The opinion of such an eminent zoologist will always be received with respect, but we do not see the propriety of the new trivial name maculata, by which he has proposed to designate the species.

11. *R. marginata.* Bordered ray.

This species is described by La Cepede from the manuscripts of M. Noel, as having been seen by him at Liverpool and Brighton. See *Hist. Nat. des Poissons,* vol. v. p. 663. tab. 20. f. 2.

12. *R. pastinaca.* Stinging ray.

This appears to be common in the English seas, but it is very rare in Scotland. It is however mentioned by Sibbald.

13. *R. Cuvieri.* Cuvierian ray.

Mr Neil is the only British naturalist who has seen a specimen found on our coasts. It was taken in a traul net in the Frith of Forth, in summer 1808.

14. *R. radiata.* Starry ray.

This species is figured by Donovan in his British Fishes, tab. cxiv. where he says "it was caught on the north coast of Britain, and obligingly communicated to us by Mr Statchbury of the Old Jewry, London."

15. *R. microcellata.* Small-eyed ray.

This species is found on the west coast of England, and is confounded by the fishermen with the shagreen ray, and called duncow. It is described by Montagu in the *Memoirs of the Wernerian Natural History Society,* vol. ii. p. 430.

GENUS IV. TORPEDO. *Cramp Fish.*

Cramp fish.

16. *T. vulgaris.* Common cramp fish.

This celebrated fish has been taken at various places on the southern coasts of England and Ireland.

GENUS V. SQUALUS. *Shark.*

Shark.

A. With temporal orifices.

1. With an anal fin.

17. *S. catulus.* Rough hound.

The rough hound is found sparingly on all parts of the coast. It is now generally admitted by ichthyologists that the *S. canicula,* or spotted dog-fish, is merely the female.

18. *S. galeus.* Tope.

Occasionally found in the English seas, rarely off the coast of Scotland.

19. *S. mustelus.* Smooth hound.

Found on all parts of the coast. It is the *murlock* of the Frith of Forth.

British Fishes.

20. *S. vulpes.* Fox shark.

Sometimes taken in the English seas.

2. Destitute of an anal fin.

21. *S. acanthius.* Piked dog-fish.

This species swarms on the east coast of Scotland, whence it is called dog-fish. It follows the shoals of herrings, and appears to be gregarious.

22. *S. Lelanonius.* Lochfine shark.

This species is figured and described by Dr Leach in the second volume of the *Mem. Wernerian Soc.* p. 64. tab. 2. fig. 2. from a specimen obtained by the late Dr Walker from Lochfine. He considers it as the same with the basking shark of Pennant found at Loch Ransa. Stewart however inserts it in the section furnished with a temporal orifice.

B. Destitute of temporal orifices.

23. *S. carcharias.* White shark.

This formidable monster is occasionally found in our seas. The jaws of one taken in the Pentland Frith are now before us.

24. *S. maximus.* Basking shark.

This is common in the Scottish seas. On the west coast it is called *sail-fish, sun-fish, or cairban*; in Orkney it is called *Homer,* and in Zetland *brigdie.*

25. *S. glaucus.* Blue shark.

The blue shark frequents the coasts of Cornwall chiefly during the pilchard season.

26. *S. cornubicus.* Porbeagle shark.

Occasionally found in the sea at different parts of the coast. It is the same as the Beaumaris shark.

Genus VII. Squatina. *Angel Fish.*

Angel fish.

27. *S. vulgaris.* Common angel fish.

Found on many parts of the coast. In some places in England it is called fiddle-fish or puppy-fish. It has been repeatedly taken in the frith of Forth.

Halsydrus. *Sea Snake.*

Sea snake.

28. *H. pontoppidiani.* Sea snake.

This is the great sea snake of the Orkney islands, already taken notice of.

Genus IX. Lophius. *Angler.*

Angler.

29. *L. piscatorius.* Common angler, or fishing frog.

Common on all parts of the coast. In Scotland it is called *wide-gab, or mulrein.*

30. *L. cornubicus.* Mounts-bay angler.

This species is described by Borlase in his History of Cornwall, 266. Tab. 27. fig. 6. Donovan seems disposed to conclude, but apparently without sufficient reason, that the description of this fish must have been taken from a dried specimen of the common angler.

31. *L. Fergusonii.*

This species is described in *Phil. Trans.* vol. liii. p. 170. and figured tab. 13. It was taken in King Road near Bristol. It is quoted by Pennant as synonymous with the L. cornubicus, although its characters are sufficiently obvious to point out a specific difference.

Genus XI. Chimæra. *Sea Monster.*

Sea monster.

32. *C. monstrosa.* Arctic sea monster.

Occasionally found in the Scottish seas, rarely on the English shores.

Genus XIII. Acipenser. *Sturgeon.*

Sturgeon.

33. *A. sturio.* Common sturgeon.

Frequently found in the salmon nets in the large rivers.

Genus XV. Tetrodon. *Sun Fish.*

Sun fish.

34. *T. mola.* Common sun fish.

This fish has been frequently taken in the frith of Forth. It was common on the Cornish coast in the days of Borlase.

35. *T. truncatus.* Oblong sun fish.

This species is occasionally found in the English seas, where they have been taken of five hundred pounds in weight.

36. *T. stellatus.* Starry sun fish.

This is the globe Diodon of Pennant. It is of rare occurrence on the English shores, although common in the seas of more southern latitudes.

Genus XIX. Syngnathus. *Pipe Fish.*

Pipe fish.

37. *S. typhle.* Short pipe fish.

Found on all the British shores, lurking among the sea weeds in shallow water.

38. *S. acus.* Needle pipe fish.

This is so nearly allied to the preceding in character and habit, that doubts are entertained by many naturalists as to the propriety of continuing it as a distinct species.

39. *S. pelagicus.* Pelagic pipe fish.

This is caught in the winter season among the sprats on the English coast, and was first described as British by Donovan.

40. *S. equoreus.* Equoreal pipe fish.

We owe the knowledge of the occurrence of this species on the English shores to the late Mr Montagu.

41. *S. barbarus.* Long pipe fish.

This has been found on different parts of the coasts of England and Scotland.

42. *S. ophidion.* Snake pipe fish.

This is a species of frequent occurrence. It is, unlike its congeners, said to be oviparous.

Genus XX. Cyclopterus. *Sucker.*

Sucker.

43. *C. lumpus.* Lump sucker.

This is frequent on all the coasts, and is sometimes brought to market.

44. *C. liparis.* Unctuous sucker.

This species is taken on our coasts, but it is a fish rather of rare occurrence.

45. *C. bimaculatus.* Bimaculated sucker.

First described and figured by Pennant, from the communications of the Duchess Dowager of Portland. It has been found at several places on the English coast.

46. *C. Montagui.* Montagu sucker.

This species was first observed by the late Mr Montagu, and named in honour of him by Mr Donovan. It was found by him on the coast of Devon.

Genus XXI. Lepadogaster.

47. *L. gouani.* Lesser sucking fish.

Sucking fish.

This is the Jura sucker of Pennant. It has been found in the sea at the island of Jura, and on the coasts of Cornwall and Devon.

Genus XXIV. Centriscus. *Trumpet Fish.*

Trumpet fish.

48. *C. scolopax.* Snipe trumpet fish.

This fish has been taken on the coasts of Devon and Cornwall according to Donovan, who first introduced it into the list of the British species.

OSSEOUS FISHES.

Genus XXVII. Leptocephalus.

49. *L. morrisii.*

This species was first observed by Mr William Morris in the sea near Holyhead, and has since been found by several English naturalists.

XXIX. Genus Trichiurus. *Blade Fish.*

50. *T. lepturus.*

Blade fish.

A specimen of this fish was cast ashore in the Moray Frith, near Gordon Castle, which was about 12½ feet in length without the head. An account of it by Mr Hoy is published in the Linnæan Transactions, vol. xi. part 2d.

Sea serpent.

GENUS XXXI. OPHISURUS. *Sea Serpent.*

51. *O. ophis.* Spotted sea serpent.

This species was first described as British by Merret in his *Pinax*, page 185, under the title Serpens Marinus. It was omitted by Pennant in his British Zoology, but continued by Berkenhout and others.

Eel.

GENUS XXXVI. MURÆNA. *Eel.*

52. *M. anguilla.* Common eel.

Found in lakes, ditches, and rivers throughout the kingdom. In many places, they appear to live in the sea during the winter, from whence in spring they migrate to the fresh waters. They return again in harvest, and at that season are considered as in the best state for the table.

53. *M. conger.* Conger eel.

Common in the sea.

54. *M. myrus.* This species inhabits the Mediterranean, and is inserted in the list of British fishes on the authority of Berkenhout.

GENUS XXXVII. AMMODYTES. *Launce.*

Launce.

55. *A. Tobianus.* Sand launce, or sand eel.

Found in the sea on the sandy shores. Is less common in the northern than in the southern parts of the island.

GENUS XXXVIII. OPHIDIUM.

56. *O. barbatum.*

This species is well known as a native of the Mediterranean and Red Seas. It is inserted in the British list on the authority of Berkenhout.

57. *O. imberbe.*

First described as British by Pennant, who obtained it from the sea near Weymouth. Montagu found it on the south coast of Devon, and has published a minute description of it in the *Memoirs of the Wernerian Nat. Hist. Soc.* vol. i. p. 95. t. iv. f. 2.

XL. ZIPHIAS. *Sword Fish.*

Sword fish.

58. *Z. gladius.* Common sword fish.

Willoughby states, that he has seen a fish of this species in England fifteen feet in length. It is, however, a fish of rare occurrence.

59. *Z. rondelatii.*

This species is described by Dr Leach in the *Memoirs of the Wernerian Society*, vol. ii. p. 58. He considers it the Ziphias or Gladius of Rondeletius, although it has a second anal fin, of which that author takes no notice. We are inclined to consider these as belonging to one species, and to attribute the differences in the accounts which have been given of them to the imperfection of the specimens described.

GENUS XLII. ANARCHICHAS. *Wolf-Fish.*

Wolf fish.

60. *A. lupus.* Common wolf-fish.

Frequent on the coast, especially in the northern parts of the island, where it is called *Cat-fish.*

GENUS XLVII. CALLIONYMUS. *Dragonet.*

Dragonet.

61. *C. lyra.* Gemmeous dragonet.

Common in the Frith of Forth, where it is called *Gowdy.* The female, or sordid dragonet of naturalists, is called *Sting-fish* on the coast of Devon.

GENUS IV. TRACHINUS. *Weever.*

Weever.

62. *T. major.* Greater weever.

Pennant is the first naturalist who describes this species. It inhabits the sea near Scarborough, and is occasionally brought in the spring to the London market.

63. *T. draco.* Common weever.

Not uncommon on the English coasts. Rare in the Scottish seas.

GENUS XLI. GADUS. *Cod.*

Cod.

SECTION II. *With three dorsal fins, chin bearded.*

64. *G. morhua.* Common cod.

This is found in the sea in all parts of the island, but the greatest fisheries are on the Scottish coasts. Their capture gives employment to a great number of seamen.

65. *G. æglifinus.* Haddock.

Equally common as the cod, but more capricious in its migrations. Haddocks have appeared in the Frith of Forth in the month of June this year, in great numbers, after a partial absence of several years.

66. *G. callarias.* Dorse.

Inserted on the authority of Willoughby. It is not mentioned by Pennant or Donovan.

67. *G. luscus.* Bib.

This species is nowhere found in any numbers, and is seldom sought after.

68. *G. barbatus.* The pout.

It is not a common species. By the Scarborough fishermen it is called Fleg, and its flesh is considered delicate.

69. *G. minutus.* Poor.

This species, common in the Mediterranean, was observed on the Cornish coast by the Rev. Mr. Jago.

70. *G. punctatus.* Speckled cod.

This species, which is said to be frequently taken in the weirs at Swansea, is described by Dr. Turton in his *British Fauna*, p. 90.

SECTION II. *With three dorsal fins; chin beardless.*

71. *G. carbonarius.* Coal fish.

Very common, especially in the tideways in the northern islands. When young they are good to eat, but when full grown they are very coarse and unpalatable.

72. *G. merlangus.* Whiting.

Taken in the spring months in considerable numbers, on all the coasts of the island.

73. *G. pollachias.* Pollack.

Common on the English coast, and on the west coast of Scotland, but seldom found on the east. At Scarborough they are called *Leets*, with us *Lythes.*

74. *G. virens.* Green cod.

This species is not uncommon in the northern seas. It was first described as British by Pennant, from the observations of Sir John Callum.

SECTION III. *With two dorsal fins; chin bearded.*

75. *G. molva.* Ling.

Common on all parts of the coast. In the northern islands, the salting of these fish for exportation is a considerable article of trade.

76. *G. lota.* Burbot.

This species lives in the fresh water, and prefers clear waters, where the current is slow. It is unknown in Scotland, and in England it is found only in a few rivers. Its flesh is excellent, and eagerly sought after.

77. *G. mustela.* Five bearded cod.

Not uncommon on the English shores. First accurately discriminated by Pennant.

78. *G. argenteolus.*

This is a new species, described by Montagu in the 2d volume of the *Memoirs of the Wernerian Nat. Hist. Society*, p. 449. It is common on the western coast of England, and is more nearly allied to the three bearded cod than to any other of the genus.

79. *G. triarratus.* Three bearded cod.

This is a common species, frequenting the rocky parts of the coast. By some it has been injudiciously considered as a variety of the five bearded cod.

SECTION IV. *With two dorsal fins; chin beardless.*

80. *G. merluccius.* Hake.

This fish is unknown in Scotland, and is seldom seen on the east coast of England; but in the south-west shores of that kingdom, and on the south-east shores of Ireland, it is found in great shoals, and caught for the market. It is not held in high estimation, as its flesh is soft and insipid.

SECTION V. *With one dorsal fin; chin bearded.*

81. *G. brosme.* Tusk.

This species is chiefly found in the seas around the Zetland islands. It is rare in Orkney, and very seldom found to the south of the Pentland Frith. Considerable confusion has arisen in the determination of the synonymes of this fish, in consequence of calling our fish *torsk* instead of *tusk*, as the former name on the continent designates a very different species.

We are aware that several other species of cod have been described by naturalists as natives of our seas, but their claims to rank as distinct species have not been satisfactorily ascertained.

GENUS LIII. BLENNIUS. *Blenny.*

Blenny.

SECTION I. *Two dorsal fins; head with tentacula.*

82. *B physcis.* Forked Blenny.

First observed by Mr Jago on the Cornish coast. It is the Forked Hake of the British Zoology.

SECTION II. *One dorsal fin; head with tentacula.*

83. *B. ocellaris.* Ocellated Blenny.

This well known Mediterranean species, was found in the year 1814 by the late Mr Montagu, at Torcross, Devonshire, and is figured and described by him in the second volume of the *Memoirs of the Wernerian Nat. Hist. Society.* La Cepede has erroneously placed this in his first section, as if it had two dorsal fins, and has, without sufficient reason, changed the trivial name into lepus.

84. *B. gattoruginea.* Gattorugine Blenny.

Described by Pennant as having been found on the coast of Anglesea. Montagu has likewise met with it on the south coast of Devon.

85. *B. galerita.* Crested Blenny.

It is found on the rocky shores of the English coast, but is by no means a common species.

86 *B. Montagui.*

This species is described at length, and figured by Montagu in the first volume of the *Memoirs of the Wernerian Nat. Hist. Society.* He entertains doubts as to its claims to rank as a species distinct from the preceding, although its characters are sufficiently well marked.

SECTION III. *One dorsal fin; no tentacula on the head.*

87. *B. pholis.* Smooth Blenny.

This species is found plentifully on the south coast of England under stones.

88. *B. viviparus.* Viviparous Blenny.

This is the most common species, being found near the shore under stones, and among the sea-weed at all parts of the coast.

89. *B. gunnellus.* Spotted Blenny.

This is equally common with the last in the same situations. Mr Low, in his *Natural History of Orkney,* notices a fish allied to this species, which he calls Purple Blenny. He says, "I should almost take it for a variety, (of B. gunnellus) were it not the colour is different; being in this reddish purple; the fins lightest, and of the same shape and size of the former. It likewise wants the spots on the back, the other has; instead of eleven in the former, this has only a single one, and that placed near the beginning of the back fin. In other circumstances, both of its shape and way of life, it agrees altogether with the former." Fabricius and other naturalists have described several varieties of the gunnel blenny, differing chiefly in the number and colour of the spots.

GENUS LVII. LEPIDOPUS. *Scale-foot.*

Scale foot.

90. *L. tetradens.* Four-toothed Scale-foot.

The late Mr Montagu described and figured this species for the first time as a British fish, in the *Memoirs of the Wernerian Nat. Hist. Society,* vol. i. p. 81. Tab. 2. It was taken in Salcomb harbour on the coast of South Devon in 1808. A smaller specimen occurred near the same place two years afterwards.

GENUS LIX CEPOLA. *Band-fish.*

Band fish.

91. *C. rubescens.* Red Band-fish.

The only British specimen of this fish which has occurred, was caught in Salcomb bay on the 25th of February 1803; and figured and described by Montagu in the seventh volume of the *Linnæan Transactions,* p. 219. Tab. 17.

GENUS LXI. GOBIUS. *Goby.*

Goby.

92. *G. niger.* Black Goby.

Not uncommon on the English coast, where it is termed *Rock-fish.* Sometimes found on the west coast of Scotland.

93. *G. minutus.* Spotted Goby.

This species, which is frequent on the English shores, is likewise found on those of Scotland. It is chiefly obtained from the shrimp nets.

GENUS LXVI. SCOMBER. *Mackrel.*

Mackrel.

94. *S. scomber.* Common Mackrel.

Common on all parts of the coast, principally during the autumn months. The Coly Mackrel of some authors appears to be only a variety.

95. *S. thynnus.* Tunny Mackrel.

Not uncommon on the west coast of Scotland. They appear to be rare on the English coast.

96. *S. pelamis.* Bonito.

We insert this in the British list on the authority of Stewart, who, in his *Elements of Natural History,* 2d edit. vol. i. p. 363, says, "It has been taken, though rarely, in the Frith of Forth."

GENUS LXVIII. CARANX. *Scad.*

Scad.

97. *C. trachurus.* Common Scad.

This is a rare fish on our coasts. It has occurred to Pennant and Donovan, but few other British naturalists have met with it.

GENUS LXXXIV. ECHINEIS. *Sucking Fish.*

98. *E. remora.* European sucking fish.

This fish holds its place in the British list on the authority of Turton, who says, in his *British Fauna,* p. 94, "taken by the author, in Swansea, from the back of a cod fish, in the summer of 1806.

GENUS LXXXIX. ASPIDOPHORUS. *Pogge.*

Pogge.

99. *A. cataphractus.* Mailed pogge.

Common on all parts of the coast. It ascends the large rivers as far as the water is brackish.

GENUS XCI. COTTUS. *Bull Head.*

Bull head.

100 *C. gobio.* River bull head.

Frequent in England in the clear brooks.

101. *C. scorpio.* Father lasher.

This is a very common species. It is found in all parts of the coast, and sometimes ascends the larger rivers, into brackish water.

Stickle back.

GENUS XCIV. GASTEROSTEUS. *Stickle Back.*

102. *G. aculeatus.* Three spined stickle back.

Common in rivers and ditches. During floods it is sometimes swept into the sea, where it attains a greater size than in fresh water.

103. *G. pungitius.* Ten spined stickle back.

Chiefly found on the coast. Is rare in Scotland.

104. *G. spinachia.* Fifteen spined stickle back.

Inhabits the sea. It appears to be a weak fish, as it is frequently cast ashore by the tide.

GENUS CII. TRIGLA. *Gurnard.*

Gurnard.

105. *T. gurnardus.* Grey gurnard.

This is very common on all parts of the coast. Being easily taken, it is much used as food by the crews of our coasting vessels.

106. *T. cuculus.* Red gurnard.

Common on the English coast. Unknown in Scotland.

107. *T. Lyra.* Piper.

Found on the western coasts of England, where it is held in some estimation.

108. *T. hirundo.* Sapphirine gurnard.

This remarkably beautiful fish is found on the coast of Wales and Devonshire.

109. *T. lastoviza.* Streaked gurnard.

The species described by Donovan as the streaked gurnard, *Trigla lineata*, tab. iv. appears referable to this species of La Cepede, from the coincidence of the numbers of the rays of the fins. The last author, however, is silent with respect to the branching of the thread-like ridges on the belly. The specimen which Donovan figures, was taken on the eastern coast of England.

110. *T. lineata.* Lineated gurnard.

This is the species originally described by Mr Jago, and introduced into the *British Zoology* by Mr Pennant. It has been taken on the coast of Devon in great abundance, by the late Mr Montagu. In this species the ridges are not branched, and do not reach the length of the belly.

111. *T. lævis.* Smooth gurnard.

This is a new species, found on the coast of Devon, described by Montagu in the second volume of the *Memoirs of the Wernerian Natural History Society*, p. 455. "It is taken," he says, "by the shore nets as well as by hook, the finest when fishing for whiting, by a bait of Launce. It is sometimes called Yellock, at Torcross, by the fishermen, but generally confounded with the Sapphirine, the Red and the Streaked (lineated) gurnards, under the denomination of Tub."

GENUS CV. GYMNETRUS.

112. *G. Hawkenii.*

Dr Shaw, in his *General Zoology*, vol. iv. p. 198, after describing this species, says, "it appears from a print published in the year 1798, that a specimen of this fish was thrown on the coast of Cornwall in the month of February in the same year. Its length was eight feet six inches, its breadth in the widest part ten inches and a half, and its thickness only two inches and three quarters. The tail in this specimen was wanting. The colours the same as in the specimen figured by Dr Bloch."

GENUS CVI. MULLUS. *Surmullet.*

Surmullet.

113. *M. barbatus.* Red surmullet.

The only evidence of this species being found in our seas, is the following passage in the *British Zoology*: "We have heard of this species being taken on the coast of Scotland, but had no opportunity of examining it; and whether it is found on the west of England with the other species or variety, we are not at this time informed."

114. *M. surmuletus.* Striped surmullet.

This species is not uncommon on the English coast, and has been considered by some as merely a variety of the former species, an opinion with which we are disposed to agree.

GENUS CX. LABRUS. *Wrasse.*

Wrasse.

115. *L. gibbus.* Gibbous wrasse.

Inhabits the coast of Anglesea, and first described by Pennant as a British species.

116. *L. trimaculatus.* Trimaculated wrasse.

First observed by Pennant on the coast of Anglesea, and afterwards on the coast of Devon. In the Frith of Forth it is called the *Sea Perch.*

117. *L. cornubicus.* Goldfinny.

This appears to be a common species, and was first observed by Mr Jago in Cornwall. In the Frith of Forth, according to Mr Neill, it is called the *Brassy.*

118. *L. julis.* Indented striped wrasse.

This species was observed by Miss Pocock on the coast of Cornwall in the year 1802, and is figured by Donovan in his *British Fishes*, tab. 96.

119. *L. tinca.* Ancient wrasse.

Not uncommon on the English shores. It has likewise been found in the Frith of Clyde.

120. *L. bimaculatus.* Bimaculated wrasse.

Brunich observed this species at Penzance, on whose authority it was inserted in the *British Zoology.*

121. *L. variegatus.* Striped wrasse.

Pennant obtained this species off the Skerry isles, on the coast of Anglesea, from which place Donovan likewise obtained specimens.

122. *L. coquus.* Cook wrasse.

This is rather a doubtful species, as no naturalist has found it since the time of Mr Jago.

123. *L. lineatus.* Streaked wrasse.

This species is figured by Donovan in his *British Fishes*, tab. 74, as a new species. It was taken on the Cornish coast, where it is called *green fish.*

124. *L. comber.* Comber wrasse.

This species is but little known. Pennant says, "I received this fish from Cornwall, and suppose it to be the comber of Mr Jago."

GENUS CXVII. SPARUS. *Gilt Head.*

Gilt head.

125. *S. aurata.* Lunulated gilt head.

This species is not uncommon on the coast of Wales; in other parts of this country it may be considered as rare.

126. *S. pagrus.* Red gilt head.

Not uncommon on the coast of Devon, where it is taken near the shore by the hook, and in nets.

127. *S. lineatus.* Black gilt head.

This species, which Montagu considered a non-descript, and which he has figured and described in the *Memoirs of the Wernerian Natural History Society*, vol. ii. p. 451, tab. xxiii. is frequent on the coast of Devon, in company with the preceding species.

128. *S dentex.* Four toothed gilt head.

This species has been added to the list of British fishes by Mr Donovan. It is figured at tab. lxxiii. of his British Fishes, from a specimen caught in the sea off the coast of Hastings in Sussex.

129. *S. Raii.* Rayan gilt head.

This species was first observed by Mr Johnston, who communicated it to Ray. By this author it was described under the title, "Brama marina cauda forcipata." Pennant describes it as the *toothed gilt head.* Bloch afterwards gave a figure of it under the name of S. Raii. La Cepede rejects the name which Bloch had bestowed on it, substitutes a French provincial name in its place, and named it S. castaneola. Shaw, to increase the difficulty, describes two spari, S. Raii and S. castaneola, as if they were distinct species. Amidst so many changes, it is surprising that no one has done justice to Johnston, to whom we owe its discovery. This is a rare species in England, but it has frequently occurred on the east coast of Scotland.

GENUS CXX. CENTROPOMUS. *Basse.*

Basse. 130. *C. punctatus.*

This is the Perca labrax of Linnæus. It is frequent on the English coast, and is sometimes taken in the Frith of Forth. Its flesh is prized as excellent food.

GENUS CXXV. HOLOCENTRUS.

131. *H. cernua.* Ruffe.

This is found in several of the English streams, but appears to be unknown in Scotland. It is the Perca cernuca of Linnæus.

132. *H. Norvegicus.* Sea Perch.

This species has generally been confounded with the Perca lineis utrinque septem transversis of Artedi, the Perca marina of Rondeletius, Willoughby, Belonius, and Salvianus. This last, however, has ten spinous rays and fifteen branched ones in the dorsal fin, while our species has fifteen spinous and fourteen branched rays in the same fin. The H. Norvegicus is rather a rare species on our coasts. In the northern islands of Scotland it is called *Bergylt.*

GENUS CXXVI. PERCA. *Perch.*

Perch. 133. *P. fluviatilis.* Common Perch.

This is common in many parts of our island in lakes. In the north of Scotland it is a rare fish.

GENUS CXLIX. ZEUS. *Doree.*

Doree. 134. *Z. faber.* Common Doree.

Found on the English coast, and brought to market. It is rare on the coast of Scotland.

GENUS CLI. CHRYSOTOSUS. *Opah.*

Opah. 135. *C. luna.* Common Opah.

Various instances are on record of this fish having been cast ashore on the Scottish shores. It has likewise been observed on the English coast.

GENUS CLIII. PLEURONECTES. *Flounder.*

SECTION I. *Eyes on the right side.*

Flounder. 136. *P. hippoglossus.* Holibut.

Common on all parts of the coast. In the Scottish markets it goes by the name of *Turbot.*

137. *P. limanda.* Dab.

This species is equally common as the last on all our shores. In the Edinburgh market it is termed *Saltie* or *Salt Water Fleuk.*

138. *P. Solea.* Sole.

The principal fisheries are on the western coasts of England. In Scotland they are in a great measure neglected. They occasionally enter our large rivers, and seem capable of living in brakish water.

139. *P. platessa.* Plaise

Very common on all parts of the coast.

140. *P. flesus.* Common Flounder.

Common, subject to variations in colour. The *P. roseus* of Shaw's General Zoology, vol. iv. p. 302. tab. 43.* is a rose-coloured variety. The P. passer of Linnæus is a reversed variety, having the eyes on the left side.

141. *P. microcephalus.* Smear Dab.

This species is found on the southern and western coasts of England, and was first figured and described by Donovan in his British Fishes, tab. 42.

142. *P. variegatus.* Variegated Sole.

This is another species, for the discovery of which we are indebted to Donovan. He has figured and described it in his British Fishes, tab. 107. It was found along with other flat fish in the Billingsgate market.

143. *P. limandula.* Smooth Dab.

This is the Smear Dab of Pennant, and is sometimes found on the English stalls.

144. *P. arnoglossus.* Lantern fish.

This is the smooth sole of Pennant. It was described by Ray, but has not been observed by any naturalist since his time.

SECTION II. *Eyes on the left side.*

145. *P. maximus.* Turbot.

Common on all parts of the coast, and highly prized.

146. *P. rhombus.* Brill or Pearl.

Common on the English coast. Mr Neill says that it is found in Aberlady bay, and is called *Bonnet Fleuk.*

147. *P megastoma.* Whiff.

This is the Whiff of Ray, and has been confounded with the Brill and the Spotted Flounder by the continental ichthyologists. It is not uncommon on the English shores.

148. *P. punctatus.* Spotted Flounder.

This species has been observed among the Zetland isles, and likewise on the English coast. It is described in the Wernerian Mem. vol. ii. p. 241.

149. *P. cyclops.* Cyclops Flounder.

This new species of flounder was discovered by Captain Merrick of Aberfraw in Anglesea, and has been described and figured by Donovan in his British Fishes, tab. 90.

GENUS CLVII. COBITIS. *Loche.*

150. *C. barbatula.* Common loche. Loche.

This is a very common fish in our small rivers and streams. In England it is frequently called the *groundling,* in Scotland the *lying loche.*

151. *C. tænia.* Armed loche or groundling.

This species, which is not mentioned by Pennant, is found in the Trent, according to Berkenhout, and is said by Turton to inhabit the clear streams of Wiltshire.

GENUS CLXXX. SALMO. *Salmon.*

152. *S. salar.* Common salmon. Salmon.

Common in all the large rivers, and a species of vast commercial importance. The fisheries are regulated by laws which should be revised, as they are founded, in some instances, on mistaken notions with respect to the habits of the fish, and are exceedingly partial in their operation.

153. *S. eriox.* Grey.

This species was first described by Ray. They are found in several of the rivers of England and Scotland. The tail is even at the end, the spots on the body are large, round, and purplish. The flesh when boiled is pale pink coloured.

154. *S. trutta.* Salmon trout.

This species, like the preceding, migrates from the sea into the rivers to spawn, and is very common. It is often termed the *sea-trout,* or the *bull-trout.*

155. *S. fario.* River trout.

This is the most common species, and is found in all our rivers and streams. It varies in colour according to the qualities of the water in which it resides.

156. *S. salvelinus.* Red-belly.

This is an alpine species, and appears to be common to the lakes of Wales and Scotland. It was first distinctly pointed out as a British fish by Donovan in his *British Fishes*, tab. 112.

157. *S. alpinus.* Char.

Frequent in the larger lakes in the middle and southern parts of the kingdom.

158. *S. Cambricus.* Sewin.

This fish is figured and described by Donovan in his *British Fishes*, tab. 91. It is very common in Wales. It appears to have been confounded with the S. eriox, and even with the Sheiffer mulleri of Bloch, but the form of the tail and of the spots furnish sufficient characters of distinction.

159. *S. albus.* White.

This species is described by Pennant in his *British Zoology*, as inhabiting the Esk in Cumberland. He considers it as the Phinock of the Scots. Is the S. cumberland of La Cepede specifically distinct?

GENUS CLXXXI. OSMERUS. *Smelt.*

Smelt.

160. *O. eparlanus.* Smelt or Spirling.

This species frequents many of the larger rivers, and is gregarious. It feeds upon the smaller crustacea.

GENUS CLXXXII. COREGONUS.

161. *C. lavaretus.* Gwiniad.

This is common in some of the Welch lakes, and is likewise found in those of Scotland.

162. *C. thymallus.* Grayling.

Common in many of the English rivers. Mr Low, in his Natural History of Orkney, p. 224, informs us that it is very common in that country.

163. *C. albula.* Juvangis.

Stewart, in his *Elements of Natural History*, vol. i. p. 373, refers the *Juvangis* of Lochmaben to this species. Mr Pennant considered it as the Gwiniad. In the *Statistical Account of the Parish of Lochmaben*, vol. vii. p. 236, it is said that "they have a mark of a heart on the head."

164. *C. clupeoides.*

This species, described by La Cepede from the communications of M. Noel, is the *fresh water herring* of Loch Lomond. According to the observations of Dr Stewart of Luss, however, it is the gwiniad, and is also called powan and pollag.

GENUS CLXXXVIII. ESOX. *Pike.*

Pike.

165. *E. lucius.* Common Pike.

This fish, which is now found in many of the lakes and rivers of this kingdom, is said to have been introduced into England in the reign of Henry VIII. in 1537. But as *pykes* and *breams* are stated to have been served up in plenty, at the feast given by the Archbishop of York in 1466, it is probable that even at that time pikes were not uncommon in the country. In the south of Scotland it is called *ged.*

166. *E. belone.* Gar pike.

The gar pike is taken on all our coasts, and in general makes its appearance with the mackrel. We have seen specimens thrown ashore in the winter season in the northern islands.

GENUS CXCI. LEPISOSTEUS. *Gar-fish.*

Gar-fish.

167. *L. Osseus.* Common gar-fish.

This species was first described as British by Berkenhout, as having been found on the Sussex coast. Mr Stewart, in his *Elements of Natural History*, 2d edit. vol. i. p. 374, adds that it has been taken in the Frith of Forth.

GENUS CXCIII. SCOMBERESOX. *Saury.*

Saury.

168. *S. saurus.* Common saury.

Ray was the first who described this species as British under the name *skobster* or *skipper*, and as inhabiting the coasts of Cornwall. Pennant afterwards contributed to make it more generally known. It has since been found by several naturalists on various parts of the coast. In the Frith of Forth it is called *gowdnook*, or *gaufnook*, and sometimes *Egyptian herring*.

GENUS CXCVII. ARGENTINA. *Argentine.*

Argentine.

169. *A. sphyræna.* Pearly Argentine.

First described as British by Pennant. It is a rare species, and has seldom come under the observation of British ichthyologists. Mr Low in his *Nat. Hist. of Orkney*, p. 225. examined one found on the shores of that country.

GENUS CXCVIII. ATHERINA. *Atherine.*

Atherine.

170. A. *hepsetus.* European Atherine.

According to Pennant, this fish is very common in the sea, about Southampton, and Donovan obtained them from the coast of Devon. In Scotland, according to Mr Neill, they are found washed ashore in the Frith of Forth, and we have observed young specimens in the Tay.

GENUS CCI. MUGIL. *Mullet.*

Mullet.

171. *M. cephalus.* Common Mullet.

This fish is found on many of our shores, near the mouths of rivers, both in Scotland and England.

GENUS CCV. EXOCŒTUS. *Flying Fish.*

Flying fish.

172. *E. volitans.* Common Flying Fish.

There is but one instance on record of this fish having been found on our shores. In June 1765 one was caught at a small distance below Caermarthen, in the river Towy, being brought up by the tide, which flows as far as the town. An account of it was communicated to Pennant, by John Strange, Esquire, at Caermarthen, who saw the fish.

GENUS CCIX. CLUPEA. *Herring.*

Herring.

173. *C. harengus.* Common Herring.

Very common on the coasts of Scotland and the north of England. Those which are caught on the west coast of Scotland, are preferred to those taken on the east, as being larger and fatter, from their living in deeper water.

174. *C. sprattus.* Sprat.

This is frequently confounded with the herring fry. It is much more frequent in England than in Scotland. With us it is called *garvy.*

175. *C. alosa.* Shad.

This fish is not uncommon in the great rivers, into which it enters to spawn. It feeds on young herring and other small fishes. Above and below the forked division of the tail on both sides, we have observed subsidiary finlets or plaits, which do not appear to be taken notice of by authors.

176. *C. encrassicolus.* Anchovy.

This species has hitherto been met with but sparingly on our shores. Ray observed it in the estuary of the Dee. Pennant obtained it in Flintshire, and Donovan from the coast of Hampshire.

GENUS CCXI. CLUPANODON. *Pilchard.*

Pilchard.

177. *C. pilchardus.* Common Pilchard.

This fish is occasionally seen in the Scottish seas, but it appears to be very common on the Cornish shores. It is very distinct from the herring, with which, however, it has been often confounded.

GENUS CCXVII. CYPRINUS. *Carp.*

SECTION I. *Bearded.*

Carp.

178. *C. carpio.* Common Carp.

This fish is a native of the warmer countries of Europe, but on account of the excellence of its flesh it has been naturalized in many of the northern kingdoms. It is generally said to have been introduced into England about the year 1514 by Leonard Maschal. But Mr Donovan proves, from a passage in the *Boke of St Alban's*, by *Wynken de Worde*, published in the year 1496, that it was known in England at that period, although considered as rare. A few unsuccessful attempts have been made to translate them into Scotland, where it is said they will not breed in the ponds.

179. *C. barbus.* Barbel.

This is common in the still, deep parts of the English rivers. It is not known as an inhabitant of Scotland, into which, however, it might easily be translated.

C. gobio. Gudgeon.

This is a very common fish in England, being found in almost all the streams and pools of fresh water. It is unknown in Scotland.

180. *C. tenca.* Tench.

It inhabits tranquil waters, and is common in the lakes and rivers of England. The only evidence of its being found in Scotland is in the Statistical Account of the parish of Inch in Galloway, by the Rev. Peter Ferguson. Speaking of the lakes in the parish, he says "they abound in pike, perch, carp, *tench*, roach, white and red trout." *Stat. Ac. Scot.* vol. iii. p. 137.

SECT. II. *Beardless.*

181. *C. carassius.* Crusian.

According to Pennant, this species is common in many of the fish ponds about London, and other parts of the south of England. He believes that that is not a native fish. It is not however ascertained by whom, or at what period it was introduced.

182. *C. phoxinus.* Minnow.

This gregarious species is found in almost every gravelly stream.

183. *C. leuciscus.* Dace.

The dace is very common in the early part of summer in many of the English rivers. It is unknown in Scotland. The *graining* of Pennant, found in the Mersey, appears to be a variety of this species; it is the C. Lancastriensis of Shaw. *General Zoology*, vol. v. p. 234.

184. *C. rutilus.* Roach.

This is found in many of our deep rivers and lakes. It is rare in the eastern parts of Scotland; but on the west it is common, and known by the name of *Braise* or *Gilt-head.*

185. *C. idus.*

This species is inserted as British on the authority of Mr Stewart in his *Elements of Natural History*, 2d edit. vol. i. p. 382, who says, "Found in the Nith by Dr. Walker."

186. *C. orfus.* Rudd, or Finscale.

This Linnæan species is unquestionably the Rutilus latior of Willoughby, and minutely described by him as a native of the English Lakes.

187. *C. erythropthalmus.* Red Eye.

This species is figured by Donovan, tab. xl. We may observe that disputes have arisen about our English Rudd; some supposing it the *orfus* of Linnæus, while others regard it as the *erythropthalmus.* To us it appears extremely probable, that both species are found in our lakes; and had the descriptions of Pennant and Donovan been as copious and minute as that of Willoughby, all doubts upon the subject would easily have been removed.

188. *C. Jeses.* Chub.

The chub is common in the deep holes of rivers in England: in Scotland, according to Pennant, it is found in the Annan.

189. *C. alburnus.* Bleak.

Very common in some of the English rivers; unknown in Scotland.

190. *C. brama.* Bream.

The bream is common in the lakes and deep parts of rivers in England and Ireland: in Scotland it is found in Lochmaben.

191. *C. auratus.* Gold fish.

This species was introduced into England about the year 1691. It breeds freely in the open waters: in Scotland it does not increase.

In the preceding list of our native fishes, we have purposely omitted a few spurious species which have a place in some of the works on British zoology. Perhaps one or two in the present list may, upon farther inquiry, be found mere varieties. This, we suspect, will prove to be the case with some of the species of the genera Squalus, Raja, Salmo, and perhaps Cyprinus.

(J. F.)

ICOLMKILL, or I-COLUMB-KILL. See IONA.

ICOSANDRIA. See BOTANY.

IDA. See TROY and TROAD.

IDAAN, a race of mankind dispersed through several islands of the Eastern seas, and principally characterized by the singularity of their customs. Mr Dalrymple justly observes that "the Idaan of different places go under different denominations, and have different languages," and accordingly we find them under the name of Idaan, Maroot, Alforese, Horaforas, Dejakkese, Biadjoos, and Oraa-Abing. All these seem to constitute but a single race of people, but the appellation Idaan is more specially applicable to those in the northern parts of Borneo; Alforese to those of the Molucca islands, now nearly extirpated from some of them; and Horaforas to those of the eastern islands in general. See BORNEO, Vol. III. p. 729.

IDEA. See LOGIC and MORAL PHILOSOPHY.

IDEAL BEAUTY. See TASTE.

IDENTITY. See LOGIC.

IDOLATRY. See POLYTHEISM.

IDRIA, is a district of Carniola, dependent on the circle of Adlerberg, in the dominions of the emperor of Austria. Having been wrested from that monarch by the French in 1809, it was constituted a canton and mayoralty, extending over eleven miles square, and forming part of the Illyrian provinces. It was further subdivided into the town of Idria, the village of Lower Idria, and eight hamlets. The whole of this territory is mountainous, and interspersed with narrow vallies, which are copiously watered by torrents from the hills. The river Idrixa rises in the Julian Alps, about three leagues from the town of Idria, and after receiving the Canomla, Zalla, and several subterraneous streams, it falls into the Isonzo, 19 leagues lower down. This river abounds with fish, among which are fine trout of remarkable size. Several sluices and canals are formed in the valley where it runs, one of which, of superior construction, was executed by the French in 1813, on the torrent Woitschaik, for the purpose of floating wood.

Climate.

Thunder storms prevail in summer, and there are sometimes two or three in a day: the heat is then oppressive, owing to the reflexion of the sun from the surrounding hills: autumn is rainy, and winter is of long duration. The thermometer in the most severe cold falls a few degrees below zero. Two chains of mountains 1728 feet high, bounding the valley of the Idria, are covered with snow nearly six months of the year: and 300 or 400 men are employed while storms prevail, clearing the great road to Laybach. The medium height of the barometer is 27 inches 5 lines; its variations are neither frequent nor considerable. A strong prejudice subsists in the country regarding the insalubrity of the climate, which of late has been controverted. But although two thirds of the district are forests, vegetable life is languid in the immediate vicinity of the town of Idria; fruits and grain seldom ripen, and cattle always decline. Tooth-ach is universal among the inhabitants, few persons have good teeth, and they are lost by all at an early age. As the inhabitants are principally divided into miners and forresters, the one class enjoys vigorous health, while the other is subjected to disease: and the consequences are beheld even in their respective offspring. Life is here of short duration; many die young, and forty is an age beyond which great expectations of survivance are not entertained. The unusual insalubrity of Idria is traced to the mines and metallurgic operations, by those who consider the atmosphere of the same constitution as in other places.

Mineralogy.

The minerals of Idria are in considerable number and variety, and also of uncommon value compared with their narrow bounds. Among these are white marble, found in the valley of the Canomla; thick beds of different coloured jasper in the country of Woiska; fine and coarse free stone; sulphuretted iron and indications of coal.

Quicksilver mines.

But the chief riches of Idria are its quicksilver mines, the largest, most magnificent, and most productive in the world. The metallic stratum is situated about 240 yards deep; it extends 800 yards in one direction by 1000 in another: and lies in a valley, whose surface is 507 feet above the level of the sea. Six shafts penetrate the mine, four of which are vertical, and two have an inclination. The former are named St Barba, St Theresa, St Francis, and the Emperor Joseph; three of them are appropriated for the extraction of the mineral substances, or discharging water, which is accomplished by 15 pumps, worked by a hydraulic wheel 36 feet in diameter; while the fourth is reserved for introducing the materials necessary for the operations below. Access is gained from within a spacious building, situated in the town of Idria, leading almost horizontally under a lofty vault to a staircase, always kept in excellent repair, constructed mostly of stone steps, but partly of wood. It reaches to the depth of 150 yards, after which the remainder of the descent is accomplished by wooden ladders, which are sometimes damp, and on that account less convenient and agreeable. Dr Brown observes, that in leaving the mine, he ascended by a ladder of 639 staves. There are several landing places paved with flag stones in the course of the descent, and benches to rest upon: and the whole mine is kept remarkably clean and in good order. The subterraneous excavations are occupied by nine horizontal galleries, including intermediate ones, with their numerous ramifications, about seven feet high, and as much in width. They are arched over by artificial building, unless where they penetrate the solid rock, which requires no support, and are in general well aired from currents being established between them. According to Jars, by whom the mine was visited about the year 1759, the entrance to the principal gallery is covered by an iron grating, at the moment the workmen descend, which is kept down until their return. At the distance of 260 yards from the mouth of the same gallery, there is a chapel where mass is performed on all festival days, and the images of saints, protected by a grating, stand in niches. Kuttner says the principal shaft is 86 fathoms in depth, and Keysler, that the lowest part of the mine lies 840 below the surface of the earth. The temperature of some parts is such as to cause profuse perspiration in the workmen: numerous thermometrical observations prove, that among great beds of rich ores, the heat is from 80° to 95°. Every thing within seems to announce disorder and chaotic confusion: the whole mineral kingdom apparently has been confounded by some catastrophe, to constitute the treasures which this spacious cavern contains. Enormous heaps of shells are intermixed with mercury, bitumen, and sulphur, and the ores are disseminated in the most unequal manner. On account of its uncommon arrangement, the mine of Idria bears no resemblance to any other, and presents none of those facilities in the working which are found in mines with veins.

Considerable misapprehension seems to have prevailed concerning the quality of the ores of Idria. Some authors have affirmed, that it contains 50 per cent. of metal at an average, and that portions afford even 80 per cent. But the mean produce of 9908 tons was only 8.616 per cent. by exact observation. Virgin mercury, as we have seen in the preceding list of combinations, exists in various situations, elaborated exclusively by the hand of nature. It appears in pure globules, and has been known to issue in a slender stream from some narrow fissure in the rocks. A miner is said to have collected 36 pounds of mercury in this manner in six hours. The quantity of virgin mercury procured annually is very unequal. When Dr Pope visited the mines in 1663, it amounted to 11,862 pounds, which nearly doubled the product of 1661, and somewhat exceeds the statement of Keysler and Jars, at 100 quintals, or 10,000 lib. Probably it is more rare at present. A small portion is always presented in a leathern purse to foreigners of distinction who inspect the mines.

Extraction of the metal.

The ores being separated, according to their quality, by the miners, are drawn up in strong square boxes, each capable of containing 700 or 800 lib. by means of a hydraulic wheel put in motion by the water of a canal led from the Idrixa. All are then conveyed to the lavatories, or washing rooms, where they undergo a new assorting, and the richer kinds are set apart by themselves. The object of washing is to disengage all the earth which contains no mercury; and for this purpose seven wire sieves are first employed, and the result then transferred to another set of very expert workmen. Sieves suspended in a cistern, and, while immersed, kept in constant motion, are now used, that the heaviest particles may fall to the bottom; and great care is taken to preserve those of a red colour, as they contain cinnabar. After these two levigations the ores are pounded, and again carried to the lavatories to undergo a third on inclined planes. From the lavatories they are conveyed to furnaces to be subjected to distillation; but, before being exposed to the action of the fire, the whole are rigorously assayed, in order to anticipate what product may reasonably be expected. As there are two kinds of ore, one in large pieces and the other in powder, there is a furnace for each. The furnace destined to receive the first has two fire-places and four chambers or ovens, which communicate by lateral conduits with two rows of reservoirs, or very high chambers of mason-work, separated by intermediate walls, but mutually communicating by means of alternate apertures a foot square. Of these reservoirs or condensers there are twenty-eight. The second furnace, appropriated for burning the ores in powder, has six furnaces and twenty-four chambers, instead of twenty-eight. The area in both is inclined to facilitate the flowing of the mercury, and a conduit common to the whole condensers brings the mercury into another great reservoir, where it is collected for use. The charge of the first furnace is 30,000 lib. of ore, that of the second 60,000. When the furnaces are charged, all their apertures, and those of the condensing chambers, are carefully luted with clay and slacked lime. The fire is then progressively augmented during nine hours, until the earthen clods, wherein pieces of ore or the powder have been put, become red hot, and the ores burn vehemently. The whole is then allowed to cool for six days, and the mercury, completely disengaged, is collected in the general reservoir. As the heat of the furnace, particularly of that which burns the larger pieces, is retained a long time, it would be difficult to collect the metal sooner. A single charge of the furnaces will frequently produce 8000 pounds of quicksilver. The mercury is taken out of the common reservoir, and packed in white sheep-skin bags, which have been tanned with alum, in quantities of 25, 50, or 100 pounds. The bags are then conveyed to a magazine, where each is covered by a second skin, and packed up in casks, which are exported to the various places where they are required.

Mercurial preparations.

But, independent of the pure mercury thus obtained, and exported from Idria, there are mercurial preparations to a very great extent of all the different kinds which are known in commerce. With the exception of Chinese vermilion, the products seem scarcely susceptible of improvement. For these purposes there is a spacious building, divided into three great laboratories. The first is appropriated for amalgamation of sulphur and mercury, which is then converted to cinnabar; the second is consecrated to the preparation of vermilion, wherein eight mills are employed in grinding the cinnabar; and in the third there are twenty-two furnaces, each provided with six large iron capsules. Much accessory apparatus is used besides.

In addition, and subsidiary to the mining establishment, and that for mercurial preparations at Idria, there are several branches of arts and manufactures. These consist chiefly of a glass work, for providing the bottles and window glass; a pottery for all the earthen ware required; a tannery for preparing the leather packages; and a rope work which furnishes cordage. Numerous mechanics, and artisans of all descriptions, are also ready to provide the necessary apparatus for the various operations.

Produce of the mines.

As the mines of Idria are the most productive which are known, it may not be uninteresting to learn the quantity of metal obtained from them. It has been different at different periods, which is not surprizing, considering the uncertainty which attend subterraneous researches. In the year 1663, they produced 255,981 pounds. About the year 1730, the quantity seems to have been 360,000; twenty years later it was calculated at 300,000; and in the year 1799, Kuttner was informed that the product has been known to amount to 1,000,000 or 1,200,000 pounds, which is probably erroneous. But by an accurate computation made by the director of the mines under the French regime between the years 1809 and 1813, we learn that the average quantity obtained yearly in that time amounted to about 365,928 pounds. Of the total product, there were delivered into the magazines the following proportions in quintals of 100 pounds each.

Mercury	14,194 quintals	25 lib.
Cinnabar	702	25
Vermilion	2,700	29
Corrosive sublimate . .	24	50
Calomel	64	—
Red precipitate	28	67
	17,713	96

The whole of this was obtained in 56 months. Thus the profits of the mines, which are the property of the Emperor of Austria, and carried on at his expense, are very considerable; being at a medium about 800,000 francs, or £35,000 Sterling yearly. To render the average nearly the same, the rich and poor ores are worked at once.

A great quantity of the quicksilver was formerly exported to Spain, and from thence to South America, where it was employed in the separation of the metal in the silver mines. The Dutch were accustomed to purchase 100,000 lib. yearly. Most part of it is now carried to Vienna, and a large proportion to England.

In the year 1663, there were 280 miners, but at present 700 are employed, besides 300 wood cutters, who are under an inspector general; and there are nearly 600 pensioners, including women and children. The whole of this great establishment is under the most admirable system of administration. All the workmen are divided into companies; they assemble at three in the morning, when their names are called over, and they descend into the mine, each with a lamp in his hand. Owing to the high temperature of the galleries, the rarefaction of the air, and evolution of certain gasses in the combustion of the lamps, as well as the deleterious effluvia escaping from the metals, their health suffers severely. Those who are occupied where native mercury is found, inhale small particles of it, and very soon lose their teeth; those employed in sweeping the chambers of condensation also inspire a considerable quantity of metal while detaching it from the sides of the condensers. Thus they undergo a copious salivation. "We saw there," says Dr Pope, "a man who had not been in the mines above half a year before, so full of mercury, that putting a piece of brass in his mouth, or rubbing it in his fingers, it immediately became white like silver. I mean it had the same effect as if he had rubbed mercury upon it. And so paralytic, that he could not, with both his hands, convey a glass half full of wine to his mouth, without spilling it, though he loved it too well to throw it away." Some observers affirm, that the quicksilver insinuates itself into the bodies of those who work the virgin mercury, so that when they go into the warm bath, or are put into a profuse sweat by steam, drops of pure mercury have been known to issue through the pores from all parts of their bodies. This much is certain, however, that the workmen who have been occupied several years in the furnaces, become subject to shiverings, convulsions, decrepitude, and a premature old age. Their wages, partly in grain, and partly in money, are exceedingly moderate; but by the paternal care of government, all are provided with a competency when they are unable to continue their labours.

History.

The quicksilver mine of Idria was accidentally discovered in the year 1497, by a peasant, while receiving the water of a spring into a tub for the purpose of trying if it was tight. He was astonished on emptying its contents to find some metallic globules at the bottom, which he immediately ascribed to witchcraft. But having conquered his apprehensions, he collected them together for the inspection of a goldsmith in the small town of Bischoflaach, about four leagues distant. Neither promises nor presents, however, could induce him to point out the spot; and he engaged another peasant, Cazian Anderlin, to assist him in working the mine. But soon ceasing to find native mercury, their labours were abandoned. Other peasants followed in their footsteps, and were equally disappointed. A company of miners nevertheless had better success. In 1525, the works were interrupted, and the miners totally ruined by an earthquake; nor was the pursuit resumed with activity until 1572. The Archduke Charles of Austria having taken possession of the mines, established a regular system for their management. Vast quantities of mercury were extracted from them; and their riches, together with their great extent, attracted the notice of the curious from all parts of the world. In 1803, a fire broke out in the mine, which did great damage, and occasioned the loss of several lives; but it was observed, that the subterraneous temperature was lower, and that the air of certain galleries was less easily vitiated than before. The French extorted the cession of Idria in 1809, and worked the mine for behoof of the order of the *three golden fleeces*. Numerous and important improvements were made by them, until the Emperor of Austria regained possession of it in 1813.

Town of Idria.

Immediately above the site of the mines the town of Idria is built, spreading over the valley, and up the sides of the hills. All the houses are detached; they are small; but each is inhabited by two or three families, and has a piece of ground from which the owners endeavour to raise a few vegetables. Though irregularly built, its aspect is not unpleasant to the eye, and it exhibits none of that black and dismal appearance which is common to towns in the vicinity of mines. Its principal public buildings are, a handsome parish church; a very fine hospital, to which two physicians and a surgeon are attached; and a dispensary for supplying medicines to the sick. There is a public school for the education of youth, with six masters, and a female to superintend that of girls. An old castle contains the treasure for the necessary expenditure, and a magazine for storing up the products of the mine; also one for provisions to the inhabitants; several public offices, as a hall for the council of administration, and accommodation for its chief director. Some of the edifices devoted to public purposes were erected here during the occupation of Idria by the French. In the year 1812, the population of the town amounted to 4095, and that of the whole district to 7060. Lat. 46° 16′ W.; Long. 33° 53′ E. Distant 18 miles from Upper Laybach. See *Philosophical Transactions*, vol. i. iv.; Brown's *Travels*, p. 83; Kuttner's *Travels*; Jar's *Voyages Metallurgiques*, tom. ii.; Keysler's *Travels*, vol. ii. (*c*)

JEDBURGH, a burgh town of Scotland, and the principal town of the county of Roxburgh, is pleasantly situated on a declivity on the north side of the river Jed. From historical evidence, it appears that a village, castle and church, had been founded at New Jedworth, now called Jedburgh, before the middle of the ninth century.* As Roxburgh, originally the principal town of the county, was often possessed by the English, and the village reduced to ruins by the frequent sieges of the castle, the seat of the judicatories was transferred to Jedburgh after the reign of David the First. The natural beauty of its situation, as well as its vicinity to the borders, attracted the frequent residence of some of the princes and persons of high distinction in both nations, as the town occasionally fell into the hands of the English or the Scots. Here the pious David founded, or, according to the opinion of some historians, rebuilt, A. D. 1138, a monastery, which he dedicated to the holy Virgin, and appropriated to canons regular of the order of St Augustin, imported from Beauvais in France. A church had been erected at Jedburgh during the Saxon period, in the ninth century; and, as the lower storey and gable wall of the monastery still remaining, exhibit beautiful specimens of the Saxon architecture, it affords a strong presumption of their remote antiquity.† Great additions, during successive ages, were made to the revenue of the abbots and monks, by the liberal donations of the heirs of the throne, and of opulent barons and individuals belonging to both kingdoms. Before the expiration of the 12th century, the churches of Ancrum, Longnewton, Oxnam, Eckford, Crailing, Nisbet, Hobkirk, Liddel or Castleton, had all become the property of the abbey of Jedburgh; and various accommodations of fuel, fish, &c. were also acquired in distant districts of the country. The increasing emoluments of the monastery of Jedburgh were beheld with a jealous eye by the bishops of Glasgow, to whose diocese it belonged, and occasioned frequent disputes and litigation between them and the abbots, which were at length terminated by the interposition of royal authority.‡ A convent of Carmelites was founded at Jedburgh by the donations of the citizens and neighbouring inhabitants in 1513, which gives colour to a conjecture, that the constant rage of hostile incursions from the neighbouring kingdom did not intrude upon the tranquillity of religious communities, and that even the savage spirit of the border warriors was overawed by a reverence for superstitious pageantry, and the display of consecrated grandeur. The names of all the streets and closes in the town of Jedburgh, and of the adjacent fields, denote the ancient occupancy and predominance of the ecclesiastical orders; Canongate, Abbot's Tower, Abbey Close, Dean's Close, Friars, Prior Meadow, Monklaw, Virgin, Ladysyards, &c. A part of the ruins of the Abbot's Tower, at the head of the Abbey Close, and of the castle, on the hill at the west entrance to the town, have been lately removed. The only building of antiquity now remaining, with the exception of the abbey, is a house at the bottom of the town, celebrated on account of its having been the residence of Queen Mary, October 1566, when she held a justice court at Jedburgh, and from whence she made a visit to Bothwell at his house in Liddisdale, distant from Jedburgh 17 Scots miles, and returned the same day.

All the lands, baronies, and estates, vested in the Abbey of Jedburgh, were conferred by James VI.

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* It was called New Jedworth, as distinguished from Old Jedworth, five miles south, and nearer the English border.

† See CIVIL ARCHITECTURE, Plate CLXVII.

‡ The bishop of Durham claimed a right to Roxburghshire as a part of his diocese, ascertained and acknowledged by ancient treaties between the kings of England and Scotland.

1662, on Sir Andrew Kerr of Fairnieherst, and converted into a temporal lordship, together with the title of Lord Jedburgh.*

It is to be regretted, that the superstitious veneration, which in barbarous ages had protected the religious edifices, lost all its influence on the Protestant reformers, whether of warlike or ecclesiastical characters. The abbey, as well as the town of Jedburgh, was burnt and demolished by Lord Surrey, 1523, on his second incursion into Scotland. But, as has been observed, the ground or lower parts of the monastery escaped devastation at that time, nor did it afterwards sustain any damage from the fanatical rancour of domestic reformers. Jedburgh has the honour of parochial precedency, being the oldest parish in Scotland of which any historical record has been transmitted to posterity.

As Jedburgh was exposed to frequent depredations from the incursions of the English, and the greatest proportion of the property and all authority were engrossed by the ecclesiastical dignitaries, it does not appear to have made any progress in the manufactures and commerce, which, previous to the Reformation, began to be cultivated, in a limited degree, by several of the towns and burghs removed from the scene of rapine. In the estimate of the revenue of the burghs for fixing the assessment of tax for the defence of the borders, in the minority of Queen Mary, Jedburgh stands perhaps lower in the list than any one of the same population and extent.

After the union of the crowns, when free intercourse was opened between England and Scotland, the town of Jedburgh derived great profit, and attained a considerable degree of commercial prosperity, from the exportation of salt, skins, and malt, into the neighbouring county of Northumberland, and carrying wool to the coast towns, to be thence exported to the continent. This contraband traffic continued for many years after the union of the legislatures, till it was checked by the exaction of the malt tax 1728, and the more unrelaxed vigilance of excise officers on the English borders. From this period, the population and industry of the town of Jedburgh underwent a rapid decline. Efforts were made, from time to time, by some of the neighbouring gentlemen, and by the wiser citizens, to set on foot different branches of manufacture. A linen company was established. The manufacture of coarse wools was also attempted, but, from the discontinuance of these speculations, they appear to have disappointed the expectations of their patrons. The delusive hope of acquiring indolent independence, as the price of political service, and party contests and divisions, repeatedly occasioned by the return of elections after the union of the legislatures, deadened the spirit of enterprize, and retarded the occupation and improvement of those local advantages, which, in later years, have so much redounded to the credit and melioration of the community.†

About fifty years ago, a few enterprising individuals began to carry on a considerable manufacture of flannels, blankets, and coarser woollen fabrics. Their success roused the emulation of their fellow-citizens. A spirit of industry pervaded all ranks; and a great variety of woollen manufactures were pursued with dexterity and profit. During this period of industry, the wages of labourers have been doubled. There has been no want of employment for any class of men. Shops have been multiplied, and better furnished; and the surrounding fields brought to the most perfect state of culture. In the course of ten years preceding the year 1816, several hundreds have been added to the population of the town of Jedburgh, and more money has been expended in building and improvements of every kind than for forty years preceding.‡ Land in the vicinity of Jedburgh was then seldom purchased at more than £20 pounds per acre, and a few years ago it has been sold for £100, and £150 per acre. The rent of the surrounding inclosures has been raised from 10s. and 20s. to £5, and, in some instances, to £6 or £7 per acre. This description of the prosperity of Jedburgh must, however, be understood to refer to a period preceding the year 1816, when, from obvious reasons, which need not be mentioned, every species of manufacture and labour began gradually to slacken, and more than two-thirds of the persons employed are now laid aside from work. A great proportion of the fields, surrounding the town, had been purchased by the successive heirs of the Lothian family; but, as these made no part of the entailed estate, they were sold in separate lots, about twenty years ago, to private individuals, who are inhabitants of the town.

After the Reformation, Roxburghshire was consigned to the diocese of the bishop of Glasgow, and Jedburgh was then, and still continues to be, the seat of the presbytery. The parish is of great extent, reaching from the river Teviot to the borders of Northumberland.

The total population of the parish was found, upon the late survey in 1813, to amount to 4927, of which 2827 reside within the royalty of the burgh. The males in the town 1354. Females 1473.

There are, besides the parochial church, three dissenting meeting-houses, all attended by large congregations. The parish church, consisting of the western division of the abbey, was repaired in 1792, and adapted, with great taste and propriety, to the style of the ancient edifice; and may be considered as one of the most elegant churches in the kingdom. The grammar and English schools, the former in the patronage of the heritors, the latter in the patronage of the magistrates, are now united, and conducted with great success by the present incumbent Mr Robison.

The set of the burgh is nearly the same as that of Edinburgh, consisting of a provost, four bailies, dean of guild, and treasurer; eight deacons of the trades; and fourteen merchant councillors. The revenue of the burgh arises entirely from the rent of the mills, to which the inhabitants of the town are thirled, and from the customs upon meal, barley, &c. imported into the town for sale. The magistrates of Jedburgh preside, together with the chamberlain of the Duke of

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* The Marquis of Lothian is the male representative of this ancient family, and his ancestors sat as peers in the Scotch Parliament, with the title of Lord Jedburgh.

† The situation of Jedburgh is well calculated for the manufacturing of woollen goods, being situated on a river, affording a variety of convenient situations and falls for mills. From the vicinity of Cheviot hills, any quantity of Cheviot wool may be procured and laid down by the farmer, free of any expense for carriage. If the manufacture of worsted goods or English blankets is preferred, an abundant supply of Leicester wool, with the same advantage, can be procured from the stock farms on the lower grounds. In the year 1815, one hundred and four persons were employed in the manufacture of coarse woollen cloth, Scotch blankets, baize of different colours, flannels, &c. and 205 were employed in the lamb wool hosiery.

‡ In the year 1773, the whole population of Jedburgh amounted to nearly 2000, and now amounts to 2827. Within the last forty years, six bridges have been built within less than three miles of the town, three of them immediately contiguous. A magnificent court-house was erected eight years ago in the middle of the town, and adds to the beauty of the streets. An asylum is also provided for the reception of persons deranged. Persons convicted of crimes are also confined in it to hard labour.

Roxburgh, at St James's fair in the vicinity of Kelso, and enjoy the half of the customs; privileges which redound more to their honour than profit, as they are supposed to have been conferred as a reward for meritorious services during the period of the Border wars, but are not productive of any solid emolument. There are four fairs held annually in the town of Jedburgh The whole revenue of the town does not exceed £500 per annum, of which a large part is expended annually for the interest of debt. The mills were formerly included in the lordship of Jedburgh, conferred on Sir Andrew Kerr; but were afterwards transferred, either gratuitously or for a small sum, to the burgh, and confirmed by a charter of James the First.

The poor of the town are maintained by an assessment, laid upon the inhabitants in proportion to the value of their houses and landed property within the royalty. The number of poor now in the list of supply amounts to 67, and the assessment granted for the last half year, (July 1817) to the sum of £135. The annual rent of the houses and gardens within the royalty is estimated at £4000. A parish bank was established July 1815 in the town of Jedburgh, in partnership with the country parish, and six neighbouring parishes, which has fully answered the hopes of its patrons; the small sums deposited now amounting, July 1817, to £1996. An auxiliary bible society was established two years ago, under the direction of the most respectable, neighbouring gentlemen, and the ministers of the town. A branch of the British Linen Company was established at Jedburgh in the year 1791, and carries on business to a great extent.

There is a good butcher market in the town of Jedburgh; the bread has been long excellent; and in the summer months, and in winter when the weather is mild, the town is well supplied with fish, brought from the distance of thirty miles A stage-coach runs from Jedburgh three days in the week, and returns in the alternate days. A coach also runs from Hawick to Berwick, which passes through Jedburgh and returns the same day. The greatest grievance to which the town and neighbourhood are subjected arises from the dearness of fuel, consisting chiefly of coals brought from Northumberland. The average price may be stated at 1s. 7d. per cwt.

The diversity of surface, and the adjacent woods and brooks, afford a variety of beautiful picturesque scenes. The soil is deep and fertile even to the top of the hills, and peculiarly favourable to horticulture and orchards, for which Jedburgh has been long celebrated. Some of the pear-trees, which bear the marks of great antiquity, are supposed to have been planted by the hands of ecclesiastical proprietors before the Reformation.*

JEDO. See Jidda.

JEJURRY is the name of a pretty large Mahratta town in India in the province of Bejapoor. It is principally celebrated for its temple, dedicated to an incarnation of Mahadeva, or Siva. It is built of fine stone, and has a very majestic appearance and situation, on a high hill, in a beautiful country. The ascent to the temple is by a handsome flight of broad stone steps, arches being in many places thrown across over the stairs. The inner temple where the deity is placed is ancient and not very handsome. The establishment of dancing girls attached to it, amounted in 1792 to 250. The revenues of the temple are derived from offerings, and from houses and lands given by pious persons. The annual expenditure on account of the idol is £6000. The idol has horses and elephants kept for him, and along with his spouse, is bathed daily in rice and Ganges water, the last of which is brought from a distance of 1000 miles. At the annual fair which is held in January, no fewer than 100,000 persons visit Jejurry. East Long. 74° 17′, and North Lat. 30° 54′. See Moor's *Hindoo Pantheon*.

JELLY. See Chemistry, Vol. VI. p. 130.

JEROM, or Hieronymus, was born about the year 329 at Strido, a town on the confines of Pannonia and Dalmatia. His father, who was a person of rank and property, took great care of his education; and sent him at a proper age to study at Rome, under the best masters of those times. Under the celebrated Donatus, he made great progress in the belles lettres, and all the learned languages; and was particularly careful to accomplish himself in the art of oratory, that he might the better recommend the Christian tenets. Having finished his education at Rome, he travelled into various countries in pursuit of knowledge, examining all the public libraries, and conversing with all the men of learning in his way. Upon his return to Rome, he resolved to devote his future life to study, and to withdraw himself entirely to some remote region, at a distance from large towns and civilized life. Taking with him only his books, and money sufficient to defray the expense of his journey, he proceeded through Asia Minor to Jerusalem; thence to Antioch, where he had a dangerous illness; and finally settled in a frightful desert of Syria, where he entered upon a strict monastic course of life, in the 31st year of his age. He applied himself especially with the utmost assiduity to the study of the sacred scriptures, and of the oriental languages; but, after four years of laborious application, his health became so much impaired, that he found it necessary to return to Antioch. By Paulinus, bishop of that city, he was ordained a priest in the year 378; but with the express stipulation on his part, that he should not be confined to any particular cure. In 381, he went to Constantinople, where he acknowledges himself to have received much valuable instruction relating to the Scriptures from Gregory Nazianzen; and, in the following year, he accompanied Paulinus of Antioch to Rome, where he became secretary to Pope Damasus. After the death of that pontiff in 385, and in consequence of the vexations which he experienced from the followers of Origen, he again removed from the city of Rome, and took up his abode at Bethlehem in Judea. Thither he was followed by many persons of both sexes from various parts, who had resolved to embrace the monastic life, and who were attracted by his fame for learning and piety to put themselves under his superintendence. Here he enjoyed all that repose in which he so much delighted, and employed the remainder of his life in composing a variety of learned works, and in diligently attending to the religious instruction of those who had collected around him as their pastor. He was much engaged particularly in writing against the prevailing heresies of his time, especially against the errors of Origen, and those who supported the tenets of that rival father. He lived to the age of 90 years, retaining his vigour of mind to the last; and died on the 30th of September, A. D. 420. He has been pronounced by Erasmus, "the greatest scholar, the greatest orator, and the greatest divine, that Christianity had then produced;" but Le Clerc professes to shew, that his eloquence is often the most hyperbolical declamation, his acquaintance with the learned languages far from accurate, and his reasonings generally obscure and inconsistent. His style as a writer, is nevertheless acknowledged to be in no small degree both elegant and animated; and his judgment and learning to have been upon the whole

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* The Editor is indebted for this article to Thomas Somerville, D.D. F.R.S.E.

superior to those of any of the fathers who preceded him. His talents were better than his temper; and he made greater attainments in the knowledge than in the spirit of Christianity. He was a man of the most choleric disposition, and ready to burst into the most outrageous abuse upon the slightest provocation; insatiably greedy of fame, and bitterly censorious of his most respectable rivals and opponents. The first edition of his works was published by Erasmus at Basle in 1526, with an account of his life prefixed; but the latest and fullest was published at Verona by Vallersius, in 11 vols. folio. They consist chiefly of his Latin version of the scripture, distinguished by the name of the Vulgate, commentaries on different books of scripture, polemical treatises, letters, and biographical accounts of preceding ecclesiastical authors. Of these, the commentaries and letters are accounted the most useful, and the chief advantage of his writings consists in the information which they afford respecting the opinions of the learned Jews in biblical literature, and the fragments which they contain of the ancient Greek translations of the Bible. See Mosheim's *Ch. Hist.* vol. i.; Lardner's *Works*, vol. ii.; Milner's *Ch. Hist.* vol. iii.; Cave's *Hist. Liter.* vol. ii.; Le Clerc's *Questiones Hieronymianæ*; and Jortin's *Remarks on Eccl. Hist.* (*q*)

Climate.

JERSEY, is an island in the English Channel, subject to the dominion of Great Britain, lying off the coast of Normandy in France. Its form is an irregular parallelogram, the extreme length of which is 12 miles, the extreme breadth 7, and the superficial area 62½ square miles, or 40,000 acres. The climate is so mild, that frost is rarely of any duration, and snow seldom lies above two or three days in winter. Shrubs requiring shelter in the southern parts of England, sustain no injury here from exposure, and spring flowers blow in the open air of the colder season. Fogs are not uncommon, and there are frequent gales, together with keen and penetrating winds from the east, which are severe on delicate constitutions. Pulmonary affections are often fatal, and there are numerous cases of scrophula, which some have ascribed to the habitual use of salted provisions.

The surface of Jersey is an inclined plane, rising abruptly from the sea on the north, where its lofty cliffs are in general 100, or frequently 200 feet high, and declining gradually to the southern coast. Its shore is deeply indented by many fine bays, of which St Aubin, Brelade, de Lecq, and Boulay, are the most important. But they are not well sheltered from storms, and the ports of St Helier and St Aubin are both dry at low water. A chain of rocks runs out from the north and north-east, dangerous to mariners, as are the shallows in other parts; and the tides, which rise from 40 to 50 feet, exhibit some singular phenomena.

The island is watered by numerous streams, and so copiously, that it has been observed, there is scarcely a house which has not a spring or a brook near it. All the mineral waters hitherto discovered are chalybeate; but only two have attracted any notice on account of their medicinal properties—one in the parish of St Mary, the other in that of St Saviour.

Mineralogy.

A large portion of Jersey consists of sienite, especially the northern coast, where there are rocks of various elevation, generally exhibiting broad and perpendicular faces to the sea, and every where intersected by veins also perpendicular running north and south. Many remarkable caverns have been formed in them by the action of the waves. What approaches nearest to granite is quarried at Mont Mado, of which ample use is made for architectural purposes. Varieties equally hard and compact are obtained at St. Brelade's Bay and Plemont. These of sienite appear in some places to pass into porphyry, in others into a kind of green stone in a state of partial or entire decomposition. No metallic traces, except of iron and manganese, are seen in any part of Jersey. It has been said that copper ore is found. Ochre of different colours is obtained in various places, and there are some specimens of tripoli.

Vegetable produce.

The surface of the island is extremely irregular, consisting of numerous small vallies running across the island; and the soil, which is principally a light and fertile earth, has been compared to that of Guernsey. Considerable variety of vegetables is produced here. Madder grows wild, also the luteola, single chamomile, and a number of aromatic herbs. Laver and samphire grow on the coast, and chiefly to the north. Fine fruits of the highest flavour come to maturity in the orchards. A kind of pear called *chaumentelle* is particularly celebrated, some attaining a pound in weight. It sells for a high price at all times, and is sent in presents to England. From the profusion of apples a great quantity of cider is obtained yearly. There are no woods of forest trees throughout the island; but one of the most important vegetables is sea weed, or *vraic*, which grows all around the rocky shore, and is used, either in a recent state for manuring the land, or when dried, as fuel. Only two seasons in the year, which are proclaimed by order of the magistrates, being appointed for cutting it, whole families watch the period when it is torn off the rocks by tempests, to rake it together. The ordinary farinaceous grain of England is cultivated: also bearded wheat, called *froment tremais* in Jersey, which is reaped in three months, and the various edible roots. Lucern and clover are in general cultivation, but hops have not succeeded. Instead of reserving a field for each kind of grain, it is common to sow several in patches in those of very small size. The vegetable produce of the island is considerably less than its consumption; and there is sometimes a temporary scarcity in the town of St. Helier, extending both to bread and meat.

Animals.

Many species of fish frequent the shores, but the inhabitants do not seem to avail themselves of the great advantage to be derived from them. Rays, turbot, plaise, soles, and mullet are caught, besides others. "But," in the words of an old author, "the sea about Jersey may be stiled the kingdom of congers," which are seen among the rocks at all seasons; some six feet long, and weighing 54 pounds. Oysters, lobsters, and crabs, are plentiful. Numbers of small snakes, all harmless, and also beautiful lizards, are seen on the island. It is infested by toads of monstrous size, though none are found on Guernsey. The red legged partridge was once common, but is now nearly extirpated. There are three species of field mice, one of which, in as far as we can learn, is the *mus* typhlus, or blind mole, hitherto ascribed to southern Russia. It approaches to the size of a rat, and is of a grey colour, with long hair: the eyes are so small as to be scarcely discernible; and under the fur there are in the site of the ears two bare vesicles. The horses of the island are small, strong, and hardy; and the cows are of that breed known in England by the name of Alderney cows. Sheep are diminutive in size, and mostly black. Another species is alluded to by authors of the seventeenth century, as "those famous sheep with six horns, three of each side; one whereof bent towards the nose, another backwards towards the neck, and the third stood erected upwards in the midst of the other two, mentioned by writers as one of the singularities of this island, are become very rare." Some goats are bred; and hares are scarce.

Inhabitants.

The inhabitants are distinguished by few peculiarities from those of the rest of the British dominions, except in their language, which is French. This is the vernacular tongue; divine service, pleadings in court, and the public acts, are all in good French, which is understood, and occasionally spoken, by the upper ranks; but, in compliance with custom, they frequently converse in the provincial language, which is described as consisting of more dialects than those of ancient Greece. But English is becoming more prevalent daily, and, if it received greater encouragement, would soon be universal.

Towns.

In the year 1806, the total population of Jersey amounted to 4363 families, consisting of 10,284 males and 12,571 females, being 22,855 souls, which is at the rate of 365 persons to each square mile. These are dispersed in twelve parishes, containing two towns, several villages, and several fortresses. The town of St. Helier is the capital, situated on the east side of St. Aubin's Bay, and consisting of about 1000 houses, wherein between a third and a fourth of the whole population, or above 6000 individuals, reside. In the year 1693, it seems to have consisted of only 210 houses. Their antique appearance is now modernized; many of the streets have footpaths, but they are liable to be overflowed by the channels of a stream from the north, and the town is not yet lighted; consequently, a great number of small lanterns are seen in motion at night. There is a square, wherein stands a gilt statue of King George II. in Roman costume, surrounded by a neat iron railing. The parish church, which is the most modern in the island, was built in 1341; but, since that time, it has undergone considerable alterations. It contains a neat organ, and some handsome mural monuments. There are also chapels for Presbyterians and Wesleyan Methodists, both of which are neat and spacious buildings of recent erection. The Roman Catholics perform divine worship in a private apartment, not being sufficiently affluent to erect an edifice exclusively devoted to the exercise of their religion. There are a workhouse and a public hospital here for the use of the whole island. The latter was rebuilt in 1783, in consequence of another being damaged by an explosion of gunpowder. It has commonly about 100 patients, of whom not above two-thirds are natives of Jersey, and about a tenth part of the whole labour under mental derangement. On one side of the square is the court-house, a plain but solid structure, wherein are held the assembly of the states and the courts of judicature; and the governor of the island has a house and garden belonging to the town. A new prison, situated at the west extremity of St. Heliers, on the sea shore, was completed in 1815. The basement of this edifice has a squared front of sienite from Mont Mado, and is separated from the upper story by a fascia of dark grey granite from Sorel, a rocky promontory in the northern quarter of the island. Above this the sienite is resumed; and the uniformity being relieved by pilasters between every window, the whole is completed with an elegant cornice of Portland stone. The front stands on an arcade extending 120 feet in length by 8 in width; and the intercolumnations are grated to the crown of the arches. The space within the arcade is for the accommodation of the male prisoners, when they leave their dormitories. Water is raised to a capacious cistern in the roof, by means of a forcing pump, and the prisoners of every description have access to a constant and ample supply. The centre of the upper floor forms a chapel, divided by partitions of sufficient height, to prevent any communication whatever, whither the prisoners of the several classes are conducted by different doors. An unfinished house in the town was converted to a theatre, where some comedians occasionally repair from England to perform during a few months of the year, and there are regular assemblies in winter. A public library was established by the Rev. Mr Falle in the 17th century, which since that time has received considerable accessions. There are three gazettes in French published here on Wednesday, and one in English on Saturday. A weekly market is held for fish and provisions, which is well supplied, especially from the coast of France since the late peace; most of the flour is brought from that country and England. Several packets are established between St. Helier's and Weymouth, and there are regular traders to Southampton, whither the voyage is usually made in between 16 and 24 hours. The town of St. Aubin's stands on the opposite side of the bay, to which it gives name, about four miles from St Helier's. It is a small place, situated under a long range of cliffs, and consists principally of one street, well sheltered from the prevalent winds, and commanding a fine and interesting prospect of the bay. Being distant from the church of St Brelade, to which parish it belongs, a neat chapel has been erected by private subscription. This town is protected by a fort mounting 14 guns, which has been erected on a rock dry at low water, but insulated with the rise of the tide. A strong pier projects from the fort, within which there are 30 feet water at new and full moon, and although this is merely a tide harbour, St Aubin's, on account of it, enjoys some portion of foreign trade.

Fortifications.

Jersey, from its peculiar situation, has been strengthened by more than an ordinary portion of military architecture. Elizabeth Castle, which is the proper residence of the governor, is a strong fortress in St Aubin's Bay, defending the approach to St Helier's, from which it is distant 663 geometrical paces, and is accessible by a sandy beach during five or six hours while the tide ebbs, but is insulated with its flow. A fortification, which was recently constructing on the town hill overhanging St Helier's, is designed to contain 2000 or 3000 men. Here a well has been sunk 233 feet through the solid rock, which has from 80 to 100 feet of fine water. Besides these, may be named other strong places, as Mont Orgueil, Fort Henry, La Rocco, Seymour Tower, a fort at Noirmont Point, and Ich-Ho; as also a chain of Martello towers, redoubts, and batteries in every maritime part of the island. Barracks for the accommodation of regulars are erected in various quarters. In the time of war there were, belonging to the island, a troop of cavalry, six battalions of militia, consisting of above 2000 men, and a company of artillery amounting to 600 or 700.

Manufactures, commerce.

Few manufactures are conducted on a large scale in Jersey. About 24,000 hogsheads of cider, however, which is the common beverage of the island, are made annually; and a plentiful year will yield 36,000. Tanning, soapmaking, candlemaking, and other works, are among the manufactures for supplying the inhabitants. Great quantities of worsted stockings are spun and knit in the island. The principal exports are cider, of which 1800 hogsheads are sent to England; fruit, potatoes, cattle, and worsted stockings. During the five years preceding 1813, the exports were at an average 768 cows, 13 bulls, 900 pipes of cider, 1228 tons of potatoes. From England are imported corn, flour, seeds, live and dead stock, cloth, linen, crockery and glass ware, paving stone, and in general all articles necessary for subsistence, apparel, and furniture. Salt fish to a large extent is imported from Newfoundland. The commercial relations of Jersey were formerly restricted for the most part to England and France, after which another field was opened to that island, where about 80 fishing vessels

Exports and imports.

were employed during peace; and now it trades with almost every country in Europe, and also with America. During the year 1813, there entered inwards 734 vessels, and 813 cleared outwards, of which 440 were in ballast. Those constituting the difference, 79, were vessels from England for oysters, which make no entry inwards, but clear outwards. Fifty-nine vessels, whose united burden amounted to 6003 tons, and navigated by 549 men, belonged to the island in the year 1812. Until lately, the currency of the island was principally French, with a small proportion of Spanish money; and the amount of specie was about £80,000 Sterling. After the French Revolution, the coin of England came into more gradual use, until, by the gradual rise of gold and silver, almost the whole specie of the island was withdrawn. The established banking-houses, of which there were three, became obliged to issue notes of five and ten shillings value. Others soon adopted the same plan; and at length no fewer than 80 bankers were circulating notes, from the value of one pound down to one shilling. From the want of coinage of low denomination, they were readily taken; but the hazard inseparable from such an inundation of paper money was diminished by the introduction of £10,000 of silver coinage by government, accompanied by a prohibition against issuing notes of lower value than one pound. Mr Colquhoun, in his work on the *Wealth and Resources of Great Britain*, computes, that the total worth of the island, as property, is £2,610,030. In this estimate are included the value of the soil, of the public and private buildings, farm stocking, shipping, furniture, and coinage; but probably the whole is not worth above £2,000,000 at the highest calculation.

Government.

Jersey is under a peculiar form of government, which some have supposed to be exactly similar to that of the British islands. It consists of a court of judicature, and an ecclesiastical body separately exercising their respective jurisdiction, but which, together with twelve constables, and a military governor, are combined into an *Assembly of the States*. The court of judicature is composed of a bailiff, who presides, and twelve jurats; together with an attorney and solicitor-general, a high sheriff, two under sheriffs, six pleaders, and an usher. The bailiff is appointed by the king, and the jurats are chosen by the masters of families: he keeps the public seal, which however he cannot use without the consent of three jurats. The clergy consist of eleven rectors and a dean, corresponding to the twelve parishes in the island, and forming a regular spiritual court, of which the dean is the head. In the assembly of the States, the attorney-general and high sheriff are admitted *ex officio*, but have no vote. No assembly can be held without the governor's permission, who has a negative voice. But by an order of James VI. in council, he must summon the States within 15 days if the bailiffs or jurats require it. Likewise he is directed to abstain from using his negative voice, except in such points as shall concern the king's special interest. Seven of each class of jurats, clergy, and constables, must be present to constitute an assembly of the states, whose business is chiefly raising money for the public service. There are several peculiarities in the laws of Jersey, of which a code was compiled by the States in 1771, and sanctioned by the king. Legitimation by subsequent marriage is recognised, and the *cessio bonorum* of the Scottish law. The punishment of death is seldom inflicted; but mutilations are practised: A criminal convicted of forgery, which is not a capital crime, was sentenced in 1814 to lose the tip of his right ear.

Antiquities.

Falle, the historian of Jersey, observes, that there are "yet remaining in this island, some old monuments of paganism. We call them *poquelays:* they are great flat stones, of vast bigness and weight, some oval, some quadrangular, raised three or four feet from the ground, and supported by others of a less size. At ten or twelve feet distant is a smaller stone set up on end, in manner of a desk, where it is supposed the priest kneeled and performed some ceremonies while the sacrifice was burning on the altar." The monuments here alluded to are cromlechs, which the author, from the quantity of ashes found around them, and their position on eminences near the sea, supposes were altars dedicated to its divinities. Only four of a decided character now remain, one of which is broken down. Jersey had formerly an abbey, dedicated to St. Helier, four priories, above twenty chapels, and twelve parish churches. All the last, which were consecrated between 1111 and 1341, are still preserved, and some of the chapels.

History.

Jersey is supposed to be the island mentioned under the name of Cæsarea, in the itinerary of Antoninus, and to have thence derived its present name. It is said to have been afterwards called Angia, in a grant by Childebert king of France in the sixth century. About the year 857, it is affirmed that a certain St. Helier suffered martyrdom here, but how, or for what cause, or wherein his sanctity consisted, we are not informed. Indeed these early notices are extremely obscure and indefinite. Having belonged to Normandy of old, Jersey became an appendage of the British isles, when William the Conqueror subdued England; and it was annexed to the crown, along with those in the neighbourhood, by Henry I. However, the French made frequent endeavours to recover what they conceived pertained more naturally to their kingdom, from geographical position, and in the course of the civil wars between the houses of York and Lancaster, they reduced about one half of the island. In the year 1518, it was visited by the plague, which became so destructive in the town of St Helier, as to occasion the removal of the courts of justice and the market. About this time the superficies was partitioned among a number of petty owners, whose oppressions and dissensions were such, that Henry VII. instead of himself applying the sword of justice, which might have produced extermination, obtained a papal bull, excommunicating those guilty of intestine commotions. In the reign of Queen Mary, the island was surprised by a company of Flemings, who probably did not retain it long; and it participated deeply in the civil wars of Charles I. and his son. From that period Jersey seems to have enjoyed profound repose until 1779, when an unsuccessful attempt to take it was made by a body of French troops. In January 1781, the Baron De Rullecourt endeavoured to capture it by a coup-de-main, with 1200 men But part of his force being wrecked, only 700 gained the shore, who surprised the town of St Helier, took the lieutenant governor prisoner, and compelled him to sign articles of capitulation, and likewise to direct the troops and fortresses to surrender. But the officers who held the fortresses, having learned that these orders were given by the lieutenant governor while under restraint, refused obedience; and a body of military, having collected under Major Pierson, speedily expelled the enemy, though with the loss of their own brave commander. Distant 17 miles from Carteret and Bail on the coast of Normandy; 21 from Guernsey; 75 from Weymouth; and 120 from Southampton. Lat. of St. Aubin 49° 12′ 59″ N. Long. 2° 10′ 44″ W. (c)

Jersey, New.

JERSEY, NEW, one of the United States of North America, is situated between 39° and 41° of North Lat. and 74° and 75° 29′ of West Long. Its length from north to south is 160 miles. Its least breadth in the centre 42 miles. Its greatest breadth in the north 70 miles, and in the south 75. It contains nearly 8320 square miles, and 5,324,000 acres. It is bounded on the north by New York, on the east and south-east by Hudson's River, New York Bay, and the Atlantic Ocean; and by Delaware Bay and River on the south-west and west, by which it is separated from the states of Delaware and Pennsylvania. The state is divided into 13 counties, which contain 116 towns, viz.

No. of Counties.	No. of Towns.	Population.		Chief Towns.
	.	1800.	1810.	
Cape Mary	3	3,066	3,632	Bridgetown.
Cumberland	8	9,529	12,670	
Salem . . .	9	11,371	12,761	Salem.
Gloucester .	10	16,115	19,744	Woodbury Gloucester
Burlington	12	21,521	24,979	Burlington Borden-town.
Hunterdon	10	21,261	24,553	Trenton.
Sussex . . .	15	22,534	25.549	Newtown.
Bergen . .	7	15,156	16,603	Hackinsac.
Essex . . .	10	22,269	25,984	Newark. Elizabeth-town.
Middlesex .	8	17,890	20,381	Amboy.
Monmouth	7	19,872	22,150	Freehold.
Somerset . .	7	12,815	14,728	Boundbrook
Morris . . .	10	17,750	21,828	Modesttown
Total . . 13	116	211,149	245,562	

General aspect.

The three northern counties of this state are mountainous, and the next four are agreeably diversified with hills and vallies. The south mountain, which is one great ridge of the Alleghany range, crosses the state in Lat. 41°, and the Kittatinny ridge passes a little to the north of the south mountain. The highlands of Navesink, on the coast, near Sandyhook, are about 600 feet above the sea. The greater part of the six southern counties are occupied with that long range of flat land, which commences at Sandyhook, and lines the coast of the middle and southern states.

Soil and agriculture.

Nearly four-fifths of the six southern counties, or two-fifths of the whole state, are entirely barren, producing only shrub oaks, and yellow pines; but the rest of the state contains good soil, and excellent pasturage. Great numbers of cattle are raised in the mountainous parts for the markets of New York and Philadelphia, and wheat, rye, maize, buckwheat, potatoes, oats and barley, are raised for home consumption. Large dairies are also kept, and great quantities of butter and cheese made.

Manufactures.

Great quantities of leather are manufactured at the valuable tanneries of Trenton, Newark, and Elizabeth-town. There is a considerable shoe manufactory at Newark, a glass house in Gloucester county, and paper mills and nail manufactories are erected and wrought to advantage in several parts of the state. The iron works, which are a great source of wealth, are erected in Gloucester, Burlington, Sussex, Morris, and other counties. There are no fewer than seven rich iron mines in Morris county, two furnaces, two rolling and slitting mills, and about 30 forges, with from two to four fires each. The annual produce of these works is about 540 tons of bar iron, 800 tons of pigs, besides large quantities of hollow ware, sheet iron, and nail rods. In the whole state, the annual produce is computed at 1200 tons of bar iron, 1200 tons of pigs, and 80 tons of nails, exclusive of small articles.

Commerce.

The annual amount of articles exported from the seaports of New Jersey, was, in 1810, 430,267 dollars. The aggregate tonnage of the state for 1807, was 22,958. The exports through New York and Philadelphia are very great. The exports are flour, wheat, horses, cattle, hams, cider, lumber, flax seed, leather, and iron.

Rivers.

The principal rivers in New Jersey, are the Delaware and Hudson rivers; the Passaic, which is navigable for 10 miles, and has very interesting cataracts at Patterson; the Hackinsac, which is navigable 15 miles; the Great Egg Harbour river, which is navigable 20 miles for boats of 200 tons burthen; the Maurice, which is navigable for 20 miles by sloops of 100 tons; and the Musconecunk, which runs into the Delaware.

Towns.

The principal towns of the state are *Newark*, a flourishing well built town, with a population of 8008 in 1810; *Trenton*, the seat of government, with a population of 3002; *Perth Amboy*, so called from James Drummond, Earl of Perth and Ambo, with a population of 815; *Burlington*, with a population of 2419; *New Brunswick*, where there is a college, founded in 1770, and a population of 6312; *Princetown*, a village with 80 houses, where there is a celebrated college called Nassau Hall, founded in 1738; and *Elizabeth Town*, with a population of 2977.

Literature.

Besides 15 incorporated academies, this state has two colleges, viz. the college at Princetown, and Queen's College at New Brunswick. The college edifice at Princetown is of stone, and is 180 feet in length, 54 in breadth, and 4 stories high, and divided into 42 convenient chambers for the accommodation of the students, besides a chapel, dining hall, and room for the library. A theological seminary with two professors, has lately been added to this establishment. In winter, there are from 70 to 80 students in the five classes of the college, exclusive of the grammar school; and in the summer from 80 to 90. The college at New Brunswick was founded by ministers of the Dutch church for the education of their clergy, and was incorporated in 1770.

Religious state.

There are a number of different religious denominations in New Jersey. The Presbyterians, who are the most numerous, had, in 1811, 64 churches, and 42 clergymen; the Dutch reformed churches 64, and 42 clergymen; the Episcopal church 24 churches, and 10 clergymen; the Baptist church 30 churches, and 23 clergymen; the Congregational churches 9 churches, and 5 clergymen. The Methodists are very numerous; the number of their communicants was about 6739 in 1811. The Quakers have 44 meeting houses in the state.

History.

This state was included, in 1664, in the patent of Charles II. to his brother the Duke of York and Albany, who soon after conveyed it to Berkely and Carteret. In the same year, three inhabitants of Long Island purchased from the Indians a tract of land, and called it Elizabeth Town; and in the year following, the colony received its own governor Sir G. Carteret, and became a distinct province.

Inhabitants.

The inhabitants are a collection of Low Dutch, Germans, English, Scotch, Irish, and New Englanders, or their descendants.

Population.

In 1810, the population was,

Males	115,357
Females	111,511

Total population in 1810, 226,868

The militia in 1810, amounted to 33,710 men. See Morse's *American Geography*.

JERUSALEM, a city of Palestine, in the pachalic of Damascus, and the capital of the ancient kingdom of the Jews. It occupies the declivity of a barren basaltic mountain, at the extremity of an extensive plain, in a climate comparatively cold, from its elevated situation, where much snow falls, together with copious rains. The plan of the city is irregular; but excluding the citadel at the west end, it approaches to a quadrangular form. It is surrounded by crenelated walls of reddish freestone of considerable height, strengthened by square towers, and mounting a few old 24-pounders, on carriages without wheels. The walls are modern, having been built by Soliman, the son of Selim, as appears from inscriptions upon them. They are too thin to admit of defence, and Jerusalem is not tenable as a military post, being commanded by neighbouring heights on all sides. There are six gates, whose names are partly of Hebrew origin. The total circuit of the city does not exceed two miles and a half. Some authors exaggerate its ancient limits to a great extent, while others conclude that it has scarcely ever exceeded its present boundaries. The streets are narrow, as is usual in the east, but straight and well paved. Several of them have foot-paths, and they are kept cleaner than is common in Palestine. Vacant spaces, and some covered by ruins, are seen towards the west, but no open square has been purposely left within the walls. In general, the houses are well built of free-stone, and for the most part two or three stories high, with a plain simple front, without windows in the lower stories, so that it has been said that a passenger walking the streets of Jerusalem may conceive himself in the corridor of a vast prison: the door, besides, is so low, that a person must bend almost double to gain admission. The roofs are either terraced, or rise in domes, and the dull uniformity of the whole is interrupted by the steeples of the mosques and churches, and the tops of a few cypress trees, and tufts of nopals. Some houses have small gardens.

Inhabitants.

The total population of Jerusalem amounts to 30,000; but from having been peopled by Jews originally, this city exhibits a great mixture of other nations, whose appearance, habits, and sentiments, are at considerable variance. Of these it is computed that 20,000 are Christians of different sects and denominations; 7000 Mahometans, Turks, or Arabs; and only a few Jews. About 2000 of the Mahometans are fit to carry arms. The men are distinguished by no peculiar character. Handsome women are rarely seen: they are in general of a melancholy disposition; of a pale deadly white complexion, and ungraceful mien. The circumstance of wearing a white veil or a fillet round their faces, makes them resemble so many walking corpses; but the faces of the Christian females are exposed as in Europe. Much variety of costume is beheld in the streets; every one, whether Jew, Arab, Syrian, or Turk, adopting what he prefers. The lower orders, however, usually wear a shirt of white or black, or one of broad striped brown, as in Arabia. Christians and Jews wear a blue turban as a mark of distinction, though a few diversify the colour; and shepherds in the neighbourhood have theirs white or striped like the Mahometans. It ought not to escape observation, that blue is in many parts of the East a characteristic of Christianity; and it is not unlikely that its frequency among the lower classes in some parts of Europe has a similar origin. Persons in easy circumstances adopt the Turkish costume, with a high turban. Both the Turkish and Arabic languages are common in Jerusalem.

The mode of life among the inhabitants is dull and monotonous. They have little to interest them: no active pursuit of manufactures, arts, or sciences; no general bond of union; no object of common interest in view. They labour under the oppression of a despotic government, which exercises incessant extortions, without encouraging the means which would enable the people to satisfy its avarice; and so obnoxious is the pasha, that on his approach the inhabitants desert the city. Almost all the Christians entertain a decided antipathy to each other, independent of which a strong aversion subsists between them and the Mahometans. All the different sects reciprocally consider the rest as schismatics and infidels. Those of each persuasion believing that they alone possess the true light of heaven, and an exclusive right to enter paradise, consign the rest without distinction to the infernal regions. Nevertheless, this apparently goes no farther than words; for there is more unrestrained intercourse among the inhabitants of Jerusalem, than of any other place under the sway of Mahometans, which is supposed to arise from the predominant number of Christians. Some sociality is practised among them; and even Christians and Mahometans mix indiscriminately together. All the former, of whatever sect or denomination, devoutly implore the downfal of the Turks; and certainly with sufficient reason, for one leading feature in the political economy of Mahometans is extortion from those who are incapable of resistance.

The sciences have entirely disappeared from Jerusalem. Formerly, there existed large schools belonging to a Mussulman temple, but at present hardly any traces of them remain, and only a few subsist where children of every sect learn to read and write the tenets of their respective religion. The grossest ignorance is found to prevail among persons of the highest rank, who, on the first interview, seem to have received a liberal education. The arts are nearly in a state of equal degradation: a late traveller affirms that he did not see a single lock or key of iron during his abode in the city. There are some weaving looms, and very handsome yellow slippers are made, but the other manufactures are apparently inconsiderable. An immense quantity of relics was wont to be made for the convents, as it is not evident that these were fabricated within their walls; which was either for export to Catholic countries, or to supply those whose devotion led them hither in pilgrimages. The traffic is not yet abandoned. Jerusalem forms a kind of central point between Arabia, Egypt, and Syria, and is a rendezvous for the Arabs of these three countries, who come for the purpose of commercial concerns. But the chief trade of all Palestine consists in exporting oil and importing rice by the way of Acre. However, little benefit seems to be derived from it by Jerusalem. Possibly those who have contemplated its former grandeur in history draw a contrast with its present state, which is scarcely warranted by the reality; for the activity required by the very supplies which a city of 30,000 inhabitants demands, is inconsistent with the picture of desolation which some travellers, such as Chateaubriand, give of the streets. "Enter the city; nothing will console you for its sad exterior: you wander over an unequal surface in narrow unpaved streets, walking amidst clouds of dust, or among rolling flints. The darkness of this labyrinth is heightened by cloths stretched between the houses. Vaulted bazars, replete with infection, deprive the desolate city of the remaining light. Some mean shops display nothing but misery to the sight; and they are frequently shut up from the dread of a cadi passing near them. No one appears in the streets —no one stands at the gates of the city. Sometimes only a peasant glides along in the shade concealing the fruit of his labour under his vestments, in the apprehension that a soldier may despoil him of it. All the noise which is heard in the city is the galloping of a horse in the desert bearing a janisary out on his way to pillage, or carrying him home with the head of a Bedouin Arab." Jerusalem is abundantly supplied with game: provisions of all kinds are cheap, and the wine is good. The shops and markets are, in the ordinary streets, not restricted to a separate bazar, as is usual elsewhere.

Pilgrims. Independent of the stationary inhabitants and the other subjects of the Turkish government, Jerusalem is a great resort of pilgrims, among whom were many Europeans in former times. But though the zeal for pilgrimage has greatly declined, yet it is still very considerable. In 1806, the number amounted to 1500, which was thought small; but there were only two Europeans, of whom one was a traveller. It has been believed that the visits of Catholic pilgrims were the source of great riches to the convents of Jerusalem—a point disputed by Chateaubriand, who quotes various instances to confute the assertion. The city swarms with mendicants, allured thither in expectation of alms from the pilgrims.

Public officers. Jerusalem has a governor, who lives in state, and receives strangers in a dignified manner; a cadi, or civil judge, who is sent annually from Constantinople; a governor of the citadel; a sheik el haram, or chief of the Mahometan temple; and a mufti, or chief of the law.

Edifices. This city is particularly interesting to Europeans, in having been the capital of a people from whom all their religious opinions are derived, and from being the theatre of some events, which not only excited great sensation at the time, but have been carefully transmitted to posterity. Its public edifices are still numerous: the spots which are mentioned in Scripture in the environs are yet pointed out with pious anxiety; but it must not be disguised, that some recent travellers, leaning more to ancient history than the affirmation of the moderns, begin to question the identity of the localities which have remained undisputed for ages. **Citadel.** The present citadel, which is supposed to occupy the site of David's palace, is a Gothic edifice throughout, with interior courts, fosses, and covered ways. No cannon are seen on its walls; and in one deserted apartment, full of old helmets, lie numbers of weapons resembling musket barrels, of which the use is now unknown. This structure is also called the Pisan's Tower, having been built, according to Doubdan, by the republic of Pisa, when the Christians were in possession of the Holy Land. But the religious edifices are more important and interesting. **Convents.** There are several convents of Christian monks, whose total number in 1807 amounted to 61; and of these no less than 48 were natives of Spain. The Franciscan convent of St Salvador is a spacious structure like a fortress, which, with all its conveniences in relation to the usual accommodations of Palestine, has been compared to "a sumptuous and well furnished hotel, open to all comers who may be attracted hither by curiosity or devotion. Meals are served up in an apartment called the Pilgrim's Chamber, consisting of sufficient variety, and adapted to every national taste. Even the beverage of tea is copiously supplied to the Dutch and English, and abundance of liqueurs may be obtained." All pilgrims are received here: on their arrival, they undergo some ceremonies, and the feet of Europeans are washed by the superior of the convent. They are lodged and supplied with whatever they require, and conducted to every sanctified place; but the duration of their residence is limited to a month. It is common for persons of condition to make a present to the convent on their departure, which, in Pococke's time, amounted to about £6 sterling. At present, however, their table is apart from that of the fathers: they bear their own expences, and the convent derives no advantage from their residence. Only the poor are gratuitously maintained. The funds of the convent are ample, being the result of donations from Catholics of all ranks, and especially Catholic princes, either in money or in goods and merchandise. But the monks were lately reduced to great distress from the interruption of their European supplies by the war; and they are also occasionally harassed by the exactions of the Turkish officers. In eight years of the present century, they were compelled to pay 40,000 piastres, or about £6000. Nevertheless, they have obtained the esteem of the people among whom they dwell, by their excellent organization and the regularity of their conduct. The Armenian convent is the largest in Jerusalem. It is maintained in a degree of splendour, attended with neatness, cleanliness, and good order unexampled in Palestine. "Every thing pertaining to it is oriental. The patriarch appears in a flowing vest of silk instead of a monkish habit, and all around him bears the character of eastern magnificence. He receives his visitors in regal stateliness, sitting amidst clouds of incense, and regaling them with all the luxuries of a Persian court."

Sepulchre of Christ. The church of the Holy Sepulchre has been celebrated for ages as containing within its precincts a tomb believed to be that in which the body of Jesus Christ was deposited. This structure stood on Mount Calvary. It consisted of several churches united; and, besides the tomb, covered about twelve places consecrated as the scenes of remarkable transactions. The tomb itself, a white marble sarcophagus of ordinary dimensions, occupies a subterraneous chamber highly decorated. Its sanctity, however, is denied by Mahometans; and the later travellers, though they rest their opinions on very different principles, have called its identity in question. The former deny its sanctity, because Christ ascended to heaven after imparting his likeness to Judas, who was crucified in his stead; and the latter doubt its identity, because there is no evidence that the tomb attracted any notice until centuries subsequent to the event. Nay, they are disposed to go much farther, and to question the identity of all the localities pointed out as those of scripture, partly because the topography of the moderns is inconsistent with ancient descriptions, and partly from the cause above assigned, that such points were not determined until the age of the Empress Helena, who lived some centuries after the death of Christ. Under this impression, the real sepulchre has been sought for among the neighbouring catacombs of a hill facing Mount Sion. The empress now named is said to have founded the church of the Holy Sepulchre from the real cross on which Christ suffered being discovered on the spot; and the tomb was covered by a superb rotunda forming one end of that structure, which has been lately destroyed by fire. This conflagration is ascribed to the Armenians, who sought, by these means, to gain possession of the whole edifice, which was partitioned into churches and chapels belonging to various sects professing the Christian religion. The monks who superintended the sepulchre were particularly the objects of Turkish oppression, which the sincerity of their devotion alone could enable them to support. They not only suffered grievous exactions, but were repeatedly exposed to personal insult and danger. The Mussulmen of Jerusalem themselves revere the tombs of many saints, which afford a profitable speculation to individuals, either from the pious endowments annexed to them, or the collection of alms.

Jewish synagogue.

At present the Jewish synagogue is a miserable structure, consisting of three or four apartments, with roofs so low that they may be reached by the hand; the whole is covered with filth and cobwebs, and disgustingly dirty. The Jews of Jerusalem are restricted to a certain quarter, and are represented as living in a very miserable condition.

Mahometan temple.

This city is equally sanctified in the eyes of Mahometans as of Christians. They call it *el Kods*, or the holy, and have a magnificent temple here, whose interior has been anxiously veiled from the latter. Their presence would be deemed profanation; and although Dr Clarke was furnished with the most powerful of all recommendations, the governor of Jerusalem declared, that the forfeiture of his own life would follow his consent to give him access. But we are now in possession of a detailed description of it from an enterprising traveller, who more recently traversed much of the east under the guise of a Mahometan.

The disciples of the prophet acknowledge two sanctified temples, that of Mecca, and that of Jerusalem; both are named *el Haram* by way of distinction, and are alike prohibited to Jews, Christians, and all who do not profess the Mussulman faith. Mosques are merely named the place of assembly; and although the entrance of infidels is not specially prohibited, it is unwelcome, and must be sanctioned by an order of some public authority. "But no Mussulman governor dares to allow an infidel to pass into the territory of Mecca, or into the temple of Jerusalem. Such a permission would be deemed a horrid sacrilege; it would not be respected by the people, and the infidel would become the victim of his own temerity." Solomon's temple, which has so often been held up to admiration, while many superior works have passed unnoticed, was totally destroyed when the city was sacked by the Romans. An Arabian historian relates, that, on being taken by the Caliph Omar, he enquired, what would be the most suitable place for erecting a mosque, of the patriarch Sophronius, who led him to the ruins of the temple. A new edifice was raised upon their site, which consists of a court, or enclosed square, 1369 feet long by 825 broad. The whole has not been constructed at once, however, as it is a group of mosques erected at different times. Access is gained by nine gates, entering on the north and west sides. The principal part of the structure is composed of two piles of magnificent buildings, called *el Aksa* and *el Sahara*, which, in their respective situation, may be considered as two distinct temples, but together form one consistent and symmetrical whole. *El Aksa* is composed of seven naves supported by columns, and the centre nave is surmounted by a fine spherical cupola, with two rows of windows, and richly ornamented with arabesque paintings and gildings of exquisite beauty. This cupola is 32 feet in diameter, and is sustained by four arches, reposing on four square pillars, the different sides of which are enlarged with handsome columns of brown marble. Each side of the nave which it crowns rests on seven arches slightly pointed, springing from cylindrical pillars above two feet and a half in diameter, and sixteen high. The walls rise thirteen feet above the tops of the arches, and each contains two rows of windows. A frontispiece, inlaid with pieces of beautiful marble, ornaments the niche from whence the Imam directs the prayer, with six small columns of white and green decorating the entrance. In a vault at one side the Caliph Omar was accustomed to pray. A causeway, 284 feet long, fronts the principal gate of the temple, in the middle of which is a fine marble bason, with a fountain in form of a shell that formerly supplied the water; and at the end of the causeway is a fine staircase leading to the other temple *Sahara*, which takes its name from a rock greatly revered in the centre of the edifice. This temple is octagonal, 61 feet of a side, and 159 in diameter. It occupies a platform 460 feet long, 399 broad, raised 16 feet from the ground, which is ascended by eight staircases. The exterior is encrusted to half its height with various kinds of marble, and the remainder covered with small bricks, or squares of different colours. On each side of the octagon are five large windows filled with glass finely painted in arabesques. The temple is entered by four gates, on the north, east, west, and south, and is surmounted by a cupola also, elevated 93 feet above the surface below, which is a superb spherical segment, with two rows of large windows, and is supported by four large pillars, together with 12 magnificent columns ranged in a circle. The rock of Sahara approaches the segment of a sphere 33 feet in diameter; it is of its natural shape; the surface rugged and uneven. Here the Mahometans exhibit the print of their prophet's foot when he came to pray; and they believe, that, next to the temple of Mecca, the prayers of mankind offered up at the rock of Sahara are the most acceptable to heaven. It is surrounded by a high gilt railing, and the sacred impression itself is protected by a cage of gilt wire. The Mahometans are taught that it is surrounded by an ordinary guard of 70,000 angels, which is daily relieved, and that other invisible troops of angels and prophets resort hither to offer up their prayers. In the pavement near the rock is a piece of waved green marble or jasper, fastened down by four or five gilt nails, which, however uninviting, they affirm is the gate to paradise. Some of the nails they relate to have been removed by the devil attempting to pass, but he was overheard in time, and beaten back for ever. In this temple there is preserved a koran of enormous size, being four feet long, and above two and a half broad, which was used by the Caliph Omar. Every night 180 lamps are lighted up here, and 175 in the mosque Aksa. Besides these two structures, there are several others, and also platforms for oratories, within the spacious limits of the Mahometan temple, on one of which the throne of Solomon is supposed to have stood.

Hospital.

Not far from the centre of the city is a magnificent building called the hospital of St Helena, which is still devoted to charitable purposes. Every Mahometan presenting himself at the gate formerly received a supply of food, but the extent of the charity has declined.

Environs of Jerusalem.

It must not be conceived, that the few edifices hitherto named exhaust the curious and venerable remains of the capital of the Jews. On the contrary, they are so numerous, that authors divide them into six different classes: 1. Those purely Jewish; 2. Greek and Roman monuments in the time of the Pagans; 3. Greek and Roman monuments under Christianity; 4. Arabian or Morisco monuments; 5. Gothic monuments under the kings of France; 6. Turkish monuments. Many places without the walls of the city are alike interesting, as the brook Kedron, the pool of Siloe, the valley of Jehosaphat, and the mount of Olives. On this last, which is called Djebel Tor by Mahometans, the Christians assert 7200 prophets have been buried; and here also is a Christian church, containing a marble slab with an impression of the foot of Christ left as he ascended to heaven. The city occupies a portion of mount Sion. In the neighbourhood there are numerous ancient catacombs excavated in the sides of the hills, where brief Greek inscriptions are seen on some of the tombs, and ancient paintings on the walls, executed after the manner of those discovered in the subterraneous cities of Herculaneum and Pompeii.

History. According to the Jewish chronology, Jerusalem was founded by their high priest Melchisedeck in the year of the world 2032, and was originally named *Salem*, which signifies peace. But its principal glory was reserved for Solomon, a wise and politic prince, who lived a thousand years later, and founded the celebrated temple, whose riches are the admiration of posterity. The history of the temple is thenceforward in a great measure to be considered as the history of Jerusalem. It was destroyed 600 years anterior to the Christian era, but afterwards rebuilt; and Alexander the Great is said to have offered a sacrifice in it to the deity worshipped by the Jews. Jerusalem frequently became an object of contention among surrounding nations, and suffered all the vicissitudes common to eastern cities. It was repeatedly pillaged; its inhabitants slain or led into captivity: and the conquerors erected statues of their own divinities in the temple. At length Judæa became a Roman province, and our Saviour was soon after put to death by order of the governor, for declaring that he was king of the Jews. Probably the governor thought the punishment too severe; but being viewed as a political offence, he found it expedient to yield to the voice of the people. Judæa being treated as a conquered country, the inhabitants revolted; which led to the celebrated siege of Jerusalem by Titus, in the year 71. All the sufferings induced by famine were endured; the vilest substances were welcome food; and parents even devoured their own children. The city was stormed, after a brave and vigorous defence; and the miserable citizens inhumanly tortured to death and butchered by the ferocious Roman soldiery. Not less than 200,000 were computed to have died of hunger, and 1,100,000 perished in the assault. In a new revolt of the Jews, Adrian, in the year 118, completed the destruction of what had been spared by Titus: but a new city called Ælia Capitolina was immediately built, where the presence of the Jews was absolutely prohibited. The name of Jerusalem at length became so utterly obliterated, that during the persecution of Dioclesian, a martyr having said he belonged to it, the governor who heard him supposed it some factious city secretly erected by the Jews. Towards the close of the seventh century, its new name of Ælia Capitolina was still retained. The Christian religion at length found a protector in the Empress Helena, and her son Constantine, who demolished the images of heathen deities, to make way for the erection of crucifixes. An attempt to rebuild the temple by the mild and philosophic Emperor Julian, about 37 years later, is recorded to have proved abortive, from fiery eruptions escaping out of the earth and dispersing the workmen. Jerusalem was taken by Chosroes, King of Persia, in 613, but recaptured by Heraclius in 627. Nine years later, it fell into the power of the Caliph Omar, the third in succession from Mahomet, after a siege of four months; and having undergone still farther revolutions, suddenly became an object of ambition among European potentates, who, notwithstanding their reciprocal contentions, united in disturbing the peaceful possessors of Palestine. During the crusades of 1099, they conquered Jerusalem, and established a sovereignty in Syria, which continued with some interruption until the year 1291, when they were totally expelled. Selim, emperor of the Turks, early in the sixteenth century, finally annexed all Syria to the Ottoman empire, under which it still remains. (*c*)

JESSO, a large island of Asia, the situation, extent, and description of which, have presented the most embarrassing problems to modern geographers. Some have supposed it to be a continent little inferior to Europe in dimensions; others reduce it to an inconsiderable island; and it has also been conceived to be a portion of eastern Asia, very nearly united to the western shores of America. Later observations, however, combined with those of older date forgotten and neglected, have dispelled these obscurities, and satisfactory illustrations can now be given of this particular portion of the globe. **Form and extent.** The figure of Jesso approaches to that of an irregular triangle, extending about 300 miles in length from north to south, and little less in extreme breadth. It stretches from Cape Nadeshda, in 41° 25′ 10″ north latitude, to Cape Romanzoff, in latitude 45° 25′ 50″, the most southern and northern points; and the centre of the island lies in about 217° of east longitude. This island is washed on the west by the Gulf of Tartary; on the east by the North Pacific Ocean; it is divided from Japan by the Straits of Sangar, which are of dangerous and intricate navigation; and separated from the island or peninsula of Saghalin on the north by Perouse's Channel. Its whole circumference is indented by deep bays and inlets, in many places forming secure harbours, by the numerous capes and promontories projecting around them. One of those best known to Europeans is Volcano Bay, towards the south-east, secure and spacious, and containing Endermo harbour, which is completely sheltered by the land. Two lakes are said to be in the centre of the island, each the source of a river flowing into the sea; but none of the estuaries have been surveyed by recent navigators. **General aspect.** The general aspect of Jesso is wild and mountainous: a barren and rugged chain traverses it from north to south, parallel to which it is conjectured that another ranges at some distance. Several of the mountains exhibit active volcanoes, and some of them are extinct volcanoes; three of the former, separated by short intervals, stand on the shore of Volcano Bay. **Productions.** The mineral and vegetable productions are imperfectly described. Gold and silver mines are reported to have been wrought in the eastern parts of the island by the Japanese during the seventeenth century; but they seem to be now abandoned. Neither of these metals, nor precious stones, are valued by the inhabitants. The soil is of unequal quality, and much of the surface is uncultivated. Perhaps also the climate is unfavourable for agriculture.

Productions.

It is remarked, that the northern extremity of Jesso seems to possess many advantages over the southern. Nevertheless about Endermo harbour, the soil is good, and the produce luxuriant. Wild grapes are abundant. The woods contain elm, oak, ash, and all the common trees of England; while the gardens exhibit the ordinary esculent plants. Millet and other grain are plentiful; but the natives are very little addicted to agriculture, as they subsist principally on wild fruits or roots, as the saranna, and by hunting and fishing, although the houses of the Japanese are environed by gardens and plantations. Fish is found in great variety in the surrounding seas. A particular species of anchovies, called nising, of delicious flavour, appears in vast shoals on the surface, driven towards the coast by whales; and quantities of salmon are caught, either for immediate use or winter store. Whales, porpoises, and turtle, are also numerous; but it has been affirmed that the first are unmolested, on account of their services in pursuing the nising. Tripang, or biche de mar, a kind of holothuria prized in eastern repasts, is obtained by diving among the rocks, as also various other animals of the mollusca tribes, whose names are not yet recognised in the works of naturalists; and many crustacea. Of birds, there are numerous aquatic species resembling those of Europe: Eagles are kept tame in cages, and supposed to be an article of food, though it is more probably on account of their feathers for arrows; two kinds of hawk, one of a yellow colour; crows, pigeons, and a yellow bird resembling a linnet. The quadrupeds are horses, which have perhaps been introduced within a century by the Japanese; wolves, foxes, dogs, bears, deer, and rabbits. Deer and bears inhabit the mountains. The latter are seen in considerable numbers among the natives, by whom they are taken young, domesticated, and then killed, and ate as dainties at a certain season, while a portion is used as a medicine. The dogs resemble those of Kamtschatka, but are of a smaller breed. They are trained for draught, and harnessed to sledges in winter, which would indicate, that during a portion of the year the ground is covered with snow. These, however, it is likely, do not exhaust the list of the quadrupeds on this island.

Inhabitants.

Jesso is inhabited by two distinct races of mankind; the aborigines who call themselves Ainos, and the Japanese, who have wrested the island from their possession, and now hold them in subservience. The opinions entertained regarding the former, who also inhabit the island or peninsula of Saghalin, are so singular and discordant as to merit a brief investigation. They have been commonly denominated wild Kuriles, and are supposed to be covered with hair in unnatural profusion—a peculiarity at this day ascribed to the inhabitants of the Kurile Islands. Nor is this opinion more prevalent among the natives of the neighbouring countries than among Europeans who have visited the country. Mozin, a name formerly given to the island by the Japanese, signifies the land of hairy people; and Kannemon, an intelligent interpreter of that nation, by whom it was visited in 1652, says the beards of the men are sometimes two feet long; that the whole face, excepting the eyes and nose, is covered by it; and that the portion depending from the upper lip is raised when they drink. Froes, a Portuguese missionary, who was at Miaco in Japan in 1565, had previously been acquainted with this latter fact, as also that the people were very hairy all over the body; and Saris, an English navigator, learned at Jedo in 1613, that they were as hairy as monkeys. In the fragment which is preserved of the journal of the Castricum in 1643, the hairiness of the whole body, and the size of the beard almost totally covering the face, were both the subjects of observation. It was likewise remarked from her consort the Breskens, a Dutch vessel, which navigated the coasts of Jesso in the same year, that the people leaving the south part in a boat, had long stiff black beards; and in 1738, Captain Spanberg, a Russian, landed on a large island in 43° 50′ north latitude, which if not Jesso itself, as there is some reason to believe, is in its immediate vicinity, where the bodies of the men were wholly covered with long hair. Further, the last English navigator who visited Jesso towards the close of the preceding century, employs these words in describing the natives of the southern extremity. "Their beards were thick and large, covering the greatest part of the face, and inclining to curl. The hair of the head was very bushy, which they cut short before on the forehead, and behind the ears; behind it was cut straight. *Their bodies were almost universally covered with long black hair, and even in some young children we observed the same appearance.*" This combination of testimony would assuredly seem conclusive, did not the still more recent visitors of the Ainos, in the present century, deny that any such characteristic is common among them. Their intercourse, indeed, was more with the northern inhabitants. But in Saghalin they admit that a child of this description was seen, though its parents were distinguished by nothing of the same kind.—We are induced to conclude, upon the whole, that the aborigines of Jesso are more hairy than the generality of mankind. They are somewhat below the middle size, strong and swift, of a dark brown complexion, almost black, with black eyes, and an agreeable physiognomy, and resemble the Kamtschadales, but have more regular features; however, new born children are perfectly white. The women have rather pleasant countenances to the south, while to the north they are ugly, and are scarcely any fairer than the men. The long rough black hair of the latter hangs down from the head behind, and that of the women of the same colour is frequently tied above in a knot, or combed over the face. It is not said that the men lacerate their bodies in any fashion for the purpose of ornament; but the women are tattooed on the hands, face, and feet, and in some parts of the island around the mouth, in flowers or other figures, which are executed by the mother during the earlier age of her offspring. Children go entirely naked. There is little difference between the dress of adults of either sex, but the feet are usually bare. A tobacco box, pipe, and knife, are carried in a belt girding their vestments around the waist. The men wear large ear-rings of gold, silver, or baser metals, according to their rank; the women an ornament of the same kind, consisting of a short chain of two or three silver rings of still greater dimensions. Besides strings of glass beads, and other ornaments, a small shining silver plate or mirror hangs from the neck. Their fashions seem to have undergone little alteration since the earliest visits of Europeans. The Ainos testify a remarkably quiet and placid disposition, intermixed with a large portion of liberality and benevolence. They freely part with their property without any expectations of return, and are always ready to be serviceable. The women are exceedingly timid and reserved, but preserving less gra-

Inhabitants.

vity than the men, who seem tinctured with jealousy, if this may be inferred by their withdrawing them from the view of strangers, and never quitting them for a moment while in their presence. Their oldest visitors describe them as very jealous of strangers when approaching their wives and daughters. Their salutations are exceedingly humble, approaching the strangers who visit their shores in an attitude of abject submission, sitting down cross-legged, stroking their beards, often stretching forth their hands, and bowing almost to the ground.

They speak in a slow and timid accent; and their language, which is peculiar, is intermixed with many Japanese words. They call themselves Ainos, but the real import of this word is not fully understood, whether simply meaning *people*, or distinguishing a particular race.

The Ainos around Endermo harbour, and indeed throughout the island, subsist principally on dried fish, boiled with sea-weed, and mixed with oil. They have also some fruits and vegetables, but excepting about Matzumay, their cultivation of the earth extends no farther than to scanty patches; and subsistence, on the whole, seems precarious. According to the older Eastern authors, all the tame bears are killed in winter, the flesh ate, and the liver reserved as medicinal against poison, and various diseases. But they have little skill in medicine; and in cases of small-pox, or any contagious disorder, they are said to send the sick person to the top of a lofty mountain, or to some remote place. Their houses are built of wood, thatched with reeds, and are generally of an oblong form: The whole family sleep on mats or skins, on a platform around the fireplace, which is in the middle. Small openings to carry off the smoke are made at each end of the roof. Both sexes are very fond of smoking tobacco, yet that plant is not cultivated among them.

The men occupy themselves in the more laborious pursuits of hunting and fishing, while the women are engaged in domestic duties, making cloth of the bark of trees, and sewing and embroidering, which they do very neatly. However, the arts are but in a low state, as is seen in their arms, their boats, and habitations. All articles whose fabrication requires any portion of ingenuity, are supplied by the Japanese. The men are most expert archers, discharging their arrows with remarkable force and precision. The bow is only 37 inches long, the arrow 12 inches; feathered, barbed, and poisoned with so deleterious a substance for killing wild animals, that blood immediately gushes from the mouth and nose, and they die in a few minutes. Their other arms are swords, pikes pointed with iron, and a weapon once known in Europe, which consists of a ball attached by a chain to a handle, somewhat resembling a flail. Their shields are made of seal skin, tripled. They are ignorant of the use of fire arms. The boats of these people are principally built of fir, sewed together with twisted willows, and sharp at both ends. In rowing, each oar or skuller is moved alternately, which prevents the boat from advancing in a straight line.

Manners and customs.

The transient visits of Europeans to Jesso scarcely enable us to speak of the manners and customs of the inhabitants with any degree of certainty, unless in what has casually been the subject of observation; and there is considerable risk of error in misinterpreting what the natives of Japan have written regarding them. Polygamy is said to be practised here without any regard to consanguinity: a brother marries his sister, and the men have from four to eight wives, according to their circumstances. Adultery is punished by cutting the hair off the offender. The infringement of ordinary contracts is attended with the forfeiture of something exceeding the value of the engagement. A tree is planted on the graves of their dead, and blood is then spilled either by mutual encounters somewhat similar to the practice of the savages of New Holland, or by voluntary lacerations, as are frequent in other parts of the world. No external demonstrations of religion have been observed among the Ainos, in temples or places of public worship; neither does it appear that they adore supreme or intermediate deities, though before eating and drinking they offer up a prayer, and likewise pray during sickness.

Political state.

In regard to the political state of this island, the Japanese seem to be masters of the whole, and to employ the natives exclusively for their own benefit. It is divided into five districts, and the government is committed to the prince of Matzumay, but whether he is resident here, or on a neighbouring island, or in Japan, is not explained. We should rather infer that the executive is committed to a viceroy, who lives in the town of Matzumay. It is certain that the Ainos are tributary to the Japanese, and among themselves they have no form of government. Each district is under a chief, whose consideration is proportioned to its extent and population. The inhabitants always add the name of their district to their own name; another peculiarity coinciding with the practice of the New Hollanders. Probably they are collected chiefly towards the coast, where a number of their villages appear; but it is not likely that the island is populous.

It is difficult to form any precise opinion regarding the degree of civilization which has been attained by the Ainos. They are considerably removed from the state of savages, not only in the absence of ferocity, a general attribute, but both in food and clothing. Yet they seem to have undergone only the slightest changes since they are first mentioned in history. A Japanese author of 1720 compares the condition of the Ainos to that of his countrymen 660 years before Christ: "They are ignorant of all ceremonies and social ties, and differ but little from brutes: they eat raw flesh, and drink the blood of animals, nor are they aware that viands cooked are more savoury than raw. Nevertheless, at different places on the east coast they have for some time learned the cultivation of the earth, and to sow grain, from the Japanese; but they are unacquainted with the two seasons for planting rice."

Matzumay.

Besides the aborigines, it rather appears that there is a different race dispersed in scanty numbers in the island, of which no correct intelligence is yet obtained. But the Japanese have been long settled here in different establishments on the coast, the principal of which is Matzumay, said to signify the town of firs. It is situated towards the south-west extremity of the island in Lat. 41° 32′ north, and Long. 219° 56′ east, extending along the margin of an open bay about four miles wide at the entrance, and ascending the rising grounds behind, interspersed with trees and gardens. This town, which has not been visited by modern Europeans, is of considerable magnitude, built of wood and fortified. There are a light-house or observatory on the west side of the bay, which is much frequented by shipping, and two small islands opposite to the town. Between Matzumay and Japan constant and regular intercourse is carried on, but it would seem that the Ainos have always had some channel of communication with Corea or

Jesso.

Tartary. They pay a tribute to the prince of Matzumay, which for those on the coast consists of fish, and for those in the interior of game: and this prince acknowledges the supremacy of Japan by presents and other acknowledgments to the sovereign.

During the greater independence of the Ainos, they resorted to the northern parts of Japan for the purposes of traffic with peltry and the skin of a kind of seal called rakko, a certain marine plant, eagles feathers for arrows, and other commodities; and at present, though subservient to that nation, it is probable some trade is carried on with them.

History.

To trace the history of an island which has been enveloped in so much obscurity, doubt, and perplexity, would be no easy matter. In the words of a learned geographer, who wrote in the middle of the preceding century, "no country of the terrestrial globe has been so differently represented for these last 150 years as the land of Jeso, Jezo, Yeço, Eso, Jedso, Jesso, Yesso," names by which, as well as Insu, it was known. The Japanese seem to carry back the history of this island to a period corresponding with the second year of the Christian æra, at which time it was probably called Mozin: and according to the Chinese histories, it was divided into 55 provinces or districts. In 658, the sovereign of Japan sent a fleet hither with troops, who conquered part of the inhabitants, then divided into three races, one of which was characterised as savage. The Japanese had occasion to repress the natives in 762, when a great stone inscribed with their respective boundaries was erected, which still subsisted in 1720. But the proper history of Jesso is considered as commencing in 1443, when Fakeda Noboe Firo crossing the straits, subdued one half of the island, while the other half submitted to him; and his descendants still inherit the government of it. On occasion of a revolt previous to 1652, which Japanese forces were employed to quell, that nation perhaps first gained a correct knowledge of the country and its inhabitants, who are now driven towards the coast. Before this period, however, Europeans, animated by the desire of propagating their religious opinions, had reached that remote territory. Whether Froes the Portuguese missionary, who gives the earliest account of the natives in 1565, had been in the island, is not evident; but other two missionaries of the same nation, J. Caravaglio, and Jerome de Angelis, were certainly at Matzumay in 1620 and 1621. The people were then represented nearly the same as at present, only very warlike, and much dreaded by the Japanese. The murder of these two missionaries soon after, upon the proscription of the Christian doctrines in Japan, terminated a source of information, which added so much to the geographical knowledge of different Asiatic countries. The loss was in some respects indemnified by the transient observations of successive mariners, which, conjoined to the writings of the Japanese, have illustrated the nature of Jesso, and the manners of its inhabitants. It is singular, however, and ought not to escape notice, that Saris, an English navigator of the beginning of the 17th century, was sufficiently aware of the insular nature of Jesso, its distance from Japan, the Straits of Sangar, and the position of Matzumay, from the information of the Japanese, which were all the subjects of doubt in Britain nearly 200 years later. Indeed, the accuracy of some early navigators is surprising, and there is a general coincidence between their narratives regarding the natives of Jesso, and those which the Japanese obtained somewhat more recently. (*c*)

Jessop.

JESSOP, William. This able engineer and excellent man was born January 12, O.S. 1745, at Plymouth dock, where he was educated. After making some progress in the classics, he acquired a perfect knowledge of the French language, and a considerable share of mathematical science. He early discovered a propensity to mechanical pursuits, and possessing a dexterity of working in wood and metals, he constructed with facility such articles as juvenile projects occasionally required; and his family are now in possession of a tolerably good violoncello of his workmanship when a boy.

These early dispositions recommended him to the notice of Mr Smeaton, then employed in rebuilding the Eddystone light-house, who confirmed his desire of learning the profession of a civil engineer; and he accordingly entered regularly into Mr Smeaton's service, under articles for seven years. This event not only afforded opportunities of employing his talents in a way suited to his natural inclination, but was the means of acquiring the friendship of an able and judicious man, who was well qualified to form his judgment and direct his labours.

Mr Smeaton having, after the completion of the Eddystone light-house, full employment as a civil engineer, his pupil of course benefited by the surveying, investigating, and executing the various works comprehended in such extensive practice. The construction of mills, drainages, harbours, and bridges, and the improvement of river navigations, (as may be seen in Mr Smeaton's reports,) during his seven years regular service, afforded an ample field for acquiring useful knowledge and practical skill. Even in canal making, the repeated surveys, discussions, and progressive practical operations during the execution of the inland navigation between the rivers Forth and Clyde in Scotland, which was under Mr Smeaton's direction, enabled him to obtain, at an early period of life, competent information upon an important part of his profession, which was at that time almost new in British engineering.

The advantages which Mr Jessop thus derived from Mr Smeaton were certainly great; yet there is reason to believe, that his early and constant connection with this eminent engineer, created a degree of timidity in the exercise of his own talents; for we have good authority for stating, that, for some years after the expiration of his articled service, he was almost unwilling to undertake business on his own account. He therefore continued to live with Mr Smeaton, and to act under his immediate direction, and, even when occasionally engaged in business for himself, he took no step without consulting his preceptor. This conduct may, no doubt, be partly attributed to his having become necessary to Mr Smeaton, and to the uninterrupted mutual confidence and esteem which always subsisted between them.

In 1773, he was appointed engineer to the Aire and Calder River navigation in Yorkshire, which, (according to a memorandum in our possession) he states as having found with an income of only £5000 a year, whereas twenty-five years afterwards he left it in the receipt of £30,000 per annum. For several years the improvement of river navigations and drainages constituted his chief employment, though he was also on several occasions consulted in regard to bridges and harbours. In the year 1783 he was appointed engineer for directing the improvements upon the river Trent, in which capacity he continued to act during the rest of his life. He made several surveys and reports for improving the rivers Severne, Mersey, and Irwell; and also the upper part of the Thames.

After Mr Smeaton withdrew from business, Mr Jessop stood at the head of his profession: In the prime of life, and with a sufficient fund of knowledge and experience, his talents became eminently useful during the rapid progress which, at this time, inland navigation made in England. To enumerate the objects of his labours, from the year 1780 to 1800, would be to give a list of nearly all the improvements, of this kind, which were projected and executed during that period: But as this would exceed our prescribed limits, we shall here only observe that the map of the canals in the counties of Derby, Nottingham, Leicester, and Lincoln, were planned and executed under his direction, as was likewise the grand junction canal which connects the midland counties with the metropolis. Besides these, he was occasionally consulted in regard to most of the other canals which were then carrying on in other parts of the kingdom. For several years, previous to his death, he acted jointly with Mr Telford in conducting the great Caledonian canal in the north of Scotland, and that engineer embraced every opportunity of acknowledging, in the warmest manner, the advantages and satisfaction which he derived from the able, upright, and liberal conduct of his enlightened colleague and friend.

In consequence of Mr Jessop's merited reputation, he was consulted respecting the inland navigation of the sister kingdom, which was for many years conducted solely under his direction. The leading arrangements were then made, in order to establish a water communication from the city of Dublin on the east, to the river Shannon in the interior, and by it to Limerick on the west; besides various collateral branches to the southern and northern parts of that fine island. The principal and most difficult operations required to accomplish these desirable objects, were performed under his direction, and the whole put into a state of progress, which afterwards only required to be regulated by the financial resources and growing demands of that rising country.

In regard to harbours, besides many of comparatively inferior importance, which we have not room to enumerate, the great canal and magnificent West India docks in the Isle of Dogs; the extensive improvements in the ports of Bristol, Hull, and Dublin, were planned and executed under his direction. These undertakings, upon an unexampled scale of magnitude and perfection, afford unequivocal evidence of his abilities as an engineer, and at the same time formed a valuable school for others who had occasion to construct similar works.

From being scarcely of sufficient importance to constitute a separate profession when he entered into it, works requiring the attention of a civil engineer, were, in a short time, so greatly increased, that Mr Jessop found that the most unremitting exertions were unequal to the demands upon his services; he, therefore, in the year 1785, introduced Mr Rennie as engineer to the Lancaster canal. This selection is a striking evidence of his discernment of human character, and although as the demand about that time became urgent, such natural talents and assiduity must ultimately have acquired distinction, yet their progress was not a little facilitated by the long continued aid of so experienced and enlightened a friend.

The preceding narrative contains only a rapid sketch of the professional career of this valuable man, who departed this life on the 18th Nov. 1814.

It will be evident to the reader, that in the course of discussing the important article *Inland* NAVIGATION, we shall have frequent opportunities of stating more at length the share that Mr Jessop had in the public works which are here only slightly alluded to, and also the peculiarities in his mode of practice, as well as the particular benefits for which his profession was indebted to him.

His mind was comprehensive, inventive, and sincere. At the age of threescore his mental energies were unabated. Unshackled by prejudices, he retained a youthful ardour for professional improvements; and he would even then not unfrequently display a degree of jealousy, lest a more perfect mode was possible. He constantly devoted his whole mind to the subject before him, and from which all personal considerations seemed excluded. Under these impressions his uniform aim was to accomplish his purposes by the simplest and most economical means: these he sometimes carried to a length to which the average talents of mankind could not always do justice in the execution; but he invariably disdained to screen personal responsibility by unnecessary expenditure, upon the grounds, that it was the business of an engineer, and what ought chiefly to distinguish him from the common workman, to effect his purposes rather by ingenuity of construction, than quantity of materials: that it was an imperative duty rather to risk occasional partial failures from imperfect workmanship, than uniformly to persevere in an unpardonable waste of capital; and that no clamour of ignorance, or prejudice, or consideration of personal interest, should for a moment deter him from this conduct.

His discerning and ingenious mind led him to found his practice upon observation and just principles rather than precedent. In the important articles of Locks, Wharfs, and Retaining Walls, he introduced an entirely new form, composed of nearly one half the quantity of materials employed by the French and early English engineers; he contrived an excellent method of draining morasses and boggy land, more especially for the purpose of constructing a navigable canal through it; he communicated very judicious views respecting the management of flood waters; he seized with eagerness the idea of acquiring an expeditious mode of conveying heavy materials by iron rail roads; and was particularly zealous for the general use of cylindrical broad wheels upon roads composed of gravel. But all these matters, as has been already observed, will be discussed under their proper heads; our intention in mentioning them at present being merely to exhibit the general tenor of Mr Jessop's mind and conduct.

Besides these extensive pursuits in the British islands, his reputation as an engineer led to his being consulted respecting a proposed canal in Spain. What the practical result was, in that distracted and feeble kingdom, it is easy to conjecture. He was also applied to by the American states, to select a properly qualified person for investigating and arranging several proposed inland navigations in that extensive region. In consequence of this, Mr Weston, a very ingenious and well-informed person, was for several years employed in North America; but we suspect that some centuries must yet elapse, before the introduction of this expensive improvement can, with propriety become general in that infant country.

Like most men of truly great minds, his manners were simple; when disengaged from business, and in the company of intimate friends, he not unfrequently displayed a playfulness of disposition, and a fund of entertaining anecdotes. Totally free of all envy and jealousy of professional rivalship, his proceedings in business were free from all pomp and mysticism, and persons of merit never failed in obtaining his friendship and encouragement. Although indefatigable in performing all the duties of an active life, the writer of this article, who for more than twenty years enjoyed his uninterrupted intimacy, has heard it said that he had a natural tendency to indolence; no symptom of it, however, could ever be discovered in his conduct, but rather, as has already been noticed, a degree of anxiety to be of the utmost service to his employers, and to render as perfect as possible the works under his consideration.

A mind thus constituted, and exercising the profession of a civil engineer, was, as might be expected, never behind in regard to physical knowledge and experimental philosophy: His acquirements in these branches of knowledge, joined to his well-earned reputation, led to intimacy with eminent persons of similar characters, such as the celebrated Mr Watt and Dr Franklin. For an acquaintance with the latter he was indebted to an accidental discovery, made as early as the year 1772, with regard to the repelling property of oil on water, and which the Doctor mentions in his works as having been communicated to him by an ingenious pupil of Mr Smeaton.

Mr Jessop has not appeared before the public in the character of an author; for although many of his reports were printed, yet as this was done at the expence of private companies, and as they were not exposed to sale, they are of course in the hands of few. As he was always perfectly master of the subject, his mode of treating it was singularly distinct, comprehensive, and laconic.

Founder.

JESUITS, or the Society of Jesus, one of the most celebrated monastic orders of the Romish church, was founded in the year 1540 by Ignatius Loyola. This extraordinary person was a native of Biscay; and while serving as an officer in the army of Ferdinand V. of Spain, was dangerously wounded in the defence of Pampeluna in 1521. During the progress of a lingering cure, he happened to have no other amusement than what he found in reading the lives of the saints. The perusal of their history inspired his enthusiastic and ambitious mind with an ardent desire of emulating their fabulous exploits. Forsaking the military for the ecclesiastical profession, he engaged himself in the wildest and most extravagant adventures, as the knight of the blessed Virgin. After performing a pilgrimage to the Holy Land, and pursuing a multitude of visionary schemes, he returned to prosecute his theological studies in the universities of Spain, when he was about thirty-three years of age. He next went to Paris, where he collected a small number of associates; and, prompted by his fanatical spirit or the love of distinction, began to conceive the establishment of a new religious order. He produced a plan of its constitutions and laws, which he affirmed to have been suggested by the immediate inspiration of heaven, and applied to the Roman pontiff (Paul III.) for the sanction of his authority to confirm the institution. The Pope referred the petition to a committee of cardinals; and, upon their representing the proposed establishment to be unnecessary and dangerous, refused to grant his approbation. Loyola, however, soon found means to remove the scruples of the court of Rome. He proposed, that the members of his society, besides the usual vows of poverty, chastity, and monastic obedience, should take a fourth vow of subserviency to the Pope, binding themselves, without requiring reward or support, to go wherever he should direct for the service of the church, and to obey his mandate in every part of the globe. At a time when the papal authority had received so severe a shock from the progress of the Reformation, and was still exposed to the most powerful attacks in every quarter, this was an offer too tempting to be resisted. The reigning pontiff, though naturally cautious, and though scarcely capable, without the spirit of prophecy, of foreseeing all the advantages to be derived from the services of this nascent order, yet clearly perceiving the benefit of multiplying the number of his devoted servants, instantly confirmed by his bull the institution of the Jesuits, granted the most ample privileges to the members of the society, and appointed Loyola to be the first general of the order.

Object of the Society.

The simple and primary object of the society was to establish a spiritual dominion over the minds of men, of which the Pope should appear as the ostensible head, while the real power should reside with themselves. To accomplish this object, the whole constitution and policy of the order were singularly adapted, and exhibited various peculiarities which distinguished it from all other monastic orders. The immediate design of every other religious society was to separate its members from the world; that of the Jesuits to render them masters of the world. The inmate of the convent devoted himself to work out his own salvation by extraordinary acts of devotion and self-denial; the follower of Loyola considered himself as plunging into all the bustle of secular affairs, to maintain the interests of the Romish church. The monk was a retired devotee of heaven; the Jesuit a chosen soldier of the Pope. That the members of the new order might have full leisure for this active service, they were exempted from the usual functions of other monks. They were not required to spend their time in the long ceremonial offices and numberless mummeries of the Romish worship. They attended no processions, and practised no austerities. They neither chaunted nor prayed. "They cannot sing," said their enemies, "for birds of prey never do." They were sent forth to watch every transaction of the world which might appear to affect the interests of religion, and were especially enjoined to study the dispositions and cultivate the friendship of persons in the higher ranks. Nothing could be imagined more open and liberal than the external aspect of the institution, yet nothing could be more strict and secret than its internal organization. The gates of the society were thrown open to the whole world, as if there were nothing in its nature to dread disclosure. Men of every description were invited to enter, and talents of every kind were drawn together. It was a company, such as had never yet appeared, of which all mankind might be free at pleasure, but of which every member became in reality an irredeemable slave. Other religious orders were in a manner voluntary associations, of which the executive authority might be vested in certain heads; but whatever affected the whole body as an act of legislation, was regulated by the common suffrage of all its members. Loyola, however, influenced perhaps by the notions of implicit obedience which he had derived from his military profession, resolved that the government of the Jesuits should be absolutely mo-

Form and constitution of the order.

narchical. A general, chosen for life by deputies from the several provinces, possessed supreme and independent power, extending to every person, and applying to every case. By his sole authority he nominated or removed every officer employed in the government of the society. He administered at pleasure the revenues of the order; and disposed of every member by his uncontroulable mandate, assigning whatever service, and imposing whatever task he pleased. To his commands they were required not only to yield outward obedience, but to resign to his direction the inclinations of their wills, and the sentiments of their understandings. Every member of the order, the instant that he entered its pale, surrendered all freedom of thought and action; and every personal feeling was superseded by the interests of that body to which he had attached himself. He went wherever he was ordered; he performed whatever he was commanded; he suffered whatever he was enjoined; he became a mere passive instrument, incapable of resistance. The gradation of ranks was only a gradation in slavery; and so perfect a despotism over a large body of men, dispersed over the face of the earth, was never before realised. To render the subordination more complete, and to enable the general to avail himself to the utmost of his absolute dominion, he was provided with effectual means of perfectly ascertaining the characters and abilities of the agents under his controul. Every novice, who offered himself as a candidate for admission into the order, was required to *manifest his conscience* to the superior, or to a person of his appointment; and not only to confess his defects and vices, but to discover the inclinations, passions, and bent of his soul. This manifestation was renewed every sixth month during the novitiate, which was of considerable length; and every member was also constituted a spy upon the candidates, whose words and actions, and every thing of importance concerning them, he was bound to disclose to the superior. They were required, under this scrutiny, to pass through several gradations of rank, and to have attained the full age of thirty-three years, before they were permitted to take the final vows, and to become professed members. The superiors, under whose immediate inspection they were placed, were thus thoroughly acquainted with their dispositions and talents; and the most minute details of every one's character and capabilities were regularly transmitted to the head office at Rome. These reports were digested and entered into registers, where the general could survey at one view the state of the society in every quarter of the world; the qualifications and talents of its members; and the kind of instruments awaiting his selection for any department in the service. The number of these reports, from the whole thirty-seven provinces of the order, have been calculated at 6584 annually. Besides these, there may be "extraordinary letters," or such as are sent by the monitors or spies in each house; and the provinces were farther bound to state the civil and political circumstances of the various countries where they had their residence. These statements, when relating to matters of importance, were conveyed by a particular cypher known only to the general. The situation and interests of every department were thus intimately known by the head of the whole body; and the employment of every individual member was precisely adapted to his faculties. The meanest talents were in requisition; and, according to their own expression, "the Jesuits had missionaries for the villages, and martyrs for the Indians." There was thus a peculiar energy imparted to the operations of this singular society; which has been compared to a system of mechanism, containing the greatest possible quantity of power distributed to the greatest possible advantage. "The Jesuits," it was said with justice, "are a naked sword, whose hilt is at Rome."

Its maxims and spirit.

The maxims of policy adopted by this celebrated society were, like its constitution, remarkable for their union of laxity and rigour. Nothing could divert them from their original object; and no means were ever scrupled, which promised to aid its accomplishment. They were in no degree shackled by prejudice, superstition, or real religion. Expediency, in its most simple and licentious form, was the basis of their morals, and their principles and practices were uniformly accommodated to the circumstances in which they were placed; and even their bigotry, obdurate as it was, never appears to have interfered with their interests. The paramount and characteristic principle of the order, from which none of its members ever swerved, was simply this, that its interests were to be promoted by all possible means, at all possible expences. In order to acquire more easily an ascendancy over persons of rank and power, they propagated a system of the most relaxed morality, which accommodated itself to the passions of men, justified their vices, tolerated their imperfections, and authorised almost every action, which the most audacious or crafty politician would wish to perpetrate. To persons of stricter principles they studied to recommend themselves by the purity of their lives, and sometimes by the austerity of their doctrines. While sufficiently compliant in the treatment of immoral practices, they were generally rigidly severe in exacting a strict orthodoxy in opinions. "They are a sort of people," said the Abbé Boileau, "who lengthen the creed and shorten the decalogue."

Missions.

They adopted the same spirit of accommodation in their missionary undertakings; and their Christianity, cameleon-like, readily assumed the colour of every region, where it happened to be introduced. They freely permitted their converts to retain a full proportion of the old superstitions, and suppressed without hesitation any point in the new faith, which was likely to bear hard on their prejudices, or propensities. They proceeded to still greater lengths; and, besides suppressing the truths of revelation, devised the most absurd falsehoods, to be used for attracting disciples, or even to be taught as parts of Christianity. One of them, in India, produced a pedigree to prove his own descent from Brama; and another in America assured a native chief that Christ had been a valiant and victorious warrior, who, in the space of three years, had scalped an incredible number of men, women, and children. It was in fact their own authority, not the authority of true religion, which they wished to establish; and Christianity was generally as little known, when they quitted the foreign scenes of their labours as when they entered them.

Secret rules.

But the most singular regulations, which principally contributed to extend the power of the Jesuits, and to form that enterprising and intriguing spirit by which they were distinguished, were long unknown to the rest of mankind, and were concealed with a degree of care, which might alone have excited the worst suspicions of their nature. It was their favourite maxim, from their first institution, never to publish even the ordinary rules and registers of the order. These were preserved, as an impenetrable mystery, not only from strangers, but even from the greater part of their own members. They refused to produce them, when required by courts of justice; and it was not till the public prosecutions against them in Portugal and France, which terminated in their overthrow, had commenced, that the mysterious volumes of the institute were unveiled to the world. But the "*Secreta Monita*,"* or hidden rules of the society, which were not discovered till nearly fifty years after the abolition of the order, and which most unequivocally unfold the detestable nature of the institution, were most anxiously withheld from every eye, except those of the most thoroughly initiated. They were directed to be communicated, even to professed members, with the utmost caution, and then only as the result of personal experience, not as the recorded rules of the institution. In the event also of their falling into the hands of strangers, it was expressly enjoined, that they must be positively denied to be the rules of the society. A few extracts from these hidden precepts will furnish the reader with the best exposure of the spirit and tendency of jesuitism. "Princes and distinguished persons must by all means be so managed (by the members of the society), that they may gain their ear, which will easily secure their hearts; so that all persons will become dependent upon them, and opposition be prevented.—Since ecclesiastics secure the greatest favour by winking at the vices of the great, as in the case of incestuous marriages, &c. such persons must be led to hope, that, through their aid, a dispensation may be obtained from the Pope, which he will no doubt readily grant.—It will further their object, if their members insinuate themselves into foreign embassies, but especially in those to the Pope.—Favour must, above all, be obtained with the dependents and domestics of princes and noblemen, who, by presents and offices of piety, may be so far biassed as to impart intelligence of their employer's inclinations and intentions.—Princesses and females of rank may be gained by women of their bedchambers, who must therefore be particularly addressed, whereby there will be no secrets concealed from their members.—Their confessors must allow greater latitude than those of other orders, in order that their penitents, being allured with such freedom, may relinquish others, and entirely depend on their direction and advice.—Prelates must be engaged to employ the Jesuits both for confessors and advisers. Care must be taken, when princes or prelates found either colleges or parish churches, that the society always have the right of presenting, and that the superior of the Jesuits for the time being be appointed to the cure, so that the whole government of that church and its parishioners may become dependent on the society.—Wherever the governors of academies thwart their designs, or the Catholics or heretics oppose their foundations, they must endeavour, by the prelates, to secure the principal pulpits.—Their members, in directing the great, must seem to have nothing in view but God's glory; and not immediately, but by degrees, interfere in political and secular matters, solemnly affirming, that the administration of public affairs is what they engage in with reluctance, and only as compelled by a sense of duty.—In order to induce rich widows to be liberal to the society, they must be provided with confessors, who may urge their remaining unmarried, by assuring them that they will thereby infallibly secure their salvation, and effectually escape the pains of purgatory.—That the widow may dispose of her property to the society, she must be told of those who have devoted themselves to the service of God, and be led to expect canonization from the court of Rome. Confessors must also enquire of their penitents what family, relations, friends, and estates they possess, and what they have in expectancy, as also their intentions, which they must endeavour to mould in favour of the society. Such members as make a scruple of acquiring riches for the society must be dismissed; and if they appeal to the provincials, they must not be heard, but pressed with the statute, which commands implicit obedience from all.—Such as retain a love for other orders, for the poor, or their relations, must be dismissed, since they are likely to prove of little service.—All, before dismission, must be prevailed upon to subscribe and make an oath, that they will never, directly or indirectly, either write or speak any thing to the disadvantage of the order; and the superiors must keep an account of the sins, failings, and vices, which they formerly confessed, to be used against them, if occasion requires, in order to prevent their future advancement in life; and noblemen and prelates, with whom they may have credit, must be prevailed upon to deny them their protection.—All must be caressed, who are distinguished either for their talents, rank, or wealth, especially if they have friends attached to the society, or possessed of power; such must be sent to Rome, or some celebrated university, for study; but, if they prefer the provinces, the professors must inveigle them into a surrender of their effects to the society, and the superiors must shew a particular regard to such as have allured any promising youths into the society. The preceptors must not chastise or keep in subjection young men of good genius, agreeable persons, and noble families, like their other pupils: they must be won by presents, and the indulgence of liberties peculiar to their age; but on other occasions, especially in exhortations, they must be terrified with threats of eternal punishment, unless they obey the heavenly invitation of joining the society. If any member expects a bishopric or other dignity, he must take an additional vow always to think and speak honourably of the society; never to have a confessor who is not a Jesuit; nor determine any affair of moment, without first consulting the society. The society will contribute much to its own advantage, by fomenting and heightening (but with caution and secrecy) the animosities that arise among princes and great men, in order that they may weaken each other."

History and progress of the society.

These detestable objects and principles, however, were long an impenetrable secret; and the professed intention of the new order, was to promote with unequalled and unfettered zeal the salvation of mankind. Its progress, nevertheless, was at first remarkably slow. Charles V. who is supposed, with his usual sagacity, to have discerned its dangerous tendency, rather checked than encouraged its advancement; and the universities of France resisted its introduction into that kingdom. Thus, roused by obstacles, and obliged to find resources within themselves, the Jesuits brought all their talents and devices into action. They applied themselves to every useful function and curious art; and neither neglected nor despised any mode, however humble, of

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* These and other institutions, which contributed most essentially to the power and permanence of the society, are attributed to the genius of Laynez and Aquaviva, the two generals who succeeded Loyola, and who were far superior to their fanatical master in the science of government and the knowledge of human nature.

gaining employment or reputation. The satirist's description of the Greeks in Rome, has been aptly chosen to describe their indefatigable and universal industry.

> *Grammaticus, rhetor, geometres, pictor, aliptes,*
> *Augur, schenobates, medicus, magus, omnia novit*
> *Græculus.*——

They laboured with the greatest assiduity to qualify themselves as the instructors of youth; and succeeded, at length, in supplanting their opponents in every Catholic kingdom. They aimed, in the next place, to become the spiritual directors of the higher ranks; and soon established themselves in most of the courts which were attached to the Papal faith, not only as the confessors, but frequently also as the guides and ministers of superstitious princes. The governors of the society, pursuing one uniform system with unwearied perseverance, became entirely successful; and, in the space of half a century, had in a wonderful degree extended the reputation, the number, and influence of the order. When Loyola, in 1540, petitioned the Pope to authorize the institution of the Jesuits, he had only ten disciples; but in 1608, the number amounted to 10,581. Before the expiration of the sixteenth century, they had obtained the chief direction of the education of youth in every Catholic country in Europe, and had become the confessors of almost all its noblest monarchs. They thus formed the minds of men in their youth, and retained the ascendancy over them in their advanced years. They took part in every public measure, and possessed at different periods the direction of the principal courts in Europe. They preserved the highest degree of influence with the Roman pontiffs, as the most zealous champions of their authority; and were equally celebrated by the friends, and dreaded by the adversaries of the Catholic faith, as the ablest and most enterprising order in the church. In 1710, they possessed 24 professed houses, 59 houses of probation, 340 residences, 612 colleges, 200 missions, 150 seminaries, and 19,998 members.

Its power and wealth.

In spite of their vow of poverty, their wealth increased with their power; and they soon rivalled, in the extent and value of their possessions, the most opulent monastic fraternities. Besides the sources of wealth common to all the regular clergy, they possessed one peculiar to themselves. Under the specious pretext of facilitating the success and support of their mission, they obtained a special license from the court of Rome to trade with the nations whom they laboured to convert; and though these mercantile schemes tended ultimately to accelerate their ruin, they proved, during a century and a half, a most lucrative source of property and influence. Besides carrying on an extensive commerce both in the East and West Indies, and opening warehouses in different parts of Europe for the purpose of vending their commodities, they aimed at obtaining settlements, and reigning as sovereigns. It was in this latter capacity, unsuitable as it may seem to their whole character, that they exhibited the most wonderful display of their abilities, and contributed most essentially to the benefit of the human species.

Its establishments in South America.

About the beginning of the 17th century, they obtained from the court of Madrid the grant of the large and fertile province of Paraguay, which stretches across the southern continent of America, from the mountains of Potosi to the banks of the river La Plata; and, after every deduction which can reasonably be made from their own accounts of their establishment, enough will remain to excite the astonishment and applause of mankind. They found the inhabitants in the first stage of society, ignorant of the arts of life, and unacquainted with the first principles of subordination. They applied themselves to instruct and civilize these savage tribes. They commenced their labours, by collecting about fifty families of wandering Indians, whom they converted and settled in a small township. They taught them to build houses, to cultivate the ground, and to rear tame animals; trained them to arts and manufactures, and brought them to relish the blessings of security and order. By a wise and humane policy, they gradually attracted new subjects and converts; till at last they formed a powerful and well organized state of 300,000 families. Over these they exercised a mild and patriarchal government, and their subjects, docile and grateful, revered their benefactors as divinities. The country was divided into 47 districts, over each of which a Jesuit presided. A few magistrates, chosen by the Indians themselves, assisted in every town to secure obedience to the laws. In other respects all the members of the community were, as one family, on a footing of perfect equality, and possessed all things in common. Every individual was obliged to labour for the public, and the fruits of their industry were deposited in common-store houses, from which every person received whatever was necessary for the supply of his wants. Punishments were rare, and always of the mildest description, such as an admonition from the Jesuit, a slight mark of disgrace, or at most a few lashes with a whip. Industry was universal, but wealth and want were equally unknown; and most of those passions, which disturb the peace of society, were deprived of every opportunity to operate. Even the elegant arts began by degrees to appear, and full protection was provided against every invader. An army of 60,000 men was completely armed and regularly disciplined, consisting of cavalry, infantry, artillery, and well provided with magazines of all the implements of war. The Indians of Paraguay, in short, under the government of the Jesuits, were an innocent and happy people, civilized without being corrupted, and yielding with entire contentment the most perfect submission to an absolute but equitable government. Yet, even in this most meritorious effort for the welfare of mankind, the peculiar spirit of the order was sufficiently discernible. In order to preserve their influence, they found it necessary to keep their subjects in a state of comparative ignorance; and, besides prohibiting all intercourse with the adjacent settlements of the Spaniards and Portuguese, they endeavoured to inspire them with a hatred and contempt of those nations. They prevented their subjects from learning any language, except a native dialect, (the Guarani,) which they endeavoured to improve as a general standard, and plainly aimed at establishing an independent empire, subject only to their order, which could scarcely have failed, from its excellent constitution and police, to have extended its dominion over all the southern continent of America.

Reverses and overthrow of the society.

Though the power of the Jesuits had become so extensive, and though their interests generally prospered during a period of more than two centuries, their progress was by no means uninterrupted; and, by their own misconduct, they soon excited the most formidable counteractions. Scarcely had they effected their establishment in France, in defiance of the parliaments and universities, when their existence was endangered by the fanaticism of their own members. John Chastel, one of their pupils, made an attempt upon the life of Henry IV.; and Father Guiscard, another of the order, was convicted of composing writings favourable to regicide. The parliaments seized the moment of their disgrace, and procured their banishment from every part of the kingdom, except the provinces of Bourdeaux and Toulouse. From these rallying points, they speedily extended their intrigues in every quarter, and in a few years obtained their re-establishment. Even Henry, either dreading their power, or pleased with the exculpation of his licentious habits, which he found in their flexible system of morality, became their patron, and selected one of their number as his confessor. They were favoured by Louis XIII. and his minister Richelieu, on account of their literary exertions; but it was in the succeeding reign of Louis XIV. that they reached the summit of their prosperity. The Fathers La Chaise and Le Teltier, were successively confessors to the king; and did not fail to employ their influence for the interest of their order; but the latter carried on his projects with so blind and fiery a zeal, that one of the Jesuits is reported to have said of him, "he drives at such a rate, that he will overturn us all." The Jansenists were peculiarly the objects of his machinations, and he rested not till he had accomplished the destruction of their celebrated college and convent at Port Royal. Before the fall, however, of this honoured seminary, a shaft from its bow had reached the heart of its proud oppressor. The "Provincial Letters of Pascal" had been published, in which the quibbling morality and unintelligible metaphysics of the Jesuits were exposed in a strain of inimitable humour, and a style of unrivalled elegance.[*] The impression which they produced was wide and deep, and gradually sapped the foundation of public opinion, on which the power of the order had hitherto rested. Under the regency of the Duke of Orleans, the Jesuits, and all theological personages and principles were disregarded with atheistical superciliousness; but under Louis XV. they partly recovered their influence at court, which, even under Cardinal Fleury, they retained in a considerable degree. But they soon revived the odium of the public by their intolerant treatment of the Jansenists, and probably accelerated their ruin by refusing, from political rather than religious scruples, to undertake the spiritual guidance of Madame de la Pompadour, as well as by imprudently attacking the authors of the *Encyclopedie*. Voltaire directed against them all the powers of his ridicule, and finished the piece which Pascal had sketched. Their power was brought to a very low ebb, when the war of 1756 broke out, which occasioned the famous law-suit that led to their final overthrow. By that time the society had indicated many symptoms of decay, both in point of talents and activity, and had rendered themselves at once contemptible and odious. They had disgusted the court by their scruples, irritated the philosophers by their clamours, exasperated the other religious orders by their persecutions, and alienated the public by their long and insolent domination. A reasonable pretext was all that was wanted to put down a sect, which had long ceased to be either popular or formidable. The opportunity was soon furnished by their own impudent obstinacy. The war recently commenced, had occasioned great losses in their trade with Martinico, the weight of which would have fallen in part upon the society's correspondents at Lyons and Marseilles. These merchants, however, alleged that the Jesuits in France were responsible for the debts of their missionaries in America, and insisted upon being indemnified from the funds of the order. The claim was resisted, and a law suit commenced, which the Jesuits, by virtue of their privilege, removed from the provincial parliament to the great chamber at Paris. This measure rendered the dispute and their defeat subjects of more general notoriety. They were condemned to pay large sums to the adverse party, and prohibited thenceforth from meddling in commercial concerns. The sources of their wealth were thus diminished, and their enemies encouraged to renewed attacks. The questions at issue in the commercial dispute, had given the magistrates a plausible occasion for demanding to inspect the constitutions of the society; and, in a luckless hour for themselves, they consented to produce their books. The parliament instantly saw and seized the advantage which they had gained, and resolved to effect the destruction of the order. By an arret of the 11th August 1761, the Jesuits were required to appear at the end of a year to receive judgment on their constitution, which, it was now discovered, had never been approved with the requisite forms. In the mean time the king of Portugal was assassinated; and Carvalho, the minister, who detested the Jesuits, found means to load them with the odium of the crime. Malagrida, and a few more of these fathers, were charged with advising and absolving the assassins, and having been found guilty, were condemned to the stake. The rest were banished with every brand of infamy, and were treated with the most iniquitous cruelty. They were persecuted without discrimination, robbed of their property without pity, and embarked for Italy without previous preparation; so that no provision having been made for their reception, they were literally left to perish with hunger in their vessels. These incidents prepared the way for a similar catastrophe in France. During the year allotted for the investigation of their rules and records, the court evinced a disposition to protect them, and the bishops declared unanimously in their favour; but an unforeseen public calamity rendered it necessary to appease the nation by some acceptable measure; and the Jesuits, after all, are supposed to have been sacrificed more as a trick of state than as an act of justice.

In March 1762, the French court received intelligence of the capture of Martinico by the British; and dreading a storm of public indignation, resolved to divert the exasperated feelings of the nation, by yielding the Jesuits to their impending fate. On the 6th of August 1762, their institute was condemned by the parliament, as contrary to the laws of the state, to the obedience due to the sovereign, and to the welfare of the kingdom. The order was dissolved, and their effects alienated. But still the members, though no longer dressed in their religious habit, continued to hover about the court; and, had they preserved their original cautious and patient policy, might have succeeded in recovering their privileges. But former successes inspired them with a fatal confidence. One of the archbishops, indignant that the parliament should presume to dispense with ecclesiastical vows, issued a mandate in favour of the Jesuits, and the fathers were accused of having employed themselves too industriously in the circulation of this paper. The parliament took the alarm, and pronounced a decree, that every Jesuit, whether professor or novice, should, within eight days, make oath that he renounced the institution, or quit the kingdom. In a body, whose moral principles were so

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[*] See also *La Morale Pratique des Jesuits*, per Arnauld.

relaxed, and whose members, while it existed, scrupled no subtilties in promoting its interests, it is a remarkable circumstance, that, as secularized individuals, they acted in this instance with strict integrity, and refused the alternative of the oath. They were therefore ordered to quit the kingdom, and this judgment was executed with the utmost rigour. The poor, the aged, the sick, were included in the general prescription. But in certain quarters, where the provincial parliaments had not decided against them, Jesuits still subsisted; and a royal edict was afterwards promulgated, which formally abolished the society in France, but permitted its members to reside within the kingdom under certain restrictions. *

In Spain, where they conceived their establishment to be perfectly secure, they experienced an overthrow equally complete, and much more unexpected. The necessary measures were concerted under the direction of De Choiseul, by the Marquis D'Ossun, the French ambassador at Madrid, with Charles III. King of Spain, and his prime minister the Count D'Aranda. The execution of their purpose was as sudden as their plans had been secret. At midnight, (March 31st 1767), large bodies of military surrounded the six colleges of the Jesuits in Madrid, forced the gates, secured the bells, collected the fathers in the refectory, and read to them the king's order for their instant transportation. They were immediately put into carriages, previously placed at proper stations; and were on their way to Carthagena before the inhabitants of the city had any intelligence of the transaction. Three days afterwards, the same measures were adopted with regard to every other college of the order in the kingdom, and ships having been provided at the different sea-ports, they were all embarked for the ecclesiastical states in Italy. All their property was confiscated, and a small pension assigned to each individual as long as he should reside in a place appointed, and satisfy the Spanish court as to his peaceable demeanour. All correspondence with the Jesuits was prohibited, and the strictest silence on the subject of their expulsion was enjoined under penalties of high treason. A similar seizure and deportation took place in the Indies, and an immense property was acquired by the government. Many crimes and plots were laid to the charge of the order; but whatever may have been their demerit, the punishment was too summary to admit of justification; and many innocent individuals were subjected to sufferings beyond the deserts even of the guilty. Pope Clement III. prohibited their landing in his dominions; and, after enduring extreme miseries in crowded transports, the survivors, to the number of 2300, were put ashore on Corsica. The example of the King of Spain was immediately followed by Ferdinand VI. of Naples, and soon after by the Prince of Parma. They had been expelled from England in 1604; from Venice in 1606; and from Portugal in 1759, upon the charge of having instigated the families of Tavora and D'Aveiro to assassinate King Joseph I. Frederick the Great of Prussia was the only monarch who shewed a disposition to afford them protection; but, in 1773, the order was entirely suppressed by Pope Clement XIV. who is supposed to have fallen a victim to their vengeance.† In 1801, the society was restored in Russia by the Emperor Paul; and in 1804, by King Ferdinand in Sardinia. In August 1814, a bull was issued by the present Pope, Pius VII. restoring the order to all their former privileges, and calling upon all Catholic princes to afford them protection and encouragement. This act of their revival is expressed in all the solemnity of Papal authority; and even affirmed to be above the recal or revision of any judge with whatever power he may be clothed; but to every enlightened mind it cannot fail to appear as a measure altogether incapable of justification, from any thing either in the history of Jesuitism or in the character of the present times.

General character of the Jesuits.

It would be in vain to deny, that many considerable advantages were derived by mankind from the labours of the Jesuits. Their ardour in the study of ancient literature, and their labours in the instruction of youth, greatly contributed to the progress of polite learning. They have produced a greater number of ingenious authors than all the other religious fraternities taken together; and though there never was known among their order one person who could be said to possess an enlarged philosophical mind, they can boast of many eminent masters in the separate branches of science, many distinguished mathematicians, antiquarians, critics, and even some orators of high reputation. They were in general, also, as individuals, superior in decency, and even purity of manners, to any other class of regular clergy in the church of Rome. Their active and literary spirit furnished, likewise, a most beneficial counteraction to the deadening influence of their contemporary monastic institutions. Even the debased species of Christianity, which they introduced among the savage tribes of America, and the more civilized nations of the East, was infinitely superior, both in its consolations and morals, to the bloody and licentious rites of idolatry. But all these benefits by no means counterbalanced the pernicious effects of their influence and intrigues on the best interests of society.

The essential principles of the institution, viz. that their orders is to be maintained at the expence of society at large, and that the end sanctifies the means, are utterly incompatible with the welfare of any com-

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* The Duke de Choiseul, the French minister, was a principal agent in procuring their final suppression, and the following origin has been assigned to be the hostility with which he pursued the whole order in every quarter of Europe. The Duke having no employment in the government of France, happened one evening at supper to say something very strong against the Jesuits. Some years afterwards, he was sent ambassador to Rome, where, in the usual routine of his visits in that situation, he called upon the General of the Jesuits, for whose order he professed the highest veneration. "Your Excellence did not always, I fear, think so well of us," replied the General. The Duke, much surprised at this observation, begged to know what reasons he had for thinking so, as he was not conscious that he had ever mentioned the order but in terms of the highest respect. The General, to convince him of the contrary, shewed him an extract from a large register book belonging to the society, in which the particular conversation alluded to, and the day and the year in which it happened, were minuted down. The ambassador blushed, and excused himself as well as he could, and soon went away, resolving within himself, whenever he should become prime minister, to destroy a society that kept up such particular and detailed correspondences, of which it might make use to the detriment of administration and government."—Seward's *Biographiana.*

† It was long a current story at Rome, that this pontiff was accustomed to withdraw in the course of the grand mass to take some refreshment; that a young priest, on one of these occasions, brought chocolate to his Holiness, and immediately withdrew; that the proper officiating priest soon after appeared with another cup, the pope shook his head, as conscious of having received a fatal potion; that he pined from that day of a lingering disease, which reduced his body to the appearance of a skeleton; and that he was known to have said, in allusion to the secret cause of his death, "I am going to eternity, and I know for what."

munity of men. Their system of lax and pliant morality, justifying every vice, and authorizing every atrocity, has left deep and lasting ravages on the face of the moral world. Their zeal to extend the jurisdiction of the court of Rome over every civil government, gave currency to tenets respecting the duty of opposing princes who were hostile to the Catholic faith, which shook the basis of all political allegiance, and loosened the obligations of every human law. Their indefatigable industry, and countless artifices in resisting the progress of reformed religion, perpetuated the most pernicious errors of Popery, and postponed the triumph of tolerant and Christian principles. Whence, then, it may well be asked, whence the recent restoration? What long latent proof has been discovered of the excellence or even the expedience of such an institution? The sentence of their abolition was passed by the senates, and monarchs, and statesmen, and divines, of all religions, and of almost every civilized country in the world. Almost every land has been stained and torn by their crimes; and almost every land bears on its public records the most solemn protests against their existence. Even they who loved popery, but dreaded the atrocities and ambition of Jesuitism; even an infallible pontiff, in his cool judicial capacity, after a most solemn hearing, and in the face of its most powerful advocates, pronounced its condemnation. What new witness has appeared to testify its virtues? What adequate cause been made out for its revival? If an instrument is wanted, (says an able opponent of Jesuitism*), which may at once quench the flame of charity—throw us back in the career of ages—sow the seeds of everlasting division—lay a train which is to explode in the citadel of truth, and overturn her sacred towers—we venture confidently to affirm that Jesuitism is that instrument. But, as for any other advantages either to Protestantism or Popery, it is for the Pope, or any other infallible reasoner, to shew. Till some such superior being shall stoop down to instruct us on this point, and to establish a fact which the Jesuits themselves for two centuries, and by a whole regiment of folios, endeavoured to establish in vain, we must venture to conclude, with our forefathers, with the kings, and queens, and parliaments, and judges, and churches of Europe, and with the infallible Pope Clement XIV. that Jesuitism is a public nuisance; and that he who endeavours to let it loose upon society, is chargeable with high treason against the common interests and happiness of his species." See Robertson's *History of Charles V.* vol. ii. *and the authorities there cited*; D'Alembert's *Narrative of the destruction of the Jesuits*; *A short View of the Polity of the Jesuits in Paraguay*, attributed to the pen of Mr Burke, and to be found in the 1st vol. of *The European Settlements in America*; Southey's *History of Brazil*; Adolphus' *History of England*, vol. i.; Mosheim's *Ecclesiastical History*, vol. iv.; *Christian Observer*, vol. vi.; and *A Brief Account of the Jesuits, &c.* London, 1815. (*q*)

JESUS. See CHRISTIANITY, ECCLESIASTICAL HISTORY, vol. viii. p. 302, and THEOLOGY.

JET. See MINERALOGY.

JET D'EAU. See HYDRODYNAMICS, vol. xi. page 507.

JEWELS. See GEMS and MINERALOGY.

JEWS.

IN the present article, we propose to lay before our readers, in the first place, a brief sketch of the history of the Jews from the period of their return to Jerusalem from Babylon, and the rebuilding of their city and temple under Ezra and Nehemiah, when the scriptures leave off any farther accounts, and when profane historians begin to take notice of them, till the destruction of Jerusalem under Titus;—in the second place, notices of their history since that event, especially such as relate to their history in England;—and lastly, a general view of their opinions, traditions, rites, and ceremonies.

History.
534 B. C.
Nehemiah.

I. In the year 534 B. C. the foundations of the temple at Jerusalem were laid; and after a great many obstacles and delays, it was finished, as related in the books of Ezra and Nehemiah. The last of these chiefs died about the year 409 B. C. He justly may be ranked among the great characters of ancient history. He forsook a place of influence at the most splendid court of Asia to encounter every hardship, actuated by the patriotic and beneficent wish of bestowing independence and happiness upon his poor, ignorant, and wretched countrymen, and of raising them, by moral and religious education, to the rank of a brave, industrious, and comparatively virtuous nation. Before Nehemiah, the Jews were addicted to idolatry, and totally ignorant of a future state; he however succeeded, by a wise and judicious selection of their laws and traditions, and by directing their attention more to practice than to disputation, in rendering them austerely moral, and brave defenders of their independence.

351 B. C.

Still there existed sources of calamity and distress among them; their country was only a province of Syria, subject to the kings of Persia. The Syrian governors, in order to secure and extend their influence and power, conferred the administration of affairs upon the high-priests. The bad effects of this measure soon became apparent, in creating jealousies among those who thought they had a claim to this office. The first public calamity that befel the Jewish nation after their return from Babylon occurred in the year 351 B. C.; when, in consequence of their having offended the king of Persia, he took Jericho, and carried off all the inhabitants captives. When Alexander invaded Persia, they seem to have pursued commerce with such great success, that it appeared to that monarch an object to obtain the settlement of Jewish colonies in his sea ports. He also favoured them in many other respects; but the story of his interview with the high-priest seems of very doubtful credit. On the death of Alexander, Judea, from its locality, lying between Syria and Egypt, was exposed to all the revolutions and wars which his successors waged with each other. After Ptolemy had succeeded in wresting Syria and Phœnicia from Leomedon, he laid siege to Jerusalem. The Jews were prepared for a long and obstinate resistance; but Ptolemy being informed that they would not fight

Jerusalem
taken by
Ptolemy.

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* *Christian Observer*, vol. xiv.

on their Sabbath, assaulted the city on that day, and easily took it. When this monarch, five years afterwards, was obliged to yield Judea to Antigonus, the latter behaved to the Jews in such a tyrannical manner, that great numbers of them fled into Egypt and Syria, and Judea seemed in danger of being entirely depopulated till it was recovered by Ptolemy in the year 292 B. C. In the reign of Ptolemy Philopater, a dreadful persecution was carried on against them, in consequence of their attempting to prevent that monarch from profaning the temple, by entering into the sanctuary.

Jews favoured by Antiochus, 204 B. C.

Civil discords, 176 B. C.

Judea ravaged by Antiochus, 168 B. C.

On their ready submission, in the year 204 B. C. to Antiochus the Great, they gained such a strong hold on his favour, that he promised to restore Jerusalem to its former splendour, to recall the Jews, and to replace them, as far as possible, in their ancient privileges. He actually granted an exemption of taxes to all the dispersed Jews that would come, within a limited time, to settle in Jerusalem; and he ordered all who were slaves in his dominions to be set free. But the Jews were not long to enjoy this prosperity. About the year 176 B. C. a quarrel happened between the high-priest and the governor of the temple, which was attended with the most fatal consequences, a civil war ensuing, in which many fell on both sides. When Antiochus Epiphanes ascended the throne of Syria, Jason, the high-priest's brother, purchased from that monarch the high-priesthood; and afterwards introduced Grecian customs, and the ceremonies of paganism among the Jews. From this time the service of the temple was neglected, and a general apostacy took place. The power of Jason, however, was not of long continuance; for his brother Menelaus having offered to the Syrian monarch a higher price than Jason gave for the priesthood, and having moreover promised to renounce Judaism, and embrace the religion of the Greeks in all respects, that monarch gave Menelaus a force sufficient to drive Jason out of Jerusalem. Menelaus conducted himself with great tyranny towards the Jews, who complained of him to Antiochus; but that monarch paid no attention to their complaints so long as Menelaus could procure money to bribe him. About the year 170 B. C. Antiochus marched against Jerusalem, in consequence of the Jews having rebelled, and made great rejoicings on the report that he had been killed at the siege of Alexandria. He soon made himself master of the city, where he behaved with such cruelty, that it is supposed, in the course of three days, 40,000 Jews were killed, and as many sold for slaves. Menelaus still retained the protection and favour of the Syrian monarch, and if possible exceeded his former acts of tyranny and cruelty. But the Jews were reserved for yet greater calamities; for, about the year 168 B. C. Antiochus, having been most severely mortified by the Romans, resolved to wreak his vengeance on the Jews. He accordingly dispatched an army of 22,000 men to plunder all their cities, to murder all the men, and to sell the women and children for slaves. The Jews, incapable of resistance, beheld their city taken, their temple profaned, and their religion abolished. About 10,000 of them, who escaped the slaughter, were carried away captive. In order still more effectually to accomplish his purpose, the Syrian monarch ordered the temple to be dedicated to Jupiter Olympius, and his statue to be set up on the altar of burnt-offering. All who refused to come and worship were massacred, or tortured till they complied. Altars, groves, and statues were raised throughout Judea, at which the inhabitants were compelled to worship, while it was instant death to observe the Sabbath, circumcision, or any other of the rites and ceremonies instituted by Moses.

Jews roused by Mattathias. 167 B. C.

The Jews now yielded to despair, when an eminent priest, named Mattathias, had the courage to oppose the orders of the king, and, by his example and exhortations, roused the spirits and the zeal of his countrymen. In the year 167 B. C. Mattathias, finding that his followers daily increased in number, attacked the Syrians and apostate Jews, marching from city to city, overturning the idolatrous altars, and opening the synagogues. He was so successful, that in the space of a year he had extended his reformation throughout a considerable part of Judea, and he could probably have completed it had he not died.

Judas Maccabeus, 163 B. C.

He was succeeded by the famous Judas Maccabeus, who, at the head of 6000 men, made himself master of some of the strongest fortresses in Judea, and after defeating the Syrians in five pitched battles, drove them entirely out of the country, except from a strong fort built over against the temple. In the year 163 B. C. after the death of Antiochus, a peace was concluded upon terms very advantageous to the Jewish nation; but it was not of long continuance. Judas was again successful in five engagements; in the sixth, however, having been abandoned by all his troops except 800, he, together with this gallant band, was slain in the year 161 B. C. Jonathan and Simon, his brothers, succeeded him. The latter drove the Syrian garrison from the fortress of Jerusalem, but was at last treacherously murdered by his son-in-law about 135 B. C.

Alexander Jannæus, 105 B. C.

Rebellion of the Pharisees.

Simon was succeeded by his son Hyrcan, who made himself master of all Palestine, as well as of Samaria and Galilee. He was successful and happy till the last year of his life, when he became involved in a quarrel with the Pharisees, which is supposed to have shortened his days. The factious and turbulent spirit of this sect also proved very troublesome to Alexander Jannæus, who obtained the royal power in the year 105 B. C. and who seems to have been a monarch of great activity, enterprise, and talent. While he was engaged in subduing his foreign enemies, the Pharisees raised a rebellion at home, but this he quashed in the year 86 B. C.; and, by treating them with very great severity, not to say cruelty, he prevented them from again disturbing his reign. Alexander having made several conquests in Syria, died about 79 B. C. He left two sons, Hyrcanus and Aristobulus, but bequeathed the government to his wife as long as she lived. The Pharisees by this time had again put forth their power, and became so turbulent as to render the situation of the queen very unpleasant: they even compelled her to persecute the Sadducees in a most cruel manner. On her death, contests began between her sons: the Pharisees supported Hyrcanus, but his army deserting to Aristobulus, the former was obliged to abandon all title both to the royal and pontifical dignity. His party, notwithstanding, still existed and were active; and having obtained the assistance of the King of Arabia, invaded Judea, defeated Aristobulus, and closely besieged him in Jerusalem. In this situation, the latter called in the Romans, and by their means drove the Arabians out of the country.

After this, both the brothers agreed to constitute Pompey, at that time commander in chief of all the

Pompey interferes in the affairs of Judea.

63 B. C.

Roman forces in the east, the arbitrator of their differences. Pompey had resolved to take the part of Hyrcanus; and Aristobulus, suspecting this, prepared to defend himself against the Romans. On this, the Roman general summoned him to appear before him, which he reluctantly did. Pompey insisted that he should deliver up all the fortified places he possessed. Upon this he fled to Jerusalem, but being quickly followed by Pompey, to prevent hostilities, he promised to pay him a large sum of money. Some troops were accordingly sent to receive the stipulated sum, but they were repulsed by the garrison of Jerusalem. This exasperated Pompey so much, that he immediately marched against that city. The Jews were still so scrupulous, that they would not do any thing on the Sabbath to prevent the besiegers from carrying on their works. The city was therefore taken in the year 63 B. C. Twelve thousand of the inhabitants were slaughtered, and many more put an end to their own lives. Hyrcanus was restored to the dignity of high priest, with the title of prince, but forbidden to assume the title of king, or to extend his territories beyond Judea. The walls of Jerusalem were destroyed, and a Roman governor and garrison were left in it. Aristobulus, and his two sons Alexander and Antigonus, were carried by Pompey to Rome; but Alexander escaped into Judea, and raised an army of 11,500 men. Hyrcanus on this applied to the Romans for assistance: Alexander ventured a battle, but was defeated with considerable loss. After this, his mother contrived to make his peace with the Romans. Judea was at this period divided into five districts, in each of which a separate court of judicature was erected. The first of these was at Jerusalem; the second at Gadara; the third at Amath; the fourth at Jericho; and the fifth at Sephoris in Galilee.

Jews favoured by Cæsar.

Jerusalem taken by the Romans, 37 B. C.

Herod rebuilds the temple. 23 B. C.

The Jews having ingratiated themselves with Cæsar, during the civil wars between him and Pompey, were so highly favoured while he lived, that they could scarcely be said to feel the Roman yoke. After his death, however, great commotions prevailed among them, which were not put down till Herod, who was created King of Judea by Marc Anthony in the year 40 B. C. was firmly established on the throne by the taking of Jerusalem by the Romans in 37 B. C. But the Jews soon found that they had only changed civil commotions for the most dreadful tyranny. The whole conduct of Herod was so cruel, that an attempt was made to destroy him. This, however, did not succeed; and Herod, having discovered the authors of the plot, caused them and their families to be put to death. Shortly after this, however, he regained, in some degree, the confidence and attachment of his subjects, by his generosity to them during a famine. About the year 23 B. C. he rebuilt the temple with great splendour and magnificence. These, however, were only intervals of his cruelty and tyranny. At length, he was seized with a most loathsome and incurable disease, of which he died. He divided his kingdom among his sons in the following manner: To Archelaus, he allotted Judea; to Herod, or Antipas, Galilee and Pirea; and to Philip, Trachonitis, Gaulon, Batanea, and Panias.

Augustus divides Judea.

No sooner was his death known, than tumults, seditions, and insurrections arose. An appeal was made to Augustus, who made the following division of the kingdom: Archelaus had one half, with the title of Ethnarch. His portion contained Judea Proper, Idumea, and Samaria. The remainder was divided between Philip and Herod; the former of whom had Trachonitis, Batanea, and Auranitis, together with a small part of Galilee; the latter had the rest of Galilee, and the countries beyond the Jordan.

Declared a Roman province.

Pontius Pilate appointed governor of Judea. A. D. 16.

A few years after this division, Archelaus was summoned to Rome by the Emperor, in consequence of complaints against his tyranny. His effects were confiscated, himself banished, and a Roman governor appointed over Judea, which was declared a Roman province. The Jews, dissatisfied at this arrangement, and moreover, excited to tumult by the taxes imposed upon them by their new masters, were seldom quiet; their restlessness was increased by their expectation at this time of their Messiah; and, as they anticipated in him a temporal prince, they looked forward to his coming as the era of their emancipation from the Roman yoke, and their restoration to national independance and power. The governors appointed by the Romans were frequently changed, but seldom was the change beneficial to the Jews. About the 16th year of Christ, Pontius Pilate was appointed governor: his administration was one continued scene of rapine, tyranny, and cruelty. Seven years after his condemnation of our Saviour, he was removed from the government, and Agrippa, the grandson of Herod, was raised to the royal dignity. His character and conduct were similar to those of his grandfather, and his death was equally dreadful and singular. On his death, Judea was again declared a Roman province. The governors appointed to rule over it were distinguished for every species of vice; and from them the Jews suffered so much, that many of the inhabitants emigrated. About this time it was computed that there were in Jerusalem between 2,500,000 and 3,000,000 Jews.

War between the Jews and Romans, A. D. 67.

Jerusalem besieged by Titus. A. D. 72.

In the year 67 A. D. that fatal war between the Jews and the Romans commenced, which ended in the destruction of Jerusalem and the dispersion of the Jews. The immediate cause of this war was a dispute between the Jews and the Syrians respecting the city of Cæsarea. Nero decided the question against the former, who immediately took up arms. Dreadful cruelties were committed by both parties, but the Jews suffered most: 20,000 of them were massacred by the Syrians and Romans at Cæsarea; 50,000 at Alexandria; 2000 at Ptolemais, and 3500 at Jerusalem. Soon after these massacres, the Jews obtained some partial and temporary successes, in consequence of which Vespasian was sent into Judea with an army of 60,000 men in the year 68 A. D. His success was great and rapid, while the Jews, instead of uniting to oppose him, and save their country, were divided into two parties: one were for submitting to the Romans, the other opposed all peaceable measures. This dissension was not confined to Jerusalem, but spread through all the cities, towns, and villages of Judea: even houses and families were divided against each other. Jerusalem was the scene of their contentions. The city was filled with butcheries of the most horrid kind. Twelve thousand persons of noble extraction, and in the flower of their age, were put to death by the Zealots, for so that party who were for war with the Romans were called. The Zealots, after having massacred or driven away the opposite party, turned their arms against themselves, till, in the year 72 A. D. Titus advanced at the head of a powerful army against Jerusalem. This for a while suspended their mutual animosities; but they soon returned to them, and thus facilitated the triumph of the Romans.

As Titus wished, if possible, to preserve the city, he sent the besieged offers of peace, but they were rejected; upon which he resolved to carry on the siege with vigour a fortnight after it commenced; a breach was made in the outer wall, by which the Romans entered, the Jews retiring behind the next inclosure. Five days after gaining this advantage, the Romans entered into the second inclosure. Famine and pestilence now raged in the city to a dreadful degree; and these scourges were increased by intestine feuds. As soon as Titus learned their condition, he again offered them peace; but his offer was rejected. Upon this, he caused the city to be surrounded with a strong wall, which, though nearly five miles in circuit, was finished in three days. By means of it, the besieged could not escape, nor receive provisions or succour. Nothing could be more dreadful than the famished condition to which they were now reduced. It was at this juncture, according to Josephus, that a mother butchered and ate her own child. When Titus heard of this horrid deed, he swore he would effect the total extirpation of the city and people. About the end of July, the Romans gained possession of the fortress Antonia, which obliged the Jews to set fire to the galleries which joined it to the temple. The factious in the city, instead of mutually yielding and opposing the enemy, grew more embittered against each other; and one of them actually plundered the temple. On the 8th of August, Titus having in vain endeavoured to save that edifice, ordered the gates of it to be set on fire; but he afterwards caused the fire to be extinguished before the temple itself was destroyed. On the 10th of that month, he determined on a general assault; but before this took place, the temple was set on fire, whether by the Jews or the Roman soldiers is uncertain. Titus in vain endeavoured to extinguish the flames: his soldiers would not obey his orders for that purpose. A dreadful massacre followed soon afterwards, in which many thousands perished. In the meantime, great preparations were making for an attack on the palace, which took place on the 8th, when the city was entered by Titus. The whole number of Jews who perished during this war is computed at nearly 1,500,000. Three castles were still untaken, two of which soon capitulated; but the third, Massador, made a desperate resistance. It was extremely strong; and the Roman general, having in vain tried his engines and battering rams against it, ordered it to be surrounded with a high wall, and the gates to be then set on fire. In this dreadful situation, the commander persuaded the Jews to kill their wives and children, and afterwards to choose ten men by lot which should kill all the rest, and, lastly, one out of these ten to dispatch them and himself, having previously to his own destruction set fire to the place. This was accordingly done. Two women, however, who had concealed themselves, came out, when the Romans were preparing to scale the walls, and acquainted them with the fate of their town's people. Thus ended the Jewish nation and worship in their own country.

Temple burnt.

Jerusalem taken.

History of the Jews in England.

II. It is uncertain at what period the Jews first settled in England. From the preface to Leland's *Collections*, it appears that Mr Richard Waller believed them to have settled here during the government of the Romans. This opinion was founded on the circumstance of a Roman brick having been found at London, having on one side a bas-relief, representing Sampson driving the foxes into a field of corn. From the elegance of the sculpture, and other circumstances, it was inferred that this brick could not be the work of later ages; and if Roman, of Roman Jews, from the subject. However this may be, it is certain that the Jews were numerous in England, so early as the year 740, since the 24th paragraph of the Canonical Excerptions, published by Egbright, Archbishop of York, in that year, forbids any Christians to be present at the Jewish feasts. In a charter of Witglaff, King of Mercia, made to the monks of Croyland, there are confirmed to them not only such lands as had been given to the monastery by the kings of Mercia, but all their possessions whatever, whether they were originally bestowed on them by Christians or Jews. During the feudal ages, the Jews, from their aversion to war, and their love of gain, seem to have been the most opulent, as well as the most polished and enlightened portion of the laity. They were the only bankers of the period. They conducted foreign trade, and in the course of it often visited the countries of southern Europe. Most of the gold and silver ornaments for altars were wrought by them. William Rufus encouraged them to enter into solemn contests with his bishops concerning the true faith; swearing by the faith of St Luke, his favourite oath, that, if the Jews were victorious in the dispute, he would turn Jew himself. Accordingly during his reign there was a public meeting for this disputation, at which the Jews opposed the Christians with so much vigour, promptitude, and acuteness, that the clergy felt considerable anxiety respecting the issue.

Favoured by William Rufus.

Numbers and wealth in the reig of Henry II

Henry II. in the 24th year of his reign, granted a burial-place to the Jews on the outside of every city where they dwelt. At this period, one Joshua, a Jew, furnished the rebels in Ireland with great sums of money; and another Jew of Bury St Edmunds took in pledge certain vessels appropriated to the service of the altar. Such was the confidence they felt either in their numbers or their wealth, that at this time they underrated the highest dignitaries of the church. In the year 1188, the parliament of Northampton proposed to assess the Jews at £60,000, and the Christians at £70,000, towards carrying on a projected war. In the reign of Richard I. the prejudices of the people of England seem to have been for the first time generally and strongly excited against them. A crusade had been resolved on; the populace, roused by the declamations of the clergy, easily turned their zeal against the Jews. In London, their houses were broken open and plundered. On this occasion, three persons only were punished, who through mistake had damaged the houses of Christians. In the space of six months, the persecution of the Jews became general throughout the kingdom. The most dreadful outrage against them was committed at Stamford fair. Here were collected an immense number of the populace, who were preparing to go with the king to the Holy Land. As for this enterprise they had already expended the little property they possessed; they resolved to force the Jews also to contribute their share. With this intention, they attacked them when assembled in great numbers at this fair, and quickly made themselves masters both of their persons and fortunes; the former of which they treated with all kinds of barbarity. A few of them were so fortunate as to obtain shelter in the castle. The king did not endeavour to prevent this outrage, nor did he punish it. At this period, it is supposed by some writers that they invented bills of exchange, since mention seems to be made of them by the name of Starra, (from the Hebrew *Shetar*,) in certain Latin documents of this era. By an edict of Richard I. for registering their

Plundered in the reign of Richard I.

property, it appears that they were still permitted to exercise the liberal professions; this edict ordering that their contracts should be made in the presence of two assigned lawyers who were Jews, two who were Christians, and two public notaries. This king also appointed *Justicers* of the Jews, whose business it was to collect and pay into the exchequer the taxes assessed upon them. The Jews found their situation under Richard so intolerable, that nearly all the wealthier of them emigrated, and there was a consequent defalcation of the revenue. This was so considerable in the reign of John, that that monarch, in the year 1199, used his utmost endeavours to tempt them back to England; not only confirming their ancient privileges, but granting them new ones, particularly that of appointing a high-priest. Upon this, many of them returned; but they were more cruelly plundered than ever. It has been remarked, that Magna Charta sanctions an injustice to this ill-used race, by enacting, that "if any persons have borrowed money of the Jews, more or less, and die before they have paid the debt, the debt shall not increase while the heir is under age;" but, in our opinion, this clause had no reference to the Jews *as Jews*, but merely as money-lenders, and as they were the only money-lenders of that period, they alone are mentioned.

Many emigrate.

Situation under Henry III.

As long as the rage for crusading lasted, the Jews were liable to great indignities and oppression, particularly from those who had performed a pilgrimage to Jerusalem. Against these, Henry III. ordered them to be protected; he also liberated such as were in prison. In order to distinguish them, he directed them to wear upon the fore part of their upper garment two broad stripes of white linen or parchment. It was in this reign that the Archbishop of Canterbury, and the Bishops of Lincoln and Norwich, published injunctions throughout their respective dioceses, that no Christian should presume to have any communication with the Jews, or sell them any provisions, under pain of excommunication. The king, however, interfered in their behalf; and thus rescued them from starving. The prior of Dunstable was more liberal than his superiors; for, about this time, he granted to several Jews liberty to reside on his land, and to enjoy all the privileges which his other vassals enjoyed, in consideration of the annual payment of two silver spoons.

Synagogue built in London. A.D. 1230.

In the year 1230, the Jews took advantage of the protection and favour of Henry, and erected a very costly and magnificent synagogue in London; but the people petitioned the king to take it from them, and have it consecrated, which was accordingly done. In the 18th year of his reign, on a petition of the inhabitants of Newcastle, he granted them the privilege that no Jew should ever reside among them. It was during the reign of Henry that the Lombards settled in England, and by gradually superseding the Jews in the lending of money, and thus rendering them less necessary, paved the way for worse treatment than they had hitherto experienced. To such a pitch of hatred was the prejudice which had been gradually instilled into the people against the Jews arrived, that in 1262, the barons being then opposed to the king, and wishing to bind the citizens of London to their cause, ordered 700 Jews to be slaughtered at once, their houses to be plundered, and their new synagogue burnt. It was however, rebuilt; but in 1270 it was taken from them, on the complaint of the Friars Penitents, that they were not able to make the body of Christ in quiet, on account of the great howlings which the Jews made during their worship.

Seven hundred Jews murdered, A. D. 1262.

Edward I. seizes their property, A. D. 1290, and expels them.

In the third year of Edward I. a law passed the Commons concerning Judaism, which seemed to promise them some security. Nevertheless, in the year 1290, this monarch seized on all their real estates, and banished the whole of them from the kingdom. From 15,000 to 16,000 Jews were thus ruined, and then expelled. They left behind them several valuable libraries, particularly at Stamford and Oxford. The latter being sold among the students, most of the Hebrew books were bought by the famous Roger Bacon, who, in a short note written in one of them, declares they were of great service to him in his studies. The expulsion of the Jews at this time was so complete, that no farther traces of them in England occur till long after the Reformation.

Cromwell restores them.

Oliver Cromwell made the first attempt to restore to England the industry and wealth of the Jews: the intercourse between them was managed by means of one Henry Martin, who persuaded a deputation from the Jews at Amsterdam to wait upon the English ambassador there: from him they obtained permission to send a public envoy with proposals to London. Manasseh Ben Israel, who stiled himself a divine and doctor of physic, but who was in reality a printer and bookseller, was selected for this embassy, of which he published a particular account. On his arrival in England, he presented an address to Cromwell, recognising his authority, and soliciting his protection. On the 4th of December 1655, the Protector summoned a convention, consisting of two lawyers, seven citizens, and 14 noted preachers, to consult upon this request of the Jews; but he found so much prejudice and opposition, that, after a conference of four days, he dissolved the meeting. While this affair was pending, a Rabbi propagated the opinion that Cromwell was the expected Messiah. About this time a few appear to have settled in London, since, in the year 1663, their register of births contained twelve names; and during the whole reign of Charles II. who introduced the sale of patents of denization, their numbers increased. In 1684, James II. remitted the alien duty upon all goods exported in favour of the Jews. This privilege was opposed by the English merchants, petitions from the Hamburgh company, from the Eastland company, and from 57 of the leading merchants of the city, being presented against it. After the Revolution, this privilege was taken away from the Jews. In the first year of Queen Anne, a statute was passed to encourage the conversion of young Jews, by emancipating such converts from all dependance upon their parents; and in the 6th year of George II. it was proposed that the Lord Mayor and Court of Aldermen of London, should apply to Parliament for the suppression of Jew brokers; no public proceeding, however, ensued.

Numbers increase under Charles II.

Public proceedings respecting them, James II. William III. and 6th of George II.

Bill for naturalizing them, 1753.

Arguments in support of it.

In the 7th year of James I. an act was passed preventing all persons from being naturalized, unless they first received the sacrament of the Lord's supper, according to the rites of the church of England. This act effectually excluded the Jews from being naturalized. In the year 1753, a bill was brought into the House of Lords, and passed there without opposition, which provided that all persons professing the Jewish religion, who had resided in Great Britain or Ireland for three years, might be naturalized without receiving the sacrament of the Lord's supper. On the 16th of April this bill was sent down to the House of Commons, and, on its second reading, a motion was made for its being committed. The bill was supported by the petitions of a few merchants, chiefly dissenters: In behalf of it, it

Against it.

was argued, that it would increase the numbers and wealth of the people; that a great portion of the funds belonging to foreign Jews, it would be highly politic to induce them to follow their property; that, connected as the Jews were with the great bankers and monied interests of Europe, their residence in England would, in future wars, give the nation a great command of capital, and facilitate loans; that, even their prejudices as a sect would operate in our favour, and occasion our manufactures to be dispersed among the Jew-shopkeepers in Europe, who now had recourse to the Jew merchants of Holland and other tolerant countries; and lastly, that Poland had never risen to so high a pitch of prosperity, as when her policy was most liberal to the Jews; and that the sect itself had always abandoned its offensive prejudices in proportion to its good usage. On the other side it was urged, that by naturalizing the Jews, we should import vagrants and cheats to burden our rates, and supplant the industry of our labouring classes; that the rites of Jews would always prevent them from incorporating with the nation, or becoming any real addition to its intrinsic strength; while their early marriages and frequent divorces would occasion such a rapid increase of their numbers, that in the end they might become troublesome or even dangerous; that Jewish nationality would intrigue all the trade into their own hand; that they were enemies upon principle to all Christians; and that it was endeavouring to oppose the plans, and to frustrate the prophecies of the Almighty, to gather together a sect of which the Bible foretold the dispersion.

Petitions against it.

The lord mayor, aldermen, and livery of London, first presented a petition to parliament against the proposed naturalization, in which they expressed their apprehension that the bill, if passed into a law, would tend greatly to the dishonour of the Christian religion, and endanger the constitution. Alarm and prejudice spread rapidly and powerfully; a zeal, the most furious, vociferated in the pulpits and the corporations against the bill; and by the next sessions of parliament, instructions were sent to almost all the members to solicit a repeal of it; the minister yielded, and the bill was repealed by an act which received the royal assent the same session.

Repealed.

Laws regarding them.

By the 10th of George III. cap. 10, whenever any Jew shall present himself to take the oath of abjuration, the words "upon the true faith of a Christian," shall be omitted out of the oath. In courts of justice, they are sworn according to their peculiar rites. If Jewish parents refuse to allow their Protestant children a suitable maintenance, the lord chancellor may make such order as he may think proper.

Society for converting them.

A few years since a society was formed in London for promoting Christianity among the Jews, and branches of the society have been established in different parts of the kingdom. They have published several reports; but the utility of this society has been questioned, and it has been alleged, we hope without reason, that they have not been sufficiently attentive to the investigation of the character and probable motives of their converts.

Jews in France.

Our limits will not permit us to dwell long on the history or present state of the Jews in other countries; nor are we in possession of materials sufficient to enable us to enter into detail on these points. In France, the prejudices of Voltaire against the Jewish religion, for a long time prevented the philosophic sect in that country from extending their liberal ideas of toleration towards the Jews. In 1788, however, the academy at Metz proposed as a prize question, "Are there means of rendering the Jews in France usefuller and happier?" A Polish Jew, a counsellor of Nancy, and the celebrated Abbé Gregoire, shared the prize. The work of the Abbé on the moral, physical, and political regeneration of the Jews, is an admirable performance. In the constituent assembly, Mirabeau, Clermont, Tourere, and Rabaud, advocated their cause. The attention of the French government, however, does not seem to have been directed towards them till the year 1806, when Bonaparte issued a decree regarding them, in which he appointed an assembly of deputies from them at Paris in the month of July: when they met, they were attended by commissioners on the part of Bonaparte. After assurances of liberty and protection on the one hand, and of gratitude and obedience on the other, it was agreed that a grand Sanhedrim should be opened at Paris, at which should be preserved as much as possible the ancient Jewish forms and usages. This was announced to the Jews in France and Italy, in an address, which advised them to choose men known for their wisdom, in order to give to the Sanhedrim a proper degree of weight and consideration. The Sanhedrim assembled on the 9th of February 1807: they drew up 27 articles for the re-organization of the Mosaic worship; and passed several regulations on the subjects of divorce, polygamy, marriage, moral, civil, and political relations; useful professions, loans among themselves, and loans between Israelites, and those who are not Israelites. At their second meeting in March, a law for the condemnation of usury was passed. Bonaparte soon found, however, that he was not likely to accomplish his object of constraining his Jewish subjects to assist in the cultivation of the land, and in furnishing their quota of conscripts. In March 1808, he issued another decree respecting them, in which he calls upon them to follow the pursuits of honest industry, and to purchase landed property. This decree also annuls all obligations for loans made by Jews to minors, without the sanction of their guardians; to married women without the consent of their husbands; or to military men without the authority of their officers. There were also severe regulations respecting usury. At this period, the following return was made to Bonaparte of the number of Jews in all the different parts of the habitable globe, viz. in the Turkish empire, 1,000,000; in Persia, China, and India, on the east and west of the Ganges, 300,000; and in the west of Europe, Africa, and America, 1,700,000, making an aggregate population of 3,000,000. It would appear, however, from subsequent enquiries on this subject, that this number is very far below the truth. Indeed, in Poland alone, recent and well-informed travellers reckon that there are 2,000,000 Jews. The Prince Primate of Frankfort, following the example of Bonaparte, put an end to every humiliating distinction between the Jewish and Christian inhabitants of that city. Since the overthrow of Bonaparte, however, the inhabitants of Frankfort are said to have displayed great illiberality and intolerance against the Jews: and, indeed, this feeling has manifested itself generally throughout Germany. In this part of Europe, the popular prejudice against Judaism was attacked some years ago by Lessing in his plays of Nathan the Wise and the Monk of Lebanon; and, at the same time, Moses Mendelsolm published an excellent defence of general toleration, under the title of *Jerusalem.* C. W. Dohm, a Prussian, in the year 1781, published in German, *Re-*

In Germany.

Jews in Holland.

In Italy.

In Spain.

marks on the means of improving the civil condition of the Jews, which called forth several pamphlets on the same topic, of which the best were those of Schlotzer and Michaelis. In Holland, the condition of the Jews has long been favourable. In Italy, the first attempts were made to prepare the minds of the people for their toleration. Simone Lazzarato, of Venice, is mentioned as a pleader in their cause; the friends of the Socini, also, were thought to entertain sentiments favourable to them; but the interference of the inquisition in 1546, to suppress the club of Vicenza, proved prejudicial to the Jews, in depriving them of several of their most zealous advocates or apologists. In Spain, they obtained a footing after the Mahomedan conquest of that country, but they were driven out of it by the decrees of Ferdinand and Isabella. Mr Semple, in his second Journey in Spain, relates, that the Jews of Barbary, Smyrna, and Constantinople, generally speak corrupted Spanish, which he considers as a clear proof of the amazing numbers of that people that must have been driven out of Spain, and scattered all over the coasts of the Mediterranean. The laws, both of Spain and Portugal, are still most cruel against them, though they are not now often strictly enforced.

In Poland.

The Jews have long been very numerous and very favourably treated in Poland: it is said that they owe their privileges to Esther, a fair Jewess, the favourite mistress of Cassimir the Great; but it is probable that this monarch protected and encouraged them in his dominions, rather because in his time, (A. D. 1370), they were the richest and most commercial individuals in Europe. They still carry on the principal retail trade in all parts of Poland and Lithuania: a poll-tax is levied upon them.

In Asia and Africa.

Though it was not till after the Mahomedan conquest that the Jews obtained a "resting place for their feet" in Asia and southern Europe, yet in most of the Mahomedan states at the present day, they are treated with great cruelty and indignity. Mr Semple says, that the insults to which Christians are exposed in the states of Barbary, are nothing when compared with those which the Jews must hourly suffer. The Jews have larger settlements, and more permanent abodes in India, than they have any where in Europe. In Barbary, there are several thousand Jews, who do not refuse to communicate with the Mussulmans, or to bear arms. Cashmere also contains a large colony, supposed by Bernier to have settled there during the Babylonish captivity.

Traditions, customs, &c.

III. The Jewish history is generally divided into two periods: the first reaching from Abraham to Christ; the other from Christ to the present time; and the Jews of these two periods have been respectively distinguished as ancient and modern. The same distinction ought to be made with regard to Judaism, or the opinions, traditions, rites and ceremonies, of the Jews. Ancient Judaism may be defined as the system of doctrines and rites prescribed in the Old Testament; these were retained in their most essential points, though much corrupted, till the time of Christ: modern Judaism comprehends the opinions, traditions, rites and ceremonies, which began to be received before the destruction of the second temple, were afterwards systematized and embodied in the Cabalistic and Talmudic writings; and have been followed and professed by the great body of the Jewish nation ever since. Ancient Judaism is fully detailed in those parts of the Old Testament which treat of the law of Moses; in the remainder of this article, we propose to confine ourselves to a brief account of the most important parts of modern Judaism.

Their division of the Bible.

Targums.

The Jews divide the books of the Old Testament into three classes: the law, the prophets, and the hagiographa, or holy writings. They have counted not only the large and small sections, the verses and the words, but even the letters in some of the books; and they have likewise reckoned which is the middle letter of the Pentateuch, which is the middle clause of each book, and how often each letter of the alphabet occurs in the Hebrew scriptures. Besides the scriptures, the Jews pay great attention to the Targums, or Chaldee paraphrases of them: it seems probable that these were written either during the Babylonish captivity, or immediately afterwards, when the Jews had forgotten their own language, and acquired the Chaldee of the Targums, at present received by the Jews; the most ancient are that of Onkelos on the Law, and that of Jonathan Ben Uzliel on the Prophets: the former is supposed to be of greater antiquity than the latter, and it approaches in simplicity and purity of style to the Chaldee of Daniel and Esra. The Targum on the prophets is believed to have been written before the birth of Christ, and though inferior in respect of style to the Targum of Onkelos, is much superior to any other Targum.

Talmud.

The Jews also regard, with great veneration, what is called the Talmud. This work consists of two parts; the Mishna, which signifies a second law; and the Gemara, which means either a supplement or a commentary. The Jews suppose that God first dictated the text of the law to Moses, which he commanded to be put in writing, and which exists in the Pentateuch, and then gave him an explication of every thing comprehended in it, which he ordered to be committed to memory. Hence the former is called the written, and the latter the oral law. These two laws were recited by Moses to Aaron four times, to his sons three times, to the seventy elders twice, and to the rest of the people once; after this the repetition was renewed by Aaron, his two sons, and the seventy elders. The last month of Moses' life was spent, according to the Jews, in repeating and explaining the law to the people, and especially to Joshua his successor. A prophet might suspend any law, or authorise the violation of any precept, except those against idolatry. If there was any difference of opinion respecting the meaning of any law or precept, it was determined by the majority. When Joshua died, all the interpretations he had received from Moses, as well as those made in his time, were transmitted to the elders; these conveyed them to the prophets, and by one prophet they were delivered to another. This law was only oral, till the days of Rabbi Jehuda, who perceiving that the students of the law were gradually decreasing, and that the Jews were dispersed over the face of the earth, collected all the traditions, arranged them under distinct heads, and formed them into a methodical code of traditional law; thus the Mishna was formed. It is written in a concise style, chiefly in the form of aphorisms, which admit of a variety of interpretations. On this account, a gemara or commentary was written by a president of a school in Palestine, which, together with the mishna, forms the Jerusalem Talmud. The Jews in Chaldea, however, not being satisfied with this gemara, one of their Rabbis compiled another, which, together with the mishna, forms the Babylonian Talmud.

Cabala.

One of the principal branches of modern Judaism, is the Cabala, the study of which is regarded as the sublimest of all sciences. By the Cabala, the Jews mean those mystical interpretations of the scripture, and metaphysical speculations concerning the Deity, angels, &c. which they regard as having been handed down by a secret tradition from the earliest ages. The Cabala is of two kinds, theoretical and practical; the former relates to subjects only adapted to speculation; the latter is, in fact, a system of magic drawn from a mystical interpretation of the Scriptures. The Jews believe that Abraham, Moses, Solomon, &c. were adepts in this kind of magic. It was much cultivated in the middle ages; but now the Jews have in a great measure discarded faith in the practical Cabala.

In the 11th century, the famous Rabbi Maimonides drew up a summary of the doctrines of Judaism, which every Jew is required to believe, on pain of excommunication in this world, and condemnation in the next.

Articles of faith.

This summary consists of 13 articles, which he calls foundations or roots of the faith. The articles are as follow:—1. That God is the creator and active supporter of all things. 2. That God is one, and eternally unchangeable. 3. That God is incorporeal, and cannot have any material properties. 4. That God must eternally exist. 5. That God alone is to be worshipped. 6. That whatever has been taught by the prophets is true. 7. That Moses is the head and father of all contemporary doctors, and of all those who lived before or shall live after him. 8. That the law was given by Moses. 9. That the law shall always exist, and never be altered. 10. That God knows all the thoughts and actions of men. 11. That God will reward the observance, and punish the breach of the laws. 12. That the Messiah is to come, though he tarry a long time. 13. That there shall be a resurrection of the dead when God shall think fit.

Customs respecting child-birth.

Before the delivery of a Jewess, her husband, or some friend, describes with chalk a circle on each of the walls round the bed, and on the outside and inside of the door; he also inscribes on these, in Hebrew characters, the words, Adam, Chara, Chuts, Lilith; *i. e.* Adam, Eve, rejoice; Lilith signifying a wish, that if the child be a boy he may be like Adam, and blessed with a wife like Eve; but if a girl, that she may not, like Lilith, who, according to Jewish tradition, having been formed before Eve out of the ground, on that account deemed herself equal to Adam, and refused to be obedient to him. Lilith, also, is supposed to have the power of weakening and destroying young infants, and therefore the names of three angels are written on the inside of the chamber in which the pregnant woman lies. A Christian midwife must not be employed except in cases of most clear and urgent necessity, and then she must be surrounded and watched by several Jewesses. In order to accelerate the birth, a rabbi recites the 20th, 38th, 92d, and 102d psalms. On the evening of the Sabbath after delivery, if a boy is born, a feast is held called Jeshua Haben, or the safety of the son.

Circumcision.

Preparations are next made for circumcision. The guests must be at least ten in number, and must all have passed their 13th year. No woman or Christian is allowed to circumcise, except in cases of necessity. Where the latter performs the operation, some of the blood must be drawn afresh from the part by an Israelite. The regular circumcisers are distinguished by their very long and sharp nails; they are taught their business by operating on the sons of poor Jews, whose consent is obtained for money. Besides the circumciser, a person named Baal Berith, or the master of the covenant, must assist. The operation ought not to take place before the eighth, or later than the twelfth day after the birth. Two chairs are provided, one for the circumciser and the other for Elijah, who is supposed to be present. As soon as the circumciser and his attendant have entered the room, some boys make their appearance bearing twelve wax tapers, bowls of wine, a knife, a plate of sand, and a platter with olive oil, in which the linen to be applied to the wound is steeped. The infant must be bathed before the ceremony. He is brought to the door by a woman, who is not allowed to enter the room. If a child die uncircumcised, he is circumcised in the burial ground, that the reproach of uncircumcision may be taken away. No prayers are said on this occasion, but a name is given him, that, at the resurrection, when every one will be called by his name, his parents may recognise him. The birth of a girl is attended with little feasting. The rabbis have abolished the distinction made by the Mosaic law between the period of the purification of a woman after the birth of a son and a daughter. They have also altered the law respecting the mode of redemption of the first born, if a son.

Redemption of a son.

According to them, the child cannot be redeemed before the thirtieth day, nor after the thirty-first. On that day the priest asks the father, whether he would prefer his child, or the five shekels required for his redemption? to which the father replies, that he prefers his son, and that he wishes the priest to accept the money. The priest cannot accept less; but he may return what he accepts. If the father dies before the thirty-first day, the mother is not bound to redeem the child; but a piece of parchment is suspended on the child's neck, with an inscription, that he is a son not redeemed, to teach him, that he must redeem himself.

Education of females.

The education of the female children of the Jews is very much neglected. They are seldom taught more than to pronounce the words of a Hebrew prayer-book, without understanding the meaning of a single sentence.

Of males.

The sons are taught to read the law, the mishna, the gemara, and the prayer-book. Very few of them learn the Hebrew grammatically. At the age of 13 years and one day, a Jewish youth receives the appellation of Bar Mitsrah, a son of the commandment, and is required to observe the 613 precepts, which, according to the rabbis, comprehend the whole of the law. From this time he is deemed liable to punishment if he transgresses them; whereas the sins he commits before this age are ascribed to his father, who is liable to the punishment denounced against them. At this age the father, in the presence of several Jews, declares, that he is no longer chargeable for the sins of his son. Jewish girls are accounted of full age at 12 years and a day old.

Marriages.

Marriage is reckoned the indispensible duty of every Jew. Men who live in celibacy long after eighteen are considered by the rabbis as living in sin. Polygamy is sanctioned by the Talmud, but is not practised by the European Jews. The betrothing sometimes takes place six months or a year before the marriage. Ten men at least must be present at the marriage, otherwise it is null. A velvet canopy is brought into the room where the ceremony is to take place, and extended on four poles. Under this canopy the bride, having her face covered with a veil, is led by two women, and the bridegroom by two men; these are always their parents, or near relations. After a short prayer, the bride and bridegroom drink of the wine which is offered them by the rabbi. A ring is used, as at Christian marriages. The marriage contract is next read; and, as soon as the reading is ended, the priest takes another glass of wine, and repeats seven benedictions; then the married couple drink the wine; after which the empty glass is laid on the floor, and the bridegroom stamping on it breaks it to pieces, indicating by this the frailty of life. The company next shout, “Good luck to you!” The ceremony is concluded by a contribution for the poor in the land of Canaan, and a nuptial feast.

Divorces.

A Jew is at liberty to divorce his wife at any time, or for any cause; but, in order to counteract the consequences of this liberty, the synagogue has ordered a great many formalities to be observed, which allow time for the parties to become cool, and to reconsider the matter. When the divorce takes place, the parties are not allowed to marry again, nor to be together by themselves: if the woman has been divorced for adultery, she cannot marry her paramour. A man at a distance from his wife, may send her a bill of divorce by a messenger, which is legal, provided the messenger is specially appointed—heard the husband order the notary to write the bill—saw it written and signed—received it from the husband in the presence of two subscribing witnesses, with a special and formal commission, and provided he delivers it to the woman in the presence of two witnesses, with a prescribed declaration of its nature. A girl betrothed under ten years of age is entitled to a divorce any time before she arrives at the age of twelve years and a day, simply by declaring before two witnesses, who write out her declaration, that she will not marry the man; this is called a divorcement of dislike.

Singular change of names.

Rites at deaths, and burials.

In reading the Jewish prayers for the sick, it is customary, in cases of great and imminent danger, to change the name of the sick person, under the belief that thus the sentence of death which may have been issued against him in heaven may be averted or evaded. There is a particular form in their liturgy for changing the name, in which it is said to be done with the knowledge of God, and the approbation of the celestial tribunal; and that his change of name may annul all hard decrees, and reverse the sentence which may have passed against him. In this prayer, he is represented as another man, an infant just born, &c. When a Jew dies, all the water in the same and adjoining houses is instantly thrown away, and no priest must, on any account, remain in any of these houses till the body is removed. Immediately on his decease, the body is stripped and laid on the floor with clean straw under it, and watched by a Jew till the ceremony of cleansing it with warm water is performed. During this ceremony great care must be taken that no water enters the mouth of the corpse. Near it are placed a lighted taper, a bason of water, and a clean towel, that the soul may cleanse itself from the defilements it contracted in this world. For this purpose it is supposed to return to the place every night for a month, during which period the things are kept in the room, and the water is changed every night. In cases where the relations of the deceased are too poor to defray the expence of this ceremony, a subscription is made by the richer Jews; and a few years ago a society was established in London for this purpose—so very sacred and imperative is this ceremony esteemed. The Jews do not make use of close coffins, but only four plain boards loosely joined together. This is done in order that the worms may the sooner destroy the body. The talleh, or square garment with fringes, is put over the sepulchral garment. At the place of interment, the coffin is opened, and some earth, said to have been brought from Jerusalem, is placed under the head in a small bag, or strewed about the body. The relations and friends of the deceased then take hold, one after the other, of his great toes, imploring him to pardon all their offences against him, and not to report evil against them in the other world. The nearest relations rend their garments. When the coffin is placed in the grave, each of the relations throws some earth on it. As soon as the grave is filled, all the attendants run away lest they should hear the knock of the angel, who is supposed to come and knock on the coffin, and to ask the deceased if he can repeat the passage in scripture which has an allusion to his name: if he is not able to repeat it, the angel beats him with a hot iron till he breaks his bones. When the relations return from the funeral, they all sit down on the floor, and eat a small portion of hard boiled eggs, salt, and bread, in order to break the fast which they are supposed to have kept from the moment of the decease of their relation. Morning and evening, ten Jews who have passed the age of thirteen repeat prayers for the dead; and at the close of these prayers, the nearest male relatives repeat the Kodesh, a prayer which is supposed to deliver the deceased from hell. The Jews believe in a resurrection, but the rabbis say it will take place in the land of Canaan, and that Israelites buried in other countries will be rolled thither through subterranean caverns; hence Jews in neighbouring countries, if rich, are removed into Canaan before they die. On the decease of a brother, sister, wife, daughter, or son, the upper garment is cut on the right side, and then rent about a hand-breadth in length; but on the death of a father or mother, the rent is made on the left side in all the garments. The mourning continues seven days, during which no business is to be transacted, nor is the house to be left; but the mourners are to sit on the ground without shoes, and to give free access to every visitant: they must not shave their beards, cut their nails, or wash themselves for 30 days.

Garments.

There are very particular rules laid down by the rabbis respecting the materials, form, and colours of the garments to be worn by the Jews; but in general they conform to the mode of dress in the country where they reside. It is, however, deemed unlawful to wear any garment made of linen and woollen woven together, or made with either of these and sewed with the other. Every male is required to have a quadrangular garment, called talleh. It consists of two quadrangular pieces of woollen or silk joined together at the upper edge by two fillets. These rest on the shoulders, and the pieces hang down, one on the back, and the other over the breast. This is constantly worn as an inner garment. From each of the corners hangs a fringe, consisting of eight threads, and tied with five knots. The sanctity of this garment is supposed to depend upon these fringes, The threads composing them must be of wool that has been shorn, not pulled, and spun by a Jewess for the express purpose. There are also minute and very particular regulations regarding the colour and the folding of the threads. The talleh is not required to be worn at night, nor is the wearing of it obligatory on women, servants, or young children. It is never to be sold or pledged to a Christian. Other appendages of Jewish devotion are the phylacteries, one for the head, and one for the arm. The former is made of skin or leather stretched on a block, and sewed so as to form a leathern box, divided into four compartments, having impressed on one side of it the letter Shin, and on the other a character resembling that letter, only with four points instead of three. In the compartments are inclosed four passages of the law, written on parchment, which is bound round with hair pulled from the tail of a cow, and well washed. The strap which fastens the phylactery to the head ought to be black on the outside, and any colour except red on the inside. It is fastened in such a manner, that the little box including the parchments rests on the forehead below the hair, so that the divine precepts may be fixed in the brain. The phylactery for the arm is nearly similar, except that it has only one cavity, and is without the impression of the letter Shin. It is fastened to the naked skin, on the inner part of the left arm, so as to be near the heart. It would be tiresome to enumerate the directions for tying on these phylacteries, which are excessively minute and multifarious. Besides phylacteries, there are schedules for door-posts, which are generally placed on the right hand of the entrance, and touched or kissed by such of the Jews as wish to be deemed very devout.

Synagogues.

No synagogue can be instituted except there be at least ten men who have passed the age of thirteen. The highest ground is chosen, and no Jew is permitted to build a house of superior or even equal height. In prayer, their faces are always turned towards the land of Canaan; the door of the synagogue, therefore, is always placed at the opposite point of the compass. A closet or chest called the Ark, in which the book of the law is deposited, is opposite to the entrance into the synagogue. Every copy of the pentateuch must be in manuscript. The rabbis have laid down rules for transcribing it, which must on no account be omitted or infringed. The ink employed is to be made of prescribed ingredients. The book itself is to be in the form of a roll. Near the middle of the synagogue is a desk or altar where the law is read, and sermons delivered. No seats are admitted between the altar and the ark. The women are not allowed to sit with the men, and they are even screened from their notice by a wooden lattice. In each synagogue there is a reader or chanter, clerks for the management of pecuniary matters, besides inferior attendants. The general business of the congregation is superintended by wardens or elders. The privilege of folding and unfolding the law, and of performing other public services, is accounted a high honour, and, as such, is put up to public auction. The money arising from these sales is paid into the general stock of the synagogue.

In every country there is a chief, or presiding rabbi, who exercises not only a spiritual, but also a civil, jurisdiction: his authority is kept up by ecclesiastical censures, excommunications, &c. The title of rabbi is little more than an honorary distinction, and is easily obtained by any individual well versed in the Talmud.

Religion, ceremonies, prayers, &c.

The Jewish religion is, perhaps, more a religion of minute and trifling rites and ceremonies, than even the Catholic religion. The minutest circumstances in dressing and undressing, washing and wiping the face and hands, and other necessary actions of common and daily life, are enjoined by the rabbis to be performed exactly according to the prescribed regulations. Their prayers also are numerous, and some of them relate to the most trifling circumstances. Those esteemed the most solemn and important are called *Shemoneh Esreh*, or the Eighteen prayers, though they actually consist of nineteen, the last having been added against heretics and apostates. They are enjoined to be said by all Jews above the age of thirteen, wherever they may be, three times a-day. The members of the synagogue are required to repeat at least a hundred benedictions every day. A son who survives his father is enjoined to attend the nocturnal service in the synagogue every evening for a year, and to repeat the Kodesh, in order that his father may be delivered from hell. This service may be suspended by any person going up to the desk and closing the book. This is not unfrequently done in case of quarrels; and the prayers cannot be renewed till a reconciliation takes place.

Sabbath.

Nothing is to be undertaken on a Friday which cannot be finished before the evening. In the afternoon they wash and clean themselves, trim their hair, and pare their nails. They begin with the left hand, but think it wrong to cut the nails on two adjoining fingers in succession. Even the parings are directed by the Talmud to be disposed of in a particular manner; for it says, "he that throws them on the ground is an impious man; he that buries them is a just man; he that throws them into the fire is a pious and perfect man." Every Jew, of whatever rank, must assist in the preparation for the Sabbath. Two loaves, baked on the Friday, are set on a table. This is done in memory of the manna, of which a double portion fell on the sixth day of the week. The table remains spread all the Sabbath. Before the sun is set, the candles are to be lighted; one at least with seven wicks, in allusion to the number of days in a week, is to be lighted in each house. The Talmudical directions respecting the wicks and oil form part of the Sabbath evening service; they are most ridiculously and childishly minute. The lesson appointed for the Sabbath is divided into seven parts, and read to seven persons at the altar. The first called up to hear it, is a descendant of Aaron, the second of Levi, the third an Israelite of any tribe; the same order is then repeated; the seventh may be of any tribe. The portion read from the law is followed by a portion from the prophets. There are three services, morning, afternoon, and evening. On their return from the last, a wax candle, or a lamp with two wicks, is lighted, and held by a child. The master then takes a glass of wine in his right hand, and a box of spices in his left. After a prayer, a little of the wine is spilled on the floor; and the wine being taken in the left, and the spices in the right hand, after another prayer, he and all the family smell to the spices, and taste the wine. This ceremony is called *Habdala*, or the separation, because it separates the Sabbath from other days. The works forbidden on the Sabbath, according to the rabbis, may be reduced under thirty-nine general heads; of which writing, blotting out, ruling paper, kindling a fire or quenching it, form some. Other forbidden actions are brought under these heads by a very forced analogy. Thus, curdling milk is included under the forbidden head of building, because a whole is formed by the composition of different bodies. Filling ditches is deemed unlawful, and therefore some rabbis have forbidden the sweeping of a room on the Sabbath, lest any furrow or chink in the floor should be filled by the operation. Walking over new ploughed ground is also forbidden, lest a hole should thus be filled up. A tailor must not go out of doors with a needle stuck in any of his clothes. The use of stilts is prohibited, because, though the stilts seem to carry the man, yet in fact the man carries the stilts, and to bear a burden on the Sabbath is unlawful. Dirt on the coat, &c. may be scraped off with the nails while it is moist, but not if it is dry, because thus it would raise some dust, and that would resemble grinding or breaking to pieces.

Chronology. The vulgar Jewish chronology reckons only 1948 years to the birth of Abraham, and in several other particulars it is at variance with the Bible. The modern Jews follow the practice of their ancestors, while in Egypt, of commencing the year at the autumnal equinox. The present Jewish calendar was settled by Rabbi Hittel, about the middle of the 4th century of the Christian era, and is constructed with great ingenuity and astronomical exactness, not equalled by Christians till the improvement of the Julian calendar by Pope Gregory.

Festivals. Of the festivals of the Jews we can mention only a few, and those merely in a cursory manner. The principal are those of the new moon, of the Passover, of Pentecost, of the new year, the fast of atonement, and the feast of tabernacles. That the festival of the new moon might be celebrated as nearly as possible on the day of the moon's conjunction with the sun, most of the months contain alternately twenty-nine and thirty days; and the feast of the new moon is held on the first, or on the first and second days of the month; the women are not allowed to work, the men may. Good eating and drinking particularly distinguish this festival. The feast of the Passover commences on the 15th day of the month Nisan, and continues among Jews who live in or near Jerusalem seven days, and elsewhere eight days. The Sabbath preceding is called the Great Sabbath, and is kept with most scrupulous strictness. The mode and materials for making the unleavened cakes for the Passover, are most minutely described by the rabbis, as well as all the ceremonies of this feast. It is customary for every Jew to honour it by an exhibition of the most sumptuous furniture he can afford. The table for the feast is covered with a clean linen cloth, on which are placed several dishes; on one is the shank bone of a shoulder of lamb or kid, and an egg; on another, three cakes, wrapped in two napkins; on a third, some lettuce, parsley, celery, or other herbs; these are their bitter herbs. Near the sallad is a cruet of vinegar, and some salt and water. There is also a dish, representing the bricks which their forefathers were required to make in Egypt: this is composed of apples, almonds, nuts, and figs, formed into a paste, dressed in wine and cinnamon. The first two days, and the last two, are kept with particular solemnity and strictness. Contracts of marriage may be made, but no marriage is to be solemnized during this festival. The feast of Pentecost, on the 6th day of the month Sivan, continues two days, and is kept with the same strictness as the first two days of the Passover. It is a received opinion of the Jews, that the world was created on the day of their new year; and they therefore celebrate the festival of the new year by a discontinuance of all labour, and by repeated services in the synagogue. The fast of atonement is on the 10th day of Tisri; the first ten days of the month are called days of penitence, during which the Jews believe that God examines the actions of mankind, but he defers passing sentence till the tenth. On the eve of the fast, a ceremony, evidently designed as a substitute for their ancient sacrifices, is performed; this consists in killing a cock, with great formality. The cocks must on no account be red; white is the preferable colour. Before the fast begins, they endeavour to settle all their disputes. In the afternoon they make a hearty meal to prepare for the fast, which is of the most rigid kind. The feast of tabernacles commences on the 15th of Tisri, and is kept nine days. Every Jew who has a court or garden is required to erect a tabernacle on this occasion, respecting the materials and erection of which the rabbis have given special directions. The eighth and ninth are high days, particularly the last, which is called the day of the rejoicing of the land.

Food. The Jews are not permitted to taste the flesh of any four-footed animals, except those which both chew the cud and part the hoof; nor any fish except such as have both scales and fins; they are not to eat the blood of any beast or bird. Cattle for their use must be slaughtered by a Jew, duly qualified, and especially appointed for that purpose. If the carcase has the least blemish, it cannot be eaten; if it is perfectly sound, he affixes to it a leaden seal, with the word *casher*, right, and the day of the week. If there be no Jew butcher, a Jew appointed by the synagogue is stationed at the Christian butcher's to superintend the cutting up of the carcase, and to affix the seal. The hind quarters are not to be eaten unless the sinew of the thigh is taken out. A cow and her calf, an ewe and her lamb, a she goat and her kid, must not be killed in the same day. The knife used for slaughter must be very sharp and free from notches. Meat and butter must not be eaten together, on account of the law, "not to seethe a kid in his mother's milk." For this reason, also, they make their cheese without rennet. No knife, fork, spoon, or culinary vessel, used for meat, is to be used for milk.

Caraites. Such are the opinions, traditions, rites and ceremonies, of the great majority of the modern Jews; but besides these, there is a small sect denominated Caraites, that is textualists—persons attached to the text of the Scriptures. They reside chiefly in the Crimea, Lithuania, and Persia; and at Damascus, Constantinople, and Cairo; their whole number is very inconsiderable. They agree with other Jews in denying the advent of the Messiah. The principal difference between them consists in their adherence to the letter of the Scripture, and in their rejection of all paraphrases and interpretations of the rabbis. They also differ from the rabbis in various particulars respecting the feasts of the Passover, Pentecost, and Tabernacles. They observe the Sabbath with far greater strictness; they extend the degrees of affinity within which marriage is prohibited, but they are more strict in matters of divorce.

See Josephus' *Jewish Antiquities, and his Own Life*; *Histoire de la Religion des Juifs pour servir de continuation a l'Histoire de Josephe, par* Basnage; Tovey's *Anglia Judaica*; *Monthly Magazine*, vol. i. for the year 1796; *Gentleman's Magazine* for 1810 and 1811; *Modern Judaism, by* John Allen. (W. S.)

IGNATIUS LOYOLA. See LOYOLA.

IGNIS FATUUS, commonly called *Will i'the Wisp*, or *Jack and the Lanthorn*, is a meteor which is commonly seen in dark nights, in marshy grounds and other damp places. A full account of it will be given under the article METEORS.

IGUANA. See HERPETOLOGY.

JHANSU-JEUNG. See THIBET.

JIDDA, JEDDA, JODDA, ZITTA, or DSCHEDA, is a small trading town of Arabia Felix, situated in the district of Tahamah, about 40 miles distant from Mecca, north latitude 20° 28′ 1″, and east longitude from

Greenwich 39° 16′ 45″. It is defended by a fort, and surrounded by a ruinous wall, built in the year 1514. Its harbour is very extensive, formed by numberless reefs of Madrapore, extending about four miles from the shore, and full of small islands and sunken rocks. The entrance is sufficiently dangerous, but the pilots are expert, steering safely by the eye alone, and easily perceiving the rocks below the smooth surface, especially when the sun is behind the vessel. Between these shoals and islands are deep channels, with a good bottom, where ships may lie at anchorage in six or twelve fathoms, and where the water is as smooth as glass, in the heaviest gales. The surrounding country is sandy, barren, and destitute of water, and the town is very ill supplied with provisions. A desert plain to the eastward is occupied by Bedouins, or country Arabs, who live in huts made of long bundles of bent grass, or spartum, and who supply the inhabitants of Jidda with milk and butter. The situation is as unwholesome as it is unproductive; and, besides several stagnant pools in the vicinity, the north-west wind which chiefly prevails, blowing along the direction of the gulf, brings a great dampness through the greater part of the year. The highest degree of the thermometer observed by Mr Bruce in July was 97°, and the lowest 78°. The barometer in June was between 26° 6′, and 25° 7′; wind north-west. The town of Jidda derives all its celebrity, and even its existence, from its vicinity to the city of Mecca, to which it is the nearest sea-port, and the great receptacle of the India trade, which arrives once a-year. The inhabitants of the place, indeed, derive little advantage from this rich traffic, which passes on to Mecca, and for which the payments return to the ships, without leaving much profit by the way to the townsmen. The influx of strangers, on the contrary, raises the price of provisions; and the native traders, after the market is over, which does not last above six weeks, retire to Yemen and the neighbouring countries, where every article of subsistence is found in abundance. Jidda, however, is also the great depot of all merchandize intended to be carried to Suez for the demands of Egypt; and great multitudes of the inhabitants find employment in landing and reshipping these goods, in providing warehouses for their safe deposit, and in acting as factors in receiving and disposing of them. The English traders, in 1777, made an attempt to carry their cargoes directly to Suez, without passing them through Jidda into native vessels; and this trade, which continued about three years, was encouraged by the Egyptian Beys, as the English merchants paid them twice as much impost as the Jidda importers. But the Sheriffe of Mecca, who draws the customs of the port of Jidda, procured an order from the Grand Seignior, that all vessels bound for Egypt should stop at Jidda, and pay duty there; and obliged the merchants, when once in his harbour, to unship their goods, and send them forward to Suez in other vessels. The Sultan secured a share of these profits, and regularly appointed a pasha, who resided in the citadel of Jidda, and divided the receipts of the custom-house with the Sheriffe's Vizier. During the convulsions of Egypt, and the insurrections of the Wachabees, the Sheriffe contrived to expel the representative of the Sultan, and to appropriate the whole duties to himself. His extortions, however, in the name of presents to himself and his servants, have caused a great diminution of the trade formerly carried on by the English with Jidda; and many of the richest merchants have retired from the place. The Sheriffe, made aware of his folly by the reduction of his revenues, has become more moderate in his demands. The duties recently proposed, amount to about eight per cent. and the presents to about half as much; but a merchant, when once in the harbour, from which he could scarcely escape without a native pilot, could never be secure against further demands. See Bruce's *Travels*, vol. ii.; Parson's *Travels*; and Valentia's *Travels*, vol. iii. (*q*)

ILANTZ, in the Rhetian language *Ilan* or *Ilon*, a town of Switzerland, in the territory of the Grisons, and the capital of the division of the Grey League. The town is situated in the widest part of the valley of the same name, at the foot of the mountain Mundaun, or Karlisberg. It is the first town that we meet with on the Rhine, and is the only town in the world where the Rhetian language is still spoken. It has two fauxbourgs, viz. that of St Nicholas, and that of Portasura. The bridge built over the Rhine is remarkable. The inhabitants profess the reformed religion. The women in the neighbourhood are very much subject to the Goitre necks.

The tribunal of the Grey League meets at Ilantz, Thousis, and Trons, in rotation; but it is at Ilantz that the archives of the League are preserved. A great fair for cattle is held at Ilantz. Excellent fish, about 22 pounds weight, are caught in the Rhine.

At Rouvis, above Ilantz, on the left bank of the Rhine, a mine of galæna, containing silver, has been wrought. The mineral is contained in nests in the gneiss. The mine of Rouvis, and one of yellow copper at Ober-Sax, have been wrought since the year 1806 by M. Demengha. In descending the valley of Ilantz, the rocks are composed of argillaceous schistus as far as Tamino. See Ebel's *Manuel d'une Voyageur en Suisse*, tom. iii. p. 227.

ILAY. See ISLAY.