THE EDINBURGH NEW PHILOSOPHICAL JOURNAL,

EXHIBITING A VIEW OF THE

PROGRESSIVE DISCOVERIES AND IMPROVEMENTS

IN THE

SCIENCES AND THE ARTS.

CONDUCTED BY

ROBERT JAMESON,

REGIUS PROFESSOR OF NATURAL HISTORY, LECTURER ON MINERALOGY, AND KEEPER OF THE MUSEUM IN THE UNIVERSITY OF EDINBURGH;

Fellow of the Royal Societies of London and Edinburgh; Honorary Member of the Royal Irish Academy; of the Royal Society of Sciences of Denmark; of the Royal Academy of Sciences of Berlin; of the Royal Academy of Naples; of the Geological Society of France; Honorary Member of the Asiatic Society of Calcutta; Fellow of the Royal Linnean, and of the Geological Societies of London; of the Royal Geological Society of Cornwall, and of the Cambridge Philosophical Society; of the Antiquarian, Wernerian Natural History, Royal Medical, Royal Physical, and Horticultural Societies of Edinburgh; of the Highland and Agricultural Society of Scotland; of the Antiquarian and Literary Society of Perth; of the Statistical Society of Glasgow; of the Royal Dublin Society; of the York, Bristol, Cambrian, Whitby, Northern, and Cork Institutions; of the Natural History Society of Northumberland, Durham, and Newcastle; of the Imperial Pharmaceutical Society of Petersburgh; of the Natural History Society of Wetterau; of the Mineralogical Society of Jena; of the Royal Mineralogical Society of Dresden; of the Natural History Society of Paris; of the Philomathic Society of Paris; of the Natural History Society of Calvados; of the Senkenberg Society of Natural History; of the Society of Natural Sciences and Medicine of Heidelberg; Honorary Member of the Literary and Philosophical Society of New York; of the New York Historical Society; of the American Antiquarian Society; of the Academy of Natural Sciences of Philadelphia; of the Lyceum of Natural History of New York; of the Natural History Society of Montreal; of the Franklin Institute of the State of Pennsylvania for the Promotion of the Mechanical Arts; of the Geological Society of Pennsylvania; of the Boston Society of Natural History of the United States; of the South African Institution of the Cape of Good Hope; Honorary Member of the Statistical Society of France; Member of the Entomological Society of Stettin, &c. &c. &c.

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Memorandum.—New Publications will be noticed in our next Number.

CONTENTS.

MEMORANDUM.

Owing to the large space occupied by the Proceedings of the British Association for the Promotion of Science, held at Edinburgh in the month of August 1850, various interesting communications are delayed until the next number of the Philosophical Journal.

THE

EDINBURGH NEW

PHILOSOPHICAL JOURNAL.

Geographical Distribution of Animals. By Professor Louis Agassiz.

The greatest obstacles in the way of investigating the laws of the distribution of organized beings over the surface of our globe, are to be traced to the views generally entertained about their origin. There is a prevailing opinion, which ascribes to all living beings upon earth one common centre of origin, from which it is supposed they, in the course of time, spread over wider and wider areas, till they finally came into their present state of distribution; and what gives this view a higher recommendation, in the opinion of most men, is the circumstance, that such a method of distribution is considered as revealed in our sacred writings. We hope, however, to be able to shew that there is no such statement in the Book of Genesis; that this doctrine of a unique centre of origin, and successive distribution of all animals is of very modern invention; and that it can be traced back for scarcely more than a century in the records of our science.

There is another view to which, more recently, naturalists have seemed to incline; viz., the assuming several centres of origin, from which organized beings were afterwards diffused over wider areas, in the same manner as according to the first theory, the difference being only in the assumption of several centres of dispersion instead of a single one.

We have recently been led to take a very different view of the subject, and shall presently illustrate the facts upon which the view rests. But before we undertake to introduce more directly this subject, there is another point which requires preliminary investigation, which seems to have been entirely lost sight of by all those, without exception, who have studied the geographical distribution of animals, and which seems to us to be the keystone of the whole edifice, whenever we undertake to reconstruct the primitive plan of the geographical distribution of animals and plants. The distribution of organized beings over the surface of our globe in its present condition cannot be considered in itself; and without an investigation, at the same time, of the geographical distribution of those organized beings which have existed in former geological periods, and had become extinct before those of the present creation were called into being. For it is well ascertained now that there is a natural succession in the plan of creation—an intimate connection between all the types of the different periods of the creation from its beginning up to this day; so much so, that the present distribution of animals and plants is the continuation of an order of things which prevailed for a time at an earlier period, but which came to an end before the existing arrangement of things was introduced.

The animal kingdom, as we know it in our days, is therefore engrafted upon its condition in earlier periods; and it is to the distribution of animals in these earlier periods that we must look, if we would trace the plan of the Creator from its commencement to its more advanced development in our own time.

If there is any truth in the view that animals and plants originated from a common centre, it must be at the same time shewn that such an intimate connection between the animals existed at all periods; or, at least, we should, before assuming such a view for the animals living in our days, discover a sufficient reason for ascribing to them another mode of dispersion than to the animals and plants of former periods. But there is such a wonderful harmony in all the great processes of nature, that, at the outset, we should be carefully on our guard against assuming different modes of distribution for the organized beings of former periods, and for those which at present cover the globe. Should it be plain that the animals and plants did not originate from a common centre at the beginning of the creation, and during the different successive geological periods, we have at once a strong indication that neither has such been the case with the animals of the present day; and, on the other hand, if there were satisfactory evidence that the animals and plants now living originated from a common centre, we should consider the matter carefully before trusting to the views derived from geological facts. Let us, therefore, examine first the value of the evidence on both sides.

We have already expressed, and we repeat here, our earnest belief that the view of a unique centre of origin and distribution rests chiefly upon the supposed authority of the Mosaic record; and is in no way sustained by evidence derived from investigations in natural history. On the contrary, wherever we trace the animals in their present distributions, we find them scattered over the surface of our globe in such a manner, according to such laws, and under such special adaptations, that it would baffle the most fanciful imagination to conceive such an arrangement as the mere results of migrations, or of the influence of physical causes over the dispersion of both animals and plants. For we find that all animals and plants of the arctic zones agree in certain respects and are uniform over the three continents which verge towards the northern pole, whilst those of the temperate zone agree also in certain respects, but differ somewhat from each other within definite limits, in the respective continents. And the differences grow more and more prominent as we approach the tropical zone, which has its peculiar Fauna and Flora in each continent; so much so, that it is impossible for us to conceive such a normal arrangement, unless it be the result of a premeditated plan, carried out voluntarily according to predetermined laws.

The opinion which is considered as the Biblical view of the case, and according to which all animals have originated in a common centre, would leave us at a loss for any cause by which to account for the special dispersion of animals and plants beyond the mere necessity of removing from the crowded ground to assume wider limits, as their increased number made it constantly more and more necessary and imperative. According to this view, the animals of the arctic zone as well as those of the tropics,—those of America as well as those of New Holland,—have been first created upon the high lands of Iran, and have taken their course in all directions, to settle where they are now found to be strictly limited. It does not appear how such migrations of polar animals could have taken place over the warmer tracts of land which they had to cross, and in which they cannot even be kept alive, in our days, with the utmost precautions: nor how the terrestrial animals of New Holland, which have no analogies in the main continents, could have reached that large island, nor why they should have all moved thither. And, indeed, it is impossible, with such a theory, to account, either for the special adaptation of types to particular districts of the earth's surface, or for the limited distribution of so many species which are found only over narrow districts in their present arrangement. It is inconsistent with the structure, habits, and natural instincts of most animals, even to suppose that they could have migrated over any great distances. It is in complete contradiction with the laws of nature, and all we know of the changes our globe has undergone, to imagine that the animals have actually adapted themselves to their various circumstances during their migration, as this would be ascribing to physical influences as much power as to the Creator himself.

And, again, the regular distribution, requiring precise laws, as we find it does, cannot be attributed either to the voluntary migration of animals, or to the influence of physical causes, when we see so plainly that this distribution is in accordance with the geographical distribution of animals and plants in former geological periods. But about this presently. We will only add, that we cannot discover in the Mosaic account anything to sustain such a view, nor even hints leading to such a construction. What is said of animals and plants in the first chapter of Genesis, what is mentioned of the preservation of these animals and plants at the time of the deluge, relates chiefly to organized beings placed about Adam and Eve, and those which their progeny had domesticated, and which lived with them in closer connection.

Let us now look at the results of geological investigations respecting the origin of earlier races of animals and plants. It is satisfactorily ascertained at present, that there have been many distinct successive periods, during each of which large numbers of animals and plants have been introduced upon the surface of our globe, to live and multiply for a time, then to disappear and be replaced by other kinds. Of such distinct periods, such successive creations, we now know at least about a dozen, and there are ample indications that the inhabitants of our globe have been successively changed at more epochs than are yet fully ascertained. But whether the number of these distinct successive creations be twelve or twenty, the fact stands in full light and evidence, that animals and plants which lived during the first period disappeared, either gradually or successively, to make room for others, and this at often-repeated intervals; and that the existence of animals and plants which live now is of but recent origin, is equally well ascertained.

There is another series of phenomena, not less satisfactorily established, which go to shew that the extent of dry land rising above the surface of the ocean has neither been equally extensive at all times, nor has it had the same outline at all periods. On the contrary, we know that, early in the history of our globe, there has been a period, when but few low groups of islands existed above the surface of the ocean, which, through successive elevation and depression, have gradually enlarged and modified the extent and form of the mainland.

Again, in examining the remains of organized beings preserved in the different strata constituting the solid crust of our globe, we find that at each period, animals and plants were distributed in the ocean and over the mainland in a particular manner, characteristic of every great epoch. A closer uniformity in their distribution is found in the earlier deposits, so much so that the oldest fossils discovered in the southern extremity of Africa, on the eastern and southern shores of New Holland, and in Van Diemen's Land, in North America, or in various parts of Europe, are almost identical, or at least so nearly related, that they resemble each other much more than the animals and plants which at present live in the same countries; shewing that uniformity in the aspect of the surface of the globe, as well as in the nature of animals and plants, was at first the prevailing rule, and that, whatever was the primitive region of these animals and plants, their types occupied much more extensive districts than any race of living beings during later periods. Are we to infer from this fact, that, at that period, these animals and plants originated from one common centre, and were distributed equally all over the globe? By no means. Though slight, we find nevertheless such differences among them in distant parts of the world as would rather sustain the view of an adaptation in the earliest creations to more uniform circumstances, than that of one centre of origin for all animals and plants of those days. During later periods, indeed, we find from geological evidence that large islands had been formed, more extensive tracts of land elevated above the surface of the ocean, and the remains both of the animals and plants derived from these different regions present already marked differences when we compare them with each other,—varieties similar to those which exist between the respective continents at present, though perhaps less marked. Shall we here again assume that animals and plants originated from another centre, or from the same centre as those of former periods, to migrate over those different parts of the world, through the sea as well as over land? It is impossible to arrive at such a conclusion, when we consider the distribution of fossil remains in the more recent geological deposits, or in those strata which were formed during the latest geological periods, immediately before the present creation. For we find in these comparatively modern beds a distribution of fossil remains which agrees in a most remarkable manner with the present geographical arrangement of animals and plants. For instance, the fossils of modern geological periods in New Holland are of the same types as most of the animals now living there. Again, the recent fossils of Brazil belong to the same families as those prevailing at present in Brazil; though, in both cases, fossil species are distinct from living ones. If, therefore, the organized beings of the recent geological periods had arisen from one central point of distribution, to be dispersed and finally to become confined to those countries where their remains are found in a fossil condition, and if the animals now living had also spread from a common origin over the same districts, and had then been circumscribed within equally distinct limits, we should be led to the unnatural supposition, that animals of two distinct creations, differing specifically throughout, had taken the same lines of migration, had assumed finally the same distribution, and had become permanent in the same regions, without any other inducement for their removal and final settlement than the mere necessity of covering more extensive ground after they had become too numerous to remain any longer together in one and the same district. This were to ascribe to the animals themselves, or to the physical agents under which they live, and by which they may be influenced, as much wisdom, as much providential forethought, as is evinced throughout nature, both in the distribution of animals, and in their special adaptation to particular portions of the globe in which they are closely circumscribed at present, and to which they were limited under similar circumstances during those periods which preceded immediately the present arrangement of things. Now these facts in themselves leave not the shadow of a doubt in our mind, that animals were primitively created all over the world, within those districts which they were naturally to inhabit for a certain time. The next question is—were these organized beings created in pairs, as is generally thought and believed? The opinion, that all animals must he referred to one single, primitive pair, is derived from evidence worthy of consideration, no doubt, but the value of which may fairly be questioned by naturalists; since this point, at least if we except Adam and Eve, is entirely of human construction, and only assumed because it is thought to shew a wise economy of means in the established order of things which exists. It is supposed, that, if one pair were sufficient, there is no reason why the Creator should have introduced at one time a greater number of each kind, as economy of means is always considered an indication of high wisdom. But are not these human considerations? And if they are, and if we are entitled to question their value, let us see how they answer the object which was intended, namely, the peopling of the whole world with various races of organized beings.

Whenever we consider the economy of nature, we observe great varieties in the habits of different animals. There are, indeed, some which live constantly in pairs, and which by nature are designed to perpetuate their races in that way, and to spread generation after generation over their natural boundaries, thus mated. But there are others to which it is equally natural to live in herds or shoals, and which we never find isolated. The idea of a pair of herrings, or of a pair of buffaloes, is as contrary to the nature and habits of those nimals, as it is contrary to the nature of pines and birches to grow singly, and to form forests in their isolation.

But we can go further. There are animals in which the number of individuals of different sexes is naturally unequal, and among which there are either constantly more males or constantly more females born, as the result of their peculiar nature and habits in the creation. A bee-hive never consists of a pair of bees; and never could such a pair preserve the species, with their habits. For them it is natural to have one female and many males devoted to it, and thousands of neutral bees working for them. And this is the natural original mode of existence among that species of animals, which it would be utterly contrary to the laws of nature to consider as derived from a single pair. There are a number of birds, on the contrary, in which only a few males are universally found with many females, living together in companies, such as the pheasants, and our domesticated fowls. It were easy to multiply examples in order to shew that a creation of all animals in pairs would have been contrary to their very nature, as we observe it in all. To assume that they have changed this nature would be to fall back upon the necessity of ascribing to physical influences a power which they do not possess,—that of producing changes in the very nature of organized beings, and of modifying the primitive plan of the Creator.

Again, there are animals which, by nature, are impelled to feed upon other animals. Was the primitive pair of lions to abstain from food until the gazelles and other antelopes had sufficiently multiplied to preserve their races from the persecution of these ferocious beasts? Were all animals, and the innumerable tribes of ferocious fishes which live upon smaller ones, to abstain from food till these had been multiplied to a sufficient extent to secure their preservation? Or were, perhaps, the carnivorous animals created only at a later period? But we find them everywhere together. They constitute natural, harmonious groups with the herbivorous tribes, both in the waters and on land, preserving among each other such proportions as will maintain for ages an undisturbed harmony in the creation.

Again, we find animals and plants occurring in distinct districts, unconnected with each other, in such ways that it would seem almost impossible for either to migrate from any point of their natural circle of distribution over its whole surface. Have, for instance, such animals as are found identical both in America and Europe been created either in Europe or in America, and wandered from one of the continents over to the other? Have those species which occur only in the far north, and upon the higher summits of the Alps, been created either in the Alps or in the north, and wandered from one place to the other? We are at a loss for substantial arguments for believing that either one or the other place has been the primitive location of such animals, or for denying their simultaneous creation in both.

Evidence could be accumulated to shew, we will not say the improbability only, but even the impossibility, of supposing that animals and plants were created in single pairs, and assumed afterwards their present distribution. But the facts mentioned will be sufficient to introduce our argument, and from all we know of the laws of nature and of the distribution of animals, we conclude that they could neither originate from a single pair, nor upon a single spot. And as for plants, we would ask naturalists whether it were not superfluous to create more than a single stalk of most plants, as vegetables, with a few exceptions, may multiply extensively from a single stem. But if it is granted that animals could not originate from a single pair, nor upon a single spot, what is the more natural view to take of the subject?

Without entering fully into this question, we may as well state that we have been gradually led to the conclusion, that most animals and plants must have originated primitively over the whole extent of their natural distribution. We mean to say that, for instance, lions, which occur over almost the whole of Africa, over extensive parts of Southern Asia, and were formerly found even over Asia-Minor and Greece, must have originated primitively over the whole range of these limits of their distribution. We are led to these conclusions by the very fact, that the lions of the East Indies differ somewhat from those of Northern Africa; these, again, differ from those of Senegal. It seems more natural to suppose that they were thus distributed over such wide districts, and endowed with particular characteristics in each, than to assume that they constituted as many species; or to believe that, created anywhere in this circle of distribution, they have gradually been modified to their present differences in consequence of their migration. We admit these differences to be primitive and contemporaneous, from the fact, that there are other animals of different genera extending over the same tracts of land which have different representatives in each, circumscribed within narrower bounds, and this particular combination in each special district of the wider circle covered by the lion, seems, in our opinion, the strongest argument in favour of the view, that the particular districts of distribution have been primitively ascribed, with definite limits, to each species. Why should the antelopes north of the Cape of Good Hope differ from those of Arabia, or those of the Senegal, or those of the Atlas, or those of the East Indies, if they were not primitively adapted with their special modifications to those districts, when we see the lion cover the whole range? And why should the varieties we notice among the lions within these boundaries not be primitive, though not constituting distinct species, when we see the herbivorous species of the same genus differ from one district to another? And why should the differences in that one species of lion be the result of changes in its primitive character, arising from its distribution into new districts, when we see that the antelopes are at once fixed as distinct species over the same ground?

This argument cannot be fully appreciated by those who are not extensively acquainted with natural history, but we may, perhaps, make it plainer by alluding to some other similar facts. Our fresh waters teem everywhere with animals and plants. Fishes and mollusca are among the most prominent of their animals. Let us compare for a moment the different species which occur in the Danube, in the Rhine, and in the Rhone, three hydrographic basins entirely unconnected with each other throughout their whole extent. They spring from the same mountain chain, as we may take the Inn as the source of the Danube. These three great rivers rise within a few miles of each other. Nevertheless, most of their fishes differ, but there are some which are common to the three. We find the pickerel,—the European pickerel, in the three basins. The eel is also common to them all. One kind of trout occurs in the three. But how strange the distribution of some others !—for instance, the perches. In the Rhine we find *Perca fluviatilis*, and *Acerina cernua ;* in the Rhone, *Perca fluviatilis*, and *Aspro vulgaris ;* in the Danube, *Perca vulgaris*, *Lucio-perca Sandra*, *Acerina cernua*, *A. Schraitzer*, *Aspro vulgaris*, and *A. Zingel.* If these animals had not originated in these rivers separately, why should not such closely-allied species, some of which occur in the three basins, have all spread equally into them ? and if they originated in the separate basins, we have within close limits a multiple origin of the same species.

And that this multiple origin must be admitted as a fact is shewn by the following further evidence. Among the carpes we find, for instance, *Barbus*, *Gobio*, *Carpio*, common to the three. But the Danube has three *Gobios*, whilst the others have but one, one of the Danube being identical with the one of the other two rivers. The most striking fact, however, occurs in the genus *Leuciscus*. *Leuciscus dobula* is common to the three ; but in addition to it, the Danube has several species which occur neither in the Rhine nor in the Rhone. The basin of the Rhone, again, has several species which occur neither in the Danube nor in the Rhine ; and in the Rhine, there are species which belong neither to the Rhone nor to the Danube. Now, we ask, could all these species of *Leuciscus* have been created in one of the basins,—in the Danube for instance,—and have migrated in such a way, that a certain number of the species should remain solely in the Danube, while some others left the Danube altogether to settle finally only in the Rhone, and others to settle only in the Rhine; that one accompanying those species peculiar to the Rhone, remained in the Danube with those species peculiar to it, and settled also in the Rhone, with those species peculiar to that river, and also in the Rhine with the species peculiar to the Rhine? And whether we assume the Rhone as the primitive centre, instead of the Danube or the Rhine, the argument holds equally good. We have one species common to the three rivers, and several species peculiar to each, which could never have migrated (if migration took place) in such a manner as to assume their present combinations. But if, on the contrary, we suppose that all the species originated in the rivers where they occur, then we have again a multiple origin of that species which is common to the three, for it were wonderful if that one alone had migrated, when they are all so closely allied. Here, again, we arrive at the conclusion, that the same species can have a multiple origin, in the same manner as, from the considerations alluded to before, we have decided that species do not originate from single pairs, but in their natural proportion with the other species with which they live simultaneously over the whole ground which they cover. And this is the view which we take of the natural distribution of animals, that they originated primitively over the whole extent of their natural distribution; that they originated there, not in pairs, but in large numbers, in such proportions as suits their natural mode of living, and the preservation of species; and that the same species may have originated in different unconnected parts of the more extensive circle of their distribution. We are well aware that there are very many species which are known to have spread beyond what we would call their natural limits; species which did not occur in North America before the settlement of the whites, that are now abundant here over very extensive tracts of country; other species which have been introduced from

America into Europe, and also into other parts of the world, in different ways. But these are exceptional facts; and, what is more important, these changes in the primitive distribution of organised beings, both animals and plants, have taken place under the influence of man,—under the influence of a being acting not merely from natural impulses, or under the pressure of physical causes, but moved by a higher will. So that these apparent exceptions to the rule would only go to confirm it; as, within the limits of these secondary changes, we see a will acting, just as we consider that the primitive distribution of all organized beings has been the result of the decrees of the Creator, and not the result of mere natural influences.

Having thus led the way to what we would consider as a fairer ground for investigating the natural geographical distribution of animals and plants, let us now examine the natural lines which seem to regulate this distribution. Nothing can be more striking to the observer than the fact, that animals, though endowed with the power of locomotion, remain within fixed bounds in their geographical distribution, although an unbounded field for migration is open to them in all directions, over land, through the air, and through the waters. And no stronger argument can be introduced to shew that living beings are endowed with their power of locomotion to keep within general boundaries, rather than to spread extensively. There is another fact which shews that animals are made to remain within these natural limits. We would allude especially to the difficulty we experience whenever we attempt to transport animals from their native country into other countries, even if we secure for them as nearly as can be the same conditions in which they used to live. Again, observe the changes which animals undergo when they are once acclimatized to countries different from their native land. There can be no more striking evidence of this than the endless variety of our domestic animals, and there is no subject which more requires a renewed and careful investigation than this. We do not, however, feel competent to introduce this point more fully to the notice of our readers. Some facts bearing upon the question may best be mentioned in a reference to the different animals which man has thus made subservient to his social condition. We shall here allude only to the laws of distribution of wild animals in their natural condition.

It has already been stated, that the present distribution of animals agrees with the distribution of extinct types belonging to earlier geological periods, so that the laws which regulate the geographical distribution of animals seem to have been the same at all times, though modified in accordance with the successive changes which the animal kingdom has undergone from the earliest period of its creation to the present day. The universal law is, that all animals are circumscribed within definite limits. There is not one species which is uniformly spread all over the globe, either among the aquatic races or among the terrestrial ones. Of the special distribution of man, who alone is found everywhere, we shall speak hereafter. The special adaptation of animals to certain districts is not merely limited to the individual species. We observe a similar adaptation among genera, entire families, and even whole classes. For instance, all *Polypi*, *Medusæ*, and *Echinoderms*, that is to say all *Radiata*, without exception, are aquatic.* That large group of animals has not a single terrestrial representative upon any point of the surface of the globe; and during all periods of the history of our earth, we find that they have always been limited to the liquid element. And they are not only aquatic, they are chiefly marine, as but exceedingly few of them are found in fresh waters. Among *Mollusca* we find almost the same adaptation. Their element also is the sea. The number of fresh-water species is small, compared with that of marine types; and we find terrestrial species in only one of their classes. In former periods, also, *Mollusca* were chiefly marine; fluviatile and terrestrial types occurring only in more recent periods.

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* The following statements have been strictly considered, and are made in reference to a revised classification of the animal kingdom, the details of which must, however, be omitted here, as they would extend this article beyond our allotted bounds.

With the *Articulata*, we find another state of things. Two of their classes, the worms and *Crustacea*, are chiefly marine, or at least aquatic, as we have a number of fresh-water worms, and some fresh-water *Crustacea*. But insects are, for the most part, chiefly terrestrial, feeding upon terrestrial plants, at least in their full-grown condition; though a large number of these animals are fluviatile, and even some marine, during their earlier periods of life. In the *Vertebrata*, the adaptations are more diversified. Only one class of these animals is entirely aquatic—the fishes; and the number of the marine species is far greater than that of the fresh-water kinds. Among reptiles there are many which are aquatic, either throughout life, or through the earlier period of their existence. But, as if animal life rose to higher organization, as it leaves the ocean to inhabit dry land or fresh waters, we find that the greater number of the aquatic reptiles are fluviatile, and but a few marine. This fact agrees wonderfully with the natural gradation of the classes already mentioned. The lower type of animals, the *Radiata*, is almost exclusively marine. Among *Mollusca*, we have a greater number of marine types, a large number of fluviatile species, and fewer terrestrial, and these are the highest in their class. Again, among *Articulata*, the lower classes, worms and *Crustacea*, are marine, or at least fluviatile, whilst the highest class, that of insects, is chiefly terrestrial or fluviatile, during the earlier periods of their growth. Among the *Vertebrata* we see the lowest form, that of fishes, entirely aquatic, and the same rule applies partially to the reptiles; but as the class rises, the number of the fluviatile species is greater than that of the marine types. Next, among birds, which by their structure are exclusively adapted to live in the atmospheric air, we find the larger number to be terrestrial, and only the lower ones to live upon water, or dive occasionally into it, always seeking the surface, however, to breathe and to perform their most important vital functions. It is, nevertheless, not a little strange, that this class should by nature be adapted to rise into the air, just as if the first tendency towards liberating them from the aquatic element had been carried to an excess, and gave them a relation to the earth which no other class, as a whole, holds to that degree, except, perhaps, the insects, which are placed among the *Articulata* in the same relation to the lower classes and the natural element, which the class of birds maintains among *Vertebrata.* The highest class of *Vertebrata* affords us examples of these three modes of adaptation, the lowest of these being entirely aquatic, and even absolutely marine; next, we have fluviatile types of the large terrestrial mammalia, in the family of *Manatees,* again, a swimming family among Carnivora, another flying, most of them however walking upon their four extremities on solid ground, but at the head of all, man, standing upright, to look freely upwards, and to contemplate the whole universe.

This wonderful adaptation of the whole range of animals, as it exists at present, shews the most intimate connection with the order of succession of animals in former geological periods. The four great types, *Radiata, Mollusca, Articulata,* and *Vertebrata,* were introduced at the beginning simultaneously. However, the earliest representatives of these great types were all aquatic. We find in the lowest beds which contain fossils, *Polypi,* together with star-fishes, bivalve shells, univalves, chambered shells, cases of worms, and *Crustacea,* being representatives of at least seven out of nine classes of invertebrate animals, if we are not allowed to suppose that *Medusæ* existed also, and if insects were still wanting for a time. But, in addition to these, fishes among *Vertebrata* are introduced, but fishes only, all of which are exclusively marine. At a somewhat later period insects come in. We find next reptiles in addition to fishes—the lower classes, or invertebrates, continuing to be represented through all subsequent epochs, but by species changing gradually at each period, as all classes do after they have been once introduced. The first representatives among reptiles are marine, next huge terrestrial ones, some, perhaps, flying types, and with them, and perhaps even before them, birds, allied to the wading tribes: still later, *Mammalia,* beginning again with marine and huge terrestrial types, followed by the higher quadrupeds; and, last only, Man,—at the head of the creation, in time as well as in eminence, by structure, intelligence, and moral endowments.

Besides the general adaptation of animals to the surrounding media, there is a more special adaptation, which seems not less important, though it is perhaps less striking. Animals, as well as plants, do not live equally at all depths of the ocean, or at all heights above its surface. There must be a deep influence upon the geographical distribution of animals in a vertical direction derived from atmospheric pressure above the surface of the waters, and from the pressure of the water itself at greater and greater depths,—the level of the ocean, or a small elevation above its surface, or a shallow depth under its surface, being the field of the most extensive and intensive development of animal life. And it is not a little remarkable that in the same classes we should find lower types at greater depths in the ocean, and also lower types at greater heights above. We will quote a few examples, to shew how much we may expect from investigations pursued in this direction, for at present we have but little information which can aid us in ascertaining the relationship between atmospheric and hydrostatic pressure and the energies of animal life.

Among *Polypi*, the higher forms, such as *Actiniæ*, are more abundant in shallow water than the lower coral-forming types. Among *Medusæ*, the young are either attached to the bottom, or grow from the depth, while the perfect free forms of these animals come to the surface. Among *Echinoderms*, the *Crinoids* are deep-water forms; free star-fishes and *Echini*, and, above all *Holothuriæ*, living nearer the surface. Among *Mollusca*, the *Acephala*, which are lowest, have their lower types,—the *Brachiopods*, entirely confined to deep waters; the *Monomyarians* appear next, and, above them, the *Dimyarians;* among these latter, the highest family, the *Nayades*, rises above the level of the ocean into the fresh waters, and extends even to considerable heights above the sea, in lakes and rivers. A number of examples of all classes should be mentioned, to shew that this is the universal case; as, for instance, among *Crustacea* the *Macrura* are, in general species of deeper water than the true crabs, of which some come even upon dry land. Again, on the slopes of our mountains, the highest forms among *Mammalia* which remain numerous are the *Ruminants* and *Rodents.* There are no *Carnivora* living in high regions. Among birds of prey, we have the vultures, rising above the highest summits of mountains, while eagles and falcons hover over the woods and plains, by the water sides, and along the sea-shores. Among reptiles, salamanders, frogs, and toads occur higher than any turtles, lizards, &c. But the same adaptation may be traced with reference to the latitudes under which animals are found. Those of the higher latitudes, the arctic and antarctic species, resemble both the animals of high, prominent mountain chains, and those of the deep sea-waters, which there meet in the most unexpected combinations (and it is surprising to see how extensively this is the case); while, in lower latitudes, towards the tropics, we find everywhere the higher representatives of the same families. For instance, among *Mammalia* we observe monkeys only in warm latitudes, and they die out in the warmer parts of the temperate zone. The great development of *Digitigrades*—lions, tigers, &c., takes place within the tropics, smaller species, like wolves and foxes, weasels, &c., occurring in the north, whilst the *Plantigrades*, which come nearer and nearer to the seal, follow an inverse progression, the largest and most powerful of them being the arctic ice bear, which meets there his family relations, the *Pinnipedia*, that are so numerous in the polar regions. Again, the families of *Ruminants* and *Pachyderms* seem to form an exception, for though belonging to the lower types of *Mammalia*, they prevail in the tropical zone; but let us remember that they were among the earlier inhabitants of our globe, and the fact of their occurring more extensively in warm climates is rather a reminiscence of the plan of creation in older times, than an adaptation to the law regulating at present the distribution of organized beings. The gradation of animals among birds being less satisfactorily ascertained, we do not venture to say anything respecting their geographical distribution, in relation to climates. But among reptiles, we cannot overlook the fact, that the crocodiles, which are the highest in structure, are alogether tropical, and the *Batrachians*, which rank lowest, especially the salamandroid forms, are rather types of the colder temperate zone than of the warm, &c. From these facts it is plain, that the geographical distribution of all groups has a direct reference to atmospheric and hydrostatic pressure on one side, and also to the intensity of light and heat over the surface of the globe.

The special adaptation of minor groups begins very early in the history of our globe, and extends at present all over its surface. In the same manner as animals are adapted to natural limits in their large primitive groups which we call classes, we find also the minor divisions more closely adapted to particular circumstances of the physical condition of all parts of the globe. Among *Mammalia*, the great type of *Marsupialia* is placed in New Holland, and extends little beyond that continent into the adjacent islands. A very few representatives of that family are found in America. Asia, Africa, the colder parts of North America, and its southern extremity, are entirely deprived of this type. The family of *Edentata*, again, has its centre of development in South America, where the sloth, dasypus, ant-eaters, &c., form characteristic types, of which a few analogues occur in Africa, along its southern extremity and western coast. Now it is a fact upon which we cannot insist too strongly, that the same districts of New Holland and South America were, during an earlier geological period comparatively recent, the seat of an equally wide development of the same animals in the same extensive proportion as at present. We need only refer to the beautiful investigations of Dr Lund, upon the fossil mammalia of Brazil, and to those, no less important, of Professor Owen, upon the fossil remains of mammalia of New Holland, to leave not a shadow of doubt upon this adaptation, which indicates distinctly these two regions, at two distinct periods remote from each other, as the points of development of two distinct families, which have never spread over other parts of the globe at any period since the time of their existence, indicating at least two distinct foci of creation, with the same characters, at two successive epochs; a fact which, in our opinion, can never be reconciled to the idea of a unique centre of origin of the animals now living. But though other families have never been and are not now localized in so special a manner, we nevertheless find them circumscribed within certain limits, in particular districts, or, at least, in particular zones.

As already mentioned, the monkeys are entirely tropical. But here, again, we notice a very intimate adaptation of their types to the particular continents, as the monkeys of tropical America constitute a family altogether distinct from the monkeys of the Old World, there being not one species of any of the genera of *Quadrumana,* so numerous on this continent, found either in Africa or in Asia. The monkeys of the Old World, again, constitute a natural family by themselves, extending equally over Africa and Asia; but the species of Africa differ from those of Asia; and there is even a close representative analogy between those of different parts of these two continents; the orangs of Africa, the chimpanzee and gorilla, corresponding to the red orang of Sumatra and Borneo, and the smaller long armed species of continental Asia. And what is not a little remarkable is the fact, that the black orang occurs upon that continent which is inhabited by the black human race, whilst the brown orang inhabits those parts of Asia over which the chocolate-coloured Malays have been developed. There is again a peculiar family of *Quadrumana* confined to the Island of Madagascar—the makis—which are entirely peculiar to that island, and the eastern coast of Africa opposite to it, and to one spot on the western shore of Africa. But in New Holland, and the adjacent islands, there are no monkeys at all, though the climatic conditions seem not to exclude their existence any more than those of the large Asiatic islands, upon which such high types of this order are found. And these facts more than any other, would indicate that the special adaptation of animals to particular districts of the surface of our globe is neither accidental, nor dependent upon physical conditions, but is implied in the primitive plan of the creation itself. Whatever classes we may take into consideration, we shall find similar adaptations, and though, perhaps, the greater uniformity of some families renders the difference of the types in various parts of the world less striking, they are none the less real. The *Carnivora* of tropical Asia are not the same as those of tropical Africa, or those of tropical America. Their birds and reptiles present similar differences. The want of an ostrich in Asia, when we have one, the largest of the family, in Africa, and two distinct species in Southern America, and two cassowaries, one in New Holland, and another in the Sunda Islands, shews this constant process of analogous or representative species repeated over different parts of the world to be the principle regulating the distribution of animals, and the fact that these analogous species are different, again, cannot be reconciled to the idea of a common origin, as each type is peculiar to the country where it is now found. These differences are more striking in tropical regions than anywhere else. The rhinoceros of the Sunda Islands differs from those of Africa, and there is none in America. The elephant of Asia differs from that of Africa, and there is none in America. One tapir is found in the Sunda Islands, there is none in Africa, but we find one in South America, &c. Everywhere special adaptation, particular forms in each continent, an omission of some allied type here, when in the next group it occurs all over the zone.

As we ascend into the temperate zone, we find, however, the similarity greatly increased. The difference between the species of the same family in temperate Asia, temperate Europe, and temperate America is much less than between the corresponding animals of the tropical zone, and no doubt it is to this great assemblage of more uniform animals, living originally within the main seat of human civilization, that we must ascribe the idea of their common origin, which has so long prevailed and been so serious an obstacle to a real insight into these natural phenomena. What, indeed, could be more natural for man, when for the first time reflecting upon nature around him,—when seeing, as far as he could extend his investigations, all things alike,—than to imagine that every thing arose from a common centre, and spread with him over the world, as it has been the fate of the white race, and of that only, to extend all over the globe, and that, influenced by the phenomena of the zone in which he lived and wandered, and from which he extended farther, he took it for granted that all animals followed the same laws. But now that we know the whole surface of our globe so satisfactorily, there can no longer be a question about the difference between animals and plants in the lower latitudes in all continents. Besides, we see them equally striking in the southernmost extremities of the three great continents, so that there can no longer be any doubt about the primitive adaptation of these various types to the continents where they live, as we do not find a single one naturally diffused everywhere over all continents. Notwithstanding, therefore, the sligliter differences we notice between the animals of different continents in the temperate zone, we are thus led step by step to ascribe to them also a special origin upon those continents where they now occur.

But as soon as we rise to the highest latitudes, the uniformity becomes so close, that there is no longer any marked difference noticed between the animals about the arctic regions, either in America, Europe, or Asia; and we are naturally led to restrict the idea of a common centre of origin, or at least of a narrow circle of primitive development, to those animals which spread equally over the icy fields extending around the northern pole upon the three continents which meet in the north. The phenomena of geographical distribution which we observe there among the terrestrial animals are repeated in the same manner among the aquatic ones. The fishes in the arctic seas do not materially differ on the shores of Europe, Asia, and America, and through the northern Atlantic and through Behring's Straits they extend more or less towards the colder temperate zone, or migrate into it at particular seasons of the year, as do most birds of the arctic regions also. But in the temperate zone we begin to find more and more marked differences between the inhabitants of different continents, and even between those of the opposite shores of the same ocean; as, for instance, the fishes of Europe (some of the northern species excepted) are not identical with those of the temperate shores of North America, notwithstanding the very open field left for their uniform distribution across the Atlantic. Such is also the case between the fishes of Western Africa and those of Central America, and between those of the southern extremities of these continents. The fishes of the Indian Ocean, and the fishes of the Pacific vary greatly, and, though some families have a wider range, there are many which are circumscribed within the narrowest limits. It is one of the most striking phemonena in the geographical distribution of aquatic animals, to find entire families of fishes completely circumscribed within particular groups of islands, such, for instance, as the *Labyrinthici*, which are peculiar to the Sunda Islands, and the family of *Goniodonts*, which are found only in the rivers of South America.

A similar narrow limitation occurs also among the terrestrial animals, as the family of *Colubris* is entirely circumscribed within the boundaries of the warmer parts of the American continent. The appearance during the warmer season of the year of a few species of that family in the Northern States, does not make this case less strong. Examples might be multiplied without end to shew everywhere special adaptation, narrow circumscription, or representative adaptation of species in different parts of the world; but those mentioned will be sufficient to sustain the argument that animals are naturally antochthones wherever they are found, and have been so at all geological periods; that in northern regions they are most uniform; that their diversity goes on increasing through the temperate zone till it reaches its maximum in the tropics; that this diversity is again reduced in the acquatic animals towards the antarctic pole, though the physical difference between the southernmost extremities of America, Africa, and New Holland, seems to have called for an increased difference between their terrestrial animals.

We are thus led to distinguish special provinces in the natural distribution of animals, and we may adopt the following division as the most natural: *First*, the *arctic province*, with prevailing uniformity. *Second*, the temperate zone, with at least three distinct zoological provinces—the *European temperate zone*, west of the Ural Mountains, the *Asiatic tem-*

perate zone east of the Ural Mountains, and the *American temperate zone*, which may be subdivided into two, the *eastern* and the *western*—for the animals east and west of the Rocky Mountains differ sufficiently to constitute two distinct zoological provinces. Next, the tropical zone, containing the *African zoological province*, which extends over the main part of the African continent, including all the country south of the Atlas and north of the Cape Colonies; the *tropical Asiatic province*, south of the great Himalayan chain, and including the Sunda Islands, whose *Fauna* has quite a continental character, and differs entirely from that of the Islands of the Pacific, as well as from that of New Holland; the *American tropical province*, including Central America, the West Indies, and tropical South America. *New Holland* constitutes in itself a special province, notwithstanding the great differences of its northern and southern climate, the animals of the whole continent preserving throughout their peculiar typical character. But it were a mistake to conceive that the *Faunæ* or natural groups of animals are to be limited according to the boundaries of the mainland. On the contrary we may trace their natural limits into the ocean, and refer to the temperate European *Fauna* the eastern shores of the Atlantic, as we refer its western shores to the American temperate *Fauna*. Again, the eastern shores of the Pacific belong to the western American *Fauna*, as the western Pacific shores belong to the Asiatic *Fauna*. In the Atlantic Ocean there is no purely oceanic *Fauna* to be distinguished, but in the *Pacific* we have such a *Fauna*, entirely marine in its main character, though interspread with innumerable islands extending east of the Sunda Islands and New Holland to the western shores of tropical America. The islands west of this continent seem, indeed, to have very slight relations in their zoological character with the western parts of the mainland. South of the tropical zone we have the *South American temperate Fauna*, and that of the *Cape of Good Hope*, as other distinct zoological provinces. Van Diemen's Land, however, does not constitute a zoological province in itself, but belongs to the province of New Holland, by its zoological character. Finally, the antarctic circle encloses a special zoological province, including the *antarctic Fauna*, which, in a great measure, corresponds to the arctic *Fauna* in its uniformity, though it differs from it in having chiefly a maritime character, while the arctic *Fauna* has an almost entirely continental aspect.

The fact that the principal races of man, in their natural distribution, cover the same extent of ground as the great zoological provinces, would go far to shew that the differences which we notice between them are also primitive; but for the present we shall abstain from further details upon a subject involving so difficult problems as the question of the unity or plurality of origin of the human family, satisfied as we are to have shewn that animals, at least, did not originate from a common centre, nor from single pairs, but according to the laws which at present still regulate their existence.

Additional Illustrations of the Geographical Distribution of Animals.

I.—*Geographical Distribution of Sturgeons.**

The sturgeons are generally large fishes, which live at the bottom of the water, feeding with their toothless mouths upon decomposed organized substances. Their movements are rather sluggish, resembling somewhat those of the cod-fish.

Their geographical distribution is quite peculiar, and constitutes one of their prominent peculiarities. Located as they are, in the colder portions of the temperate zone, they inhabit either the fresh waters or the seas exclusively, or alternately both these elements,—remaining during the larger part of the year in the sea, and ascending the rivers in the spawning season. Although adapted to the cold regions of the temperate, they do not seem to extend into the arctic zone, and I am not aware that they have been observed in any of the waters of the warmer half of the temperate zone. The great basin of salt-water lakes or seas which extends east of the Mediterranean, seems to be their principal abode in the Old World, or at least the region in which the greater number of species occur; and each species takes a wide range, extending up the Danube and its tributaries, and all the Russian rivers emptying into the Black

* Agassiz's Lake Superior, p. 264.

Sea. From the Caspian they ascend the Wolga in immense shoals, and are found further east in the lakes of Central Asia, even as far as the borders of China. The great Canadian lakes constitute another centre of distribution of these fishes in the New World, but here they are not so numerous, nor do they ever occur in contact with salt water in this basin.

Northwards, there is another great zone of distribution of sturgeons, which inhabit all the great northern rivers emptying into the Arctic Sea, in Asia as well as in America. They occur equally in the intervening seas, being found on the shores of Norway and Sweden, in the Baltic and North Seas, as well as in the Atlantic Ocean, from which they ascend the northern rivers of Germany, as well as those of Holland, France, and Great Britain. Even the Mediterranean and the Adriatic have their sturgeons, though few in number. There are also some on the Atlantic shores of North America, along the British possessions as well as the northern and middle United States. They seem to be exceedingly numerous in the Northern Pacific, being found everywhere from Behring's Straits and Japan to the northern shores of China, and on the north-west coast of America, as far south as the Columbia River. Again, the so-called western waters of the United States have their own species, from the Ohio down to the lower portion of the Mississippi, but it does not appear that these species ascend the rivers from the Gulf of Mexico. I suppose them to be rather entirely fluviatile, like those of the great Canadian lakes.

Beyond the above limits southwards there are nowhere sturgeons to be found, not even in the Nile, though emptying into a sea in which they occur; and as for the great rivers of Southern Asia and of tropical Africa, not only the sturgeons, but another family is wanting there,—I mean the family of *Goniodonts*, which in Central and Southern America takes the place of the sturgeons of the north. Again, all the species in different parts of the world are different.

It is a most extraordinary fact, which will hereafter throw much light upon the laws of geographical distribution of animals and their mode of association, viz., that certain families are entirely circumscribed within comparatively narrow limits, and that their special location has an unquestionable reference to the location of other animals; or, in other words, that natural families, apparently little related to each other, are confined to different parts of the world, but are linked together by some intermediate form, which itself is located in the intermediate track between the two extremes. In the case now before us, we have the sturgeons extending all around the world in the northern temperate hemisphere, in its seas as well as in its fresh waters, all closely related to each other. Neither in Asia nor in Africa is there an aberrant form of that type, or any representative type in the warmer zones; but in North America we have the genus *Scaphirhynhus*, which occurs in the Ohio and Mississippi, and which forms a most natural link with the family of *Goniodonts*, all the species of which are confined exclusively to the fresh waters of Central and South America. The closeness of this connection will be at once perceived by attempting to compare the species of true *Sonicariæ* with the *Scaphirhynhus*. I know very well, that the affinities of *Goniodonts* and *Siluroids* with sturgeons are denied, but I still strongly insist upon their close relationship, which I hope to establish satisfactorily in a special paper, as I continued to insist upon the relation between sturgeons and gar-pikes, at one time positively contradicted and even ridiculed. I trust then to be able to shew, that the remarkable form of the brains of *Siluridæ* comes nearer to that of sturgeons and *Lepidostei* than to that of any other family of fishes. This being the case, it is obvious that there must be in the physical condition of the continent of America some inducement not yet understood, for adaptations so special and so different from what we observe in the Old World. Indeed, such analogies between the organized beings almost from one pole to another, occur from man down to the plants in America only, among its native products; while, in the Old World, plants as well as animals have more circumscribed homes, and more closely characterized features, in the various continents, at different latitudes.

As for the species of sturgeons which occur in the Canadian lakes, I know only three from personal examination, one of which was obtained in Lake Superior, at Michipicotin, another at the Pic, and the third at the Sault; though I know that they occur in all other Canadian lakes, yet it remains to be ascertained how the species said to be so common in Lake Huron, compared with those of Lake Superior, and with those in the other great lakes and the St Lawrence itself. As for the Atlantic species, ascending the rivers of the United States west and south of Cape Cod, I know them to differ from those of the lakes, at least from those which I possess from Lake Superior. The number of species of this interesting family which occur in the United States is, at all events, far greater than would be supposed from an examination of the published records. Upon close comparison of thes pecimens in my collection from different parts of the country, and in different museums, as those of the Natural History Society of Boston, of Salem, of the Lyceum of New York, my assistant, Mr Charles Giran, and myself, have discovered several species not described. For this comparison I was the better prepared, as I had an opportunity in former years of studying almost all the European species in a fresh condition, during a prolonged visit in Vienna.

II.—*Fishes of Lake Superior compared with those of the other great Canadian Lakes.*

Besides the interest there is everywhere in studying the living animals of a new country, there is a particular interest to a naturalist in ascertaining their peculiar geographical distribution, and their true affinities with those of other countries. It is only by following such a course, that we can hope to arrive at any exact results as to their origin. In this respect the fresh-water animals have a peculiar interest, as from the element they inhabit, they are placed under exceptional circumstances.

Marine animals, as well as those inhabiting dry land, seem to have a boundless opportunity before them to spread over large parts of the earth's surface, and their locomotive powers would generally be sufficient to carry them almost anywhere; but they do not avail themselves of the possibility; notwithstanding their facilities for locomotion, they for the most part remain within very narrow limits, using their liberty rather to keep within certain definite bounds. This tendency of the higher animals especially, to keep within well-ascertained limits, is perhaps the strongest evidence that there is a natural connection between the external world and the organised beings living upon the present surface of our globe. The laws which regulate these relations, and those of geographical distribution in particular, have already been ascertained to a certain extent, and will receive additional evidence from the facts recorded during our journey.

The fresh-water animals are placed in somewhat different circumstances. Their abode being circumscribed by dry land, within limits which are often reduced to a narrow current of water, and being further, for the most part, prevented by structural peculiarities from passing from the rivers into the ocean, they are confined within narrower limits than either terrestrial or marine types. Within these limits again they are still further restricted; the shells and fishes of the head waters of large rivers, for instance, being scarcely ever the same as those of their middle or lower course, few species extending all over any fresh-water basin from one extreme of its boundary to the other; thus forming at various heights above the level of the sea, isolated groups of fresh-water animals in the midst of those which inhabit the dry land. These groups are very similar in their circumscription to the islands and coral reefs of the ocean; like them, they are either large or small, isolated and far apart, or close together in various modes of association. In every respect they form upon the continents, as it were, a counterpart of the Archipelagos.

From their circumscription, these groups of lakes present at once a peculiar feature in the animal kingdom, their inhabitants being entirely unconnected with any of the other living beings which swarm around them. What, for instance, is there apparently in common between the fishes of our lakes and rivers, and the quadrupeds which inhabit their shores, or the birds perching on the branches which overshadow their waters? Or what connection is there between the few hermit-like terrestrial animals that live upon the low islands of the Pacific and the fishes which play among the corals, or in the sand and mud of their shores? And nevertheless there is but one plan in the creation; fresh-water animals under similar latitudes are as uniform as the corresponding vegetation, and however isolated and apparently unconnected the tropical islands may seem, their inhabitants agree in their most important traits.

The best evidence that in the plan of creation animals are intended to be located within circumscribed boundaries, is further derived from their regular migrations. Although the arctic birds wander during winter into temperate countries, and some reach even the warmer zones; although there are many which, from the colder temperate climates, extend quite into the tropics, there is nevertheless not one of these species which passes from the northern to the southern hemispheres; not one which does not return at regular epochs to the countries whence it came from. And the more minutely we trace this geographical distribution, the more we are impressed with the conviction that it must be primitive; that is to say, that animals must have originated where they live, and have remained almost precisely within the same limits ever since they were created, except in a few cases, where, under the influence of man, those limits have been extended over large areas. To express this view still more distinctly, I should say the question to be settled is, whether for instance the wild animals which live in America originated in this continent, or migrated into it from other parts of the world; whether the black bear was created in the forests of New England and the northern states, or whether it is derived from some European bear, which by some means found its way to this continent, and being under the influence of a new climate, produced a new race; whether the many peculiar birds of North America which live in forests composed of trees different from those which occur either in Europe or Asia, whether these birds, which themselves are not identical with those of any other country, were or were not created where they live; whether the snapping turtle, the alligator, the rattlesnake, and other reptiles which are found only in America, have become extinct in the Old World after migrating over the Atlantic, to be preserved in this continent; whether the fishes of the great Canadian lakes made their appearance first in those waters, or migrated thither from somewhere else? These are questions which such an inquiry into the geographical distribution of animals involves; it is the great question of the unity or plurality of creations; it is not less the question of the origin of animals from single pairs or in large numbers; and, strange to say, a thorough examination of the fishes of Lake Superior, compared with those of the adjacent waters, is likely to throw more light upon such questions, than all traditions, however ancient, however near in point of time to the epoch of creation itself.

In order to proceed methodically in this investigation, our first step must be to examine minutely, whether the fishes of Lake Superior are the same as those of other lakes, in this or any other country; and, if not, how they differ. To satisfy ourselves in this respect, we shall successively examine all the families of fishes, which have representatives in those great fresh-water seas. (*Agassiz on Lake Superior, p.* 246.) Professor Agassiz, after admirable histories of the fishes of Lake Superior, concludes with the following excellent observations :—*

III.—*General Observations; all Fresh-water Fishes of North America different from those of Europe—Lake Superior and the Lakes north of it constitute a distinct Zoological District—These Fishes have been created where they now live—Deductions from this fact.*

Such a critical revision of the fishes of Lake Superior, and the other great Canadian lakes, was the first necessary step in the investigation I am tracing, in order to ascertain the natural primitive relations between them and the region which they inhabit. Before drawing the conclusions which follow directly from these facts, I should introduce a similar list of the fishes living in similar latitudes, or under similar circumstances, in other parts of the world; and more particularly of the species of Northern Europe. But such a list, to be of any use, should be throughout based upon a critical comparative investigation of all the species of that continent, which would lead to too great a digression. The comparison of the fresh-water fishes of Europe, which correspond to those of North America, has been carried so far, that I feel justified in assuming, what is really the fact, that all the species of North America, without a single exception, differ from those of Europe, if we limit ourselves strictly to fishes which are exclusively the inhabitants of fresh water.

I am well aware that the salmon which runs up the rivers of Northern and Central Europe, also occurs on the eastern shores of the northern part of North America, and runs up the rivers emptying into the Atlantic. But this fish is one of the marine arctic fishes, which migrates with many others, annually further south, and which migratory species is common to both continents. Those species, however, which never leave the fresh waters, are, without exception, different on the two continents. Again, on each of the continents, they differ in various latitudes; some, however, taking a wider range than others in their natural geographical distribution.

The fresh-water fishes of North America, which form a part of its temperate fauna, extend over very considerable ground; for there is no reason to subdivide into distinct faunæ the extensive tracts of lands between the arctics and the Middle States of the Union. We notice over these, considerable uniformity in the character of the fresh-

* "Lake Superior," p. 373.

water fishes. Nevertheless, a minute investigation of all their species has shewn that Lake Superior proper, and the fresh waters north of it, constitute in many respects a special zoological district, sufficiently different from that of the lower lakes and the northern United States, to form a natural division in the great fauna of the fresh-water fishes of the temperate zone of this continent.

We have shewn that there are types, occurring in all the lower lakes, which never occur in Lake Superior and northwards, and that most of the species found in Lake Superior are peculiar to it; the Salmonidæ only taking a wider range, and some of them covering almost the whole extent of that fauna, while others appear circumscribed within very narrow limits.

Now, such differences in the range which the isolated species take in the faunæ, is a universal character of the distribution of animals; some species of certain families covering, without distinction, extensive grounds, which are occupied by several species of other families, limited to particular districts of the same zone.

But after making due allowance for such variations, and taking a general view of the subject, we arrive, nevertheless, at this conclusion; that all the fresh-water fishes of the district under examination are peculiar to that district, and occur nowhere else in any other part of the world.

They have their analogues in other continents, but nowhere beyond the limits of the American continent do we find any fishes identical with those of the district, the fauna of which we have been recently surveying. The lamprey eels of the lake district have very close representatives in Europe, but they cannot be identified. The sturgeons of this continent are neither identical with those of Europe nor with those of Asia. The cat-fishes are equally different. We find a similar analogy and similar differences between the perches, pickerels, eelpouts, salmons, and carps. In all the families which occur throughout the temperate zone, there are near relatives on the two continents, but they do not belong to the same stock. And in addition to these, there are also types which are either entirely peculiar to the American continent, such as Lepidosteus and Percopsis, or belong to genera which have not simultaneous representatives in the two worlds, and are therefore more or less remote from those which have such close analogues. The family of Percoids, for instance, has several genera in Europe, which have no representatives in America; and several genera in America which have no representatives in Europe, besides genera which are represented on both continents, though by representatives specifically distinct.

Such facts have an important bearing upon the history of creation; and it would be very unphilosophical to adhere to any view respecting its plan, which would not embrace these facts, and grant them their full meaning. If we face the fundamental question which is at the bottom of this particular distribution of animals, and ask ourselves, where have all these fishes been created, there can be but one answer given which will not be in conflict and direct contradiction with the facts themselves, and the laws that regulate animal life. The fishes, and all other fresh-water animals of the region of the great lakes, must have been created where they live. They are circumscribed within boundaries over which they cannot pass, and to which there is no natural access from other quarters. There is no trace of their having extended further in their geographical distribution at any former period, nor of their having been limited within narrower boundaries.

It cannot be rational to suppose that they were created in some other part of the world, and were transferred to this continent, to die away in the region where they are supposed to have originated, and to multiply in the region where they are found. There is no reason why we should not take the present evidence in their distribution as the natural fact respecting their origin, and that they are, and were from the beginning, best suited for the country where they are now found.

Moreover, they bear to the species which inhabit similar regions, and live under similar circumstances in Europe and Asia, and the Pacific side of this continent, such relations, that they appear to the philosophical observer as belonging to a plan which has been carried out in its details with reference to the general arrangement. The species of Europe, Asia, and the Pacific side of this continent, correspond in their general combination to the species of the eastern and northern parts of the American continent, all over which the same general types are extended. They correspond to each other on the whole, but differ as to species.

And again, this temperate fauna has such reference to the fauna of the arctic, and to that of the warmer zones, that any transposition of isolated members of the whole plan would disturb the harmony which is evidently maintained throughout the natural distribution of organized beings all over the world. This internal evidence of an intentional arrangement, having direct reference to the present geographical distribution of the animals, dispersed over the whole surface of our globe, shews most conclusively, that they have been created where they are now found. Denying this position were equivalent to denying that the creation has been made according to a wise plan. It were denying to the Creator the intention of establishing well-regulated natural relations between the beings he has called into existence. It were denying him the wisdom which is exemplified in nature, to ascribe it to the creatures themselves,—to ascribe it even to those creatures in which we hardly see evidence of consciousness, or, worse than all, to ascribe this wonderful order to physical influence or mere chance.

As soon as this general conclusion is granted, there are, however, some further adaptations which follow as a matter of course. Each type, being created within the limits of the natural area which it is to inhabit, must have been placed there under circumstances favourable to its preservation and reproduction, and adapted to the fulfilment of the purposes for which it was created. There are in animals peculiar adaptations which are characteristic of their species, and which cannot be supposed to have arisen from subordinate influences. Those which live in shoals cannot be supposed to have been created in single pairs. Those which are made to be the food of others cannot have been created in the same proportions as those which feed upon them. Those which are everywhere found in innumerable specimens, must have been introduced in numbers capable of maintaining their normal proportions to those which live isolated, and are comparatively and constantly fewer. For we know that this harmony in the numerical proportions between animals is one of the great laws of nature. The circumstance that species occur within definite limits where no obstacles prevent their wider distribution, leads to the further inference that these limits were assigned to them from the beginning and so we would come to the final conclusion, that the order which prevails throughout the creation is intentional,—that it is regulated by the limits marked out on the first day of creation,—and that it has been maintained unchanged through ages, with no other modifications than those which the higher intellectual powers of man enable him to impose upon some of the few animals more closely connected with him, and in reference to those very limited changes which he is able to produce artificially upon the surface of our globe.*

On the Geography and Geology of the Peninsula of Mount Sinai, and the adjacent Countries. By JOHN HOGG, M.A., F.R.S., F.L.S.; Honorary Secretary of the Royal Geographical Society, &c. Communicated by the Author.

(*Continued from page* 219.)

This town is named in Scripture Elath or Eloth; in the Septuagint Αἰλὰθ, and Αἰλὼν; Αἴλὰς, Αἐιλὰ, or Aila by the Greeks; Ælana by the Romans; and Ailah by the Arabians: it is described in 1 Kings ix. 26, as "on the *shore* of the *Red Sea* in the land of Edom;" and in 2 Chron. viii. 17, "at the *sea-side* in the land of Idumea." From Procopius, in the 6th

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* The above view of the geography of animals appeared partly in an American periodical and partly in Professor Agassiz's beautiful and important work (just received) on Lake Superior.

century, we learn the following exact account,* which agrees very well with the site of those *mounds*—" the eastern limits of *Palæstina* (including of course that part of the peninsula which he elsewhere relates† was called *Palæstina Tertia*), reach along the Red Sea. On the shore is placed the town *Ailas*, where, the sea ending, it is contracted into a very narrow bay."

Edrisi, in the 12th century, terms the steep descent from the Desert El Tyh by El Nakb to Akaba—" Akaba Ailah"—*i.e.*, the "Descent of Ailah;" and Makrisi, in the 14th century, as cited by Burckhardt (p. 511), speaks of " the *Akaba*, or steep mountain *before Aila*." Consequently, I take it to be correct that these *mounds* indicate the former position of *Elath*,‡ on the shore of the Sea of Edom or Idumea—an arm of the Red Sea.

At a short distance from them, but westward, a large space, like a marsh, seemed to be impregnated with *nitre*, which is left incrusted in some spots upon their surface. From hence, going up the extensive valley El Araba, it is found to be full of sand drifts, with here and there a few trees scattered about; the torrents, after rain, flow along the west side, and their waters, which are *not absorbed* by the *sand*, enter the sea at the north-west angle. The width of this part of the Wadi is near 5 miles, but in advancing farther to the north it becomes wider. The mountains on the east are high—from 2000 to 2500 feet; being of *granitic*, or rather *porphyritic* formation, they are highly picturesque, and have fine, lofty, jagged peaks: but those on the west, which are *sandstone* and *chalk*, are lower; rising to about a level with the desert El Tyh, they do not exceed 1500, or in places 1800 feet in elevation.

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* *Procopii* de Bell. Pers., lib. i., cap. 19.

† *Procop.* de Ædificiis Justiniani, lib. v., cap. 8. Tom. ii. Edit. *Par.* 1663.

‡ Ailah was in the middle ages considered (Robinson, i., p. 252, and Lepsius' Tour, p. 20), as *Elim*, the sixth station of the Israelites after they passed the Red Sea. But I apprehend that the error very likely arose from the word Αἰλὰμ occurring in the *Alexandrine MS.*, (2 Kings xvi. 6; and 2 Chron. viii. 17), for Αἰλάθ, which is used in the LXX., in those verses. So Αἰλὰμ had here been *mistaken* for Αἰλεὶμ, *Elim*, the word which is found in Exodus, xvi. 1; of the LXX.

Not far from Wadi Ghadyan,* towards the west side, a great marsh-like tract, apparently impregnated with *nitre*, exhibits an incrustation on its surface. And the water in the spring itself is, according to *M. De Bertou*, strong of *sulphur*.

Passing the opening of Wadi Beianeh, and still ascending, the most elevated table-land or small plateau of the Wadi-El-Araba is reached at about the line of 30° north latitude, and 35° 15′ east longitude nearly, which is very near 500 feet higher than the level of the Gulf of Akaba, according to *Herr Schubert*. About that point the *water-shed* occurs; some of the waters of the Araba flow south into the sea of Akaba, but most are carried off north by the tributaries of the Wadi-el-Jeib into the Dead Sea.

The same traveller (*Schubert*) found the depression of the bed of that deep Wadi at about 4 miles south of El Weibeh ("hole with water,") to be 91 Paris feet, or 97 English feet *below* the level of the Red Sea; the commencement, or most southern limit of that depression taking place at about 15 miles northward of Gebel Harun in Wadi-el-Araba. Consequently, the Dead Sea, Asphaltic Lake *(Bahr Lut)*—the "Sea of Lot"—must lie considerably *lower* than the level of the Gulf of Akaba; indeed, *Herr Schubert* gives the level of the *Dead Sea* as being 598 Paris feet, and M. Russegger even more than 1300 English feet *below* that of the Mediterranean.

These geographical facts then afford, as some authors have supposed, sufficient evidence that the River Jordan, although taking its source at an elevation of 1800 feet in the north Syrian mountains—*has not* flowed through the entire valley *El Araba* into the Gulf of Akaba; or rather, into the Red Sea, beyond what is now the Strait of Tiran. And certainly these facts are *decisive* that it *never has done* so—if the natural conformation of this region has *always* been the *same*, as it now exists with regard to *depth* and *height*. But against its having continued the *same*, *ab initio*, up to the present time,

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* How Robinson could suppose that this might afford a *trace* of Eziongaber, I cannot imagine. See Bib. Res., vol. i., pp. 251, 268.

much reasonable hypothesis, and several remarkable appearances may be fairly advanced.

Of the latter, some are the *volcanic* phenomena apparent around the Dead Sea and El Ghor,* on the north; in the basaltic cliffs and creeks nearly opposite the Isle of Kureiyeh; the frequent displacements of strata and rocks in many places on the north-west side of the Gulf of Akaba; the coincidences exhibited by the strata in the Isle of Tiran, with those of the Arabian and Sinaic shores; and the volcanic remains and crater-like hills between them and Sherm on the south. Moreover, it may be collected from Scripture, that certain *changes* had actually been *effected* in the vicinity of the *Dead Sea* (Gen. xix. 25); and that they were caused by *fire* (*Ibid.* xxiv. 28); if then, at that period, the southern part of the valley of the Jordan, the plain of the Dead Sea, and El Ghor had, through igneous, or volcanic, or other agency, *sunk* much *below* their former levels, it is possible that a corresponding *elevation* of the land in *Wadi-el-Araba* might have taken place at the same (or perhaps at another) time, by the same (or by a subsequent similar) agency.

Again, it seems probable from Scripture, that the *Dead Sea* and *Wadi-el-Araba* had been once continued, or more connected in their levels; because in Joshua iii. 16, and xii. 3, the former is called "the *sea of the plain* (even) the Salt Sea;" and in Deut. iv. 49, only "the *sea of the plain*;" the original Hebrew expression in all three verses is, "Yam ha Arabah;" that is, the *Sea of the Araba*; and the Septuagint renders it ἡ θάλασσα Ἄραβα. "Ha Arabah," in Hebrew, signifies the same as *El Arabah* in Arabic—a "desert-plain," or a "plain." So, likewise, we find in Deut. ii. 8, "the children of Edom" described as dwelling "in Seir, through the way of the *Plain* from Elath, and from Eziongaber;" the Hebrew and Greek words for *the plain* are here also the same, viz., "*Arabah.*" Consequently, these passages from Scripture, shewing that *both extremes*, north and south, of this great *plain* or *Wadi*,

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* *Ghor* signifies "a long *valley* between two mountains." Refer to some of these *volcanic* indications, p. 122 of *Dr Kitto's* "Physical Geography of the Holy Land." El Ghor, on the south of the Dead Sea, abounding in *salt*, is most probably "the *valley* of salt" mentioned in 2 Kings xiv. 7.

bore the *same* appellation, prove that it was esteemed one *entire* valley in its *whole extent*, from the Dead, or Salt Sea, to Elath and Eziongaber on the Red Sea, or Ælanitic Gulf, in the land of Edom (1 Kings ix. 26, and 2 Chron. viii. 17.) And, indeed, according to Dr Robertson, *no* such *division* of it, as *M. De Bertou* and some other travellers assert, into *Wadi-el-Akaba*, and *Wadi-el-Araba*,* at this day exists.

After having attained the highest point, or short table-land of the Wadi-el-Araba, the descent in fact begins in a direct line nearly due north to the Dead Sea; it is in places more elevated, rougher, and more sandy than in others; and its width also becomes greater. Gebel-el-Beianeh appears the *loftiest* of the chain on the west; but this is scarcely two-thirds as *high* as the east range, Gebel-el-Shera (*Mount Seir*); the former is entirely sterile and arid, whilst the latter is covered with herbs and occasional trees, and seems to have a sufficiency of rain. The east *Wadis* also, which are numerous, are filled with trees, shrubs, and flowers; and their eastern and *higher* portions, being well cultivated, yield good crops. So Strabo, calling the district "Nabathæa," states it *abounded in pastures; ἡ Ναϐαταία πολύανδρος ἐστα ἡ χώρα καὶ ἔυϐοτος*;† and being the country of Esau, it was "of the fatness of the earth, and of the dew of heaven from above." —*Gen.* xxvii. 39.

The range of Mount Seir, *Gebel-el-Shera, i. e.*, the mountains of a "region" or "tract," under which I have only included those mountains, commencing with Mount *Seir* itself on the north, and extending to Gebel-el-Ithm on the south. On the eastern side is now *sandstone*, veined with *oxide of iron;* and those mountains still further to the east, forming a part of the Nabathæan chain, are *limestone* with *flints*, of the same *cretaceous* series as that of the Sinaic Peninsula; they present many varied forms and shapes.

El Araba, in the approach to Wadi Gharandel, is more covered with shifting sands, broken by innumerable undulations, and low hills; into these sands the waters of Wadi

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* See *M. De Bertou's* paper in the "Journal of the Royal Geographical Society," vol. ix., p. 282.

† *Strabo* Geog., vol. ii., lib. 16–35, p. 1103. Edit. *Falconer*.

Gharandel, which, according to Burckhardt, have a *sulphureous* taste, lose themselves. In the ascent of this Wadi (Gharandel) towards Gebel Kula, a mountain is climbed which is composed of *calcareous* rocks, *sandstone* and *flints,* lying over each other in horizontal layers. Gebel Kula is covered on its summit, with a *chalky* surface. But in Wadi Dalegheh the mountains are *calcareous*, with some *flints*, and perfectly bare.

East of these valleys, and distant about six miles, are said to be the vestiges of a Roman road, which probably led near Usdaka—the *Szadeke* of Burckhardt—to Petra. Near that place is a hill with some considerable ruins, very possibly the remains of what the Peutingerian Table calls *Zadagasta ;* which word seems to have been corrupted into *Zadeka*, and *Sudaka*, or *Usdaka*. A fine spring, or *Ain*, is there much noted. Also, further north five or six miles, at Ain Mefrak, some ruins are visible. And the same traveller noticed, a few miles north of the present picturesque village of Eljy—situate a little east of Petra, in a more fertile spot—the substructions of walls and paved roads, all constructed of flints. The present road, traversed by the *Hadj*, or pilgrims, from Syria to Mecca, passes about five miles more eastwards, through Maan (*Maon*, Judges x. 12), placed in a rocky district. This town is divided by two hills, on each of which stands a portion of it. The fruits, especially pomegranates, peaches, apricots, and grapes, are there excellent, and are much sought after by the Syrian pilgrims. Burckhardt (p. 436), says here, " are several *springs*, to which the town owes its *origin ;*" and I presume the word itself, Ma'an, is abbreviated by use from *Mayan*, signifying a " fountain."

Fourthly.—" Petra," the Greek appellation of the capital of the ancient *Nabathæa*, or territory of the Nabathæi, and the *Edom* of Scripture, was called in Hebrew, *Sela ;* both words meaning a " rock," and the first of which gave *its name* to the country—" Arabia *Petræa*." It is also called *Joktheel*, in 2 Kings xiv. 7. Strabo has distinctly recorded that " Petra was the capital of the *Nabathæans who were Idumæans*." (Lib. xvi.) The former appellation having been bestowed upon this people as descendants of *Nebaioth*, (1 Chron. i. 29), or *Nebajoth* (Gen. xxv. 13), who was Abraham and Hagar's grandson, and Ishmael's first-born son. Petra is correctly described by the same Greek geographer, as well as by the Roman naturalist. The short account of the last I here transcribe: "Nabatæi oppidum *includunt Petram* nomine in *convalle*, paulo minus duum mill. passuum amplitudinis, *circumdatum montibus* inaccessis *amne interfluente*.* I will not add here any description of the very magnificent remains of this remarkable city, the city of the *Rock* —or rather excavated and carved out of the *natural rock*— whose dwellings are said to have been "in the clefts of the *rock*," (Obadiah 3), since they are now so well known.

Coming to Petra from Eljy, on the east, the body of the regular mountain on that side is limestone, and higher than the red sandstone, where the tombs in Wadi Mousa are excavated. The cliffs at Petra are of *red sandstone*, which is soft and easily cut, causing the sculptures to decay quickly, unless where they may have been *protected* from the weather. This formation extends far to the north and south, and rests on the lower masses of porphyry.

The colour of the *sandstone* rocks in Wadi Mousa is not a dull monotonous *red*, but a variety of bright hues, "from the deepest crimson," as Dr Robinson writes (vol. ii., p. 531), "to the softest pink; verging also sometimes to orange and yellow. These varying shades are often distinctly marked by waving lines, imparting to the surface of the rock a succession of brilliant and changing tints, like the hues of watered silk, and adding greatly to the imposing effect of the sculptured monuments."

The site of Petra, in the high ravine, is called by the Arabs, Wadi *Mousa;* most likely corrupted from *Moseroth*, or *Mosera* (Deut. x. 6), "where Aaron died and was buried." It is extremely interesting, and is well watered by a flowing stream—the *El Syk* of Burckhardt. The *sandstone* rocks, with their craggy and precipitous sides, have their summits resembling rounded peaks; peaks, probably owing to the softness of the stone, rounded by the effects of weather.

* *Plin.* Nat. Hist., Lib. vi., cap. 28.

The height of this *Wadi* is estimated at near 2200 feet above the adjoining Wadi-el-Araba. To the west of Petra, Mount Hor, Gebel *Harun* constitutes the loftiest point of this *sandstone* tract. It stands out conspicuously, and is a *cone* irregularly truncated with three rugged peaks, of which that to the NE. is the *highest*, and has upon it the Mahommetan *Wely;* or the tomb of *Aaron*, called *Neby Harun*. This peak rises to about 2700 feet above Wadi *Mousa*, or to 5300 feet above the sea.

Captains Irby and Mangles, the *first* Europeans who ascended Gebel *Harun*, thus describe "the view from the summit." It "is extremely extensive in every direction; but the eye rests on few objects which it can clearly distinguish, and give a name to, although an excellent idea is obtained of the general face and features of the country. The chain of Idumean mountains, which form the western shore of the Dead Sea, seem to run on to the south, though losing considerably in their height. They appear in this point of view, barren and desolate. Below them is spread out a white sandy plain, seamed with the beds of occasional torrents, and presenting much the same features as the most desert parts of the Ghor. Where this desert expanse approaches the foot of Mount Hor, there arise out of it, like islands, several lower peaks and ridges, of a purple colour, probably composed of the same kind of *sandstone* as that of Mount Hor itself, which, variegated as it is in its hues, presents in the distance one uniform mass of dark purple. Towards the Egyptian side there is an expanse of country without features or limit, and lost in the distance. The lofty district which we had quitted in our descent to Wadi Mousa, shuts up the prospect on the south-east side; but there is no part of the landscape which the eye wanders over with more curiosity and delight than the crags of Mount Hor itself, which stand up on every side, in the most rugged and fantastic forms, sometimes strangely piled one on the other, and sometimes as strangely yawning in clefts of a frightful depth."

Under the term *Nabathæan Chain*, or the chain of the mountains of Edom, I have restricted those mountains beginning north of 30° N. Lat., and which then tend round northward, by the east of Petra. They are the loftiest on the east, attaining probably to an altitude of 3000 feet above the Wadi-el-Araba. This chain presents to the view, on the east, long elevated ranges of *limestone*, sometimes with *flints*, but of more easy slopes, *without* precipices, being smooth and rounded. Further still to the east, the high plateau of the Great Eastern Desert—of which *El Nejd* is a portion—

stretches out to an almost indefinite extent. To the west and north, and around Mount *Hor*, lofty party-coloured *sandstone* ridges and cliffs prevail; then succeed high masses of *porphyry*, constituting the body of the mountains, but *lower* than the *sandstone*. And, lastly, more northwards, the chain sinks down into low hills of *argillaceous* rock, or of *limestone*.

The entire breadth of the *Seir* range seems not to exceed eighteen English miles, between Wadi-el-Araba and the Eastern Desert; whilst that of the more northern, or *Nabathæan chain*, does not exceed twenty-two miles between those districts.

Going west from Petra, the valley of the *Araba* is again entered, where the deeper *Wadi-el-Jeib* is seen to wind along, very near the middle of it, from the south, then sweeping off NW., it meets the *Wadi-el-Jerafah*, which comes in from the SW. Afterwards, it is called only *Wadi-el-Jeib;* and being a deep valley within a larger valley, it forms the chief water-course of the greater portion of the Araba, and carries down to the Dead Sea, in the wet season, an immense body of water.

El Araba, more to the north of Gebel Harun, is much wider; in parts of it there are *gravel* hills; and here and there, masses of *porphyry* lie about in the sand, having been washed down by the torrents. Eleven or twelve miles north of that Mount (*Hor*), occurs the pass of *Nemela* among low hills of *limestone*, or rather a yellowish *argillaceous* rock, the dark steep mass of the mountain being *porphyry*, as before described; thence the Wadi ascends between the porphyry and limestone formations; and on the top is a little basin of *yellow sandstone* capping the *porphyry*.

Coming back southward through the Wadi-el-Araba, as far as the *embouchure* of the valley of the *Jerafah*—meaning "gullying,"—which is about a mile wide, the mountains on this west side are found to be composed of *chalk* and *limestone;* and, in many places, with large pieces of black *flint*.

On the north, and to the east of Lussan, the mountains of Idumæa are lofty, consisting of precipitous *limestone* ranges; the solitary conical mount, about 600 feet above the plain, named *Gebel Araif-el-Naka*—"the crest of a she-camel," forms a conspicuous object; it is *calcareous*, and strewed with *flints*. Low ridges extend from it westward and eastward; the latter terminating in a headland or bluff, called Gebel *Makrah*.

The wide sandy *Wadi-el-Ghudhagidh*—the *Ghudhaghidh* of Robinson—is probably the *Gudgodah;* or, as it is written in Hebrew, *Ghudghodah*, mentioned in Deut. x. 7, whither the Israelites journeyed from Mosera (*Wadi Mousa*) after Aaron's death. After this valley were some low *chalky* cliffs, and then succeeded a barren *flinty* tract.

Towards the NW. and W., a broad open district stretches out apparently to *Gebel Jaraf*, said to be 1300 feet above the sea level, through which is the course of the *Wadi Khereir*, elevated about 1000 feet at its nearest point to that mount, and flowing northward into the large *Wadi-el-Agaba*,—upon one side, and to *Gebel Yelak*, the " white mountain," on the other side; but it is broken in some places by *limestone* or *chalk* hills.

The Wadi Ghudhagidh, and the more southern tributaries of the Jerafah, flow to the NE. to the Dead Sea, as already explained; and they, with some smaller winter torrents that unite with them, are the only water-courses in this part of *Arabia Petræa* which supply that sea. On the SE. of the upper Jerafah, some low *limestone* ridges present themselves; but, on the other side is the *sandy* plain *El Adhbeh:* beyond this, northwards, follows a level plain covered with pebbles and black *flints*. The high West Desert, called by the Arabs El Tyh, the " wandering," and so named in Edrisi and Abulfeda, near its centre at *Nakhl*, signifying " date trees" (at which station there exists a grove of those trees), at an elevation of near 1500 feet above the sea, consists of vast plains, or *plateaux* of varying, mostly higher, altitudes, a sandy, flinty, or gravelly soil, and limestone hills of the *cretaceous* or secondary formation, having very irregular ridges disposed in different directions.

The numerous *Wadis*, or water-courses, and winter torrents of this enormous desert, all run to the N. or NW., and pour their waters into the Mediterranean Sea; while those *Wadis* that lie on the other side of the Great Mountain range, which bounds the desert in its western and southern extremities—*Gebel-el-Rahah* and *Gebel-el-Tyh*—divide their waters, and so supply, in part, the Gulf of *Suez*, and in part the Gulf of *Akaba*. Of the former *Wadis*, two are the principal; namely, *Wadi-el-Agaba*, which rises somewhat to the east of the line of 34° E. long.; and *Wadi-el-Arish*, which Russegger and later authors affirm as springing to the *west* of it, and of *Gebels* Heiyalah, Yelak, and Mishea, and of which *Wadi Nesil* seems to me to be only a tributary.

The chain called *Gebel-el-Egmeh*, or *El Odjme* by Burckhardt, appears, as he says, *chalky;* and such, also, is the soil of the plain, and frequently covered with *black* pebbles (*flints*); it unites with the higher chain of the Gebel-el-Tyh, about the centre of the Peninsula,—that is to say, of the *Peninsular Triangle*, and where the branches North-el-Tyh and South-el-Tyh separate. There the height of the summit of *El Tyh* is given by Russegger as 4322 Paris feet, or 4615 English feet, above the sea; descending thence by the pass of Mureikhi, into the sandy plain of *Debbet-el-Ramleh*, the elevation of that plateau, just about the middle of it, and about half way to the head of *Wadi-el-Sheikh*, is near 4000 feet above the sea level; Alahadar being a little to the east.

In the Wadi *El Sheikh*, meaning the "Valley of the Elder," or "Chief," which is one of the principal valleys in the Peninsula, before coming to "Moses' seat" (*Mokad Seidna Mousa*), occurs a range of low hills of a substance called *Taffal*, chiefly a detritus of the *felspar* of *granite*, like pipe clay. The easiest approach to the present Sinaic district is by the east side of this Wadi, which leads into the wider Wadi, or plain *El Raha*, *i. e.*, a "plain surrounded by hills." The view of Gebels *El Deir* ("The Convent"), the now-termed *Horeb*, *Humer* (red), and others, from thence is very striking. The lower granitic mountains of the present *Sinai* are more regularly shaped than the upper; being less rugged, they have *no* insulated *peaks;* and their summits terminate in smooth *curves*. Whilst in the ascent to the higher mountains, *peaks on peaks arise*, of the form of sharp cones, and of various altitudes. *Gebel Mousa*, or "Moses' Mount," is of *red granite* for about half-way up; all the rest being a *yellowish granite*, with small *black* grains, and from *Wadi Leja* (" asylum"), these colours appear most distinct. The height of the apex of G. *Mousa* peak, which does not exceed fifty yards in width, was ascertained by Lieutenant Wellsted, from the *mean* of observations, to be 7505 feet above the sea of Akaba; and that late, able, and lamented officer, who was upon that summit in *January*, and " enjoyed the advantage of a clear serene atmosphere," which, in a more advanced season of the year, would have been hazy, with a blue mist, arising from the powerful sun, " was thereby enabled, by means of angles taken to the hills on the Arabian coast, ninety miles distant, to correctly fix the geographical position of the mountain." He has also well described the most extensive view from that peak, as follows:—

" The Gulfs of Suez and Akaba are distinctly visible; from the dark-blue waters of the latter, the island of *Tiran*, considered by the ancient geographers as sacred to *Isis*,* rears itself. Mount Agrib (*Garib*), on the other hand, points out 'the land of bondage.' Before me is St *Catherine*, its bare, conical peak now capped with snow. In magnificence and striking effect, few parts of the world can surpass the wild, naked scenery everywhere met with in the mountain-chain which girds the sea-coast of Arabia." . . . . . The monkish " Mount *Sinai* itself, and the hills which compose the district in its immediate vicinity, rise in sharp, isolated, conical peaks. From their steep and shattered sides huge masses have been splintered, leaving fissures rather than valleys between their remaining portions. These form the highest part of the range of mountains that spread out over the Peninsula, and are very generally, in the winter months, covered with snow, the melting of which occasions the torrents which everywhere devastate the plains below. The peculiarities of its *conical* formation, render this district yet more distinct from the adjoining heights that appear in successive ridges beyond it, while the valleys which intersect them are so narrow that few can be perceived. No villages and castles, as in Europe, here animate the picture; no forests, lakes, or falls of water, break the silence and monotony of the scene. All has the appearance of a

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* *Isis* is supposed to be the same as *Io*, and the island of Tiran is evidently, as I have already stated in a preceding note, that which Procopius names Ἰωταϐη, *Iotabe*. This word is probably derived from Ἰοῦς τὰ ἄϐατα,—the *shrine*, or sacred place, of *Io*.

vast and desolate wilderness, either grey, darkly-brown, or wholly black."*

And Dr Lepsius remarks on this mountain, that—

"Although it is certainly a high mountain, still it is a *secondary* one, and almost eclipsed by others of the Great Southern Chain, the geographical centre of which is neither in *Gebel Mousa*, nor the loftier *Gebel Katherin*, but in the more southern, and considerably more elevated *Gebel-um-Schomar*."

Gebel Katherin, composed principally of a coarse *red granite*, presents the same *conical peaks*. But in Wadi *Owasz*, S. by W., from the last mountain, Burckhardt noticed "a small chain of *white* and *red sandstone* hills in the midst of *granite*."

Gebel-um-Schomar ("Mount Mother *Schomar*"), also consists chiefly of *granite;* the lower part *red*, but the top is almost *white*. In its middle, between the granite, occur broad layers of brittle *black slate*, mixed with veins of *quartz* and *felspar*, and with *micaceous schist*. Its extreme *peak*, about 8800 feet above the sea, is sharp pointed, and seems to be inaccessible, owing to its perpendicular and smooth sides. Burckhardt, in his attempt to ascend it, was obliged to halt at about 200 feet below it. This was, until recently, esteemed the *highest* point in the Peninsula; but, according to Herr Russegger, two or three other peaks, to the south of it, are about 500 feet more lofty; the *extreme* elevation of this last group, which seems not to bear any distinct appellation, he estimates at 9300 English feet.

I here add, after the latter author, a sketch of the *granite peaks* of the high Modern-Sinaic mountains, from north to south, as they present so interesting and remarkable an appearance.

* Travels in Arabia, vol. ii., p. 97.

In the narrow valley, a little south of *Gebel Mohala*, which is all granite, on the east side of, or opposite to, the Schomar, is a spring named *Tabakat*, where beautiful porphyry is observed.

The south side of Mount *Schomar* is very abrupt, and there is *no* secondary chain between it and the other lofty southern mountains, and the long gravelly plain *El Kaa*.

From that plain, entering *Wadi Hebron*—a ravine about 100 yards wide—fragments of rocks, principally of *granite* and *porphyry* washed down by torrents, are frequent; a small stream is seen flowing among them; in spots, some date trees occur, and likewise the manna—producing tamarisk. Continuing to ascend, a moderately-steep pass is reached; afterwards, a descent of about 700 feet leads into the sandy *Wadi Solaf* "wine valley;" and then, gaining, with some difficulty, the summit of a steeper pass, the north-west angle of the extensive *Wadi Raha* is come to. Here, again, the present Sinaic group, beyond the plain, exhibits its rugged mountains of dark *granite*, with "stern, naked, splintered *peaks*, and ridges of indescribable grandeur."

Next, turning to the north down the narrow declivity called *Nakb Hawi*, the "windy pass," of which the stupendous *granite* walls or cliffs elevate themselves to about 800 feet, passing to the west end of *Wadi Solaf*, where it meets *Wadi Firan* and *Wadi-el-Sheikh*, and following the last valley as far as *El Szaleib*, that ascent is attained. There the formation consists of *granite*, on the upper beds of which run layers of *red felspar*. North-east of *Wadi-el-Ush* is situate *Gebel Sheyger*, which affords some native *cinnabar*. The three principal passes leading from the sandy Debbet-el-Ramleh on to the great desert over the Tyh range, are, *El Mureikhi* near the centre and near *Gebel-el-Egmeh;* then *El Warsah*, said to be of too rapid an ascent for caravans; and the third, which is most to the west, *El Rakineh* (the painted.) Afterwards, at some distance to the NW., is the valley opening past *Ras Wadi Gharandel*, that has already been described.

Proceeding, again, across the plain El Ramleh, and over the pass Mureikhi on to the Desert-el-Tyh, in the approach to the castle of *Nakhl*, on the east, a few miles off, low *chalky* hills appeared; and in places there were holes wherein *rock-salt* had been dug. The water at Nakhl is brackish, and the ground chalky, covered with loose pebbles. *Wadi Nesil* was observed to be overgrown with green shrubs. *Gebel-el-Thughar*, signifying "the mouths," presents a mountainous tract, in which followed a valley with *calcareous* hills: here deep sands were lodged, and large insulated rocks of a porous *tufa*, called by Burckhardt *tufwacke*, lie scattered in many places.

"The termination of the vast gravelly plain we had been crossing from *Nakhl* was now at hand; but we could yet see it spreading out wide to our left, the mirage giving its distant portions the appearance of a succession of blue lakes; directly in front were the mountains which close it in; and far to the right we could see, stretching away, a still higher range running to the north, and on the left the tops of the mountains about Wadi Gharandel, the *Taset* (cup) *Soddur* being conspicuous afar. We entered these mountains by a slight ascent, which struck soon after the head of a long winding valley descending towards Suez: the immense plain we had traversed, floated away in mist, and we had now done with the plateau of the Great Desert." *

Thence a plain, which is below the level of the Desert-el-Tyh, and covered with moving *sands*, extends as far as the sea-shore. These *sands* are collected by the winds, in many spots, into hills 30 or 40 feet high. The wells at *Mabuk* afford good water by digging to the depth of 10 or 12 feet.

Fifthly, Once more leaving Suez; after having passed over a small piece of marine and alluvial formation near the sea, and taking a westerly direction, a narrow tract of *tertiary sandstone*, so designated by Russegger, is observed; it is a plain which gradually ascends from the shore of the Gulf, and in it is placed the Castle of *Ajroud;* the water obtained there is very bitter. Beyond this to the west, the plain becomes *sandy*, and covered with black flints.

But the soil and hills at *Wadi Emshash*, which signify the "Valley of the Waterpits," near Ajroud, are calcareous:

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* *Bartlett's* "Forty Days in the Desert," p. 167.

the well there, called *Bir Emshash*, yields after rain good drinking water. The hills around Ajroud consist of *tertiary limestone* and *marl*. More to the south, Gebel Ataka divides this formation, itself being a *secondary limestone* belonging to the *cretaceous* series, and, according to Dr Robinson, is strewed thickly with *flint* pebbles. It terminates in *Ras Ataka*, or "Cape Deliverance," on the Gulf. The sandy and gravelly plain, *El Baidea*, the *Wadi Tawarik* of others, has been named by some, the "Valley of Moses," Wadi Mousa; it communicates on the west with *Wadi-el-Tyh*.

Gebel Deraj (steps) is limestone of the same cretaceous series as Mount Ataka; and this formation stretches out southwards to a great distance, constituting a large portion of the East Egyptian Desert.

Then on the south of the former mountain, a band of granite, which forms the northern ridge of *Gebel Kallalà*, is observed, wherein there exist remains of old *copper* mines. Those called *Reigatamerih*, situate among low hills, "have evidently been worked by the ancients, as well from the quantity of pottery and *scoriæ* there, as from the remains of miners' houses, and the regular manner in which the caverns have been cut, following up the veins."*

Near, on the SE., there is a well (*bir*) named *Horreh*, whose water is bad, owing to the *sulphur* which it contains. This is placed in *Wadi Araba*, an extensive valley, running in a direction nearly due W. and E., and descending from *Wadi Chaderat* very rapidly to the shore of the gulf, which is here termed by the Arabs *Mersa Zafraneh*, *i. e.*, "Harbour of Saffron." The coast itself is flat and marshy. The headlands on the south are a conglomerate, or *breccia* rock, of the *Tertiary* formation, composed of shells, stones, and other substances, held together by a calcareous cement. The Arabs report, that a carriage-road anciently existed through the Wadi Araba, and led to the Bay of Zafraneh. This, I conceive, might have been the road of communication to the

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* *Mr J. Wilkinson* on the Eastern Desert of Upper Egypt, p. 32, vol. ii. Journal of the Royal Geographical Society.

Egyptian colonies and copper mines on the opposite Sinaic peninsula, in *Wadi Maghara, Sarbut-el-Chadem*, &c., and over which the produce of those mines, having been shipped from the harbour of Zelime to the Mersa Zafraneh, might have been conveyed in waggons to the Nile. But, whether or not the *Araba* mountains that rise a little to the south of the opposite coast of the Peninsula had received the *same* appellation from *this valley*, there seems to be no testimony to decide. The "Monastery of St Antony"—*Deir Antonios*—distant about 17 miles from the sea, is a fortified convent of Copts, surrounded by a strong wall, of about 35 feet in height, the entrance to which is by a trap-door, wherefrom a rope descends, as in the present Sinaic convent. The keep, or place of safety, is an insulated tower, defended by a draw-bridge. According to common statement, this was the abode and place of burial of *St Antony*, the founder of Monachism. The mountains to the south, at the northern end of which stands the convent, are *calcareous* (of the same *cretaceous* formation), containing in places a great deal of *salt*. They are known to the Arabs by the term of *Gebel Kallala*, and, in fact, constitute the southern ridge of that chain. Another large and similarly protected convent, called *Deir Bolos* (Paul), distant from the former* about 15 miles in a direct SE. line, is situate in a picturesque place, and about 10 miles from the nearest point of the Gulf of Suez. An adjoining garden abounds in date and other fruit-trees. On the east, between this convent and the sea, *Wadi Girfeh* is approached, among low hills: on the tops of some of these the substructions of houses are visible, having been built with uncemented stones. Also some chambers, or catacombs, are cut in the rock: in the larger were found crystals of *rock-salt;* the strata are composed of *limestone*, and contain many fossils. Broken pieces of *terra cotta* vases, chiefly red, are everywhere observed; and they, with other vestiges, probably point out the site of a Roman colonial town.

* See the Views of the Convents of St Paul and St Anthony, plate 51, p. 128, chap. vi., book ii., vol. i., in *Pococke's* "Description of the East."

Proceeding from St Paul's to the SE., for near 15 miles, the line of the *primitive* mountains is reached on the left, whilst the *secondary* chain of Gebel Kallala, consisting of limestone with ammonites, is continued on the right, or west. South of Wadi Dthahal *micaceous schist* approaching to *gneiss* occurs, and a little further, the primitive and *sandstone*, or *gritstone* rocks join. Thence the secondary, or *cretaceous* mountains, diverging to the south and south-west, gradually decrease in altitude.

Again, southwards, some more ancient copper-works are noticed; and then, *Gebel Howashia*, whose formation is *granite*, rises a few miles off to the SE.; in its natural basin much good water is retained after rain. *Wadi Abu Hadth* next attracts attention from its possessing a good deal of fine herbage, and many gum-arabic trees. Of the granite mountains in this region, *Gebel Agrib*, or *Garib*, or *Gharib* ("camel's hump") is the loftiest, as it elevates itself to about 6000 feet above the sea level; and from its position it forms a conspicuous landmark far out at sea.

The ascent of this majestic mountain, from its steepness and numerous ravines, is found to be fatiguing. Mr J. Wilkinson* describes it as follows:—

"The first evening we reached the base of the highest cone, where we slept, and ascended the next morning to the summit, from which we had a view of the mountains on either side of the sea, and the different plains. We tracked the gazelles very nearly to the summit, and every now and then in the ravines found some solitary plants growing under the shade of a projecting stone. The peaks of this mountain resemble the *Aiguilles* near Mount Blanc; but, to equal that mountain in beauty, it requires the lower parts to be covered with the woods and verdure of the Alps, and the desert plain below to be exchanged for the green meadows of Switzerland. I calculate the height to be 5513 feet above the ravine in the plain below, which is a few hundred feet above the level of the sea."

About ten miles southward, *Bir-el-Dara*—the "Well of Dara," below the mountain of that name, occurs; there, likewise, copper *scoriæ*, smelting furnaces, and miners' houses, are observed.

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* Journal of the Royal Geographical Society, vol. ii. p. 39.

Further south, more *copper mines* are seen in a bare place, among low hills, all of which have been examined for the ore.

Advancing south-eastwards by the plain, some *calcareous* rocks are passed, and afterwards a line of *sandstone*,* with limestone over it, running parallel to, and nearly equidistant between the *two primitive* ridges. *Wadi-el-Enned* succeeds to the eastward, where a beautifully clear rivulet is found; but its water is too bad for the use of animals, being chiefly serviceable for the nourishment of numerous date palms. This spot lies at the foot of some *limestone* hills of the *cretaceous* series that join the eastern *granitic* ridge.

Next, on the south, comes *Gebel Kuffra*, where the water is so *salt* as only to be drunk by camels. *Gebel Dochan*, (smoke)—the "Mons Porphyrites" of the ancients—rising about eleven miles more southward, and in the same line with the supposed site of *Myos Hormus*, Μυὸς Ὅρμος, the "mouse harbour," is too distant from our proposed limits, to receive a full description in the present Memoir. I will only remark that at Mount *Dochan*, there exist some interesting ruins, and "those vast *quarries*, from which Rome took so many superb pieces of *porphyry*, to adorn her baths and porticoes."† On its southern side, Mr J. Wilkinson adds, "we met with some *Breccia Verde*; and of other kinds of *Breccia* we had observed great quantities and varieties at Dochan." The sea-shore, about Myos Hormus, is bare and deserted; to the west, at some distance from the harbour, the *granitic* chain extends; on the east, between it and the sea, a low ridge of *limestone* hills, which unites with the primitive rocks on the north, comes down towards the shore. "And, in the distance, on the north, is seen the mountain *El Zeit*, so called from the quantity of *petroleum* found there; whence project two small

* Mr J. Wilkinson (*ibid*, Note, p. 41), says, "Judging from the angle of its dip, it formerly rose *over* the lower, or eastern primitive range, from which, however, it is now separated by a valley, or bed of a torrent."

† *Ibid*, p. 42.—Pliny writes of the *quarries*, "quantis libet molibus cædendis sufficiunt *Lapidicinæ*." Lib. 36, cap. 7. They produced *red porphyry* of a most beautiful, close-grained kind; so Pliny says, "*rubet porphyrites* in eadem Œgypto."

headlands, forming two gulfs, at the entrance of which are many long *sandbanks.* May not this be the '*mons Eos*' of Pliny?"*

This *Gebel Zeit*, or "Mount of Oil," runs out into a promontory on one side of the Strait of Jubal; at its foot a copious supply of *Petroleum*, or rock oil, is obtained. It is about as liquid as turpentine, of a black or dark-brown colour, and is collected by the Greek Christians of Tur, who take it there and sell it, for rheumatism and for healing sores. The Arabs call it *Zeit-el-Gebel*—"oil of the mountain."

South of this promontory the sea is studded with a number of small islands, some of which are described by Strabo; all, however, I believe, except *Shadwan*, which is of secondary limestone, are of recent marine formation—chiefly of *Coral.*

(*Conclusion in our next Number.*)

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* Ibid., p. 51.

Synopsis of Meteorological Observations made at the Observatory, Whitehaven, Cumberland, in the Year 1849.

By John Fletcher Miller, Esq., F.R.S., F.R.A.S., &c. Communicated by the Author.

1849.	Standard Barometer,* Corrected and Reduced to 32° Fahrenheit.								Self-Registering Thermometer.						Pluviometer.		Wet Days.	Evaporation Gauge.	Prevailing Winds. Two Daily Observations.	Force of Wind, 0—5.
	Max.	Min.	Mean at 3 P.M.	Mean at 10 P.M.	Mean Atmospheric Pressure.	Pressure of Vapour.	Mean Pressure of Dry Air.	Range.	Absolute Max.	Absolute Min.	Mean of Max.	Mean of Min.	Mean Monthly Temperature.	Range.	Rain and Snow.	Snow.				
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	°	°	°	°	°	°	Inches	Inches		Inches		
Jan.	30·173	28·680	29·654	29·679	29·666	0·236	29·430	1·493	50·	18·7	42·14	35·82	38·987	31·3	5·683		20	·909	SW.	3·2
Feb.	30·774†	28·890	30·012	30·012	30·012	·265	29·747	1·884	51·	30·	45·91	40·07	42·990	21·	2·045		12	1·024	SW.	2·1
March	30·494	29·140	29·940	29·949	29·944	·264	29·680	1·354	54·	28·	46·79	39·96	43·375	26·	·837		13	1·558	SW. & NW.	2·1
April,	30·147	29·123	29·551	29·563	29·571	·256	29·315	1·024	62·	29·	49·73	38·51	44·124	33·	1·488	·090	16	2·620	Easterly.	2·5
May,	30·147	29·052	29·749	29·763	29·770	·354	29·416	1·095	70·	36·5	60·51	45·85	53·185	33·5	3·037		14	3·886	SW.	2·0
June,	30·122	29·516	29·867	29·873	29·884	·357	29·527	·606	67·5	40·5	61·53	48·55	55·044	27·	1·224		10	5·076	SW.	1·9
July,	30·295	29·216	29·763	29 770	29·780	·426	29·354	1·079	75·5	46·	63·93	53·74	58·835	29·5	5·478		18	4·156	NW.	2·3
Aug.	30·189	29·175	29·785	29·788	29·800	·436	29·364	1·014	72·	46·5	64·05	55·03	59·541	25·5	3·771		19	2·657	SW.	1·4
Sept.	30·464	28·924	29·826	29·831	29·842	·413	29·429	1·540	74·	42·5	62·56	50·48	56·524	31·5	2·814		12	3·337	E., Variable.	1·5
Oct.	30·489	29·129	29·720	29·731	29·739	·316	29·423	1·360	64·	34·	52·16	43·11	47·636	30·	5·252		17	1·723	SW.	2·3
Nov.	30·137	28·737	29·637	29·668	29·666	·295	29·371	1·400	55·	27·7	47·85	42·77	45·310	27·3	4·974		24	·960	SW.	2·4
Dec.	30·721‡	29·078	29·843	29·835	29·853	·233	29·620	1·643	52·5	25·	41·69	35·93	38·810	27·5	2·396		15	·793	E., Variable.	1·8
Means	30·346	29·055	29·778	29·788	29·794	·321	29·473	{ 1·291 / 2·094 }	62·3	33·7	53·24	44·15	48·696	56·8	38·999	·090	190	28·699	SW	2·1

* The readings of the barometer hitherto used require an additive correction of about 0·08 inch. All past results will be reduced to the standard instrument.

† Uncorrected Maximum, 30·820 inches.

‡ Uncorrected Maximum, 30·752 inches.

HYGROMETER.

1849.	At 3h P.M. Mean of Dry Bulb.	Mean of Wet Bulb.	Mean Dew-Point Deduced.*	Complement of Dew-Point.	Weight of Vapour. In a Cubic foot of Air.	Required for Saturation of a Cubic foot.	Degree of Humidity, (complete Saturation, =1·000).	Weight of a Cubic foot of Air.
	°	°	°	°	Grains.	Grains.		Grains.
January,	40·28	39·02	36·68	3·60	2·80	0·32	0·899	546·2
February,	44·66	42·50	40·08	4·46	3·04	0·57	0·844	546·8
March, .	45·85	43·17	40·02	5·82	3·03	0·72	0·811	543·7
April, .	48·66	43·94	39·13	9·53	2·87	1·23	0·701	535·1
May, .	58·79	52·85	48·39	10·40	3·93	1·73	0·696	527·2
June, .	60·23	53·44	48·68	11·54	3·91	1·99	0.663	527·8
July, .	63·13	57·47	53·82	9·30	4·70	1·77	0·726	522·6
August,	62·43	57·77	54·59	7·84	4·85	1·50	0·767	523·2
Sept.,	61·95	56·48	52·87	9·08	4·55	1·71	0·728	523·7
October,	51·17	48·13	45·09	6·06	3·58	0·87	0·804	533·8
November,	46·65	45·10	43·23	3·41	3·41	0·43	0·888	538·8
December,	40·25	38·74	36·40	3·79	2·71	0·41	0·878	548·1
Means, .	52·00	48·21	44·91	7·07	3·61	1·10	0·784	534·7
1848, .	51·93	48·23	44·98	6·95				
1847, .	51·94		44·12	7·82				

* From Mr Glaisher's Hygrometrical Tables, the accuracy of which my own series of observations made in the years 1847 and 1848, for the purpose of testing their correctness, shew in a very striking manner; and I think every meteorologist must feel himself greatly indebted to Mr Glaisher for this valuable compilation, which is also based on observations made under his own superintendence at the National Observatory.

In eight months of the year 1847, the difference between the observed and the deduced Dew-point at Whitehaven, is 0°·10; and in 1848, it is only 0°·07, the mean of the two periods comprising 1220 observations, amounting to the comparatively evanescent fraction of $\frac{8}{100}$ths of a degree. Such satisfactory proofs of the perfection of Mr G.'s tables have induced me to abandon Daniell's Dew-point Apparatus, for that more simple, less costly, and equally correct form of Hygrometer, the combination of the dry and wet bulb thermometers.

SOLAR AND TERRESTRIAL RADIATION.

1849.	Absolute Minima.			Mean Nocturnal Temperature.				Terrestrial Radiation.								In Sun's Rays.		
					Naked Thermometers.			Maximum.			Minimum.			Mean.				
	Six's Thermometer, 4 feet above Ground.	On Grass.	On Wool on Grass.	Six's Thermometer, 4 feet above the Ground.	On Grass.	On Wool on Grass.	Difference.	On Grass.	On Wool on Grass.	Day.	On Grass.	On Wool on Grass.	Day.	On Grass.	On Wool on Grass.	Max.	Mean.	Solar Radiation. ‡
	°	°	°	°	°	°	°	°	°		°	°		°	°	°	°	°
January,	18·7	4·	—2·8	35·82	30·35	27·71	2·64	14·7	21·5	3d	1·	1·5	7th	5·47	8·11	59	45·5	3·37
February,	30·	20·5	18·	40·07	35·38	33·08	2·30	11·5	13·	17th	1·5	1·5	3, 22d	4·69	6·99	67	54·4	8·49
March, .	28·	19·5	14·7	39·96	34·88	32·60	2·28	14·5	16·	31st	0·	1·5	11, 12th	5·08	7·36	77	61·3	14·51
April, .	29·	21·3	16·	38·51	32·72	28·88	3·84	11·5	17·5	11th	3·	3·	3d	5·79	9·63	93	69·3	19·57
May, .	36·5	26·	22·	45·85	39·27	36·27	3·00	12·	17·5	1st	1·5	2·5	15th	6·58	9·58	133	88·0	27·49
June, .	40·5	29·5	25·	48·55	41·06	37·86	3·20	14·	19·5	4th	2·	3·5	26th	7·49	10·69	106	89·2	27·67
July, .	46·	33·	29·	53·74	45·52	42·43	3·09	16·	20·	16, 17th	3·	4·	4th	8·22	11·31	106	96·3	32·37
August,	46·5	35·	31·5	55·03	49·25	46·05	3·20	19·	22·	4th	2·	3·	26th	5·78	8·98	104	85·8	21·75
September,	42·5	31·8	28·	50·48	42·84	39·53	3·31	13·	18·5	27th	2·	2·5	16, 20th	7·64	10·95	102	81·1	18·54
October,	34·	24·5	18·5	43·11	37·15	33·46	3·69	14·	21·	17th	0·	1·	25, 30th	5·96	9·65	75	64·9	12·74
November,	27·7	19·5	14·5	42·77	37·79	35·72	2·07	10·5	13·2	24, 28th	1·5	1·5	8th	4·98	7·05	67	50·9	3·05
December,	25·	17·5	11·5	35·93	30·29	27·08	3·21	17·5	21·	4th	0·	0·5	8th	5·64	8·85	56	44·1	2·41
1849, .	33·7	23·5	18·8	44·15	38·04	35·05	2·98	14·0	18·4		1·46	2·16		6·11	9·09	87·0	69·2	15·99
1848, .	32·5		20·2	43·79		35·73			15·9			1·94			8·06			
1847, .	33·7		20·5	43·50		35·95			15·1			1·14		*	7·45	90·2	71·0	17·15
1846, .	36·1		23·1						14·6			1·35		†	7·45			

* In 1847, the Thermometer was on Cork throughout the year. It is here reduced to the Standard of Raw Wool.

† In 1846, the Thermometer was placed on Cork in cloudy and wet weather. The results are reduced to the Standard of Raw Wool, by adding 0°·25 to the *recorded* annual mean.

‡ Difference between the mean maximum in the Sun's rays, and the mean maximum in the shade.

Form, &c. of Instruments.

The Barometer (the frame of which is brass) is a standard made by Barrow, under the direction of James Glaisher, Esq., of the Greenwich Observatory.

The adjustment for the difference of capacity of tube and cistern is effected previous to every observation, and the correction for capillarity and reduction to the temperature of 32° is made at the close of each month.

The difference between its readings and those of the Greenwich standard is scarcely appreciable, being only 0·002 inch.

The Dry and Wet Bulb Thermometers, also made by Barrow, are considered to have identical readings under similar circumstances, and both, too, agree with the Greenwich standard thermometer. The Dew-point apparatus, now discontinued, approximates very closely in its readings to the dry and wet bulb thermometers.

The Self-registering Thermometer is a large Six made by Dollond in 1840, and its average difference from the standard is within $\frac{2}{10}$ths of a degree. A duplicate and precisely similar thermometer (which has also been repeatedly compared with a standard at every part of the scale) is fixed by its side, so that in case of No. 1 getting out of order, No. 2 can be resorted to without detriment to the results.

These instruments all have a northern aspect, and are placed about 4 feet above the ground. The naked thermometers employed for indicating the relative amount of solar and terrestrial radiation, are precisely similar to those in use at the Government Observatories.

The Rain and Evaporation Gauges are 8 inches in diameter, and the metres are graduated to the $\frac{1}{1000}$th part of an inch. Both are read off daily. The aperture of the rain-gauge is about 7 feet above the ground. The evaporation dish is mounted on a moveable stand, 4 feet 4 inches in height, and the circular shelf on which the vessel rests, is just large enough to hold it. The gauge receives a fair proportion of wind and sunshine, and is always exposed in the open air during the day, except when *rain is falling*. At night and in wet weather, it is placed under a capacious shed, 9 feet in height, and open in front. Thus, it is conceived that the evaporating surface is freely acted upon by all the circumstances concerned in promoting this important natural process.

The direction of the wind is taken twice daily, and its force is registered on an arbitrary scale from 0 to 6 ; the highest number is reserved for storms approaching the hurricane in violence, and is very rarely recorded.

Remarks on the Weather in 1849.

January.—A damp wet month, except the first week, when sharp frost prevailed. The mean temperature is 0°·68 *above* the average. On the night between the 2d and 3d, a naked thermometer on the grass fell to 4°, and one on raw wool to 2°·8 below zero, being the lowest temperature I have recorded. The radiation indicated by raw wool was 21°·5. Between one and two o'clock on the morning of the 10th, a terrific thunder-storm burst suddenly over the town, and spread great alarm amongst the slumbering inhabitants. Seven or eight dazzling discharges of the electric fluid, followed by deafening crashes, succeeded each other in about as many minutes. The storm was almost vertical; and between several of the flashes and the accompanying thunder, there was scarcely an appreciable interval, certainly not more than a single second of time. The war of the elements ceased as suddenly as it commenced, and altogether, the storm did not last more than ten minutes. The wind, which previously blew a heavy gale, lulled almost to a calm as the last peal died away. The storm was followed by a heavy fall of rain and hail. It appears to have been pretty much confined to this town and neighbourhood. Thunder was also heard on the evening of the 14th, and lightning was seen on the nights of the 21st, 26th, and 29th. Saturn's ring was perceived at this Observatory on the night of the 31st, after a long continuance of damp, wet weather. As this singular appendage was readily seen, and was well and sharply defined, I have no doubt the instrument would have shewn it ten or fourteen days earlier, had the nights been at all favourable. The ring was also seen on the night of the 11th of September 1848, during its temporary reappearance.

February.—A fine, dry, and mild month. The temperature 3°·49 *above* the average of twelve years. On the 11th, the barometer attained the remarkably high point of 30·82 at this Observatory, which is about 90 feet above the sea level. At the Royal Observatory, Greenwich (40 feet above sea), the maximum was 30·85, being greater than any reading since January 1825, when the barometer at the Royal Society's apartments attained to 30·841, at 81 feet above the sea level; and there is no other instance recorded in the Philosophical Transactions of a reading so high as 30·8, from the commencement of the series in 1774. The maxima of pressure recorded on the 11th in various parts of the country, were all found to give a reading of 30·90 at the mean sea level.

On the 18th, primroses were in flower on the cliffs between Panton and Harrington.

March.—Similar to February. Temperature 2°·29 *above* the average, and the complement of the dew-point 2°·40 *below* the mean of the two preceding years.

First Quarter.—The temperature of the first quarter of 1849 is 2°·16 *above* the average of twelve years, and the complement of the dew-point is 1°·52 *below* that of the corresponding quarter in the unhealthy years 1847 and 1848.

The average fall of rain is 11·593 inches; in 1849, we have had 8·565, or 3·02 inches *below* the usual quantity.

The deaths in the quarter ending March 31, in the town and suburb of Preston Quarter, are 168, being 16 *above* the corrected quarterly average, which is 152. In the corresponding quarters of 1848 and 1849, the deaths were 250 and 187 respectively.

The deaths exceed the births by 25 in number.

April.—A fine, dry, but cold month. The temperature 1°·95 below the average. On the 23d the cuckoo was heard, and on the following day the swallow was seen in this neighbourhood. On Good Friday, the 6th, two parhelia, accompanied by a halo, were seen by a friend who was fishing by the river Calder. The sky was covered with a thin cirro-stratus, so that the images did not present any defined outline or disc, but consisted of three circular patches of light of nearly equal intensity, so much so, that it was difficult to distinguish the real from the phantom suns. The phenomena were first noticed about 5 P.M., and they remained visible till near six. The ring or halo passed through the centres of the parhelia, one of which was to the left, and the other to the right of the sun, with which they formed a straight line.

May.—A fine month, with an average mean temperature. The sun shone out on 29 days. The depth of rain is about an inch *above* the average quantity.

June.—A very dry month, and by far the coldest June I have recorded in the last seventeen years. The mean temperature is no less than 3°·67 below the average. The hay harvest began in this neighbourhood about the 20th.

The thermometer on the grass, on raw wool, was below the freezing point on eight nights; on the nights of the 8th and 10th it fell to 27°·5, and on that of the 19th and 20th, to 25°. On several mornings ice was seen in the immediate vicinity of the town, and on the 3d of the month there was a somewhat heavy fall of snow amongst the mountains. Highbell, Kentmere, High Street, and the mountains around Mardale, were covered with the mantle of winter to the depth of 6 inches. Such an incident has not occurred, it is said, since 1827, when several sheep were lost and smothered in snow-drifts on Mosedale and Helvellyn; and Skiddaw was covered with snow. Both snow and hail are recorded on the 10th in the register kept for me at Bassenthwaite Halls, at the foot of Skiddaw.

What is most remarkable, this unusual coldness does not appear to have been experienced at all in the southern counties of England. At Greenwich, the temperature is stated to be of the same value as that of the average from 70 years, but less than that of the preceding eight years, by 1°·9. According to Mr Glaisher's tables, published in the Registrar-General's Report for the June quarter, the mean temperature in Cornwall and Devonshire *exceeds* that of the corresponding month in 1847, by 0°·7, and south of lat. 52°, it is in excess $\frac{2}{10}$ths of a degree. Between the parallels 52° and 53°, the temperature is 1°·2 *below* that of June 1847; between 53° and 54°, it is 2°·1, and at Whitehaven, in lat. 54½°, it is 2°·7 below that of June 1847.

The extraordinary depression in the temperature has therefore been unparticipated in, by places situated south of the parallel of 53°.

Second Quarter.—The mean temperature of the quarter ending June 30, is 1°·92 *below* the average of twelve preceding years; and the difference between the air and dew-point temperatures is 1°·32 *above* that of the corresponding quarter in the years 1847 and 1848.

The average fall of rain is 8·15 inches; in the second quarter of 1849, the fall is 5·74 inches, or 2·40 inches under the normal quantity.

The deaths in the town and suburb are 139, being 21 above the corrected average number, which is 117. In the June quarters of 1847 and 1848 the deaths were 177 and 147 respectively. The births exceed the deaths by 59.

July.—Cold and wet. Temperature 1°·82 *below* the average. The hay harvest began in this neighbourhood about the 20th June; meadow hay was rather light on the ground, but the crop generally was well secured.

August.—Average temperature and depth of rain, with a serene and stagnant atmosphere. The complement of the dew point is 1°·78 *below* the average of the month in the two preceding years.

September.—A fine, mild, and rather dry month, with serene atmosphere. At the close of the month, several of the public fountains were dry, and most of the pumps in the town had ceased to yield their supplies.

Third Quarter.—The temperature of the quarter ending September 30th is 0°·37 *below* the average, and the complement of the dew-point, as compared with the two previous years, is 0°·5 *below* the mean. The depth of rain is 0·36 inch under the average quantity, which is 12·42 inches. The deaths in the third quarter of 1849, in the town and suburb, are 168, or 47 above the corrected average number; and, except in 1846, a greater number than has occurred in any September quarter since the register was begun in 1839. In the September quarter of the last four years, the deaths are as under: 1846, 255; 1847, 148; 1848, 142; and 1849, 168. The births exceed the deaths by six in number. During this quarter we had a few cases of Asiatic cholera in this town, chiefly in the month of September; and at the adjacent seaport of Workington the disease was of a most malignant character, and exceedingly fatal. The total number of deaths from the commencement of the epidemic on the 13th of August, till it entirely ceased on the 6th of November, was 172. In 1841, the population was 6041, which gives a mortality of 2·8 per cent., or one death in every 35 persons, from cholera. It is, however, believed that the population of Workington has decreased since the last census was taken; and at the time the epidemic was raging, most of the respectable inhabitants had left the place; so that the ratio of mortality amongst the then residents must have been considerably greater than is here stated. A singular fact connected with the disease is its sudden cessation for several days, at the expiration of which it returns with increased virulence. In the week between the 25th and 31st of August, the deaths were 65; from the 31st August to the 8th September there were none; on the 8th, 12; 9th and 10th, none; on the 11th, 13; and on the 12th only one death; 13th, 11; from the 14th to the 19th inclusive, the deaths averaged 2·5 daily, but on the 20th they rose to 13; and between the 21st and the end of September there were only eight deaths, which occurred on the 21st, 22d, 25th, and 27th.

Between the 1st and 20th of October the deaths were 32, and during that period there were frequently none for three or four consecutive days. There was only one death after the 20th October. It occurred on the 6th of November, when the pestilence ceased. I am informed by a resident medical gentleman, that at the commencement of the disease the cases were rapidly fatal, many of them after eight or ten hours' illness, and it was then almost entirely confined to the lower classes.

The proximate cause of the exceedingly fatal character of the disease at this seaport is probably to be found in the effluvia engendered by the extensive tract of marshy land, called the "Cloffocks," adjoining the river Derwent, and in the immediate vicinity of the town. What is most remarkable, the first case of cholera at Workington occurred on the same day of the same month, in the same house, and even in the same room in the said house, where the epidemic first broke out in the summer of 1832. There is no peculiarity in the situation of the house, nor can any reason be assigned for this most singular coincidence. I am informed that very few insects were seen about the river, and, during the height of the disease, the rooks entirely forsook their old-established quarters in the grounds adjoining the Hall.*

October.—Cold, with an average fall of rain ($5\frac{1}{4}$ inches.) The mean temperature is 2°·5 *below* the average. The grain crops were

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* The cause of this fearful epidemic is still a mystery. The meteorological conditions of the atmosphere, although slightly abnormal, are wholly inadequate to account for its induction. It is most probably induced by some gaseous poison diffused through the atmosphere, but of a nature so subtle that the most delicate analysis fails to detect its presence. According to the experiments of Dr Dundas Thompson of Glasgow, no solid matter existed in the air, but ammonia was obtained from it in the proportion of 0·319 grain of caustic ammonia, or 0·731 grain of carbonate of ammonia, to 1000 pounds of air.

above an average in point of quantity, and they were got under cover in excellent condition. Garden fruit, as pears, apples, &c., were not so plentiful as usual. On the evening of the 28th, that rare phenomenon a lunar rainbow, was seen from the grounds at Tarn Bank, near Cockermouth, by Isaac Fletcher, Esq., to whom I am indebted for the following description of it:—

In the early part of the evening the sky was clear, but at $8^h\ 30^m$ a dense mist rose from the river Derwent and entirely overspread a large segment of the northern horizon; whilst to the south, the atmosphere continued comparatively clear, the moon, within four days of full, shining brightly near the meridian. About $9^h\ 10^m$, there was a faint luminous arch in the north, which was evidently a lunar rainbow, or rather a fog-bow, for no rain whatever was visible at the time. The light reflected by the arch was white, and perfectly free from prismatic colour. Its breadth was considerable, perhaps 4° or 5°, and its centre or highest part, passed close under the star β Ursæ Majoris, so that the extreme altitude of the arch was probably about 18° or 20°. The edges were not sharply defined, but gradually shaded off. It was noticed that the denser the fog became, the more apparent was the arch, and *vice versa*, so that the phenomenon could not have been of an auroral character. The phenomenon was watched for ten or fifteen minutes, when the gradual dispersion of the fog, by destroying the refracting medium, put an end to this interesting appearance.

November.—As usual, a very dull, damp month, with but little difference between the temperature of the days and nights. Temperature 1°·20 *above* the average.

Early on the morning of the 2d, a swallow was seen on the wing in the immediate vicinity of this town. The maximum temperature of the day was 55°. Between the 9th and 12th inclusive, the extremes of day and night temperature only varied 2 degrees.

December.—A fine dry month with occasional frosty nights. Temperature 2°·15, and rain 2·19 inches *below* the average. Two loud peals of thunder and much lightning on the night of the 14th.

The remarkable meteor observed at Edinburgh on the evening of the 19th, and minutely described by Professor Forbes who witnessed it, was also seen at Whitehaven under the same circumstances and at the same time.

Last Quarter.—The mean temperature of the last quarter of 1849 is 1°·15 *below* the average, and the complement of the dew-point is 0°·87 *below* the mean of the two preceding years. The average depth of rain for the quarter is 14·64 inches; in 1849 the quarterly fall is 12·62 inches, or 2·02 inches *under* the normal quantity. The deaths in this quarter, in the town and suburbs, are 131, being 4 *below* the average number.

It is pleasant to have to announce a favourable change in the sanitary condition of this town, and to record the termination of an excessive mortality, which uninterruptedly prevailed for a period of two years and a half; for this is the only quarterly period wherein the deaths have not exceeded the average since March 1846.

In the corresponding quarters of 1846, 1847, and 1848, the deaths were 215, 161, and 176 respectively. The births exceed the deaths by 34.

The Aurora Borealis.—There have been seven exhibitions of the aurora borealis during the year 1849, two of which were sufficiently remarkable to merit something more than a passing notice.

The first occurred on the evening of January 14th. At 10 P.M., a well-defined auroral arch, about 5° in width, extended from NNE. to W., its highest part reaching nearly to Arided in Cygnus. At 11^h there was one complete arch, and segments of two other arches, all brilliant, crossing each other in the NW., and throwing off intensely bright streamers, some of which reached the altitude of the Pointers. The aurora was now exceedingly beautiful, and emitted considerable light. The streamers appeared to have a duplex lateral motion, running along the upper edge of the arch from west to north, and then backwards from north to west. The clear sky beneath the arches was almost black, from contrast. At $11^h\ 30^m$ the arches had broken up, and the streamers appeared to emanate from the horizon.

February 18.—At 9 P.M. there was a brilliant band of auroral light in the east about 6° in width, which shot upwards towards the zenith, throwing off short lateral streamers. At times, a complete arch of varying width extended from the eastern to the western horizon; at others, it was broken up into two or more detached portions. At $9^h\ 45^m$, a magnificent rainbow-like arch about 2° in width, spanned the heavens from ENE. to WSW. The altitude of the centre was apparently about 75°; the lower edge, at or near the highest point of the arch, was bounded by the star Castor. The arch was beautifully defined, and of perfectly even width throughout its entire extent; it disappeared in a few minutes after my attention was called to it, and soon after the sky became overcast. But for the absence of the moon, it might easily have been mistaken for a lunar rainbow. A precisely similar arch made its appearance here on the evening of the 21st of March 1833, and as far as my observation goes, these perfect rainbow-like arches are of exceedingly rare occurrence.

The following phenomenon though unconnected with auroræ, is probably of electric origin; and, as an unusual atmospheric appearance, is worthy of being placed on record:—*September* 16.—The sky was mostly overcast throughout the day, except a segment extending from WSW. to ENE., which was bright and clear to an altitude of about 15°. The upper boundary of the clear blue space was an elliptical segment formed by a sheet of white cloud, which was partially illuminated towards the western extremity, and somewhat resembled an auroral arch. I first noticed this blue arch about 3 P.M., and from that time until it disappeared, about six o'clock, there was not the slightest apparent change, either in its altitude or position. It was observed as early as 7 o'clock in the morning, when it was nearer to the horizon.

General Remarks.—The year 1849 is the driest we have had since 1844; the fall of rain (39 inches) is 7·9 inches under the average annual depth, which is 47 inches nearly. From some cause, the annual quantity of rain at this place is evidently on the decrease, and the diminution is, I believe, general all over the north of England. Probably the large amount of moor and waste marshy land brought into cultivation of late years, and the more efficient drainage of the country generally, by diminishing the evaporating surface, and so interfering with that invisible process of nature which is the source of every kind of atmospheric deposition, may have led to this and other changes which appear to have occurred in the climate of England within the last half century. In the first seven years (1833–39) after I began to keep a meteorological record, the average annual depth of rain was 49·93 inches, or 50 inches nearly; in the last seven years, ending with 1848, the average is reduced to 43·74 inches. The greatest quantity in the last 17 years is 59 inches, in 1836; the least, 34·69 inches in 1842. The three driest years in the period are 1842, 1844, and 1849, which yielded 34·69 inches, 36·72 inches, and 39 inches.

The temperature of the past year (48°·69) is about half a degree *below* the climatic mean, which is 49°·02. The coldest year of the last 17 was 1845, and the mildest, 1846; the mean temperatures of these years were 47°·49 and 50°·85 respectively.

The naked thermometer on the grass, placed on raw wool, has been at or below the freezing point in every month of 1849; viz., in January, on 19 nights; in February, on 14; in March, on 13; in April, on 18; in May, on 11; in June, on 8; in July, on 1; in August, on 2; in September, on 5; in October, on 16; in November, on 13; and in December, on 24 nights. The amount of radiant heat thrown off from the earth's crust at night, in the year 1849, as indicated by naked thermometers placed on raw wool and on grass, is much greater than usual. The evaporation exceeds the fall of rain in five months of 1849; viz., in March, April, May, June, and September. In 1849, we have had 12 perfectly clear days; 163 days more or less cloudy but without rain; 190 wet days; 261 days on which the sun shone out; 33 days of frost; 13 of hail; 7 of snow; 10 of thunder and lightning; and 7 days in which lightning occurred without thunder. There have also been three lunar halos, one lunar rainbow, a double parhelion, and seven appearances of the aurora borealis.

The clear days are 14, the days of sunshine are 13, and the wet days are 8 *less* than the average number. The past year has therefore afforded a smaller share of blue sky and a less amount of sunshine than usual, although the depth of rain and the number of wet days are both *below* the average for the locality.

The quantity of electricity in the air was extremely small down to the end of July, after which it was restored to its average amount.

This fact is strikingly exhibited by the following table of continuous observations taken by M. Quetelet with Peltier's electrometer:—

	Average 1844 – 1848.	Mean 1849.
January,	53°	39°
February,	47	36
March,	38	27
April,	27	20
May,	21	16
June,	18	13
July,	19	14
August,	21	21
September,	24	24

In 1849, the deaths exceed the calculated average number by 79, and the births exceed the deaths by 74.

In the seven years ending with 1845, the mean annual number of deaths in the town and suburb, with an assumed population of 17,867, is 410, being 22·9 per thousand, or one death in every 43·5 persons. In 1846, 1847, and 1848 (assumed average population 18,329), the mean annual number is 694, being 37·8 deaths per thousand, or 1 in every 26·4 persons in those three most unhealthy years. In 1849 the deaths are 606, which, assuming the population to be the same as in 1848, give 32·2 deaths per 1000, or 1 death in every 31 persons. The average annual number of deaths in the ten years 1839–48 is 495, which, with an assumed population of 17,713, gives 27·9 per 1000, or 1 death in every 35·7 inhabitants.

So that the mortality in 1849, although still above the average, shews a marked improvement in the health of the town as compared with any of the three preceding years; and, in the last quarter, the deaths are below the average for the period.

The Observatory, Whitehaven,
13*th March* 1850.

The Completed Coral Island. By JAMES D. DANA, Geologist to the American Exploratory Expedition, &c., &c.

The Coral Island, in its best condition, is but a miserable residence for man. There is poetry in every feature; but the natives find this a poor substitute for the bread-fruit and yams of more favoured lands. The cocoa-nut and pandanus are, in general, the only products of the vegetable kingdom afforded for their sustenance, and fish and crabs from the reef their only animal food. Scanty, too, is the supply; and infanticide is resorted to in self-defence, where but a few years would otherwise overstock the half-dozen square miles of which their little world consists.

Yet there are more comforts than might be expected on a land of so limited extent, without rivers, without hills, in the midst of salt water, with the most elevated point but ten feet above high tide, and no part more than 300 yards from the ocean. Though the soil is light and the surface often strewed with blocks of coral, there is a dense covering of vegetation to shade the native villages from a tropical sun. The cocoa-nut—the tree of a thousand uses—grows luxuriantly on the coral-made land, after it has emerged from the ocean; and the scanty dresses of the natives, their drinking-vessels and other utensils, mats, cordage, fishing-lines, and oil, besides food, drink, and building material, are all supplied from it. The *Pandanus*, or screw-pine, flourishes well, and is exactly fitted for such regions: as it enlarges and spreads its branches, one prop after another grows out from the trunk and plants itself in the ground; and by this means its base is widened and the growing tree supported. The fruit, a large ovoidal mass, made up of oblong dry seed, diverging from a centre, each near two cubic inches in size, affords a sweetish-husky article of food, which, though little better than prepared corn-stalks, admits of being stored away for use when other things fail. The extensive reefs abound in fish which are easily captured; and the natives, with wooden hooks, often bring in larger kinds from the deep waters. From such resources a population of 10,000 persons is supported on the single Island of Taputeouea, whose whole habitable area does not exceed six square miles.*

Water is usually to be found in sufficient quantities for the use of the natives, although the land is so low and flat. They dig wells five to ten feet deep in any part of the dry islets, and generally obtain a constant supply. These wells are sometimes fenced around with special care; and the houses of the villages, as at Fakaafo, are often clustered about them. On Aratica (Carlshoff) there is a watering-

* There are a few islands better supplied with vegetable food, though the above statements are literally true of a large majority.

place 50 feet in diameter, from which our vessels in a few hours obtained 390 gallons. The Tarawan Islands are generally provided with a supply sufficient for bathing, and each native takes his morning bath in fresh water, esteemed by them a great luxury.

The only source of this water is the rains, which, percolating through the loose surface, settle upon the hardened coral rock that forms the basis of the island. As the soil is white, or nearly so, it receives heat but slowly, and there is consequently but little evaporation of the water that is once absorbed.

These islands, moreover, enclose ports of great extent, many admitting even the largest class of vessels; and the same lagoons are the pearl fisheries of the Pacific.

An occasional log drifts to their shores; and at some of the more isolated atolls, where the natives are ignorant of any land but the spot they inhabit, they are deemed direct gifts from a propitiated deity. These drift-logs were noticed by Kotzebue, at the Marshall Islands, and he remarked also that they often brought stones in their roots. Similar facts were observed by us at the Tarawan group, and also at Enderby's Island, and elsewhere.

The stones at the Tarawan Islands, as far as we could learn, are generally basaltic, and they are highly valued for whetstones, pestles, and hatchets. The logs are claimed by the chiefs for canoes. Some of the logs on Enderby's Island were forty feet long, and four in diameter.

Fragments of pumice and resin are transported by the waves to the Tarawan Islands. We were informed that the pumice was gathered from the shores by the women, and pounded up to fertilize the soil of their taro patches; and it is so common, that one woman will pick up a peck in a day. Pumice was also met with at Fakaafo. Volcanic ashes are sometimes distributed over these islands, through the atmosphere; and in this manner the soil of the Tonga Islands is improved, and in some places it has received a reddish colour.

The officers of the "Vincennes" observed several large masses of compact and cellular basalt on Rose Island, a few degrees east of Samoa: they lie two hundred yards inside of the line of breakers. The island is uninhabited, and the origin of the stones is doubtful; they may have been brought there by roots of trees, or perhaps by some canoe.

Notwithstanding the great number of coral islands in the Paumotu Archipelago, the botanist finds there, as Dr Pickering informs me, only twenty-eight or twenty-nine native species of plants. The following are the most common of them: *Portulacca,* two species; *Scævola Konigii. Pisonia?* one species; *Tournefortia sericea; Pandanus odoratissimus; Lepidium,* one species; *Euphorbia,* one species; *Morinda citrifolia; Bœrhavia,* two species; *Cassytha,* one species; *Heliotropium prostratum, Pemphis acidula, Guettarda speciosa, Triumphetta procumbens, Sauriana maritima; Convolvulus,* one species; *Urtica,* one or two species; *Asplenium nidus;*

Achyranthus, one species; a species of grass. One or two rubiaceous shrubs. *Polypodium.*

On Rose Island, Dr Pickering found only the *Pisonia* and a *Portulacca*. The *Triumphetta procumbens*, a creeping plant, takes root, like the *Portulacca*, in the most barren sands, and is very common. The *Tournefortia* and *Scævola* are also among the earliest species. The *Pisonia*, a tree of handsome foliage, the *Pandanus*, or screw-pine, and the cocoa-nut (always an introduced species), constitute the larger part of the forests. In the Marshall group, where the vegetation is more varied, Chamisso observed fifty-two native plants, and, in a few instances, the banana, taro, and bread-fruit.

The language of the natives indicates their poverty, as well as the limited productions and unvarying features of the land. All words, like those for mountain, hill, river, and many of the implements of their ancestors, as well as the trees and other vegetation of the land from which they are derived, are lost to them; and as words are but signs for ideas, they have fallen off in general intelligence. It would be an interesting inquiry for the philosopher, to what extent a race of men, placed in such circumstances, are capable of mental improvement. Perhaps the query might be best answered by another: How many of the various arts of civilized life could exist in a land where shells are the only cutting instruments? The plants, in all but twenty-nine in number,—but a single mineral,—quadrupeds, none, with the exception of foreign mice,—fresh water barely enough for household purposes,—no streams, nor mountains, nor hills! How much of the poetry or literature of Europe would be intelligible to persons whose ideas had expanded only to the limits of a coral island,—who had never conceived of a surface of land above half a mile in breadth, of a slope higher than a beach, of a change of seasons beyond a variation in the prevalence of rains? What elevation in morals should be expected upon a contracted islet, so readily overpeopled that threatened starvation drives to infanticide, and tends to cultivate the extremest selfishness? Assuredly, there is not a more unfavourable spot for moral or intellectual development in the wide world than the Coral Island, with all its beauty of grove and lake.

These islands are exposed to earthquakes and storms, like the continents, and occasionally a devastating wave sweeps across the land. During the heavier gales the natives sometimes secure their houses by tying them to the cocoa-nut trees, or to a stake planted for the purpose. A height of ten or twelve feet, the elevation of their land, is easily overtopped by the more violent seas; and great damage is sometimes experienced. The still more extensive earthquake waves, such as those which have swept up the coast of Spain, Peru, and the Sandwich Islands, would produce a complete deluge over these islands.—(*United States' Exploring Expedition.—Geology.—By James Dana*, p. 75.)

Biographical Notice of Leopold Pilla, the Geologist. By H. Coquand.* Communicated by the Author.

Again, to bring to your recollection the numerous works which have placed Pilla among the most eminent geologists of Italy, is to do honour to the memory of an associate, whose recent loss we lament, by bestowing well-merited praises on the greatness of mind in a citizen, who nobly sacrificed a life already illustrious, and which the future promised to render still more so, to the good of his country. Yes, Italy has always been *tellus magna virum!* The chances of war, the rage of civil discord, the insults of foreign domination, may have eclipsed its political name, but they could not extinguish its genius. The blast of revolutions has respected the triple halo with which the sciences, letters, and the arts, have adorned its brow. By entrusting to one of his friends the task of enumerating his scientific labours, the Society imposes on him a very painful duty; but he undertakes it with feeling and gratitude; for the public homage rendered to the virtues of those whom we have loved, seems to bring them back to us, and softens the awards of destiny, which has too soon snatched them from us.

Leopold Pilla was born in the kingdom of Naples. While still young, the exciting scenes of Vesuvius attracted his attention, and determined his scientific career. In 1832, he undertook to write the annals of this volcano, and gave its history in two periodical collections.† It was at this period that he proved the production of flames in volcanic eruptions, and deduced from thence the ingenious conclusions which you judged worthy of a place in your memoirs.‡ This remarkable work, which of itself would have been sufficient to establish his scientific reputation, was soon followed by numerous others, which shed a new lustre on his name. The

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* Read to the Geological Society of France, at their meeting on the 16th of April 1849.

† Spettatore del Vesuvio et Bulletino del Vesuvio. Napoli, 1832.

‡ Sopra la produzione delle fiamme nei vulcani, e sopra le consequenze che se ne possono tirare. Atti del Congresso di Lucca, 1845.

study of the extinct volcano of Rocca Monfina,* in the Campania, illustrated the theory of craters *de soulevement*, and enriched it with facts of the highest importance.

With a mind at once philosophical and cultivated, he was able to generalise and describe, to unite erudition with good taste, and to treat questions of deepest science with that grace and picturesqueness of style, which renders them popular without detracting from their accuracy. His love for geology amounted to enthusiasm; he was therefore so zealous in propagating his views, that certain jealous minds could not pardon him, and led him to atone for his fault, by a voluntary exile. The apostle of the science, he likewise was its martyr; thus nothing was wanting to his fame. It is the privilege of men of genius to be persecuted. Obliged to yield to the storm, Pilla left Naples, but by his writings he belonged to Italy at large; and the unanimous acclamation which greeted him in the chair formerly occupied by Galileo, conferred on him by the liberality of the Grand Duke of Tuscany, formed at once his triumph and revenge.

Besides the works mentioned, we owe to him a Mineralogical Treatise on Rocks;† an Introduction to the Study of Mineralogy;‡ and a Geological Itinerary from Naples to Vienna.§ Thus, by approving the new productions which his activity produced, and which caused him to be better appreciated by the nation which had adopted him, the Tuscans had only to sanction the judgment they had already given of our *savant*, founded on his reputation and works.

Pilla left his heart at Naples. That city contained all the objects of his affections—a father, who had guided his first attempts in the field of science, and his family—a classical soil which had revealed to him the secret of its revolutions, a majestic landscape, which he could not find among the monotonous plains of Pisa, and above all *his own* Vesuvius. It was

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* Memoires de la Société Geologique de France, t. i., 2me serie.

† Trattato mineralogico delle Roccie, Napoli.

‡ Introduzione allo studio della geologia, Napoli.

§ Osservazioni Geologiche che si possono fare lungo la strada da Napoli a Vienna.

in this way that he recalled to his mind the mountain which had been the subject of his daily study, and from whose summit nature presented herself to his eyes in the most striking contrasts, revealing to his view its subterranean convulsions, connected with the delightful picture of the Gulf of Baia. All his thoughts brought him back to Naples. When, from the height of the terraces of Campiglia our view extended from the peaks of Mount Amiata to the banks of the Popolonia, and from the Tuscan Archipelago to the distant horizons of Corsica and Sardinia, my poor friend often interrupted our reveries by saying,—"It is almost as beautiful as Naples, but my Vesuvius is wanting;" and then adding, "How unfortunate it is that Werner did not lay the foundation of geology at Naples; *he would have made it Plutonian.*" Thus the love of his country, and the recollection of its wonders, were confounded in his mind with the cultivation of the science, and gave to his animated and poetical conversation a touching melancholy which agreeably tempered his vivacity.

During the years of his professorship at Pisa, Pilla published, in succession, a comparative Essay on the formations which compose the soil of Italy;* a Collection of the Mineral riches of Tuscany;† two Memoirs on the Etrurian Formation;‡ History of an Earthquake felt in Tuscany, in 1846;§ many notices respecting the Calcare-rosso, and on the temperature observed in the wells of Monte-Massi;‖ lastly, the first volume of his Treatise on Geology.¶ The entire work would have formed four octavo volumes. The materials were prepared, but death left the work incomplete. As these various writings are in the hands of all geologists, we give no analysis of them; which indeed would only be a faint reflection from the pictures present to your memory. I may

* Saggio comparativo dei terreni che compongono il suolo de l'Italia, Pisa.

† Breve cenno sopra la richezza mineralogica della Toscano, Pisa.

‡ Sulla vera posizione del terreno di macigno in Italia, Pisa; and Memoires de la Société geologique de France, 2me serie, t. ii.

§ Storia del tremuoto che ha devastuto i paesi della costa Toscana, il di 14 Agosto 1846, Pisa.

‖ Miscellanee di fisica e di Storia naturale di Pisa, anno 1, Nos. 7 and 8.

¶ Trattato di geologia, t. i., Pisa, 1847.

merely say, that the elevated considerations of the general physics of the globe to which he has risen in appreciating and investigating the causes of earthquakes, the comprehensive and methodical plan on which he has projected this geological treatise, by affording us a proof of the fertility and maturity of his mind, shew us, at the same time, the importance of the part reserved for a philosopher, whom death has removed from the present scene before he had reached his thirty-sixth year.

The war of independence raged at the time when Pilla was about to visit the north of Europe, in order to complete his studies in practical geology, by comparing the different formations. Every generous heart in Italy beat high at the report of the insurrection of Milan; and the Universities of Pisa and Sienna, by demanding arms and first flying to the scene of danger, shewed that hearts, proved in the fire of science, are prepared for great things. Pilla marched at the head of his pupils, and led them in the path of glory, as he had done in that of philosophy. The love of country and thirst for independence, by subjugating his heart, had stifled the calculation of reason under the impulse and delirium of enthusiasm. He had foreseen the issue of the struggle; for he said to me some days before setting out for the plains of Lombardy, "the hour of our fall has struck. Italy loses by fourteen ages of servitude the splendour of her early days. They are leading us to slaughter; but we must teach our children how to die, in order that they may know how they may one day become free."

The University legion formed a small corps which was placed on the right wing of the Piedmontese army, and occupied the positions of Curtatone and Montanara. The principal effort of the Austrian army was directed against these lines, in the affair of the 29th May 1848. Attacked by 13,000 imperial troops, the Tuscans resisted courageously, and did not fall back till they had left 250 of their men on the field of battle. Their heroic resistance paved the wav for the success of Goito. Pilla was found among the dead.

On the Chronological Exposition of the Periods of Vegetation, and the different Floras which have succeeded each other on the Earth's Surface. According to the views of M. Brongniart.

(*Continued from p.* 330 *of Volume* 48.)

" II. *Permian Period.*—The nature of the vegetables which appear peculiar to this epoch, is far from being determined in a positive manner; for the few localities where the fossils we consider as belonging to it, have hitherto been found, are not perhaps really of a formation very identical and truly contemporaneous. For it may be asked, whether the bituminous and copper slates of the county of Mansfield, classed by all geologists with the zechstein, and the sandstone of Russia, placed by M. M. Murchison and Verneuil in their Permian formation, are really contemporaneous? Finally, is there greater reason for classifying the slates of Lodève, considered by M. M. Dufresnoy and Elie de Beaumont as depending on the variegated sandstone, but so different from the same sandstone of the Vosges in its *flora*, in this period, which would thus be a kind of passage from the coal period, so well characterised, to the vosgian or variegated sandstone, which differs from it in so decided a manner?

On account of these doubts, M. Brongniart indicates these three floras separately; 1*st*, The Flora of the bituminous slates of Thuringia, composed of algæ, ferns, and coniferæ; 2*d*, The Flora of the Permian sandstones of Russia, which comprehends ferns, equisetaceæ, lycopodiaceæ, and nœggerathiæ; 3*d*, The Flora of the slates of Lodève, which is composedof ferns, asterophylliteæ, and coniferæ.

" We perceive that there are great specific differences between the plants of these localities, and that hitherto no species common to them has been found. Must we ascribe these differences to the influence of the great diversity of geographical position, or is there, besides, a difference in the period of their origin among these formations? The only character which tends to bring these two latter Floras near each other, is the relation which both of them bear to the coal-formations, of which they seem to be a kind of extract, reminding us more especially of the most recent beds.

"With regard to the plants of the bituminous slates of the Mansfeld district, they are so few in number, and appear to have been deposited in conditions so different, that we can with difficulty compare them with the two other Floras. Yet the species of Sphenopteris are extremely like each other in the three formations, and an exact comparison would perhaps establish the identity of many of them. The Pecopteris crenulata of Ilmenau, is only perhaps an imperfect state of the Pecopteris abbreviata of Lodève; lastly, the Callipteris of the Permian formation of Lodève have a very close connection between themselves and the Callipteris of the coal-formation.

"We may add, with regard to the bituminous slates of Thuringia, that many of these fossils appear to be marine plants, whose numbers would become much more considerable if we did not suppress all the imperfect impressions which have been described as such, and which are nothing more than fragments of ferns or altered coniferæ.

"II. Reign of the Gymnosperms.—During the preceding periods, and particularly during the Carboniferous period, the Acrogenous cryptogams predominated, and the Gymnospermous dicotyledons, less numerous, shewed themselves in unusual forms, and sometimes so anomalous that we are in doubt whether to place them in this or the preceding department; such are the Asterophylliteæ. At a later period, on the contrary, these anomalous and ambiguous forms, whose classification is often obscure, disappear; Acrogenous cryptogams and Gymnospermous dicotyledons evidently enter into families still existing, differing from them only in generic forms; the Ferns and Equisetaceæ, which represent the acrogens, are less numerous; the Coniferæ and Cycadeæ almost equal them in number, and usually exceed them in frequency, especially in the second period; by their abundance and size they afford the essential character of all these formations; lastly, the Angiospermous dicotyledons are wholly wanting, and the monocotyledons are in very small numbers.

"This reign of the Gymnospermous dicotyledons is divided into two periods; the first, in which the Coniferæ predominate, and in which the Cycadeæ scarcely appear; the second, in which this family becomes predominating in the number of species, in frequency and variety of generic forms. The latter may be divided into many epochs, each presenting peculiar characters.

"III. *Vosgian Period.*—This period, which does not appear to have been of long duration, and comprehends only the *variegated* sandstone properly so called, presents the following characters; 1*st*, The existence of ferns, pretty numerous, of forms very often anomalous, evidently constituting genera now extinct, and which are not found even in the most recent formations; such are the Anomopteris and the Crematopteris. Stems of arborescent ferns are more frequent than during the Jurassic period; true Equisetums are very rare; the Calamites, or rather perhaps the Calamodendrons, are abundant. 2*d*, The Gymnosperms are represented by two genera of Coniferæ, *Voltzia* and *Haidingeria*, of which the species and specimens are very numerous. The Cycadeæ, on the contrary, are very rare. M. Schimper mentions only two species founded on two unique specimens of a very imperfect character, and the determination of which may be considered doubtful.

"This consideration appears to me to separate completely, in a botanical point of view, the period of the variegated sandstone from that of the Keuper, although both are placed by geologists in the trias-formation. For the Cycadeæ become very abundant in the Keuper, are perfectly characterised, and often analogous to those of the Jurassic period; while the Coniferæ of the variegated sandstone are, on the contrary, wanting in this formation.

"IV. *Jurassic Period.*—This period is one of the most extensive by the formations which it comprehends, and the variety of different special epochs of vegetation which it embraces; although we cannot refuse to comprehend, under a common title, epochs during which very analogous forms have succeeded each other. It thus comprehends from the Keuper inclusively, up to the Wealdean formations. In fact, we find the Pterophyllum of the Keuper appear anew, with slight specific differences in the Wealdean formations. The *equisetites* of the Keuper extend to the mean oolithic formation; the *baiera* of the Lias likewise recurs in the Wealdean beds of the north of Germany; the Sagenopteris and the Camptopteris likewise appear in the Keuper, Lias, and Oolite.

"Yet these common characters, which indicate a great analogy between the Floras of each of these epochs of formation, do not prevent each of them having characters of its own, and often an assemblage of species, almost all peculiar to each particular epoch. We ought, therefore, to distinguish here those various subdivisions, the number of which will perhaps be afterwards multiplied, when we become better acquainted with the vegetables of each of the stages of the Jurassic formations.

"*Keupric Epoch.*—M. Brongniart then gives an enumeration of the vegetables of the Keupric epoch, which, in regard to the Amphigenous cryptogams, consist of Algæ; in regard to the Acrogenous cryptogams, of Ferns and Equisetaceæ; in the case of the Gymnospermous dicotyledons of Cycadeæ and Coniferæ; lastly, of two doubtful monocotyledons (*Palæoxyris* and *Preisleria.*)

"On comparing this Flora with that of the variegated sandstone of the Vosges, and with that of the Lias, we perceive that it has nothing in common with the first except the palæoxyris, which appears very nearly related to that of the variegated sandstone; on the contrary, it resembles the Flora of the Lias or Oolite in the ferns, many of which are specifically identical, or nearly allied in the *Nilsonia* and *Pterophyllum*, which are likewise either identical, or very nearly connected specifically with the Lias.

"*Lias Epoch.*—The Liasic epoch furnishes Amphigenous cryptogams, consisting of Algæ, mushrooms, and lichens; Acrogenous cryptogams, such as Ferns, Marsileaceæ, Lycopodiaceæ, and Equisetaceæ; Gymnospermous dicotyledons, represented by the Cycadeæ and Coniferæ; finally, doubtful monocotyledons, consisting of *Proacites* and *Cyperites.*

"The essential characters of this epoch are therefore, 1*st*, The great predominance of Cycadeæ, already well established, and the presence of numerous genera in this family, particularly *Zamites* and *Nilsonia; 2d,* The existence of many genera among the ferns with reticulated nerves, which scarcely shew themselves, and under forms not greatly varied, in the most ancient formations; but some of which, notwithstanding, already begin to appear in the epoch of the Keuper. Such are the *Camptopteris* and *Thaumatopteris.*

" *Oolitic Epoch.*—The Oolitic epoch furnishes, among Amphigenous cryptogams, the Algæ; among the Acrogenous cryptogams, Ferns, Marsileaceæ, Lycopodiaceæ, and Equisetaceæ; among the Gymnospermous dicotyledons, Cycadeæ and Coniferæ; lastly, among the doubtful monocotyledons, Podocarya and Carpolithes.

" This list is chiefly founded on the fossils, so varied in character, collected on the coasts of Yorkshire, near Whitby and Scarborough, in beds which are referred to different parts of the inferior oolite, and particularly to the great oolite. It likewise contains a small number of species found in the slaty limestone of Stonesfield, near Oxford, depending on these same beds.

" In France, the fossils of this formation have been collected in the neighbourhood of Morestel, near Lyon, by Dr Lortet; at Orbagnoux and Abergemens, near Nantua, in the department of the Ain, by M. Itier; in the vicinity of Chateauroux, near Châtillon-sur-Seine, by Colonel Moret; at Mamers, in the department of Sarthe, by M. Desnoyers; and, lastly, in the greatest quantity by M. Moreau, in beds of oolithic limestone of a very pure white, in the neighbourhood of Verdun, and near Vaucouleurs. Some species have likewise been found at other points of the Jura, in Normandy, near Valogne, in the neighbourhood of Alençon, in each of these localities in very small number. But the greater part of these species are not yet described and figured, and they generally differ as species from those of England. The ferns are generally less numerous, and not so well preserved; we must, however, except the *Hymenophyllites macrophyllus*, found in a perfect state at Morestel, and likewise observed at Stonesfield, and in Germany. The Cycadeæ, the species of which are not greatly varied, are referrible to the genera *Otozamites* and *Zamites;* Ctenis, Pterophyllum, and Nilsonia have not yet been observed; lastly, the Coniferæ of the genus *Brachyphyllum* are there particularly abundant, and more frequent than in the other localities.

"In Germany, it is more especially in the slaty limestone of Solenhofen, near Aichstædt, that these fossils have been observed, and particularly those of the family of Algæ. M. Gæppert likewise notices many Cycadeæ in the Jurassic formation of Ludwigsdorf, near Kreuzburg, in Silesia.

"But these localities, so diverse, are referrible to very different stages of the Oolithic series, and perhaps will constitute, when they are better known, and more fully explored, distinct epochs.

"The distinctive characters of this epoch, comprising the whole extent we have assigned to it, from the Lias to the Wealdean formation exclusively, are; among the Ferns, the rarity of ferns with reticulated nervures, so numerous in the Lias; among the Cycadeæ, the frequency of *Otozamites* and *Zamites,* properly so called; that is to say, Cycadeæ most analogous to those of the existing period, and the diminution of *Ctenis, Pterophyllum,* and *Nilsonia,* genera much more remote from living species; finally, the greater frequency of Coniferæ, viz., *Brachyphyllum* and *Thuites,* much rarer in the Lias.

"*Wealdean Epoch.*—This epoch affords, Amphigenous cryptogams, the Algæ; among Acrogenous cryptogams, Ferns, *Marsileaceœ,* and *Equisetaceœ;* among Gymnospermous dicotyledons, *Cycadeœ* and *Coniferœ;* lastly, some Carpolithes as plants of a doubtful class.

"This enumeration results principally from discoveries made, in recent years, in the Wealdean formations of the north of Germany, at Osterwald, Schaumberg, Buckeburg, Oberkirke, &c., of which the fossil plants were first described by M. Ræmer, and afterwards in a more complete manner by M. Dunker, in his monograph of these formations. To these species must be added others, less numerous and varied, previously discovered in the *Wealds* of England, near Tilgate Forest, and Hastings in Sussex, and which are so well described by M. Mantell."

This same formation has likewise been found in France, near Beauvais, by M. Graves, who observed there *Lonchopteris Mantelli*, and some other plants, of which M. Brongniart has not seen specimens, and which he quotes from Graves on the geology of the department of the Oise.

"These species, 61 in number, enumerated above, appear to be all peculiar to this formation, with the exception, perhaps, of *Baiera Huttoni*, which seems to be identical with the species of the Bayreuth Lias and Scarborough Lias; but their generic forms are almost all the same as those of the Lias and Oolitic formations. The Cycadeæ, however, already appear less numerous relatively to the ferns.

"We further observe, that this fresh-water formation, which, according to our view, terminates the reign of the Gymnosperms is connected, by the whole of its characters with other epochs of the vegetation of the Jurassic formation, and is distinguished from the Cretaceous epoch, which succeeds it, by the complete absence of every species which could be arranged among the Angiospermous dicotyledons, both in France and England, as well as in the deposits of northern Germany, so rich in varied species. On the contrary, in the lower chalk, cretaceous *glauconia*, the quadersandstein or planerkalk of Germany, we immediately find many kinds of leaves evidently belonging to the great division of Angiospermous dicotyledons, as well as some remains of palms, of which no trace is observable in the Wealdean deposits.

"I class among the Cycadeæ the stems of the Tilgate forest, formerly designated by the name of *Clatharia Lyellii*, and which I have considered as a stem related to the *Dracæna*. The whole of its characters, although the almost entire absence of the tissues prevents us examining its anatomy, appear to me to render this connection most probable, and particularly to indicate the relations between this stem and that of *Zamites gigas* found at Scarborough.

The abundance of Lonchopteris Mantelli is a character of the Wealdean formations of the south of England and the department of the Oise, where this fossil seems to make its appearance, at least in fragments, in the greater number of localities, where these beds are exposed by the excavation of potter's clay in this formation, near Savignies. In Germany, on the contrary, this species is wanting, and *Abietites Linkii* becomes the predominating plant. With regard to Brachyphyllum, I have not yet had it in my power to study them in a natural state; but the figures given of them leave little doubt as to their analogy with the species of the Oolitic epoch.

"The abundance of the Cycadeæ likewise forms a distinctive character of the Wealdean formations of Germany. Still there are, as has been seen, many species common to the two basins; and I may add, that probably the Sphenopteris Gœpperti, *Dunk.*, does not differ from Sphenopteris Phillipsii, *Mant.*

"I have not included in this list some marine plants mentioned as belonging to the beds of this epoch; 1*st*, because it appears to me doubtful whether they really belong to the Wealdean and not to the Glauconian epoch; 2*dly*, because it still appears to me uncertain, whether the species mentioned, Chondrites æqualis and intricatus, are quite identical, specifically with the species of this name belonging to the fucoidal sandstone lying above the chalk.

"III. Reign of the Angiosperms.—The dominating character of this last transformation of the vegetation of the globe, is the appearance of Angiospermous dicotyledons, those vegetables which actually constitute more than three-fourths of the vegetable creation of our epoch, and which appear to have acquired this predominance from the commencement of the Tertiary formations. For a long period I was of opinion that these vegetables did not begin to appear till after the chalk, with the earliest beds of the Tertiary formations; but more recent investigation has shewn that beds belonging to the Chalk formation present some very distinct examples.

"These vegetables appear even at the beginning of the Chalk formation; for it is certain that many well-determined species exist in the quadersandstein and planerkalk of Germany, which appear to correspond to the green sandstone of France, or green sand of English geologists; although this formation in France and England has never yielded any of them, but only some examples of Cycadeæ, Coniferæ, and marine plants.

But in southern Sweden, at Kopingue in Scania, some specimens of dicotyledonous leaves appear associated with a species of Cycadeæ, in beds which have been referred to the greensand; so that the whole Chalk formation would appear to constitute a first period in the reign of the Angiosperms, forming, so to speak, the passage between the vegetation of the Secondary and that of the Tertiary formations, still presenting, as the first, a few Cycadeæ, as the following, some Angiospermous dicotyledons, and thus paving the way to the considerable development of these vegetables in the succeeding period. This period is besides characterised by many Coniferæ peculiar to it, and which appear very distinct from those of the Wealdean formations, and from those of the Eocene epoch of the Tertiary formations; and such in particular are the *Cunninghamites.*

"We can therefore distinguish two great periods in the reign of the Angiosperms:

"1*st*, The Cretaceous period, a kind of period of transition.

"2*dly*, The Tertiary period, presenting all the characters arising from the predominance of Angiosperms, Dicotyledons, and Monocotyledons, and divisible into many epochs, the characters of which will not be well established until we have removed all doubts as to the agreement of the different local series of the Tertiary formations.

"V. *Cretaceous Period.*—The Cretaceous period, properly so called, comprehends perhaps many distinct epochs; but the beds where fossil vegetables have been observed, not having been always classified with precision in the different subdivisions of this formation, it is impossible to establish their chronology with certainty. Besides, we must distinguish an epoch which appears immediately to precede this formation, and one which follows it, and yet differs from the Eocene period.

"We are acquainted with fossil vegetables of the Cretaceous period:—

"1*st*, *Sub-Cretaceous Epoch.*—In the subcretaceous marine lignites of the Isle of Aix, near La Rochelle, and of Pialpinson, in the department of the Dordogne; these are the most ancient beds of the Cretaceous formation, or the last of the

Jurassic period. Here have been found only marine plants, wood, and branches of Coniferæ.

"2*d*, In the chloriteous chalk or greensand of southern England, the neighbourhood of Beauvais and Maus; only Cycadeæ and marine plants have been observed there.

"3*d*, In the same formation in Scania, where M. Nilson has observed leaves of Dicotyledons mixed with leaves of Cycadites.

"4*th*, At Niederschœna, near Freyberg, in Saxony, beds, analogous to greensand or quadersandstein, containing fossils of considerable variety, Cycadeæ, Coniferæ, and Dicotyledons, particularly *Credneria*.

"5*th*, In the quadersandstein of Bohemia and Silesia, at Blankenburg, at Teifenfurth, Teschen, &c., where this sandstone is characterised by the presence of dicotyledonous leaves of the genus *Credneria*, by Cycadeæ, and particularly by Coniferæ of considerable variety, described by M. Corda in Reuss' work on the Chalk of Bohemia.

"6*th*, In France, in the iron sands connected with the green sandstones, near Grand-Pré, in the department of Ardennes, where M. Buvignier has found two fossil vegetables of a very remarkable character, a stalk of an arborescent fern, and a cone previously observed in England in the same formation.

"But in other places, and in beds belonging to epochs certainly different, this period has presented only marine vegetables; such more especially are those fucoidal sandstones or macigno, characterised by Chondrites targionii, æqualis, intricatus, &c., now designated by the name of fucoidal sandstone or flysch—the geological epoch of which has long been doubtful, but which observers seem to agree in considering as a distinct formation, superior to the chalk, and inferior to the most ancient beds of the Tertiary formations.

"These fucoidal sandstones form a very distinct epoch, which hitherto appears to be characterised only by marine vegetables, and what, at least in a botanical point of view, would form the line of demarcation between the Cretaceous and Tertiary formations; for it is remarkable that the fuci found there in such great numbers have little connection with those of the Chalk, properly so called, and none whatever with those of the most ancient beds of the Tertiary formations, such as those of Monte-Bolca.

"From the study and comparison of these fossils, derived from such various sources, we may divide the Cretaceous period into three epochs, of which the middle one is the true Cretaceous epoch. The others, characterised almost exclusively by marine vegetables, are somewhat doubtful with regard to their true geological position; the one, more ancient than the Chalk, contains only the subcretaceous lignites of the neighbourhood of La Rochelle, and the Department of Dordogne; the other, superior to the Chalk, corresponds to the Sandstone with fucoides."

The *subcretaceous* epoch comprehends Algæ, Naiadeæ, and Coniferæ.

"This small Flora is almost entirely founded on fossil plants, collected among the marine lignites of the Isle of Aix, near La Rochelle, long since described by M. Fleureau de Bellevue.

"The difference of the vegetables does not appear to admit of connecting this Flora with that of the inferior chalk or greensand; but it would require to be more completely examined, both with regard to its precise geological epoch and the entire amount of vegetable species which it contains. The most abundant and characteristic of these species is the *Rhodomelites strictus*, whose branches, crossed and mingled with *Zosterites*, constitute the mass of these lignites with the wood of Coniferæ, which have not yet been studied, and small branchlets, very rare, of *Brachyphyllum orbignianum*.

"I have referred to this period the two *Cystoseirites*, described by M. de Sternberg, and mentioned by him as found in the beds between the jurassic slates and the chalk in Transylvania.

"Does this fossil Flora correspond to a formation almost entirely marine, but cotemporary with the Wealdean epoch? New investigations can alone determine this, but we may suppose an analogy between the Brachyphyllum of the two epochs."

2*d*, *Cretaceous Epoch.*—The Cretaceous epoch presents us, among the amphigenous cryptogams, with Algæ, some of which are doubtful; among the Acrogenous cryptogams, with ferns; the Monoctyledons are here represented by two species of palms; the Gymnospermous dicotyledons by the cycadeæ and coniferæ; the Angiospermous dicotyledons by a species of Acerineæ, a betulaceæ, a cupulifera, salicineæ, an acerineæ, and a juglandeæ; lastly, a few dicotyledons remain, but the determination of the families to which they belong is uncertain.

"We ought, moreover, to notice at least from ten to twelve species of dicotyledonous leaves, indeterminate, and often imperfect, figured by Geinitz, Reuss, Corda, and Gœppert, or existing in collections.

"This Flora, which contains from sixty to seventy species, is, as we perceive, remarkable in this respect, that the Angiospermous dicotyledons nearly equal the Gymnospermous dicotyledons, and in the existence of a pretty considerable number of well characterised Cycadeæ, which cease to appear at the Eocene epoch of the Tertiary formations.

"The genus *Credneria*, containing dicotyledonous leaves, with a very peculiar nervation, but the affinities of which are doubtful, is likewise one of the characteristic forms of this epoch, in a pretty considerable number of localities. With regard to the species of dicotyledonous leaves, referred to determined families, I may remark that these supposed relations, founded on very imperfect specimens, and very few in number, are still very uncertain, and incapable of furnishing a basis for comparison with the other Floras, nor any certain conclusion.

"3*d*, *Fucoidian Epoch.*—This epoch, which seems to me to form the most natural limit between the Cretaceous and Tertiary periods, is characterised by those deposits, so rich in Algæ, of a very peculiar form, that they have been called the sandstones or macignos à fucoïdes, or the flysch of Switzerland,—a formation very widely spread, especially in southern Europe, from the Pyrenees, as far as the vicinity of Vienna, and even to the Crimea.

"I have not hitherto found land plants mingled with these marine species. I do not believe that fossil woods have been met with.

"Almost all these Algæ appear to belong to the same group, the genus *Chondrites;* and although the species are pretty numerous, they pass from one to another by almost insensible shades. The Algæ of the neighbourhood of Vienna, placed in the genus *Munsteria,* are very ill characterised, and perhaps are not congenerous with those of the jurassic limestone of Solenhofen; but they appear to me to have been found in the same formation, designated by the name of gray calcareous slate, of the sandstone of Vienna, as the Chondrites of the same country."

The Flora of the fucoidean sandstone is constituted by twelve species of Algæ (*Chondrites* and *Munsteria.*)

"What is remarkable in this series of species is, that they have nothing in common, either with the Algæ of the Subcretaceous epoch, or with those of the Eocene epoch, and particularly of Monte-Bolca, with which this Flora should be almost cotemporary, according to many geologists. The identity of these species of Algæ is likewise remarkable in all the localities, however distant from each other—localities so numerous, in regard to the greater number of these species, that I have been unable to enumerate them.

"The Chondrites targionii, or perhaps a distinct species, but very nearly related, is the only one presented in another formation, in the greensand and gault of the Isle of Wight, in England, according to M. Fitton; and in this same formation, in the department of the Oise, according to M. Graves.

"M. Kurr has likewise described and figured, under the name of *Chondrites bollensis,* a fucus of the Lias—the very varied forms of which are almost identical with the Chondrites targionii, æqualis, and difformis.

"VI. *Tertiary Period.*—Considered as a whole, the vegetables of this period, cotemporary with all the Tertiary deposits, and continued even in the vegetation which now covers the earth's surface, is one of the best characterised. The abundance of Angiospermous dicotyledons, that of the monocotyledons of diverse families, but especially the Palms, during a part at least of this period, immediately distinguish it from the most ancient periods. Yet the observations made on the Cretaceous epoch have established a kind of transition between the forms of the Secondary epochs and those of the Tertiary epochs, which was not suspected a few years ago. But while, at this period, the Angiosperms appear nearly to equal the Gymnosperms, in the Tertiary period, they greatly exceed them; while at the Cretaceous epoch, there are still Cycadeæ and Coniferæ allied to the genera inhabiting tropical regions; during the Tertiary period, the Cycadeæ appear to have been completely wanting in Europe, and the Coniferæ belong to the genera of the temperate regions.

"Notwithstanding this assemblage of characters common to the whole Tertiary period, there are evidently notable differences in the generic and specific forms, and in the predominance of certain families at different epochs of this long period; but here we often experience serious difficulties in establishing a uniformity as to time among the numerous local formations which constitute the different Tertiary formations. In assigning the different localities where fossil vegetables have been observed to the principal divisions of the Tertiary series, I have not followed exactly the bases admitted by M. Unger in his Synopsis; I have approached nearer to the distribution adopted by M. Raulin, in his Memoir on the Transformations of the Flora of Central Europe during the Tertiary period (Ann. Sc. Nat., t. x., p. 193, Oct. 1848), which refers many of the formations, classified by M. Unger in the Miocene division, to the Pliocene, or most recent epoch. Yet, according to the advice of M. Elie de Beaumont, I have not placed all the Lignite formations of Germany in the Pliocene division, as M. Raulin has done, nor all of them in the Miocene division, like M. Unger; but, conformably to the old opinion of my father, I have left the Lignites from the shores of the Baltic, which include amber, in the inferior division of the old basins of Paris, London, and Brussels, considering them cotemporary with the Soisson Lignites. Those of the banks of the Rhine, of Wetteravia and Westphalia, are arranged in the Miocene division; those of Styria, and part of Bohemia, on the contrary, are placed among the recent or Pliocene formations.

"This distribution agrees pretty generally with the nature of the vegetables contained in them. One important point only leaves me in doubt: this relates to the Lignites of the environs of Frankfort or Wetteravia, the plants of which are pretty generally analogous to those of Œningen or Partschlug in Styria; although their geological position seems to call upon us to refer them to a more ancient formation.

"It is probable that a more complete knowledge of these diverse deposits would lead to a division into distinct epochs more numerous; but I think that, in the meantime, the division into three principal epochs, which I shall designate, with the majority of geologists, by the names Eocene, Miocene, and Pliocene, is sufficient for a comparison of the successive changes of the vegetable kingdom. I shall point out for each of them the localities which I think should be comprehended under these different designations.

"With regard to the general characters which result from the comparative examinations of these Floras, we find that the number of species, in the great divisions, are thus distributed in these three Floras:—

	Eocene Epoch.		Miocene Epoch.		Pliocene Epoch.	
Cryptogams, . .	33	...	10	...	13	...
Amphigenous, .	...	16	...	6	...	6
Acrogenous, .	...	17	...	4	...	7
Phanerogams, .	...	...	...	...	...	...
Monocotyledons,	33	33	26	26	4	4
Dicotyledons,	143	...	97	...	195	...
Gymnosperms,	...	40	...	19	...	31
Angiosperms, .	...	103	...	78	...	164
Total,	209	...	209	...	212	...

"It may only be remarked that, in the first column, or Eocene formation, the fossil fruits of the Isle of Sheppey—a part only of which have been described by M. Bowerbank—have a great influence on the numbers of the different divisions of Phanerogams, and that this locality appears altogether exceptional, and is, perhaps, an example of the effect of currents conveying exotic fruits from remote climates, and accumulating them on a point of the shores of Europe.

"In this point of view, the enumeration of the plants of this first epoch is in no way comparable to that of the other epochs, where I have refrained even from introducing the small number of fossil plants from the Tertiary formations of the equatorial regions that are known, in order to confine myself to a comparison of the Tertiary Floras of Europe.

"With regard to the characters drawn from vegetable forms during these three epochs, the most remarkable appear to me, 1*st*, In the Eocene period, the presence, but rarity, of the palms, limited to a small number of species.

"The predominance of Algæ and marine Monocotyledons, which must be ascribed to the great extent of marine formations during this epoch.

"The existence of a great number of extra European forms, resulting especially from the presence of the fossil fruits of Sheppey.

"2*d*, In regard to the Miocene epoch, the abundance of palms in the greater number of localities belonging, without doubt, to this epoch; the existence of a considerable number of non-European forms, in particular of the genus *Steinhauera*, which appears to me to be a rubiaceæ allied to *nauclea*, found in many localities of these formations.

"3*d*, In regard to the Pliocene epoch, the great predominance and variety of Dicotyledons, the rarity of Monocotyledons, and, above all, the absence of Palms; lastly, the general analogy of the forms of these plants with those of the temperate regions of Europe, North America, and Japan.

"A remarkable character of the Floras of these three epochs, but which is most striking in regard to the last, in which the dicotyledonous plants are most numerous, is the absence of the most numerous and characteristic families of the division of Gamopetalis. Thus, among the numerous impressions of Partschlug, Œningen, Hœrring, Radoboj, &c., there is nothing to indicate the existence of the Compositæ, Campanulaceæ Personneæ, Labiaceæ, Solaniæ, Boraginaæ, &c.

"The only Monopetales mentioned in great numbers are the Ericaceæ, Ilicineæ, some Sapotaceæ, and Styraceæ, families which belong almost as much to the Dialypetales as to the Gamopetales.

"In the Miocene flora only have been pointed out many Apocyneæ, and Rubiaceæ, which I have mentioned above.

"1. *Eocene Epoch.*—This epoch, in the most precise limits, comprehends plastic clay with its lignites, the coarse Parisian limestone and gypsum which lie above it in the same basin; but I have not thought it worth while, in the meantime, to separate from it some formations which, according to the investigations of modern geologists, are placed between the Cretaceous formations and the inferior parts of the formations mentioned; such are the Nummulitic formations of the Vicentin, comprehending the celebrated locality of Monte-Bolca, and probably some others near it, such as Salcedo, in the Vicentin. I have likewise joined to this Flora of the Eocene formations a very remarkable locality of the basin of Paris, the relations of which with the Tertiary beds are not yet perfectly determined,—these are the beds of a species of ancient Travertin which, near Sezanne, contain numerous fossil vegetables still undescribed, and of which I shall here notice the most remarkable. These plants have very peculiar remains, and belong probably to a special Flora, unless the differences can be ascribed to a diversity of station.

"Besides the different members of the Eocene formation, properly so called, of the Paris basin, I comprehend in this Flora the fossils of the same formation in England, at the Isle of Wight, and Isle of Sheppey in the London basin. These latter fossils, consisting almost solely of fruits transformed into pyrites, constitute a whole which has no analogue in any other of the Tertiary basins of Europe; not only in the number and diversity of these fruits, but in their peculiar characters, which remove them widely from the plants whose leaves occur in the other beds of the same geological epoch. Everything, therefore, would lead us to suppose that these fruits, although belonging to plants cotemporaneous with the Eocene deposits of Europe, have been brought from distant countries by marine currents, just as fruits are still brought from the equatorial regions of America to the coasts of Ireland or Norway by the great current of the Atlantic. The deposit in the Isle of Sheppey appears therefore to be an accidental case in the Eocene deposits, and the Paris basin presents none of these fossils.

"The Tertiary basin of Belgium, which follows that of London, has yielded, near Brussels, some fossil fruits in very small numbers, but which appear identical with one of the genera most abundant at Sheppey. This is the *Nipadites*, considered at first as a species of Coco, under the name of *Cocus burtini.*

"Lastly, following the advice of my learned associate, M. Elie de Beaumont, I have included in the same Flora the plants contained in the Lignites of the shores of the Baltic and Pomerania, so rich in amber, in which these vegetables have often been preserved. It is to the labours of M. Gœppert that we are indebted for a knowledge of these vegetables, most frequently represented by very small fragments, the relations of which he has determined with much skill and accuracy."

With materials collected in these various localities, but of which the greater part are still unpublished, we may construct the Flora of the Eocene epoch; but the list, comprehending only the species described, or at least determined, is only a mere sketch.

M. Brongniart then gives the names of the vegetables belonging to the Eocene epoch; these are, for the Amphigenous cryptogams, algæ, and mushrooms; for the Acrogenous cryptogams, hepatici, mosses, ferns, equisetaceæ, and characeæ. The Monocotyledons present Naiades, Nipaceæ, and palms. The Gymnospermous dicotyledons are represented by Coniferæ (Cupressinæ, Abietineæ, Taxineæ, and Gnetaceæ.) Lastly, among the Angiospermous dicotyledons, we find examples of Betulaceæ, Cupuliferæ, Juglandeæ, Ulmaceæ, Proteaceæ, Leguminosæ, Œnothereæ, Cucurbitaceæ, Sapindaceæ, Malvaceæ, Ericaceæ, and three doubtful families (Phyllites, Antholithes, and Carpolithes.)

"The most remarkable characters of this Flora are,—

"1*st*, The great quantity of Algæ and marine Naiades, characters owing to the extent and thickness of the marine formations of this epoch.

"2*d*, The great number of Coniferæ, the greater part belonging to genera still existing, but among which the Cupressineæ appear to predominate, especially if we admit as positively belonging to this family the various fruits of the Isle of Sheppey, which M. Bowerbank has described under the name of Cupressinites, and of which M. Endlicher has formed the genera Callitrites, Frenelites, and Solenostrobus. If these fruits really belong to European vegetation, they indicate very peculiar generic forms, probably now wholly extinct.

"3*d*, The existence of many large species of palm, equally shewn by the occurrence of their leaves and stems.

"2. *Miocene Epoch.*—This Eocene or middle epoch of the Tertiary formations appears to me to comprehend the following localities among those which have furnished materials for the study of the vegetation of the Tertiary period: 1*st*, In the environs of Paris, the superior sandstones, or those of Fontainebleau and the *Meulieres*, or Buhrstone, which crown our coasts; 2*d*, The sandstone, with impressions, in the environs of Mans and Angers, and probably those of Bergerac, in the department of the Dordogne; 3*d*, A part of the Tertiary formations of Auvergne, and particularly those of the mountain Gergovia, formations which, by their impressions, appear more ancient than those of Menat, but which perhaps all belong to different stages of the Pliocene epoch; 4*th*, The fresh-water formations of Armissan, near Narbonne, the Gypsum of Aix in Provence, the Lignites of Provence, whose vegetable fossils are scarcely known; finally, the Lacustrine formations, rich in the wood of palms, and in stems of Monocotyledons, from Upper Provence, near Apt and Castellane; 5*th*, A part of the Tertiary formations of Italy, and particularly those of Superga, near Turin; 6*th*, The Mollasse of Switzerland, with its Lignites, at Lausanne, Kœpfnac, and Horgen, containing the remains of palms; 7*th*, The Lignites of the banks of the Rhine near Cologne and Bonn, at Friesborf, Liblar, &c., sometimes enclosing wood of palms, and those of Wetteravia at Nidda, near Frankfort, and other places; as well as those of Weisner near Cassel, which all appear to be of the same epoch, although those of Wetteravia, by the abundance of certain genera of Dicotyledons, such as *juglans* and *acer*, and even by many cases of specific identity, seem to make a nearer approach to the Pliocene flora; *8th*, A part of the Lignites of Bohemia, and particularly those of Altsattel, whose fossils, described by M. de Sternberg and M. Rossmæssler, generally agree with those of the other localities already mentioned. The other Lignites of Bohemia, those of Bilin and of Comothau in particular, enter completely into the Pliocene flora; *9th*, Hœrring in the Tyrol, and Radoboj in Croatia, of which M. Unger has so well described the numerous impressions in his *Chloris Protogœa*, and which have almost become the type of the Miocene flora.

"With the exception of the Lignite formations of the neighbourhood of Cassel and Frankfort—the species of which have often numerous points of connection with those of Œningen and Parschlug, and which enter rather into the Pliocene flora —the different localities I have mentioned have numerous relations between them as to their fossil vegetables. Thus, the Nymphea Arethusæ is found in the *Meulières* or Buhrstone of Paris, and in the marls of Armissan; the Flabellaria rhapifolia and maxima recur at Hœring in the Tyrol, at Radoboj in Croatia, and in the superior sandstones of the environs of Angers and Perigneux.

"The Callitrites Brongniartii, Endl., is likewise met with in the formations of Armissan, Aix, in Provence, at Hœring and Radoboj.

"Lastly, the Steinhauera globosa of the Altsattel Lignites in Bohemia, is likewise found in the sandstone of the vicinity of Maus; and the Platanus Hercules of Radoboj, in Croatia, has been sent to me from Armissan, near Narbonne, by M. Toumal.

"These facts would probably multiply by a more attentive study of the different localities; but as it is, they leave little doubt as to the synchronism of the greater part of these local formations."

In the Flora of the Miocene formations, Amphigenous cryptogams occur, represented by Algæ and mushrooms; Acrogenous cryptogams, represented by mosses, ferns, and Characeæ; Monocotyledons, among which we find Naiades, Gramineæ, Liliaceæ, and Palms; of the Gymnospermous dicotyledons, Coniferæ; and Angiospermous dicotyledons, among which occur Myriceæ, Betulineæ, Cupuliferæ, Ulmaceæ, Moreæ, Plataneæ, Salicineæ, Lawrineæ, Umbelliferæ, Karolangeæ, Combretaceæ, Calycantheæ, Leguminosæ, Anacardiæ, Xanthoxyleæ, Juglandeæ, Rhamneæ, Accrineæ, Nympheaceæ, Apocyneæ, and Rubiaceæ.

"The most striking characters of this epoch consist of the mixture of exotic forms at present peculiar to regions warmer than Europe, with vegetables growing generally in temperate countries; such as the palms, a species of bamboo, Lawrineæ, Combretaceæ, Leguminosæ of warm countries, Apocyneæ, analogous, according to M. Unger, to the genera of equatorial regions, a Rubiaceæ altogether tropical, united with *erables*, walnuts, birches, elms, oaks, *charmes*, &c., genera proper to temperate or cold regions. The presence of equatorial forms, and particularly of palms, appears to distinguish this epoch essentially from the following one. Lastly, we likewise observe the very small number of vegetables with a monopetalous corolla, limited to species referred to the family of Apocyneæ by Unger, and to the genus Steinhauera, founded on a fruit which has much relation to that of Nauclea among the Rubiaceæ.

"3. *Pliocene Epoch.*—This epoch, embracing all the Tertiary formations superior to the *fahluns* of Touraine, comprehends pretty numerous localities rich in fossil vegetables, and whose position in these formations is determined as much by the *ensemble* of the vegetables they contain, as by their other geological characters. The Tertiary basins which, it appears to me, must serve as the basis of this Flora, both by their identity, and the numerous and carefully-studied vegetables they contain, are: 1*st*, That of Œningen, near Shaffouse, the species of which have been long since studied and well determined by M. Alex. Braun, whose work, though unpublished, has been communicated to many naturalists, and particularly to M. Unger.* 2*d*, That of Parschlug, in Styria,

* The following interesting observations on the Œningen formation are by Professor Agassiz, who refers it to the Miocene not to the Pliocene class:—

"This picture would be incomplete did I not institute a farther comparison between the present vegetation of those regions and the fossil plants of modern the numerous impressions of which M. Unger has collected, studied, and determined, partly published by him in his *Chloris Protogæa*, and presented altogether in a special enumeration of these species recently published under the title of *Flora of Parschlug*. In this locality alone, M. Unger has recognised and classified 140 different species ; it is the most numerous local Flora with which we are acquainted, and the

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geological epochs. If we compare, namely, the Tertiary fossil plants of Europe with those living on the spot now, we shall be struck with the differences of about the same value as those already mentioned between the eastern and western coasts of the continents under the same latitudes. Compare, for instance, a list of the fossil trees and shrubs from Œningen, with a catalogue of trees and shrubs of the eastern and western coasts, both of Europe, Asia, and North America, and it will be seen that the differences they exhibit scarcely go beyond those shewn by these different Floræ under the same latitudes. But what is quite extraordinary and unexpected is the fact, that the European fossil plants of that locality resemble more closely the trees and shrubs which grow at present in the eastern parts of North America, than those of any other part of the world; thus, allowing us to express correctly the differences already mentioned between the vegetation of the eastern and western coasts of the continents, by saying that the present eastern American flora, and I may add, the fauna also,* and probably also that of eastern Asia, have a *more ancient character* than those of Europe and of western North America. The plants, especially the trees and shrubs growing in our days in this country and in Japan, are, as it were, old fashioned; they bear the mark of former ages—a peculiarity which agrees with the general aspect of North America; the geological structure of which indicates that this region was a large continent long before the extensive tracts of land had been lifted above the level of the sea in any other part of the world.

"The extraordinary analogy which exists between the present Flora and Fauna of North America, and the fossils of the Miocene period in Europe, would also give a valuable hint with respect to the mean annual temperature of that geological period.

"*Œningen*, for instance, whose fossils of all classes have perhaps been more fully studied than those of any other locality, could not have enjoyed, during that period, a tropical or even a subtropical climate, such as has often been assigned to it, if we can at all rely upon the indications of its Flora; for this is so similar to that of Charleston, South Carolina, that the highest mean annual temperature we can ascribe to the Miocene epoch in central Europe must be reduced to about 60° Fah.; that is to say, we infer from its fossil vegetation that Œningen had, during the Tertiary times, the climate of the warm temperate

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* The characteristic genera Lagomys, Cheldyra, and the large Salamanders with permanent gills, remind us of the fossils of Œningen, for the present fauna of Japan, as well as the Liquidambar, Carya, Taxodium, Gleditschia, &c., &c.

identity of a great number of species with those of Œningen, indicates well the synchronism of these two local formations. Such other points in Styria appear likewise to be of the same epoch, as well as many localities in Hungary so rich in silicified wood. In Bohemia, the tripoli slates of Bilin and Comothau, which contain a pretty considerable number of plants described by M. de Sternberg, are no doubt referrible to this epoch, according to the nature of these plants. Lastly, the Tertiary hills, called the sub-appennine hills of Plaisantin, of Tuscany, and a part of Piedmont, as well as the gypseous formation of Stradella, near Pavia, so rich in impressions of leaves, form part of this epoch; but, with the exception of this latter point, these formations contain, in general, few vegetables.

"In France, the Pliocene epoch probably comprehends a part of the fresh-water deposits of Auvergne and Ardêche. Thus, the slates of Menat and those of Rochesauve appear to me to furnish a Flora very similar to those of Œningen and Parschlug. With regard to the marls of Gergovia and Merdogne, near Clermont, I think they ought rather to be classed in the Miocene epoch; but this question can be settled only by a more attentive determination of the species. The Flora, which recapitulates all that has been described or named in these formations, is, however, essentially founded,

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zone, the climate of Rome, for instance, and not even that of the northern shores of Africa. We are led to this conclusion by the following argument:—The same isothermal line which passes at present through Œningen, at the 47th degree of northern latitude, passes also through Boston, lat. 42°. Supposing now (as the geological structure of the two continents and the form of their respective outlines at that period seem to indicate), that the undulations of the isothermal lines which we notice in our days existed already during the Tertiary period, or, in other words, that the differences of temperature which exist between the western shores of Europe and the eastern shores of North America, were the same at that time as now, we shall obtain the mean annual temperature of that age by adding simply the difference of mean annual temperature which exists between Charleston and Boston (12° Fah.) to that of Œningen, which is 48° Fah., as modern Œningen agrees almost precisely with Boston, making it 60° Fah.; far from looking to the northern shores of Africa for an analogy, which the different character of the respective vegetations would render still less striking. The mean annual temperature of Œningen, during the Tertiary period, would not therefore differ more from its present mean than that of Charleston differs from that of Boston."—*Agassiz, on Lake Superior,* p. 150.

as may be seen by the indication of localities, on the two basins of Parschlug and Œningen.

"The Flora of the Pliocene formations is constituted by Amphigenous cryptogams, comprehending algæ and mushrooms; by Acrogenous cryptogams, including a muscite, ferns, lycopodiaceæ, and equisitaceæ; by Monocotyledons, naiades, gramineæ, cyperaceæ, and liliaceæ; by Gymnospermous dicotyledons, coniferæ, represented by cupriessineæ, abietineæ, and taxineæ; finally, by Angiospermous dicotyledons, comprehending myriceæ, betulaceæ, cupuliferæ, ulmaceæ, balsamifluæ, salicineæ, laurineæ, thymaleæ, santalaceæ, corneæ, myrtaceæ, calycantheæ, pomaceæ, rosaceæ, amygdaleæ, leguminosæ, anacardeæ, juglandeæ, rhamneæ, celastrineæ, sapindaceæ, acerineæ, tiliaceæ, magnoliaceæ, cappardeæ, sapoteæ, styraceæ, oleaceæ, ebenaceæ, ilicineæ, and ericaceæ.

"The Pliocene epoch, considered in relation to Europe, for I have intentionally excluded from the preceding list some fossils of the Antilles referred to these formations, offers as peculiar characters an extreme analogy to the existing Flora of the temperate regions of the northern hemisphere; I do not say of Europe, for this Pliocene flora comprehends many genera strangers in the present time to Europe, but proper to the vegetation of America or temperate Asia. Such are, if we admit the accuracy of the generic relations established by the botanists to whom these determinations are owing, taxodium, salisburia, comptonia, liquidambar, nyssa, robinia, gleditschia, bauhinia, cassia, acacia, rhus, juglans, ceanothus, celastrus, sapindus, liriodendron, capparis, sideroxylon, achras, and symplocos, all genera foreign to temperate Europe, but in which they have been found in a fossil state, but which, for the most part, still occur in the temperate regions of other parts of the globe.

"As to other genera still existing in Europe, but which contain only a small number of species, we find many more of them in a fossil state; such are the *Erables*, of which 14 species are enumerated in this Flora of the Pliocene epoch, and the Oaks, which are 13 in number. It ought to be remarked, that these species come from two or three very circumscribed localities which, in the present time, probably would not furnish, in a circuit of many leagues, more than three or four species of these genera. Lastly, another character, which I have already spoken of, and which makes this Flora to differ still further from that of our epoch, is the absence, or at least the small number and nature of the plants with Gamopetalous corollas.

"Thus, there are only twenty plants of this Flora arranged in the families of this division, and all are referrible to this group of Hypogynous gamopetales, which I have distinguished by the name of Isogynes; in the general organization of the flowers, they approach nearest to the dialypetales.

"Is this absence of Anisogynous gamopetales, and with irregular ovaries, the result of chance; or does it arise from this, that many of these plants, particularly among the species of temperate regions, are herbaceous, and that herbaceous plants are generally in conditions less favourable for passing into a fossil state? Or, lastly, did those families, which some botanists have been led to consider the most elevated in organization, not yet exist? These are points which cannot be positively determined in the present state of our knowledge.

"We may however remark, that at the Miocene epoch, these plants were still less numerous, but belonging to other families; and that at the Eocene period, no one is mentioned by the authors who have shewn the connection between the fossil and living plants, without having any preconceived idea on the subject.

"Another fact to be noticed, but which likewise probably depends on the herbaceous nature of these vegetables, and their leaves not being shed, is the almost complete absence of Monocotyledons, ferns, and mosses, which establishes, in regard to these families, a very great difference between the Pliocene flora and that of modern Europe.

"A difference not less important distinguishes this Flora from that of the most ancient epochs; namely, the absence, in all these formations, of the family of Ferns, which, on the contrary, furnishes so prominent a feature in the Miocene epoch. No trace of them occur in Europe in the Pliocene formations I have enumerated; while the woods of this family are very abundant in the formations of the West Indies, which is considered as an epoch at least as recent as the Pliocene formation, which appears to indicate that at this period the zones of vegetation were distributed nearly as at present.

"Indeed, in these modern formations of the Antilles, we find among the fossil woods, the only portions of their vegetables that have hitherto been collected, specimens which indicate the existence, not only of numerous and varied palms, but of many other families of the equatorial zone, such as Lianes, nearly related to Bauhinia and Menispermeæ, Pisonia, &c. The vegetation of the Antilles had therefore at this period the characters of the equatorial zone, as in Europe it had then the characters of the temperate zone.

"Lastly, and to terminate our observations on this Flora of the latter geological epoch which preceded the present one, we would remark that, notwithstanding the general analogies which exist between the vegetables of these formations and those now living in the temperate regions, no species appears to be identical, at least with the plants that still grow in Europe; and if, in some rare cases, complete identity appears to exist, it is between these vegetables and American species. Thus the Flora of Europe, even at the most recent geological epoch, was very different from the European Flora of the present day."—*L'Institut.*

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*Glacial Theory of the Erratics and Drift of the New and Old Worlds.** By Professor L. AGASSIZ.

Glacialists and Antiglacialists.—Erratic basins of Switzerland.—Similar phenomena observed in other parts of Europe.—Points necessary to be settled; first, the relation in time and character between the Northern and the Alpine erratics.—Traced in North America.—Not yet settled whether any local centres of distribution in America; but the general cause must have acted in all parts simultaneously.—This action ceased at 35° north latitude; this incompatible with the notion of currents.—In both hemispheres a direct reference to the Polar Regions.—Difficulty

* *Vide* Lake Superior, its physical character, vegetation, and animals. By Professor Louis Agassiz. 1850.

as to so extensive formation of Ice, removed; difficulties on the theory of Currents, the effects contrary to experience of Water-Action.—Erratic phenomena of Lake Superior.—The Iceberg theory.—Description of appearances at Lake Superior.—Drift; contains mud, and is without fossils.—Example of juxta-position of stratified and unstratified Drift, at Cambridge.—Date of these phenomena not fully determined, but doubtless simultaneous all over the Globe.—The various periods and kinds of Drift distinguished—Accompanied by change of level in the Continent.

So much has been said and written within the last fifteen years upon the dispersion of erratic boulders and drift, both in Europe and America, that I should not venture to introduce this subject again, if I were not conscious of having essential additions to present to those interested in the investigation of these subjects.

It will be remarked by all who have followed the discussions respecting the transportation of loose materials over great distances from the spot where they occurred primitively, that the most minute and the most careful investigations have been made by those geologists who have attempted to establish a new theory of their transportation by the agency of ice.

The part of those who claim currents as the cause of this transportation has been more generally negative, inasmuch as, satisfied with their views, they have generally been contented simply to deny the new theory and its consequences, rather than investigate anew the field upon which they had founded their opinions. Without being taxed with partiality, I may, at the outset, insist upon this difference in the part taken by the two contending parties. For, since the publication of Sefstroem's paper upon the drift of Sweden, in which very valuable information is given respecting the phenomena observed in that peninsula, and the additional data furnished by De Verneuil and Murchison upon the same country and the plains of Russia, the classical ground for erratic phenomena has been left almost untouched by all except the advocates of the glacial theory. I need only refer to the investigations of M. de Charpentier, Escher, Von Derlinth and Studer, and more particularly to those extensive and most minute researches of Professor Guyot in Switzerland, without speaking of my own and some contributions from visitors, —as the Martins, James Forbes, and others, to justify my assertion, that no important fact, respecting the loose materials spread all over Switzerland, has been added by the advocates of currents since the days of Sanssure, De Luc, Escher and Von Buch; whilst Professor Guyot has most conclusively shewn that the different erratic basins in Switzerland are not only distinct from each other, as was already known before, but that in each the loose materials are arranged in well-determined regular order, shewing precise relations to the centres of distribution, from which these materials originated; an arrangement which agrees in every particular with the arrangement of loose fragments upon the surface of any glacier, but which no cause acting convulsively could have produced.*

The results of these investigations are plainly that the boulders found at a distance from the Central Alps, originated from their higher summits and valleys, and were carried down at different successive periods in a regular manner, forming uninterrupted walls and ridges, which can be traced from their starting-point to their extreme peripheric distribution.

I have myself shewn that there are such centres of distribution in Scotland, and England, and Ireland; and these facts have been since traced in detail in various parts of the British islands by Dr Buckland, Sir Charles Lyell, Mr Darwin, Mr M'Laren, and Professor James Forbes, pointing clearly to the main mountain groups as to so many distinct centres of dispersion of these loose materials.

Similar phenomena have been shewn in the Pyrenees, in the Black Forest, and in the Vosges, shewing beyond question, that whatever might have been the cause of the dispersion of

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* A comparison of the maps, shewing the arrangement of the moraines upon the glacier of the Aar, in my *Système Glaciaire*, with the maps which Professor Guyot is about to publish of the distribution of the erratic boulders in Switzerland, will shew more fully the identity of the two phenomena.

erratic boulders, there are several separate centres of their distribution to be distinguished in Europe. But there is another question connected with this local distribution of boulders which requires particular investigation, the confusion of which with the former has no doubt greatly contributed to retard our real progress in understanding the general question of the distribution of erratics.

It is well known that Northern Europe is strewed with boulders, extending over European Russia, Poland, Northern Germany, Holland, and Belgium. The origin of these boulders is far north in Norway, Sweden, Lapland, and Liefland; but they are now diffused over the extensive plains west of the Ural Mountains. Their arrangement, however, is such that they cannot be referred to one single point of origin, but only in a general way to the northern tracts of land which rise above the level of the sea in the arctic regions. Whether these boulders were transported by the same agency as those arising from distinct centres, on the main Continent of Europe, has been the chief point of discussion. For my own part, I have indeed no doubt that the extreme consequences to which we are naturally carried by admitting that ice was also the agent in transporting the northern erratics to their present positions, has been the chief objection to the view, that the Alpine boulders have been distributed by glaciers.

It seemed easier to account for the distribution of the northern erratics by currents; and this view appearing satisfactory to those who supported it, they at once went further, and opposed the glacial theory even in those districts where the glaciers seemed to give a more natural and more satisfactory explanation of the phenomena. To embrace the whole question it should be ascertained

First, Whether the northern erratics were transported at the same time as the local alpine boulders, and if not, which of the phenomena preceded the other; and again, if the same cause acted in both cases, or if one of the causes can be applied to one series of these phenomena, and the other cause to the other series. An investigation of the erratic phenomena in North America seems to me likely to settle this question, as the northern erratics occur here in an undisturbed continuation over tracts of land far more extensive than those in which they have been observed in Europe. For my own part, I have already traced them from the eastern shores of Nova Scotia, through New England and the north-western States of North America and the Canadas as far as the western extremity of Lake Superior, a region embracing about thirty degrees of longitude. Here, as in Northern Europe, the boulders evidently originated farther north than their present location, and have been moved universally in a main direction from south to north.

From data which are, however, rather incomplete, it can be further admitted that similar phenomena occur further west across the whole continent, everywhere presenting the same relations. That is to say, everywhere pointing to the north as to the region of the boulders, which generally disappear about latitude 38°.

Without entering at present into a full discussion of any theoretical views of the subject, it is plain that any theory, to be satisfactory, should embrace both the extensive northern phenomena in Europe and North America, and settle the relation of these phenomena to the well-authenticated local phenomena of Central Europe.

Whether America itself has its special local circumscribed centres of distribution or not, remains to be seen. It seems, however, from a few facts observed in the White Mountains, that this chain, as well as the mountains of north-eastern New York, have not been exclusively,—and for the whole duration of the transportation of these materials,—under the influence of the cause which has distributed the erratics through such wide space over the continent of North America. But, whether this be the case or not (and I trust local investigations will soon settle the question), I maintain that the cause which has transported these boulders in the American continent, must have acted simultaneously over the whole ground which these boulders cover, as they present throughout the continent an uninterrupted sheet of loose materials, of the same general nature, connected in the same general manner, and evidently dispersed at the same time.

Moreover, there is no ground, at present, to doubt the simultaneous dispersion of the erratics over Northern Europe and Northern America. So that the cause which transported them, whatever it may be, must have acted simultaneously over the whole tract of land west of the Ural Mountains, and east of the Rocky Mountains, without assuming anything respecting Northern Asia, which has not yet been studied in this respect; that is to say, at the same time, over a space embracing two hundred degrees of longitude.

Again, the action of this cause must have been such, and I insist strongly upon this point, as a fundamental one, the momentum with which it acted must have been such, that after being set in motion in the north, with a power sufficient to carry the large boulders which are found everywhere over this vast extent of land, it vanished, or was stopped, after reaching *the thirty-fifth degree of northern latitude.*

Now it is my deliberate opinion that natural philosophy and mathematics may settle the question, whether a body of water of sufficient extent to produce such phenomena can be set in motion with sufficient velocity to move all these boulders; and nevertheless stop before having swept over the whole surface of the globe. Hydrographers are familiar with the action of currents, with their speed, and with the power with which they can act. They know also how they are distributed over the globe. And, if we institute a comparison, it will be seen that there is nowhere a current running from the poles towards the lower latitudes, either in the northern or southern hemisphere, covering a space equal to one-tenth of the currents which should have existed to carry the erratics into their present position. The widest current is west of the Pacific, which runs parallel to the equator, across the whole extent of that sea from east to west, and the greatest width of which is scarcely fifty degrees. This current, as a matter of course, establishes a regular rotation between the waters flowing from the polar regions towards lower latitudes.

The Gulf Stream, on the contrary, runs from west to east, and dies out towards Europe and Africa, and is compensated by the currents from Baffin's Bay and Spitzbergen emptying into the Atlantic, while the current of the Pacific, moving towards Asia, and carrying floods of water in that direction, is maintained chiefly by antarctic currents, and those which follow the western shore of America from Behring's Straits. Wherever they are limited by continents, we see that the waters of these currents, even when they extend over hundreds of degrees of latitude, as the Gulf Stream does in its whole course, are deflected where they cannot follow a straight course.

Now, without appealing with more detail to the mechanical conditions involved in this inquiry, I ask every unprejudiced mind acquainted with the distribution of the northern boulders, whether there was any geographical limitation to the supposed northern current to cause it to leave the northern erratics of Europe in such regular order, with a constant bearing from north to south, and to form, on its southern termination, a wide, regular zone from Asia to the western shores of Europe, north of the fiftieth degree of latitude, before it had reached the great barrier of the Alps? I ask, whether there was such a barrier in the unlimited plains which stretch from the Arctic seas uninterrupted over the whole northern continent of America as far down as the Gulf of Mexico?

I ask, again, why the erratics are circumscribed within the northern limits of the temperate zone, if their transportation is owing to the action of water currents? Does not, on the contrary, this most surprising limit within the arctic and northern temperate zones, and, in the same manner, within the antarctic and southern temperate zones, distinctly shew that the cause of transportation is connected with the temperature or climate of the countries over which the phenomena were produced? If it were otherwise, why are there no systems of erratics with an east and west bearing, or in the main direction of the most extensive currents flowing at present over the surface of our globe?

It is a matter of fact, of undeniable fact, for which the theory has to account, that, in the two hemispheres, the erratics have direct reference to the polar regions, and are circumscribed within the arctics and the colder part of the temperate zones. This fact is as plain as the other fact, that the local distribution of boulders has reference to high mountain ranges, to groups of land raised above the level of the sea into heights, the temperature of which is lower than the surrounding plains. And what is still more astonishing, the extent of the local boulders, from their centre of distribution, reaches levels, the mean annual temperature of which corresponds, in a surprising manner, with the mean annual temperature of the southern limit of the northern erratics.

We have, therefore, in this agreement, a strong evidence in favour of the view that both the phenomena of local mountain erratics in Europe, and of northern erratics in Europe and America, have probably been produced by the same cause.

The chief difficulty is in conceiving the possibility of the formation of a sheet of ice sufficiently large to carry the northern erratics into their present limits of distribution; but this difficulty is greatly removed when we can trace, as in the Alps, the progress of the boulders under the same aspect from the glaciers now existing, down into regions where they no longer exist, but where the boulders and other phenomena attending their transportation shew distinctly that they once existed.

Without extending further this argumentation, I would call the attention of the unprejudiced observer to the fact, that those who advocate currents as the cause of the transportation of erratics, have, up to this day, failed to shew, in a single instance, that currents can produce all the different phenomena connected with the transportation of the boulders which are observed everywhere in the Alps, and which are still daily produced there by the small glaciers yet in existence. Never do we find that water leaves the boulders which it carries along in regular walls of mixed materials; nor do currents anywhere produce upon the hard rocks *in situ* the peculiar grooves and scratches which we see everywhere under the glacier and within the limits of their ordinary oscillations.

Water may polish the rocks, but it nowhere leaves straight scratches upon their surface; it may furrow them, but these furrows are sinuous, acting more powerfully upon the soft parts of the rocks or fissures already existing; whilst glaciers smooth and level uniformly the hardest parts equally with the softest, and, like a hard file, rub to uniform continuous surfaces the rocks upon which they move.

But now let us return to our special subject, the erratics of North America.

The phenomena of drift are more complicated about Lake Superior than I have seen them anywhere else; for, besides the general phenomena which occur everywhere, there are some peculiarities noticed which are to be ascribed to the lake as such, and which we do not find in places where no large sheet of water has been brought into contact with the erratic phenomena. In the first place, we notice about Lake Superior an extensive tract of polished, grooved and scratched rocks, which present here the same uniform character which they have everywhere. As there is so little disposition, among so many otherwise intelligent geologists, to perceive the facts as they are, whenever they bear upon the question of drift, I cannot but repeat, what I have already mentioned more than once, but what I have observed again here over a tract of some fifteen hundred miles, that the rocks are everywhere smoothed, rounded, grooved and furrowed in a uniform direction. The heterogeneous materials of which the rocks consist are cut to one continuous uniform level, shewing plainly that no difference in the polish and abrasion can be attributed to the greater or less resistance on the part of the rocks, but that a continuous rush cut down everything, adapting itself, however, to the general undulations of the country, but nevertheless shewing, in this close adaptation, a most remarkable continuity in its action.

That the power which produced these phenomena moved in the main from north to south, is distinctly shewn by the form of the hills, which present abrupt slopes, rough and sharp corners towards the south, while they are all smoothed off towards the north.

Indeed, here, as in Norway and Sweden, there is on all the hills a lee-side and a strike-side. As has been observed in Norway and Sweden, the polishing is very perfect in many places, sometimes strictly as brilliant as a polished metallic surface, and everywhere these surfaces are more or less scratched and furrowed, and both scratches and furrows are rectilinear, crossing each other under various angles; however, never varying many points of the compass on the same spot, but in general shewing that where there are deviations from the most prominent direction, they are influenced by the undulations of the soil. It has been said, that the main direction of these striæ was from north-west to south-east, but I have found it as often strictly from north to south, or even from north-east to south-west; and if we are to express a general result, we should say that the direction, assigned by all our observations to the various scratches, tends to shew that they have been formed under the influence of a movement from north to south, varying more or less to the east and west, according to local influences in the undulations of the soil. It is, indeed, a very important fact, that scratches which seem to have been produced at no great intervals from each other, are not absolutely parallel, but may diverge for ten, fifteen, or more degrees. There is one feature in these phenomena, however, in which we never observe any variation. The continuity of these lines is absolutely the same everywhere. They are rectilinear and continuous, and cannot be better compared than with the effects of stones or other hard materials dragged in the same direction upon flat or rolling surfaces; they form simple scratches extending for yards in straight lines, or breaking off for a short space to continue again in a straight line in the same direction, just as if interrupted by a jerk. There are also deeper scratches of the same kind, presenting the same phenomena, only, perhaps, traceable for a greater distance than the finer ones. These scratches, instead of appearing like the tracing of diamonds upon glass, as the former do, would rather assume the appearance of a deeper groove, made by the point of a graver, or perhaps still more closely resemble the scratches which a cart-wheel would produce upon polished marble, if the wheel were chained, and coarse sand spread over the floor. The appearance of the rock, crushed by the moving mass, is especially distinct in limestone rocks, where grooves are seldom nicely cut, but present the appearance of a violent pressure combined with the grooving power, thus giving to the groove a character which is quite peculiar, and which at once strikes an observer who has been familiar with its characteristic aspect. Now, I do not know upon what the assertions of some geologists rest, that gravel, moved by water under strong heavy currents, will produce similar effects. Wherever I have gone since studying these phenomena, I have looked for such cases, and have never yet found modern gravel currents produce any thing more than a smooth surface, with undulating furrows following the cracks in the rocks, or following their softer parts; but continuous straight lines, especially such crushed lines and straight furrows, I have never seen.

When we know how extensive the action of water carrying mud and gravel is on every shore and in every water-current,—when we can trace this action almost everywhere, and nowhere find it similar to the phenomena just described, I cannot imagine upon what ground these phenomena are still attributed to the agency of currents. This is the less rational as we have at present, in all high mountain chains of the temperate zone, other agents, the glaciers, producing these very same phenomena, with precisely the same characters, to which therefore a sound philosophy should ascribe, at least conditionally, the northern and alpine polished surfaces, and scratched and grooved rocks, or at least acknowledge that the effect produced by the action of glaciers more nearly resembles these erratic phenomena than does that which results from the action of currents. But such is the prejudice of many geologists, that those keen faculties of distinction and generalization, that power of superior perception and discrimination, which have led them to make such brilliant discoveries in geology in general, seem to abandon them at once as soon as they look at the erratics. The objection made by a venerable geologist, that the cold required to form and preserve such glaciers, for any length of time, would freeze him to death, is as childish as the apprehension that the heavy ocean-currents, the action of which he sees everywhere, might have swept him away.*

Now that these phenomena have been observed extensively, we may derive also some instruction from the limits of their geographical extent. Let us see, therefore, where these polished, scratched, and furrowed rocks have been observed.

In the first place they occur everywhere in the north within certain limits of the arctics, and through the colder parts of the temperate zone. They occur also in the southern hemisphere, within parallel limits, but in the plains of the tropics, and even in the warmer parts of the temperate zone we find no trace of these phenomena, and nevertheless the action of currents could not be less there, and could not at any time have been less there than in the colder climates. It is true, similar phenomena occur in Central Europe, and have been noticed in Central Asia, and even in the Andes of South America, but these always in higher regions, at definite levels above the surface of the sea, everywhere indicating a connection between their extent and the colder temperature of the places over which they are traced.

More recently, a step towards the views I entertain of this subject has been made by those geologists who would ascribe them to the agency of icebergs. Here, as in my glacial theory, ice is made the agent; floating ice is supposed to have ground and polished the surfaces of rocks, while I consider them to have been acted upon by terrestrial glaciers. To settle this difference we have a test which is as irresistible as the other arguments already introduced.

Let us investigate the mode of action, the mode of transportation of icebergs, and let us examine whether this cause is adequate to produce phenomena for which it is made to account. As mentioned above, the polished surfaces are continuous over hills, and in depressions of the soil, and the scratches which run over such undulating surfaces are nevertheless continuous in straight lines. If we imagine icebergs moving upon shoals, no doubt they would scratch and polish

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* Berlin Academy, 1846.

the rocks in a way similar to moving glaciers. But upon such grounds they would sooner or later be stranded; and if they remained loose enough to move, they would, in their gyratory movements, produce curved lines, and mark the spots where they had been stranded with particular indications of their prolonged action. But nowhere upon arctic ground do we find such indications. Everywhere the polished and scratched surfaces are continuous in straight juxta-position.

Phenomena analogous to those produced by icebergs would only be seen along the sea-shores; and if the theory of drifted icebergs were correct, we should have, all over those continents where erratic phenomena occur, indications of retreating shores as far as the erratic phenomena are found. But there is no such thing to be observed over the whole extent of the North American continent, nor over Northern Europe and Asia, as far as the northern erratics extend. From the arctics to the southernmost limit of the erratic distribution, we find nowhere the indications of the action of the sea as directly connected with the production of the erratic phenomena. And wherever the marine deposits rest upon the polished surfaces of ground and scratched rocks, they can be shewn to be deposits formed since the grooving and polishing of the rocks, in consequence of the subsidence of those tracts of land upon which such deposits occur.

Again, if we take for a moment into consideration the immense extent of land covered by erratic phenomena, and view them as produced by drifted icebergs, we must acknowledge that the icebergs of the *present period* at least, are insufficient to account for them, as they are limited to a narrower zone. And to bring icebergs in any way within the extent which would answer for the extent of the distribution of erratics, we must assume that the northern ice-fields, from which these icebergs could be detached and float southwards, were much larger at the time they produced such extensive phenomena than they are now. That is to say, we must assume an ice period; and if we look into the circumstances, we shall find that this ice period, to answer to the phenomena, should be nothing less than an extensive cap of ice upon both poles.

This is the very theory which I advocate; and unless the advocates of an iceberg-theory go to that length in their premises, I venture to say, without fear of contradiction, that they will find the source of their icebergs fall short of the requisite conditions which they must assume, upon due consideration, to account for the whole phenomena as they have really been observed.

But without discussing any farther the theoretical views of the question, let me describe more minutely the facts, as observed on the northern shores of Lake Superior. The polished surfaces, as such, are even, undulating, and terminate always above the rough lee-side turned to the south, unless upon gentle declivities, where the polished surfaces extend in unbroken continuity upon the southern surfaces of the hills, as well as upon their northern slopes. On their eastern and western flanks, shallow valleys running east and west are as uniformly polished as those which run north and south; and this fact is more and more evident, wherever scratches and furrows are also well preserved and distinctly seen, and by their bearings we can ascertain most minutely, the direction of the onward movement which produced the whole phenomena. Nothing is more striking in this respect than the valleys or depressions of the soil running east and west, where we see the scratches crossing such undulations at right angles, descending along the southern gentle slope of a hill, traversing the flat bottom below, and rising again up the next hill south, in unbroken continuity. Examples of the kind can be seen everywhere in those narrow inlets, with shallow waters intersecting the innumerable highlands along the northern shores of Lake Superior, where the scratches and furrows can be traced under water from one shore to the other, and where they at times ascend steep hills, which they cross at right angles along their northern slope, even when the southern slope, not steeper in itself, faces the south with rough escarpments.

The scratches and furrows, though generally running north and south, and deviating slightly to the east and west, present, in various places, remarkable anomalies, even in their general course along the eastern shore of the lake. Between

Michipicotin and Sault St Marie, we more frequently see a deflection to the west than a due north and south course, which is rather normal along the northern shore proper, between Michipicotin and other islands, and from the Pic to Fort-William; the deep depression of the lake being no doubt the cause of such a deviation, as large masses of ice could accumulate in this extensive hollow cavity before spreading again more uniformly beyond its limits. To the oscillations of the whole mass in its southerly movement, according to the inequalities of the surfaces, we must ascribe the crossing of the straight lines at acute angles, as we observe also at the present day under the glaciers, as they swell and subside, and hence meet with higher and lower obstacles in their irregular course between the Alpine valleys.

In deep, narrow chasms, however, we find now and then greater deviations from the normal direction of the striæ, where considerable masses of ice could accumulate, and move between steep walls under a lateral pressure of the masses moving onwards from the north. Such a chasm is seen between Spar Island and the main land opposite Prince's Location, south of Fort-William, where the furrows and scratches run nearly east and west. But here also, there is no tumultuous disturbance in the continuation of the phenomena, such as would occur if icebergs were floated and stranded against the southern barrier. The same continuity of even, polished surfaces, with their scratches and furrows, prevails here as elsewhere. The angles which these scratches form with each other are very acute, generally not exceeding 10°; but at times they diverge more, forming angles of 15°, 20°, and 25°. In a few instances, I have even found localities where they crossed each other at angles of no less than 30°; but these are rare exceptions. It may sometimes be noticed that the lines running in one direction form a system by themselves, varying very little from strict parallelism with each other, but crossing another system, more or less strongly marked, of other lines equally parallel with each other. At other times, a system of lines, strongly marked and diverging very slightly, seem to pass over another system, in which the lines form various angles with each other. Again, there are places,—and this is the most common case, where the lines diverge slightly, following, however, generally one main direction, which is crossed by fewer lines, forming more open angles. These differences, no doubt, indicate various oscillations in the movement of the mass which produced the lines, and shew probably its successive action, with more or less intensity, upon the same point at successive periods, in accordance with the direction of the moving force at each interval. The same variations within precisely the same limits may be noticed in our day on the margin of the glaciers produced by the increase or diminution of the bulk of their mass, and the changes on the rate of their movement.

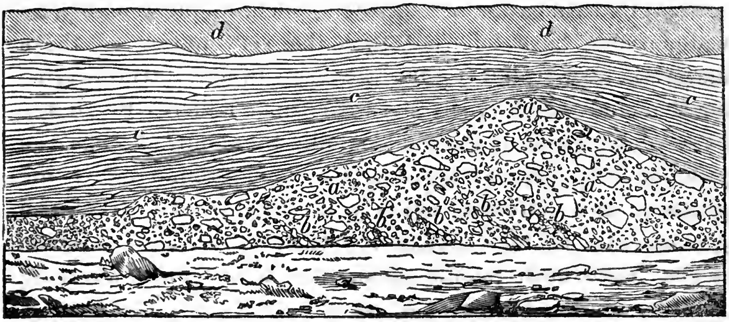
The loose materials which produced, in their onward movement under the pressure of ice, such polishing and grooving, consisted of various-sized boulders, pebbles, and gravels, down to the most minute sand and loamy powder. Accumulations of such materials are found everywhere upon these smooth surfaces, and in their arrangement they present everywhere the most striking contrast when compared with deposits accumulated under the agency of water. Indeed, we nowhere find this glacial drift regularly stratified, being every where irregular accumulations of loose materials, scattered at random without selection, the coarsest and most minute particles being piled irregularly in larger or smaller heaps, the greatest boulders standing sometimes uppermost, or in the centre, or in any position among smaller pebbles and impalpable powder.

And these materials themselves are scratched, polished and furrowed, and the scratches and furrows are rectilinear as upon the rocks *in situ* underneath, not bruised simply, as the loose materials carried onward by currents or driven against the shores by the tides, but regularly scratched, as fragments of hard materials would be if they had been fastened during their friction against each other, just as we observe them upon the lower surface of glaciers where all the loose materials are set in ice, as stones in their setting are pressed and rubbed against underlying rocks. But the setting here being simply ice, these loose materials, fast at one time and moveable another, and fixed and loosened again, have rubbed against the rock below in all possible positions; and hence, not only their rounded form, but also their rectilinear grooving. How such grooves could be produced under the action of currents, I leave to the advocates of such a theory to shew, as soon as they shall be prepared for it.

I should not omit here to mention a fact which, in my opinion, has a great theoretical importance, namely, that in the northern erratics, even the largest boulders, as far as I know, are rounded, and scratched and polished; at least, all those which are found beyond the immediate vicinity of the higher mountain ranges, shewing that the accumulations of ice which moved the northern erratics covered the whole country; and this view is sustained by another set of facts equally important, namely, that the highest ridges, the highest rugged mountains, at least, in this continent and north of the Alps in Europe, are as completely polished and smoothed as the lower lands, and only a very few peaks seem to have risen above the sheet of ice; whilst, in the Alps, the summits of the mountains stand generally above these accumulations of ice, and have supplied the surface of the glaciers with large numbers of angular boulders, which have been carried upon the back of glaciers to the lower valleys and adjacent plains without losing their angular forms.

With respect to the irregular accumulation of drift-materials in the north, I may add, that there is not only no indication of stratification among them, such, unquestionably, as water would have left, but that the very nature of these materials shews plainly that they are of terrestrial origin; for the mud which sticks between them adheres to all the little roughnesses of the pebbles, fills them out, and has the peculiar adhesive character of the mud ground under the glaciers, and differing entirely in that respect from the gravels, and pebbles, and sands washed by water-currents, which leave each pebble clean, and never form adhering masses, unless penetrated by an infiltration of limestone.

Another important fact respecting this glacial draft consists in the universal absence of marine, as well as freshwater fossils in its interior—a fact which strengthens the view that they have been accumulated by the agency of strictly terrestrial glaciers; such is, at least, the case everywhere far from the sea-shore. But we may conclude that these ancient glaciers reached, upon various points, the sea-shore at the time of their greatest extension, just as they do at present in Spitzbergen and other arctic shores; and that therefore, in such proximity, phenomena of contact should be observed, indicating the onward movement of glacial material into the ocean, such as the accumulation within these materials of marine fossil remains, and also the influence of the tidal movements upon them. And now such is really the case. Nearer the sea-shores we observe distinctly, in some accumulations of the drift, faint indications of the action of the tide, reaching the lower surface of glaciers, and the remodelling to some extent of the materials which these poured into the sea. A beautiful example of the kind may be observed near Cambridge, along Charles River, not far from Mount Auburn, where the unstratified glacial drift (*a*) presents in its upper masses strictly the characters of true terrestrial glacial accumulation, but shews underneath faint indications (*b*) of the action of tides. Above, regular tidal strata (*c*) are observed, formed probably after the masses below had subsided. The surface of this accumulation is covered with soil (*d*).



The period at which these phenomena took place cannot be fully determined, nor is it easy to ascertain whether all glacial drift is contemporaneous. It would seem, however, as if the extensive accumulation of drift all around the northern pole in Europe, Asia, and America was of the same age as the erratic of the Alps. The climatic circumstances capable of accumulating such large masses of ice around the north pole, having no doubt extended their influence over the temperate zone, and probably produced, in high mountain chains, as the Alps, the Pyrenees, the Black Forest, and the Vosges, such accumulations of snow and ice as may have produced the erratic phenomena of those districts. But extensive changes must have taken place in the appearance of the continents over which we trace erratic phenomena, since we observe in the Old World, as well as in North America, extensive stratified deposits containing fossils which rest upon the erratics; and as we have all possible good reasons and satisfactory evidence for admitting that the erratics were transported by the agency of terrestrial glaciers, and that, therefore, the tracts of land over which they occur stood at that time above the level of the sea, we are led to the conclusion that these continents have subsided since that period below the level of the sea, and that over their inundated portions, animal life has spread, remains of organized beings have been accumulated, which are now found in a fossil state in the deposits formed under those sheets of water.

Such deposits occur at various levels in different parts of North America. They have been noticed about Montreal, on the shores of Lake Champlain, in Maine, and also in Sweden and Russia; and what is most important, they are not everywhere at the same absolute level above the surface of the ocean, shewing that both the subsidence and the subsequent upheaval which has again brought them above the level of the sea, have been unequal; and that we should therefore be very cautious in our inferences respecting both the continental circumstances under which the ancient glaciers were formed, and also the extent of the sea afterward, as compared with its present limits.

The contrast between the unstratified drift and the subsequently stratified deposits is so great, that they rest everywhere unconformably upon each other, shewing distinctly the difference of the agency under which they were accumulated. This unconformable superposition of marine drift upon glacial drift is so beautifully shewn at the above-mentioned locality near Cambridge (see diagram, p. 114.) In this case the action of tides in the accumulation of the stratified materials is plainly seen.

The various heights at which these stratified deposits occur, above the level of the sea, shew plainly, that since their accumulation the main land has been lifted above the ocean at different rates in different parts of the country; and it would be a most important investigation to have their absolute level, in order more fully to ascertain the last changes which our continents have undergone.

From the above mentioned facts, it must be at once obvious that the various kinds of loose materials all over the northern hemisphere, have been accumulated, not only under different circumstances, but during long-continued subsequent distinct periods, and that great changes have taken place since their deposition, before the present state of things was fully established.

To the first period,—the ice period, as I have called it,—belong all the phenomena connected with the transportation of erratic boulders, the polishing, scratching, and furrowing of the rocks, and the accumulation of unstratified, scratched, and loamy drift. During that period the mainland seems to have been, to some extent at least, higher above the level of the sea than now; as we observe, on the shores of Great Britain, Norway, and Sweden, as well as on the eastern shores of North America, the polished surfaces dipping under the level of the ocean, which encroaches everywhere upon the erratics proper, effaces the polished surfaces, and remodels the glacial drift. During these periods, large terrestrial animals lived upon both continents, the fossil remains of which are found in the drift of Siberia, as well as of this continent. A fossil elephant, recently discovered in Vermont, adds to the resemblance, already pointed out, between the northern drift of Europe and that of North America; for fossils of that genus are now known to occur upon the northernmost point of the western extremity of North America, in New England, in Northern Europe, as well as all over Siberia.

To the second period we would refer the stratified deposits resting upon drift, which indicate, that during their deposition the northern continent had again extensively subsided under the surface of the ocean.

During this period, animals, identical with those which occur in the northern seas, spread widely over parts of the globe which are now again above the level of the ocean. But, as this last elevation seems to have been gradual, and is even still going on in our day, there is no possibility of tracing more precisely, at least for the present, the limit between that epoch and the present state of things. Their continuity seems almost demonstrated by the identity of fossil-shells found in these stratified deposits, with those now living along the present shores of the same continent, and by the fact, that changes in the relative level between sea and mainland are still going on in our day.

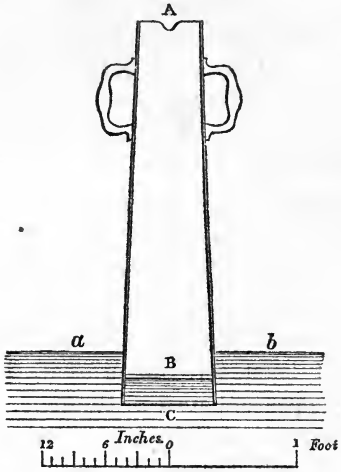
Indications of such relative changes between the level of the waters and the land are also observed about Lake Superior. And here they assume a very peculiar character, as the level of the lake itself, in its relation to its shores, is extensively changed.*

Description of the Marine Telescope. By John Adie, F.R.S.E., F.R.S.S.A. Communicated by the Author.

The instrument which has been popularly named the Water, or Marine Telescope, from the power given by its use to see into the water, consists of a tube of metal or wood, of a convenient length, to enable a person looking over the gunnel of a boat to rest the head on the one end, while the other is below the surface of the water; the upper end is so formed, that the head may rest on it, both eyes seeing freely into the tube. Into the lower end is fixed (water-tight) a

* An interesting account of the natural terraces around Lake Superior is given at p. 413–416 of "Lake Superior."

plate of glass, which, when used, is to be kept under the surface of the water.



A very convenient size for the instrument represented in the above figure, is to make the length AC, 3 feet, and the mouth A, where the face is applied, of an irregular oval form, that both eyes may see freely into the tube, with an indentation on one side, that the nose may breathe freely, not throwing the moisture of the breath into the tube. B is a round plate of glass, 8 inches diameter, over which is the rim or edge C; this rim is best formed of lead, $\frac{1}{4}$ of an inch thick, and 3 inches deep; the weight of the lead serves to sink the tube a little into the water. Holes must be provided at the junction of B to C, for the purpose of allowing the air to escape, and bring the water into contact with the glass; on each side there is a handle for holding the instrument. This size and form is very much that of the instrument brought from Norway by John Mitchell, Esq., Belgian Consul, of Mayville, with the improvement for excluding the breath, and allowing the water to get into contact with the glass, which was not provided for in that instrument.

The reason why we so seldom see the bottom of the sea, or of a pure lake, where the depth is not beyond the powers of natural vision, is not that the rays of light reflected from the objects at the bottom are so feeble as to be imperceptible to our sense, from their passage through the denser medium of the water, but from the irregular refractions given to the rays in passing out of the water into the air, caused by the constant ripple or motion of the surface of the water, where that refraction takes place. Reflections of light from the surface also add to the difficulty; and before we can with any just hope expect to see the objects distinctly at the bottom, these obstructions must be removed.

This is done to a very great extent by the use of the instrument which forms the subject of this notice; the tube serves to screen the eyes from reflections, and the water being in contact with the glass plate, all ripple is got rid of, so that the spectator, looking down the tube, sees all objects at the bottom, whose reflective powers are able to send off rays of sufficient intensity to be impressed on the retina, after suffering the loss of light caused by the absorbing power of the water, which obeys certain fixed laws, proportionate to the depth of water passed through; for as light passing through pure sea-water loses half its intensity for each 15 feet through which it passes,* we must, from this cause alone, at a certain depth lose sight of objects of the brightest lustre. The perfect purity of the water, and its freedom from all muddy particles floating in it, form an important element in the effective use of the water-telescope; for example, in the Frith of Forth, and similar estuaries, where the influx and reflux of the tide keep particles of mud in constant motion, the instrument is of little or no use; for these act in exactly the same way in limiting our vision through water, as a fog does through the air: it is therefore only in the pure waters of our northern and western shores that this contrivance is applied with any advantage; and in such situations we can speak of its powers with confidence. In a trial made with the instrument last autumn on the west coast of Scotland, the bottom was distinctly seen (a white bottom) at a depth of 12 fathoms; and on a black, rocky bottom, at 5 fathoms under water, objects were so distinctly seen that the parts of a wreck were taken up—the

* Leslie's Elements of Nat. Phil., p. 19.

exact place of which was not known previous to its use. In these experiments a lenticular form of glass was made use of at the bottom of the tube, having a plane surface to the water, but no great or marked advantage was observable from this construction. With respect to the history of this contrivance for viewing the bottom of the sea, we are unable to assign any particular date : so far as our information goes, it has been in use from a very remote period. We are informed that it is in general use in seal-shooting along our northern and western islands, where, sometimes in the form of an ordinary washing-tub, with a piece of glass fixed in its bottom, the shot-seal was looked for, and the grappling-hook let down to bring him to the surface. It may not be generally known, that in seal-shooting, the shot or wounded seal always seeks the bottom, from which he never rises after death, till washed ashore by the action of the sea: it is only when the fatal ball deprives him of the power of diving that he is ever found at the surface. In such employments, therefore, the use of this instrument, however modified, must form an important auxiliary to the best rifle. Throwing oil over the surface of the water is used in the same pursuits; but this only so far stills the ripple, leaving the reflections. Our eminent engineer, Mr Robert Stevenson, made use of the water-telescope more than 30 years ago, in works connected with harbour improvement in the north of Scotland; it has also been used to examine the sand-banks, &c., at the bottom of the River Tay, but in this case the mud prevented its use in any considerable depth of water. To obviate this difficulty, the construction was modified thus: by making the tube of considerable length, and placing the glass at the lower end, this tube was thrust through the water till within a few feet of the bottom, acting as a cofferdam to set aside the dirty water, and enable the bottom to be seen; but in this method of application it was found very difficult to hold the tube down in the water from its buoyant power, and we are informed by Mr Thomas Stevenson, C.E., that, he understood from this cause its use had been discontinued. He suggested a simple remedy; viz., to fill up the empty tube with pure water. We are indebted to Mr Mitchell, the gentleman already mentioned, for having brought this instrument into notice in the public prints, under the name of Norwegian water-telescope, on the shores of which country it is stated to be much used in fishing—in particular, that of the herring; but the herring-fishers on the east coast of Scotland inform us, that they require no such auxiliary, as, from the surrounding elevated grounds, they can tell the position of the shoal, and, from their motions seen from such situations, they know where they are to be found when they go out a-fishing.*

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* *Norwegian Water-Telescope.*

The water-telescope is thus noticed in a very promising periodical, the American Annual of Scientific Discovery, just published, of which a copy reached us a few days ago.—Ed. *Phil. Journal.*

The water-telescope is an instrument which the people of Norway have found of so great utility, that there is scarcely a single fishing-boat without one of three or four feet in length, which they carry in their boats with them when they go a-fishing. When they reach the fishing-grounds, they immerse one end of this telescope in the water, and look through the glass, which shews objects some ten or fifteen fathoms deep as distinctly as if they were within a foot of the surface. When a shoal of fish comes into their bays, the Norwegians instantly prepare their nets, man their boats, and go out in pursuit. The first process is minutely to survey the ground with their glasses, and where they find the fish swarming about in great numbers, they give the signal, and surround the fish with their large draught-nets, and often catch them in hundreds at a time. Without these telescopes their business would often prove precarious and unprofitable; as the fish, by these glasses, are as distinctly seen in the deep, clear sea of Norway, as gold-fish in a crystal jar. This instrument is not only used by the fishermen, but is also found aboard the navy and coasting-vessels of Norway. When their anchors get into foul ground, or their cables warped on a roadstead, they immediately apply the glass, and, guided by it, take steps to put all to rights, which they could not do so well without the aid of the rude and simple instrument, which the meanest fisherman can make up with his own hands, without the aid of a craftsman. This instrument has been lately adopted by the Scotch fishermen on the Tay, and, by its assistance, they have been enabled to discover stones, holes, and uneven ground, over which their nets travel, and have found the telescope answer to admiration, the minutest object in twelve feet of water being as clearly seen as on the surface. We see no reason why it could not be used with advantage in the rivers and bays of the United States.

Experimental Investigations to Discover the Cause of the Change which takes place in the Standard Points of Thermometers. By JOHN ADIE, F.R.S.E., F.R.S.S.A. Communicated by the Author.

It has long been known to experimentalists that, in thermometers constructed with the greatest care, a change takes place after a lapse of time in the standard points, as given by the melting of ice and boiling of water under a fixed pressure; on this account it has been recommended by most writers, where the employment of thermometers is treated of, that they should from time to time be compared one with another, and also at the freezing point. This change is a rising of the mercury in the tube, so that, after a length of time, the mercury will not sink to the point laid off in the construction of the instrument. To investigate to what cause this change was due, formed the object of my experiments: Was it a change in the glass of which the bulbs are formed, or in the mercury with which they are filled? I was aware that thermometers filled with alcohol were not subject to this change, which would lead to the inference, that the change was in the mercury and not the glass; but then, in the spirit-thermometer, air is left above the column of spirit, whereas, in those constructed with mercury, the air is expelled, and there is a vacuum above the column; consequently, the bulb is pressed together with the force of an atmosphere on all sides; might not this force, acting for a length of time, cause some small alteration in the arrangement of the particles forming the glass of the bulb?

This is the explanation accepted by most of the Italian and French writers on this subject. Some suppose that the mercury may contain air and moisture within its particles; but such a hypothesis I think inadmissible, as in the case of a vacuum over the mercury, these particles would seek the void, and cause rather a depression than a rising of the freezing point. Mr Daniell, in his Essay on Climate, adopts the same view; and Sir John Herschel, in his article "Heat," in the Encyclopædia Metropolitana, says: "The freezing point upon the mercurial thermometer has been supposed to undergo some slight variation, so as to appear too low upon the scales of those instruments which have been long made; and it is said that, in such cases, the just indication was again recovered by breaking off the end of the stem, so as to admit atmospheric air." But, as I had observed that the change went on for a time only, after which it ceased, and that it affected thermometers sealed with air over the mercury, as well as those with a vacuum, I undertook the following experiments:—

In September 1848 I made four thermometers having long degrees,—such that $\frac{1}{10}°$ might be easily noted, constructed of the same draft of glass tube; two of these I placed in boiling water, and kept them at that temperature for a week: my object in this was to learn if any change in the form of the bulb would take place from this slow process of annealing, as glass is known to undergo some change from such exposure.

The four thermometers were now filled with pure mercury: two of these were sealed with a vacuum over the mercury; one tube that had been boiled, and the other not: the other two tubes were sealed with air over their columns, and the freezing points of all were marked on the tubes; after which they were placed in a window freely exposed to light, where they were left till January 1849—a space of four months—when they were again placed in melting ice, and the freezing points marked; they had risen ·24°, ·24°, ·20°, ·06° parts of a degree. The whole four thermometers were now placed in boiling water, and kept there for a week, when the freezing points were again observed to have risen respectively ·48°, ·41°, ·50°, ·45°.

The instruments were now left exposed to light as at first; and, in January 1850, the freezing points were again observed, when they were found to have farther risen ·12°, ·18°, ·20°, ·13°; and, lastly, they were observed in May 1850, when no change from last observation was notable.

The whole amount of rising of the freezing point in these four thermometers, after a lapse of eighteen months, is respectively ·84°, ·83°, ·90°, ·65°; and these changes may be the full amount that would take place were the instruments observed after a greater lapse of time. From my experience, I know that there is a period after which no change takes place; but, from the method in which these experiments have been conducted, I am not at present in a condition to assign a time; moreover, it is evident that this period will be much modified by circumstances. The results above stated form the following Table:—

No.	Description of Thermometer.	Value of one Degree of Fahr.	Observed rise, Jan. 1849.	Rise after having been boiled for a week.	Rise at Jan. 1850.	Total rise.
1.	Sealed in vacuum, not boiled.	0·166	0·24	0·48	0·12	0·84
2.	Sealed in vacuum and boiled.	0·168	0·24	0·41	0·18	0·83
3.	Sealed with air, not boiled.	0·199	0·20	0·50	0·20	0·90
4.	Sealed with air, boiled.	0·154	0·06	0·45	0·13	0·65

From inspection of the Table, no very remarkable difference is observable in the rising of these four instruments. No. 4 appears to have risen less during the first period, but goes along with the others afterwards. The effect of exposure to the temperature of boiling water shews that, under high temperature, the change goes on much faster than at the ordinary temperature of the air; from the Table it will be observed, that about twice the amount of change was caused by the boiling of the thermometers for a week, than had taken place between the first and second observations, a period of four months.

It does not appear that the boiling of the thermometer tubes for eight days, previous to their being filled with mercury, had produced any change on the form of the bulbs; we should at least infer this from the change in their freezing points keeping pace so nearly with those which had not been boiled.

I now come to the concluding experiment with these instruments, and, it appears to me most interesting and anomalous. The four tubes being placed in pounded ice, the columns stood at the points indicated in the last column of the Table; in this situation the tops of the tubes were broken off, so as to admit the free pressure of the air, and instantly the thermometers fell, in the order of their numbers, ·54, ·43, ·40, ·35 of a degree, now indicating on their scales + ·30, + ·40, + ·50, + ·35. The remarkable features shewn by this experiment are; first, that the two thermometers sealed with vacuum, and the two having air over their columns, should have risen nearly equally, when two had their bulbs pressed with the whole force of an atmosphere, while the other two had no pressure externally, farther than that caused from changes in the pressure of the atmosphere. Next, that on being opened, those with air over them should have started down nearly as much as those with a vacuum; and on all these appears a permanent change from three to five-tenths of a degree. I confess that I am very much at a loss to account for these singular changes; atmospheric pressure on the bulbs would account for the change in those sealed with a vacuum; for we can easily suppose that a permanent form had been taken from long exposure to that pressure by the glass forming the bulbs: besides this permanent form, there appears to have been a spring inwards, which instantly sprung out on removal of the pressure by the admission of air over the mercury; but the same reasoning will not apply to the thermometers having air over the mercury; and before I attempt to make any suggestions as to the cause of these changes, I propose to institute the following experiments. Having had three thermometers blown and filled with mercury, I shall make one with a perfect vacuum over the mercury, the next with air over it, and the third with air condensed over it; and, noting the changes that may go on in these, I hope to be able to assign a cause or causes for the change. It is argued by some continental writers on this subject, that the reason why we do not perceive any change in the freezing point in spirit-thermometers is from the great expansion of spirit above mercury, volume for volume, thereby requiring a much smaller mass of fluid to give the same length of a degree: this I propose to test by making a thermometer with the same size of tube and bulb as those to be experimented on with mercury. In mentioning these experiments to Professor Forbes, he kindly put me in possession of some spirit-thermometers, one of these, made in 1837, having a very large bulb—this, with three others, shewed no change in the places of their freezing points.

Observations on the Discovery, by Professor LEPSIUS, *of Sculptured Marks on Rocks in the Nile Valley in Nubia; indicating that, within the historical period, the river had flowed at a higher level than has been known in Modern Times.* By LEONARD HORNER, Esq., F.R.S.S. L. & E., F.G.S., &c. Communicated by the Author. With a Plate.

The recent archaiologcal researches of Professor Lepsius in Egypt, and the Valley of the Nile, in Nubia, have given a deserved celebrity and authority to his name, among all who take an interest in the early history of that remarkable portion of the Old World. While examining the ruins of a fortress, and of two temples of high antiquity at Semne, in Nubia, he discovered marks cut in the solid rocks, and in the foundation-stones of the fortress, indicating that, at a very remote period in the annals of the country, the Nile must have flowed at a level considerably above the highest point which it has ever reached during the greatest inundations in modern times. This remarkable fact would possess much geological interest with respect to any great river, but it does so especially in the case of the Nile. Its annual inundations, and the uniformity in the periods of its rise and fall, have been recorded with considerable accuracy for many centuries; the solid matter held in suspension in its waters, slowly deposited on the land overflowed, has been productive of changes in the configuration of the country, not only in times long antecedent to history, but throughout all history, down to the present day. Of no other river on the earth's surface do we possess such or similar records; and moreover, the Nile, and the changes it has produced on the physical character of Egypt, are intimately associated with the earliest records and traditions of the human race. Everything, therefore, relating to the physical history of the Nile Valley must always be an object of interest; but the discovery of Professor Lepsius is one peculiarly deserving the attention of the geologist; for he does not merely record the facts of the markings of the former high level of the river, but he infers from these marks, that since the reign of Mœris, about 2200 years before our era, the entire bed of the Nile, in Lower Nubia, must have been excavated to a depth of about 27 feet; and he further speculates as to the process by which he believes the excavation to have been effected.

It will be convenient, before entering upon the observations I have to offer upon the cause assigned by Professor Lepsius for the former higher levels of the Nile indicated by these marks, that I should give the description of the discovery itself, by translating Dr Lepsius's own account of it, in letters which he addressed to his friends, Professors Ehrenberg and Böckh of Berlin, from the island of Philæ, in September 1844.*

"You may probably remember, when travelling to Dongola on the Lybian side of the Nile, and in passing through the district of Batn el hagér, that one of the most considerable of the cataracts of the country occurs near Semne, a very old fortress, with a handsome temple, built of sandstone, in a good state of preservation; the track of the caravan passing close to it, partly over the 4000-year-old artificial road. The track on the eastern bank of the river is higher up, being carried through the hills; and you must turn off from it at this point in order to see the cataract. This Nile-pass, the narrowest with which I am acquainted, according to the measurement of Hr. Erbkam, is 380 metres (1247 English feet) broad;† and both in itself, and on account of the monuments existing there, is one of the most interesting localities in the country, and we passed twelve days in its examination.

"The river is here confined between steep rocky cliffs on both sides, whose summits are occupied by two fortresses of the most ancient and most massive construction, distinguishable at once from the numerous other forts, which, in the time of the Nubian power in this land of cliffs, were erected on most of the larger islands, and on the hills commanding the river. The cataract (or rapid) derives its name of Semne from that of the higher of the two fortresses on the western bank; that on the opposite bank, as well as a poor village lying somewhat south of it, is called Kumme. In both fortresses the highest and best position is occupied by a temple, built of huge blocks of sandstone, of two kinds, which must have been brought from a great distance through the rapids; for, southward, no sandstone is found nearer than Gebel Abir, in the neighbourhood of Amara and the island of Sai (between 80 and 90 English miles), and northward, there is none nearer than the great division of the district at Wadi Halfa (30 miles distant.)

"Both temples were built in the time of Tutmosis III., a king of the

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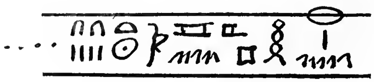
* Bericht über die zur Bekantmachung geeigneten Verhandlungen der Königl. Preuss. Akademie der Wissenshaften zu Berlin. Aus dem Jahre 1844.

† The breadth of the river itself. See Letter to Hr. Böckh, p. 27.

18th dynasty, about 1600 years before Christ; but the fortresses in which they stand are of a more ancient date. The foundations of these are granite blocks of Cyclopian dimensions, resting on the rock, and scarcely inferior to the rock itself in durability. They were erected by the first conqueror of the country, King Sesuatesen III., of the 12th dynasty, in order to command the river, so easily done in so narrow a gorge. The immediate successor of this king was Amenemha III., the Mœris of the Greeks : he who accomplished the gigantic work of forming the artificial lake of Mœris, in the Fayoum, and from whose time—the most flourishing of the whole of the old Egyptian kingdom—the risings of the Nile in successive years, doubtless by means of regular markings, as indeed Diodorus tells, remained so well known, that, according to Herodotus, they were recorded in distinct numbers from the time of Mœris. It appears that this provident king, occupied with great schemes for the welfare of his country, considered it of great importance that the rising of the Nile on the most southern border of his kingdom should be observed, and the results forthwith communicated widely in other parts of the land, to prepare the people for the inundations. The gorge at Semne offered greater advantages for this object than any other point; because the river was there securely confined by precipitous rocky cliffs on each side. With the same view he had doubtless caused Nilometers to be fixed at Assuan and other suitable places; for without a comparison with these, the observations at Semne could be of little use.

" The highest rise of the Nile in each year at Semne, was registered by a mark, indicating the year of the king's reign, cut in the granite, either on one of the blocks forming the foundation of the fortress, or on the cliff, and particularly on the east or right bank, as best adapted for the purpose. Of these markings eighteen still remain, thirteen of them having been made in the reign of Mœris, and five in the time of his two next successors. These last kings discontinued the observations; for, in the meantime, the irruption of the Asiatic pastoral tribes into Lower Egypt took place, and wellnigh brought the whole kingdom to ruin. The record is almost always in the same terms, short and simple: *Ra en Hapi em renpe* . . . mouth or gate of the Nile in the year . . And then follows the year of the reign, and the name of the king. It is written in a horizontal row of hieroglyphics, included within two lines —the upper line indicating the particular height of the water, as is often specially stated—



" The earliest date preserved is that of the sixth year of the king's reign, and he reigned 42 years and some months. The next following dates are, the years 9, 14, 15, 20, 22, 23, 24, 30, 32, 37, 40, 41, and 43; and include, therefore, under this king, a period of 37 years. Of the remaining dates, that only of the 4th year of his two successors is available; all the others, which are on the west or left bank of the river, have been moved from their original place by the rapid floods which have overthrown and carried forward vast masses of rock. One single mark only, that of the 9th year of Amenemha, has been preserved in its original place on one of the building stones, but somewhat below the principal rapid.*

"We have now to consider the relation which these—the most ancient of all existing marks of the risings of the Nile—bear to the levels of the river in our own time. We have here presented to us the remarkable facts, that the highest of the records now legible; viz., that of the 30th year of the reign of Amenemha, according to exact measurements which I made, is 8·17 metres (26 feet 8 inches) higher than the highest level to which the Nile rises in years of the greatest floods; and further, that the lowest mark, which is on the east bank, and indicated the 15th year of the same king, is still 4·14 metres (13 feet 6½ inches); and the single mark on the west bank, indicating the 9th year, is 2·77 metres (9 feet) above the same highest level.

"The mean rise of the river, recorded by the marks on the east bank, during the reign of Mœris, is 19·14 metres (62 feet 6 inches) above the lowest level of the water in the present day, which, according to the statements of the most experienced boatmen, does not change from year to year, and therefore represents the actual level of the Nile, independently of its increase by the falls of rain, in the mountains in which its sources are situated. The mean rise above the lowest level, at the present time, is 11·84 metres (38 feet 8 inches); and, therefore, in the time of Mœris, or about 2200 years before Christ, the mean height of the river, at the cataract or rapid of Semne, during the inundation, was 7·30 metres (23 feet 10 inches) above the mean level in the present day."

Such are the facts recorded by Dr Lepsius; and then follow, in the same letter, his views as to the cause of the remarkable lowering of the level of the river.

"There is certainly no reason for believing," he says, "that there has been any diminution in the general volume of water coming from the south. The great change in the level can, therefore, only be accounted for by some changes in the land, and these must also have altered the whole nature of the Nile Valley. There seems to be but one cause for the very considerable lowering of the Nile; namely, the washing out and excavations of the catacombs (*Auswaschen und Aushölen der Katakomben*); and this is quite possible from the nature of the rocks themselves, which, it is true, are of a quality that could not well be rent asunder, and carried away by the mere force of the water, but might be acted upon directly by the rising of the water-level, and the consequent effects of the sun and air on the places left dry, causing cracks, into which earth and sand would penetrate, which would then give rise to still greater rents, until, at last, the rocks would of themselves fall

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* See Plate I.

in, by having been hollowed out, a process that would be hastened in those parts of the hills where softer and earthy beds existed, and which would be more easily washed away. But that, in historical times, within a period of about 4000 years, so great an alteration should take place in the hardest rocks, is a fact of the most remarkable kind,—one which may afford ground for many other important considerations.

"The elevation of the water-level at Semne must necessarily have affected all the lands above; and, it is to be presumed, that the level of the province of Dongola was at one time higher, as Semne cannot be the only place in the long tract of cliffs where the bed of rock has been hollowed out. It is to be conceived, therefore, that not only the widely-extended tracts in Dongola, but those of all the higher country in Meroë, and as far up as Fasogle, which, in the present day, are dry and barren on both sides of the river, and are with difficulty irrigated by artificial contrivances, must then have presented a very different aspect, when the Nile overflowed them, and yearly deposited its fertile mud to the limits of the sandy desert.

"Lower Nubia also, between Wadi Halfa and Assuan, is now arid almost throughout its whole extent. The present land of the valley, which is only partly irrigated by water-wheels, is, on an average, from 6 to 12 feet higher than the level to which the Nile now rises; and although the rise at Semne might have no immediate influence upon it, yet what has occurred there makes it more than probable, that at Assuan there was formerly a very different level of the river, and that the cataracts there, even in the historical period, have been considerably worn down. The continued impoverishment of Nubia is a proof of this. I have no manner of doubt that the land in this lower part of the valley, which, as already stated, is at present about 10 feet above the highest rise of the Nile, was inundated by it within historical time. Many marks are also met with here, that leave no doubt regarding the condition of the Nile Valley antecedent to history, when the river must have risen much higher; for it has left an alluvial soil in almost all the considerable bays, at an average height of 10 metres (32 feet 9 inches) above the present mean rise of the river. That alluvial soil, since that period, has doubtless been considerably diminished in extent by the action of rain. On the 17th of August Hr. Erbkam and I measured the nearest alluvial hillock in the neighbourhood of Korusko, and found it 6·91 metres (22 feet 7 inches) above the general level of the valley, and 10·26 metres (33 feet 7 inches) above the present mean rise of the river. That rise, which at Semne, on account of the greater confinement of the stream between the rocks, varies as much as 2·40 metres (7 feet 10 inches) in different years, varies at Korusko less than 1 metre (3 feet 3 inches).

"Near Abusimbel, on the west bank, I found the ground of the temple 6·50 metres (21 feet 2 inches) above the highest water-level. This temple, it is well known, was built under Rameses the Great, between 1388 and 1322 years before Christ. Near Ibrim there are, on the east bank, four grottoes excavated in the vertical rock that bounds the river, which belong partly to the 18th and partly to the 19th dynasties; the last, under Ramses the Great, is also the lowest, and only 2·50 metres (8 feet 1 inch) above the highest inundation; the next in height is 2·70 metres (8 feet 9½ inches) above the former, and was made 250 years earlier, under Tutmes III. Although I only measured the present level of the valley near Korusko, nevertheless it appears to me that, during the whole of the new kingdom, that is, from about 1700 years before Christ to this time, the Nile has not reached to the full height of the low land of the valley.

"It is, however, conceivable that, at the time when the present low land of the Nubian Valley was formed, the cataracts at Assuan were in a totally different state; one that would, in some degree, justify the over-charged descriptions of the ancients, according to whom they made so great a noise that the dwellers near them became deaf. The damming up of the inundation at Assuan could have no material influence on Egypt, any more than that at Semne, or the land from thence to Assuan."

It appears therefore, from the above statements, that at the time mentioned, the Nile, during the inundations, stood 26 feet 8 inches higher than the highest level to which it now rises in years of the greatest floods; and that, to account for this, Professor Lepsius conceives that, between the time of Mœsis and the present day, the bed of the Nile, from a considerable distance above Semne to Assuan, must have been worn down to that extent. In the index to the volume of the Berlin Monatsbericht, in which the letters of Professor Lepsius are inserted, there is the following line:—

"Nil, *senkung seines Bettes um 25 Fuss seit* 4000 *Jahren.*"

"*Nile,* sinking of its bed about 25 feet (Paris) within the last 4000 years."

Rivers are, undoubtedly, among the most active agents of change that are operating on the earth's surface; the solid matter which renders their waters turbid, and which they unceasingly carry to the sea, afford indisputable proof of this agency. But the power of rivers to abrade and wear down the rocks over which they flow, and to form and deepen their own bed, depends upon a variety of circumstances not always taken into account; and although the great extent of that power, in both respects, is shewn in the case of many rivers, to conclude, as some have done, from these instances, that all rivers have excavated the channels in which they flow, is a generalization that cannot be safely assented to. The excavation of the bed of a river is one of those problems in geological dynamics which can only be rightly solved by each particular case being subjected to the rigorous examination of the mathematician and the physicist. The solid matter which rivers carry forward is in part only the produce of their own abrading power; and the amount of it must be proportional to that power, which is mainly dependent on their velocity; they are the recipients of the waste of the adjoining lands by other combined agencies, and the carriers of it to the lower districts and to the sea. They often afford the strongest evidence of the vast lapse of time that must be included between the beginning and close of a geological period; and, when they flow through countries whose remote political history is known to us, they supply a scale by which we may measure and estimate that lapse of time. This is especially so in the case of the Nile.

When so startling an hypothesis as that now referred to, viz., that the entire bed of so vast a river as the Nile, for more than 250 miles, from Semne to Assuan, has been excavated, within historical time, to a depth of 27 feet, is made by a person whose name carries so much weight in one department of philosophical inquiry, the statement involves such important geological considerations, that it becomes the duty of the geologist to examine, and thoroughly test the soundness of the explanation, in order that the authority of Professor Lepsius, for the accuracy of the facts observed, may not be too readily admitted as conclusive for the correctness of his theory of the cause to which they owe their existence. That there has been such an undoubting admission, appears from the following passage in the work of one of the latest writers on Nubia:—

"The translation of the name of this town (Aswán) is 'the opening;' and a great opening this once was, before the Nile had changed its character in Ethiopia, and when the more ancient races made this rock (at the first cataract) their watch-tower on the frontier between Egypt and the south. That the Nile has changed its character, south of the first cataract, has been made clear by some recent examinations of the shores and monuments of Nubia. Dr Lepsius has discovered water-marks so high on the rocks and edifices, and so placed as to compel the conviction that the bed of the Nile has sunk extraordinarily by some great natural process, either of convulsion or wear. The apparent exaggerations of some old writers about the cataracts at Syene may thus be in some measure accounted for. If there really was once a cataract here, instead of the rapids of the present day, there is some excuse for the reports given from hearsay by Cicero and Seneca. Cicero says, that 'the river throws itself headlong from the loftiest mountains, so that those who live nearest are deprived of the sense of hearing, from the greatness of the noise.' Seneca's account is: 'When some people were stationed there by the Persians, their ears were so stunned with the constant roar, that it was found necessary to remove them to a more quiet place.'" *

Note.—The learned author of an article on Egyptian Chronology and History in the "Prospective Review" for May 1850, in referring to the contributions of Professor Lepsius to Egyptian history, says, "He has discovered undescribed pyramids, equal in number to those known before; has traced the Labyrinth, and ascertained its founder. *He has detected inscriptions on the banks of the Nile, which show that its bed has subsided many feet in historic times.*" *9th June* 1850.

* Miss Martineau's Eastern Life, vol. i., p. 99.

In the assumption of an excavation of the bed of the river, we have no small amount of wear to deal with, for the distance from Semne to Assuan, following the course of the river, is not less than 250 miles; and if, as Professor Lepsius supposes, the excavation extended to Meroë, we have a distance, between that place and Assuan, of not less than 600 miles.

Although these records of a former high level of the Nile at Semne had not been noticed by any traveller prior to Professor Lepsius, we may rest fully assured of the accuracy of his statements, from the habitual care and diligence, and the established character for fidelity, of the observer. The silence of other travellers may be readily accounted for by this, that none of them appear to have remained more than a very short time at this spot—not even the diligent Russegger—whereas we have seen that Professor Lepsius passed twelve days in the examination of this gorge in the Nile Valley.

The theory of a lowering of the bed of the river by wearing, involves two main considerations, viz., the power of the stream, and the degree of hardness of the rocks acted upon. The power depends upon the volume and velocity of the river—the velocity on its depth, and the degree of inclination of the bed: the hardness of the rocks we can form a tolerable estimate of when we know their nature. To judge, therefore, of the probability of the hypothesis of Professor Lepsius, we must inquire into the physical and geological features of the Nile Valley, in Nubia.

In the observations I have now to offer, my information has been derived of course entirely from the works of other travellers, particularly those of Burckhardt, Rüppell, and Russegger,* and especially the latter, who travelled in Nubia in 1837; for he not only enters far more into the details of the natural history of the country, but he is the only traveller in Nubia who appears, from previous acquirements, to have been competent to describe its natural history with any degree of accuracy—I refer more particularly to the physical and geological features of the country. Besides full descriptions in his volumes, he has given a geological map of Nubia, and also several sections, or what may more properly be called *vertical sketches*—a term that would, perhaps, be a more appropriate designation for all sections that are not drawn to a true scale, or at least when the proportion of height to horizontal distance is not stated.

The Physical Geography of Lower Nubia.†

Russegger informs us,‡ that he believes he was the first traveller

* Reisen in Europa Asien und Afrika, in der Jahren 1835, bis 1841.—Stuttgart 1841–1846.

† With reference to the object of this paper.

‡ Reisen, Bd. ii., 545.

who had succeeded in making a series of barometrical measurements along the Nile Valley, from the Mediterranean to Sennaar and Kordofan, and thence to the 10th degree of north latitude. He gives the following altitudes, above the sea :—

	Paris Feet.		English Feet.
The upper part of the Cataract of Assuan,	342	=	364·37
Korusko, on the right bank of the Nile, in Nubia, ...	450	=	479·43
Wadi-Halfa, ...	490	=	522·00
New Dongola, ...	757	=	806·52
Abu Hammed, . . .	963	=	1026·00

I shall now give the length of the Nile along its course from Abu Hammed to the island of Philæ, at the head of the cataract of Assuan. I employ for this purpose the map in the atlas which accompanies the work of Russegger, which bears the date of 1846, and which, doubtless, was constructed on the best authorities. He mentions a map of General von Prokesch with great praise.* It flows :—

	German M.		English M.
From NE. to SW., from Abu Hammed to Meroë, about . . .	31	=	150
It makes a curve between Meroë and Old Dongola, of about . .	16	=	77
It flows between Old and New Dongola, from SE. to NW., about .	16	=	77
Then, with some short windings, nearly due north to the island of Sais, for about	30	=	145
And from Sais to the island of Philæ, from SW. to NE., about . .	68	=	327
Making the whole length of the course, from Abu Hammed to Philæ, about .	161	=	776

Ascending the river, we have, between Philæ and Korusko, a distance of 24 German, or 115½ English miles, and without any rapid, except one near Kalabsche. Korusko being 115 feet above the head of the cataract of Assuan, at Philæ, we have an average fall of the river between these two places of a foot in a mile.

Between Korusko and Wadi-Halfa there is no rapid. The distance being 20 German, or 96⅓ English miles, and the difference of altitude being 42½ feet, we have an average fall throughout that part of the river's course of not more than 5·3 inches in a mile.

This very inconsiderable fall need not surprise us ; for the average

* "Über den Stromlauf und das zunächst liegende Uferland des Nils, von der zweiten Katarakte bis Assuan, besitzen wir eine vortreffliche Karte namlich :" "Land zwischen der kleinen und grossen Katarakten des Nil. Astronomisch bestimmt und aufgenommen in J. 1827, durch v. Prokesch. Nil Grundrisse der Monumente. Wien, 1831."—Reisen Bd. ii., Thl. iii. 86.

fall of the Nile in Lower Egypt, at the lowest water, is little more than one-third of that now stated. At the time of the highest water the surface of the Nile, at Boulak, near Cairo; that is, about 116 miles in a direct line from the coast is only 43·437 English feet above the level of the Mediterranean, and at the time of the lowest water, only 17·33 feet. Thus, in the first case, there is an average fall of about 5·00 inches; in the second, of not more than 1·80 inches in a mile.*

Between Wadi Halfa and Dale, a distance of about 94 miles, six cataracts, or schellals, as they are called in the language of the country, are marked in Russegger's map. And here, it may be as well to notice, that there are no cataracts, in the ordinary sense of the term, on the Nile; no fall of the river over a precipice; all the so-called cataracts are rapids, where the river rushes through rocks in its bed; the rapids varying in their length and degrees of inclination. We have no measurements of their lengths or of their falls, except as regards the first and second cataracts. The former, according to Russegger, has a fall of about 85 English feet in a distance of about 8 miles; and he describes the latter as extending from 5 to 6 *stunden;* that is, from 12 to 14½ miles, but he does not give the height. Speaking of the schellals above Semne, Russegger says, that all may be passed in boats without difficulty for about six weeks, or two months in the year. This is the case also, at the cataract or rapid of Assuan. But between Wadi-Halfa and Dale, with some inconsiderable spaces of free navigable water, in the ordinary state of the river, there is an almost uninterrupted series of rapids. We have no measurement of the height of Dale above Wadi-Halfa, near to which the second great cataract of the Nile occurs; but this is the part of the river's course where the fall is greatest, and from Semne to Dale there are about 45 miles of this more rapid fall.

From Dale to New Dongola, a distance of 35 German, or about 168 English miles, only three rapids are marked on Russegger's map—the highest being at Hannek, about 26 English miles below New Dongola. New Dongola being 806 English feet above the sea, and the distance from that place to the rapid of Hannek being 26 miles only, we may with probability estimate the surface of the river at the rapid of Hannek at 780 feet above the sea. Now, Wadi-Halfa being 522 feet, we have a difference of height, between these two last-named places, of 258 feet; and the length of the river's course between them being 236 miles, we have an average fall of 13·12 inches in a mile; that is, in the part of the river's course where nine rapids occur, in the provinces of Batn-el-Hadjar,

* Russegger, Reisen, Bd. i., 258.

Sukkot, and Dar-el-Mahass, where the river flows over granite and other plutonic rocks ; gneiss, mica-schist, and other hard rocks, which Russegger considers to be metamorphic. But between Semne and the head of the second cataract at Wadi-Halfa, there is not a continuous rapid stream ; for Hoskins says, that about two miles above that cataract, the river has a width of a third of a mile, and, when he passed it the water was scarcely ruffled.*

From the rapid of Hannek to Abu Hammed, the distance is 329 English miles, and the difference of altitude is 246 English feet. We have thus an average fall in that distance of 9·00 inches in a mile.

Thus, in the 776 miles between Abu Hammed and Philæ, we have an average fall of the Nile

Of 9·00	inches in a mile,	for a distance of	329 miles.
Of 13·12	....	....	236 ...
Of 5·30	....	....	96 ...
Of 12·00	....	....	115 ...

Of the Breadth, Depth, and Velocity of the Nile, in Nubia.

Our information is very scanty respecting the breadth and depth of the river, either at the time of lowest water or during the inundations. About two miles above Philæ, it is stated by Jomard† to be 3000 metres, or nearly two English miles wide. At the second cataract, or rapid of Wadi-Halfa, it spreads over a rocky bed of nearly two miles and a-quarter in width (2000 klafter),‡ but contracts above the rapid to a third of a mile. Russegger also states, that the Nile, near Boulak, in Lower Egypt, is 2000 toises, nearly two-and-a-half English miles in breadth, and yet that it is considerably wider in some parts of Southern Nubia ; but Burckhardt says, that the bed of the Nile in Nubia is, in general, much narrower than in any part of Egypt. Near Kalabsche, about 30 miles above Philæ, the river runs through a gorge not more than 300 paces wide, and its bed is full of granite blocks. It shortly afterwards again widens for some distance ; but near Sialla, 78 miles above Philæ, it is contracted by the sandstone hills on both sides coming so near each other, that the river's bed is again not more than from 250 to 300 paces widē. It is about 600 yards broad about two miles above the second cataract near Wadi-Halfa, but is again very much contracted in the rocky region of Batn-el-Hadjar. At Aulike it is only 200 paces broad.§

I have not met with any measurements of the depth of the river

* Travels in Ethiopia, p. 272.

† Description de l'Egypte.—Separate Memoir entitled, " Description de Syène et des Cataractes."

‡ Russegger, Bd. ii., 3 Thl. 85. § Russegger, Bd. ii., 3 Thl. 76.

in any part of its course in Nubia; but Hoskins describes it as being so shallow at the island of Sais, 327 miles above Philæ, on the 9th of June, which would be before the commencement of the inundation, as only to reach the knees of the camels.* Near Derr, about 86 miles below the Cataract of Wadi-Halfa, Norden, in January, found the river so shallow that loaded camels waded through it, and his boat frequently struck the ground. In May, Burckhardt found the river fordable at Kostamne, 53 miles above Philæ; and Parthey states, that between Philæ and the island of Bageh, to the west of it, the river is so shallow before the commencement of the inundation, that it may be waded through.† Burckhardt says, that from March to June the Nile-water, in Nubia, is quite limpid.‡ Miss Martineau, who visited Nubia in December and January, speaking of the river above Philæ says, that it "was divided into streamlets and ponds by the black islets. Where it was overshadowed it was dark-gray or deep blue, but when the light caught it rushing between a wooded island and the shore, it was of the clearest green."§ At the second cataract she describes the river as "dashing and driving among its thousand islets, and then gathering its thousand currents into one, proceeds calmly in its course."‖

Although we have no accurate measurements of the velocity of the Nile in Nubia, we may arrive at an approximate estimate of it by comparing its fall with that of a river well known to us.

I have stated the fall of the Nile in different parts of its course to be 5·30, 9·00, 12·00, and 13·12 inches in a mile. The fall of the Thames from Wallingford to Teddington Lock, where the influence of the tide ends, is as follows:—

	Length of course.	Fall.	Fall in inches per mile.
	Miles. F.	Feet. in.	
From Wallingford to Reading Bridge,	18·0	24·1	15·72
From Reading to Henley Bridge, .	9·0	19·3	25·68
From Henley to Marlow Bridge, .	9·0	12·2	16·20
From Marlow to Maidenhead Bridge,	8·0	15·1	22·32
From Maidenhead to Windsor Bridge,	7·0	13·6	23·16
From Windsor to Staines Bridge, .	8·0	15·8	23·52
From Staines to Chertsey Bridge, .	4·6	6·6	17·28
From Chertsey to Teddington Lock,	·13·6	19·8	17·40
	77·4	125·11	

* Travels, p. 257.
† Wanderungen durch das Nilthal, von G. Parthey, Berlin 1840. 378.
‡ Travels, pp. 9 and 11. § Eastern Life, i. 10½. ‖ *Ib.*, 144.

"In general, the velocity may be estimated at from half-a-mile to two miles and three-quarters per hour; but the mean velocity may be reckoned at two miles per hour. In the year 1794, the late Mr Rennie found the velocity of the Thames at Windsor two miles and a half per hour."*

It will thus be seen that the velocity of the Nile is probably greatly inferior to that of the Thames; for it appears that, except during the inundation, for more than half the year the depth is inconsiderable. The average fall when greatest, that is, including the province of Batn-el-Hadjar, where the rapids chiefly occur, is considerably less than that of any part of the above course of the Thames; so that there must be long intervals between the rapids where the fall must be far less than 13 inches in a mile. The breadth of the Nile is vastly greater; but supposing the depth of the water to be the same as that of the Thames, on account of the friction of the bed, the greater breadth would add very little to the velocity. If we assume the average depth of the Thames in the above distance to be 5 feet, and that it flows with an average velocity of 2 miles in an hour, and if we assume the average depth of the Nile in that part of its course where the fall is 13·12 inches to be 10 feet, when not swollen by the rise, the velocity would be $2\frac{4}{5}$ miles nearly in an hour,† if the fall were equal to that of the Thames. We shall probably come near the truth, by assuming the velocity of the Nile on this part at 2 miles in an hour. That it must be considerably less in the other divisions of the course I have named, and especially in that part immediately below the second cataract, where the average fall is only 5·30 inches for a distance of 96 miles, is quite evident.

The power of a river to abrade the soil over which it flows, so far as water is by itself capable of doing so, must depend upon its volume and velocity, and the degree of hardness of the material acted upon. The power is increased when the water has force enough to transport hard substances. But even transported gravel has little action on the rocks with which it comes in contact, when it is free to move in running water, unless the fall be considerable, and, consequently, the velocity and force of the stream great. When stones are firmly set in moving ice, they then acquire a great erosive power, cutting and wearing down the rocks they are forcibly rubbed against; but this condition never obtains in Lower Nubia, as ice is unknown there.

Geological Structure of Lower Nubia.

One kind only of regularly stratified rock occurs in the 776 miles

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* Rennie, Report on Hydraulics, in the Fourth Report of the British Association for the Advancement of Science, 1834, p. 487.

† I state this on the authority of my friend, W. Hopkins, Esq., of Cambridge.

from Abu Hammed to Philæ; viz. a silicious sandstone, similar to that which occurs to a great extent on both sides of the Nile in Upper Egypt, and which Russegger, after a very careful examination of it there, considers to be an equivalent of the greensand of the cretaceous rocks of Europe. The tertiary nummulite limestone, so abundant in Egypt, has not hitherto been met with in Nubia.

The Nile flows over this sandstone for nearly 426 miles of the entire distance, but not continuously. At Abu Hammed, it flows over granitic rocks, and these continue from that place for about 120 miles. There is then about 215 miles of the sandstone, which is succeeded by igneous and metamorphic rocks, that continue for 195 miles without any interruption, except a narrow stripe of sandstone of about 15 miles near Amara. It is in this region of hard igneous rocks that nearly all the rapids occur, between that of Hannek and the great or second cataract at Wadi-Halfa. From the latter place there is sandstone throughout a distance of about 196 miles, and then commences the granitic region of the Cataract of Assuan, through which the Nile flows about 35 miles. Thus we have about 350 miles of igneous and metmorphic rocks, and about 426 of sandstone.

The general hard nature of the igneous and metamorphic rocks, over which the Nile flows for about 155 miles above Semne, and for about 40 immediately below it, will be recognised by my naming some of the varieties described by Russegger, viz. granites of various kinds, often penetrated by greenstone dykes; sienite, diorite, and felspar porphyries; gneiss, and clay slate, penetrated by numerous quartz veins.

The siliceous sandstone is very uniform in its character; and in Nubia, as in Egypt, the only organic bodies which it has as yet been found to contain, are silicified stems of wood. Occasionally, as in the neighbourhood of Korusko, interstratified beds of marly clay are met with.*

When, therefore, we take into account the hard nature of the siliceous sandstone, the durability of which is shewn by the very ancient monuments of Egypt and Nubia, that are formed of it, and the still greater hardness of the granites and other crystalline rocks, it is manifest that the wearing action of a river flowing over so gentle a fall, can scarcely be appreciable. If the occasional beds of marly clay occur in the bank of the river, they may be washed out, and blocks of the superincumbent sandstones may fall down; but such an operation would have a tendency to raise rather than deepen the bed of the river at those places; unless the transporting power of the stream were far greater than can exist with so moderate a fall, especially in that part of the river below Semne, where, for 96 miles, it is not more than 5·3 inches, and for 115 miles below that, not more than 12 inches in a mile. Even if we suppose the river to

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* Russegger, Bd. ii., 1 Thl. 569 to 584.

have power to tear up its bed for some distance above Semne and below it, as far as the rapid of Wadi-Halfa, it is evident that the materials brought down would be deposited, except the finest particles, in that tranquil run of 96 miles, which may be almost compared to a canal. The drains in Lincolnshire are inclined 5 inches to a mile.* When the annual inundations commence, the water of the Nile comes down the rapid at Assuan of a reddish colour, loaded with sand and mud only; whatever detrital matter of a larger and heavier kind the Nile may have brought with it, is deposited before it reaches that point.

From all these considerations, therefore, I come to the conclusion, that the bed of the Nile cannot have been excavated, as Professor Lepsius supposes, since the date of the sculptured marks on the rock at Semne. He says, "Es lässt sich kaum eine andere Ursache für das bedentende Fallen des Nils denken, als ein Answaschen und Aushölen *der Katakomben*." By the word *Katakomben* he can only mean natural caverns in the rock; but such caverns are rarely, if ever, met with in sandstones, and only occasionally in limestones. If the course of the Nile were over limestone instead of sandstone, we could not for a moment entertain the idea of a succession of caverns for 200 miles beneath its bed, sometimes two miles in width, the roofs of which were to fall in; and where the igneous rocks prevail, this explanation is wholly inapplicable.

But besides the objections arising from the nature of the rocks, and the inconsiderable fall of the river, there is still another difficulty to overcome. It is to be borne in mind, that this lowering of the bed of the Nile, from Semne to Assuan, is supposed to have taken place within the last 4000 years. Between the first cataract at Assuan and the second at Wadi-Halfa, there are numerous remains of temples on both banks of the Nile, some of very great antiquity. "From Wadi-Halfa to Philæ," says Parthey, "there is a vast number of Egyptian monuments, almost all on the left bank of the river, and so near the water that most of them are in immediate contact with it."† We may rest assured that the builders of these would place them out of the reach of the highest inundations then known. Although we have many accurate descriptions of these monuments, the heights of their foundations above the surface of the river are not often given; they are, however, mentioned in some instances. I shall describe the situations of some of these buildings relatively to the present state of the river's levels, and shall begin with those on the island of Philæ.

This island, according to the measurements of General von Prokesh, is 1200 Paris feet (1278 English) in length, and 420 (447) in breadth, and is composed of granite. Lancrot informs us, that, "à l'époque des hautes eaux, l'île de Philæ est peu èlevé audessus

* Rennie, Report cited above, p. 422.

† Parthey, 318.

de leur surface, mais lorqu'elles sont abaissées elle les surpasse de huit metres." It was formerly surrounded by a quay of masonry, portions of which may be traced at intervals, and in some places they are still in good preservation. The south-west part of the island is occupied by temples. According to Wilkinson, the principal building is a temple of Isis commenced by Ptolemy Philadelphus, who reigned from 283 to 247 years before Christ; and he adds, that it is evident an ancient building formerly stood on the site of the present great temple. Lancrot, in referring to this more ancient building, says :—' Il y a des preuves certaines d'une antiquité bien plus reculeé encore, puisque des pierres qui entrent dans la construction de ce même grand temple, sont des débris de quelque construction antérieure.'' Rossellini considers that it was built by Nectanabis. The first king of Egypt, of the Sebennite dynasty of that name, ascended the throne 374 years B.C., the second and last ceased to reign about 350 years B.C.*

Rossellini† informs us, that on the island of Bageh, opposite to Philæ, there are the remains of a temple of the time of Amenophis II., and a sitting statue of granite representing him. He was a king in the earlier years of the 18th dynasty, which, according to the Chevalier Bunsen,‡ began in the year 1638, and ended in 1410 B.C.

Gau,§ in describing a temple at Debu, about 12 miles above Philæ, which he visited in January, and consequently during the time of low water, states that he discovered under the sand, at the edge of the river, the remains of a terrace leading towards a temple.

A short distance north of Kalabsche, about 30 miles above Philæ, at Beil-nalli, Rossellini‖ speaks of a small temple in the following terms :—" Among the many memorials that still exist of Ramses II., the most important, in a historical point of view, is a small temple or grotto excavated in the rock;" and Wilkinson mentions it "as a small but interesting temple excavated in the rock, of the time of Rameses II., whom Champellion supposes to be the father of Sesostris or Rameses the Great."¶ He was the first king of the 19th dynasty, which began in the year 1409 B.C.**

Gau†† thus describes a monument at Gerbé Dandour :—" La chaine de montagnes qui borde le Nil est, dans cet endroit, si approchée du lit de ce fleuve, qu'il ne reste que très peu d'espace sur la rive. Cet espace est presque entièrement occupé par le monument,

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* Russegger, Reison, Bd. ii. 300 and 320. Lancrot, Description de l'Egypte, Memoire sur l'île de Philæ, 15–58. Rossellini, I Monumenti dell' Egitto e della Nubia. Monumenti del Culto, 187. Wilkinson's Thebes and General View of Egypt, 466. Smith's Dictionary of Greek and Roman Biography, Arts. Ptolemy, Ph. and Nectanabis.

† P. 187. ‡ Egyptens Stelle in der Weltgeschichte.—Drittes Buch, 122.

§ Antiquités de la Nubie, p. 6. ‖ Tome III., Parte II., p. 6.

¶ Thebes, &c., p. 482. ** Bunsen, as above. †† P. 9.

et la rivière, dans ses debordemens, arrive jusqu' au pied du mur de la terrasse."

Parthey informs us that the temple of Sebua is about 200 feet distant from the river, in which distance there are two rows of sphinxes, and that the road between them, from the temple, ends in wide steps at the water's edge; and he adds, that Champellion refers this temple to the time of Rameses the Great.*

It thus appears that monuments exist close to the river, some of which were constructed at least 1400 years before our era; so that taking the time of Amenemha III. to be, as Professor Lepsius states, 2200 years B.C., the excavation of the bed of the Nile which he supposes to have taken place, must have been the work, not of 4000 years but of 800. If the erosive power of the river was so active in that time, it cannot be supposed that it then ceased; it would surely have continued to deepen the bed during the following 3000 years.

At all events, the buildings on the island of Philæ demonstrate that the bed of the Nile must have been very much the same as it is now, 2200 years ago; and even a thousand years earlier it must have been the same, if the foundation of the temple on the island of Begh, opposite to Philæ, be near the limit of the highest rise of the Nile of the present time; so that there could be no barrier at the Cataract of Assuan to dam up the Nile when they were constructed; and thus the deafening sound of the waterfall recorded by Cicero and Seneca must still be held to be an exaggeration.

The existence of alluvial soil, apparently of the same kind as that deposited by the Nile, in situations above the Cataract of Assuan, at a level considerably above the highest point which the inundations of the river have reached in modern times, to which allusion is made by Professor Lepsius, has been noticed by other travellers, and even at still higher levels than those he mentions. Whether that alluvial soil be identical with, or only resembles the Nile deposit, would require to be determined by a close examination, and especially with regard to organic remains, if any can be found in it. There is no evidence to shew that it was deposited during the historical period, and it may be an evidence of a depression and subsequent elevation of the land antecedent to that period. It may not be of fresh-water origin, but the clay and sand, or till, left by a drift while the land was under the sea. For remote as is the antiquity of Nubia and Egypt, in relation to the existence of the human race, it appears to be of very modern formation in geological time. The greater part of Lower Egypt, probably all the Delta, is of post-pliocene age, and even late in that age; and the very granite of the Cataract of Assuan, that of which the oldest monuments in Egypt are formed, and which, in the earlier days of geology, was looked upon as the

* Warnderungen, &c., 334.

very type of the rock on which the oldest strata of the earth were founded, is said to have burst forth during the later tertiary period. We learn from Russegger, that the low land which lies between the Mediterranean and the range of hills that extends from Cairo to the Red Sea at Suez, and of which hills a nummulite limestone constitutes a great part, is composed of a sandstone which he calls a "Meeresdiluvium," a marine diluvial formation, and considers to be of an age younger than that of the sub-appennines.* This sandstone he found associated with the granite above Assuan, and covering the cretaceous sandstone far into Nubia. It appears, therefore, that, in the later ages of the tertiary period, this north-eastern part of Africa must have been submerged, and that very energetic plutonic action was going forward in the then bed of the sea. The remarkable fact of the granite bursting through this modern sandstone is thus described by Russegger:—

"We arrived at a plateau of the Arabian Chain south-east of Assuan. It is about 200 feet above the bed of the Nile, and consists of the lower and upper sandstone, which are penetrated by innumerable granite cones from 20 to 100 feet in height, arranged over the plateau in parallel lines, very much resembling volcanic cones rising from a great cleft. The sandstone is totally altered in texture near the granite, and has all the appearance as if it had been exposed to a great heat. 'I cannot refrain,' he says, 'from supposing that the granite must have burst, like a volcanic product, through long wide rents in the sandstone, and that, in this way, the conical hills were formed.'"†

An eruption of a true granite during the period of the sub-appennine formations, one possessing the same mineral structure as that we know to have been erupted during the period of the palæozoic rocks, would be a fact of so extraordinary a kind, that its age would require to be established on the clearest evidence, and especially by that of organic remains in the sandstone.

Having thus ventured—I trust without any want of the respect due to so eminent a person—to reject the hypothesis proposed by Professor Lepsius for the high levels of the Nile at Semne, indicated by the sculptured marks he discovered, it may perhaps be expected that I should offer another more probable explanation. If in some narrow gorge of the river below Semne, a place had been described by any traveller, where, from the nature of the banks, a great landslip, or even an artificial dam, could have raised the bed to an adequate height; that is, proportionate to the fall of the river, as it was more distant from Semne, a bar that, in the course of a few centuries, might have been gradually washed away, I might have ventured to suggest such a solution of the problem. But without any information of the existence of such a contraction of the river's channel, or

* Reisen, Bd. I., s. 273. † Id., Bd. II., I. Thl. s. 328.

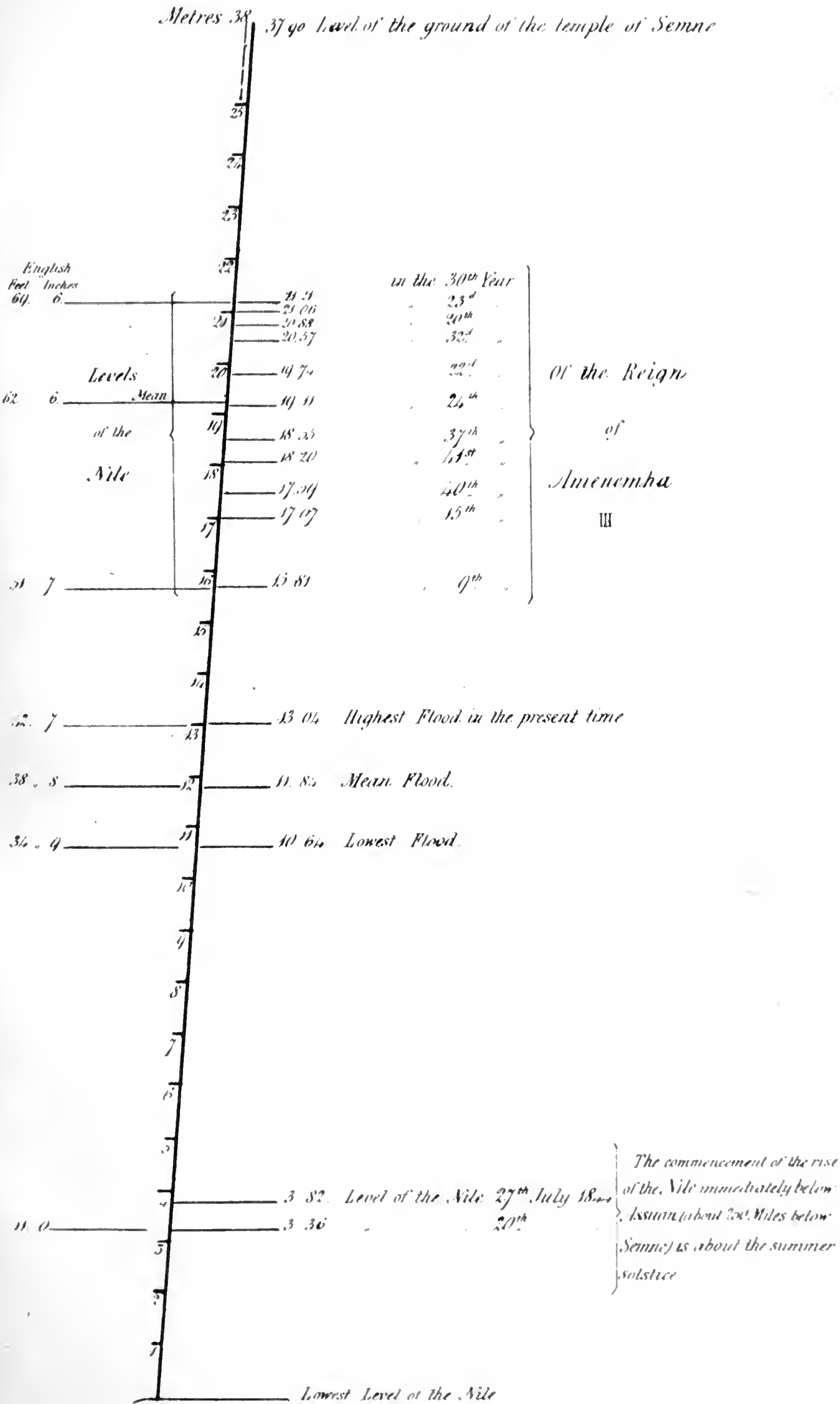
any exact knowledge of the natural outlets and dams to running water along the 250 miles of the Nile Valley, from Semne to Assuan, it would be idle to offer even a conjecture. These marks are unquestionably very difficult to account for, in the present imperfect state of our knowledge of the structure of that portion of the Nile Valley; and any competent geologist, well versed in the questions of physical structure involved, who may hereafter visit Nubia, would have a very interesting occupation in endeavouring to solve the difficulty.

7th April 1850.

On the Salmon Tribe (*Salmonidæ.*)

So long as the family *Salmonidæ* remains circumcribed as it was established by Cuvier, it seems to be a type almost universally diffused over the globe, occurring equally in the sea and in fresh-water, so that we are left almost without a clue to its natural relations to the surrounding world. Joh. Muller, working out some suggestions of Prince Canino, and introducing among them more precise anatomical characters, had no sooner sub-divided the old family of *Salmonidæ* into his *Salmonidæ*, *Characini*, and *Scopelini*, than light immediately spread over this field. Limited now to such fishes as, in addition to the mere general character of former *Salmonidæ*, have a false gill on the inner surface of the operculum, the *Salmonidæ* appeared at once as fishes peculiar to the northern temperate region, occurring in immense numbers all around the Artic Sea, and running regularly up the rivers at certain seasons of the year to deposit their spawn, while some live permanently in fresh water. We have thus in the true *Salmonidæ* actually a northern family of fishes, which, when found in more temperate regions, occurs there in clear mountain rivers, sometimes very high above the level of the sea, near the limits of perpetual snow, or in deep, cold lakes. That this family is adapted to the cold regions is most remarkably exemplified by the fact that they all spawn late in the season, at the approach of autumn or winter, when frost or snow has reduced the temperature of the water in which they live nearly to its lowest natural point. The embryos

Marks of the Levels of the Nile near the Cataracts of Semne in the time of King Amenemha III (Mœris) about 2200 Years B.C. compared with the present levels.



grow within the egg very slowly for about two months before they are hatched; while fecundated eggs of some other families which spawn in spring and summer, give birth to young fishes a few days after they are laid. The *Salmonidæ*, on the contrary, are born at an epoch when the waters are generally frozen up; that is at a period *when the maximum of temperature is at the bottom of the water*, where the eggs and young salmons remain among gravel, surrounded by a medium which scarcely ever rises above thirty or forty degrees.

It is plain from these statements, and from what we know otherwise of the habits of this family, that there is no one upon the globe living under more uniform circumstances, and nevertheless the species are extremely diversified, and we find peculiar ones in all parts of the world, where the family occurs at all. Thus we find in Lake Superior species which do not exist in the course of the Mackenzie or Saskatchawan, and *vice versa;* others in the Columbia river which differ from those of the Lena, Obi, and Yenisei, while Europe again has its peculiar forms.

Whoever takes a philosophical view of the subject of Natural History, and is familiar with the above stated facts, will now understand why, notwithstanding the specific distinctions there are between them, the trouts and white fishes are so uniform all over the globe. It must be acknowledged that it is owing to the uniformity of the physical condition in which they occur, and to which they are so admirably adapted by their anatomical structure, as well as by their instinct. Running up and down the rapid rivers and mountain currents, leaping even over considerable waterfalls, they are provided with most powerful and active muscles; their tail is strong and fleshy, and its broad basis indicates that its power is concentrated; it is like the paddle of the Indian who propels his canoe over the same waters. Their mouth is large, their jaw strong, their teeth powerful, to enable them to secure with ease the scanty prey with which they meet in these deserts of cold water; and, nevertheless, though we cannot but be struck by the admirable reciprocal adaptation between the structure of the northern animals and the physical condition in which they live, let us not mistake these adaptations for a consequence of physical causes; let us not say that trouts resemble each other so much because they originated under uniform conditions; let us not say they have uniform habits because there is no scope for diversity; let us not say they spawn during winter, and rear their young under snow and ice, because at that epoch they are safer from the attacks of birds of prey; let us not say they are so intimately connected with the physical world, because physical powers called them into existence; but let us once look deeper, let us recognise that this uniformity is imparted to a wonderfully complicated structure: they are trouts with all their admirable structure, their peculiar back-bones, their ornamented skull, their powerful jaws, their moveable eyes, with their thick, fatty skin and elegant scales, their ramified fin rays, and with all that harmonious complication of structure which characterizes the type of trouts, but over which a uniform robe, as it were, is spread in a manner not unlike an almost endless series of monotonous variations upon one brilliant air, through the uniformity of which we still detect the same melody, however disguised under the many undulations and changes of which it is capable.

The instincts of trouts are not more controlled by climate than those of other animals under different circumstances. They are only made to perform at a particular season, best suited to their organization, what others do at other times. If it were not so, I do not see why all the different fishes, living all the year round in the same brook, should not spawn at the same season, and finally be transformed into one type; have we not, on the contrary, in this diversity under identical circumstances, a demonstrative evidence that there is another cause which has acted, and is still acting, in the production and preservation of these adaptations; a cause which endowed living beings with the power of resisting the equalizing influence of uniform agents, though at the same time placing these agents and living beings under definite relations to each other?

That trouts are not more influenced by physical conditions than other animals is apparent from the fact that there are lakes of small extent and of most uniform features, in which two or three species of trout occur together, each with peculiar habits; one more migratory, running up rivers during the spawning season, &c., while the other will never enter running waters, and will spawn in quiet places near the shore; one will hunt after its prey, while the other will wait for it in ambuscade; one will feed upon fish, the other upon insects. Here we have an example of species with different habits, where there would scarcely seem to be room for diversity in the physical condition in which they live; again, there are others living together in immense sheets of water, where there would seem to be ample scope for diversity, among which we observe no great differences, as is the case between the Siscowet and the lake trout in the great northern lakes.

If these facts, statements, and inductions were not sufficient to satisfy the reader of the correctness of my views, I would at once refer to another material fact, furnished us by the family of *Salmonidæ*, namely, the existence of two essential modifications of the true type of trouts, occurring everywhere together under the same circumstances, showing the same general characters, back-bones, skull, brain, composition of the mouth, intestines, gills, &c., &c., but differing in the size of the mouth, and in the almost absolute want of teeth, these groups being that of the white fishes, *Coregoni*, and that of the true trouts, *Salmones*.

Now, I ask, where is there, within the natural geographical limits of distribution of *Salmonidæ*, a discriminating power between the physical elements under which they live, which could have introduced these differences?—a discriminating power which, allotting to all certain characters, should have modified others to such an extent as to produce apparently different types under the same modification of the general plan of structure. Why should there be, at the same time, under the same circumstances, under the same geographical distribution, white fishes with the habits of trouts,—spawning like them in the fall, growing their young like them during winter,—if there were not an infinitely wise Supreme Power, if there were not a personal God, who, having first designed, created the universe, and modelled our solar system, called successively, at different epochs, such animals into existence under the different circumstances prevailing over various parts of the globe, as would suit best this general plan, according to which man was at last to be placed at the head of creation? Let us remember all this, and we have a voice uttering louder and louder the cry which the external world equally proclaims, that there is a Creator, an intelligent and wise Creator, an omnipotent Creator of all that exists, has existed, and shall exist.

To come back to the *Salmonidæ,* I might say, that when properly studied, there is not a species in nature, there is not a system of organs in any given species, there is not a peculiarity in the details of each of these systems, which does not lead to the same general results, and which is not on that account equally worth our consideration.

A minute distinction between species is again, above all, the foundation of our most extensive views of the whole, and of our most sublime generalizations. The species of *Salmonidæ* call particularly our attention, from the minuteness of the characters upon which their distinction rests. Their number in the north of this continent (North America) is far greater than would be supposed from the mere investigation of those of the great lakes; but I shall, for the present, limit myself to these.—*Agassiz, Lake Superior*, p. 366.

Results of Observations made by the Rev. F. Fallows, *at the Cape of Good Hope, in the years* 1829–30–31. *Produced under the superintendence of* G. B. Airy, Esq., Astronomer Royal.

This important work, containing the earliest fruits of the Cape Observatory; and, while the first, at the same time some of the most valuable contributions to Southern Astronomy,—has been received too late to allow us to do more than barely mention the titles in the present number.

We are tempted, however, to extract the following short notice of a remarkable meteor; because it tends to establish the connection so very much wanted between *shooting-stars* on the one hand, and *meteorites*, or *meteor-stones*, on the other hand. The phenomenon in question had a something of the characteristics of each, but was more of the nature of the latter body, in which case the mere fact of its appearing at the epoch of the shooting-stars, may be considered in some degree significant of a connection, more especially when confirmed by a second instance in another year ; while, moreover, the November period of shooting-stars had not then been suspected ; and these two observations not only serve to confirm that period, but also to give the retrogression of the nodes of the orbit, which has been suspected. P. S.

Mr Fallows to the Secretary of the Admiralty.

ROYAL OBSERVATORY, CAPE OF GOOD HOPE,
November 9, 1829.

"SIR,—The inclosed document was drawn up at my request, by Captain Ronald. At the moment the first explosion took place (ten in the evening), I was writing in a room adjacent to that of the Transit, and imagined from the loudness of the report that it might be a signal of distress from some vessel in Table Bay. Shortly after, perhaps four or five minutes, for I cannot be certain, having no suspicion of what had been observed in the Transit-room, I heard a second report, but it was somewhat fainter than the former. This phenomenon has been noticed at Simon's Town, Stellenbosch, and beyond Koe-berg.*—I have, &c.,

"FEARON FALLOWS."

(INCLOSURE.)

Captain Ronald to Mr Fallows.

OBSERVATORY, CAPE OF GOOD HOPE,
20*th October* 1829.

"SIR,—As it may not be uninteresting perhaps to make some record of the circumstances attending the appearance of a meteor which was observed last evening, I beg leave to convey to you the following notice : remarking that having seen it only through the open roof of the Observatory, which prevented me from following the direction it took, my report must necessarily be so far incomplete.

"At the time of the occurrence of the phenomenon in question,

* *i. e.*, 20 miles to the South, 25 to the East, and 15 to the North.

about ten in the evening, I was in the Transit-room, engaged in observing the passage of a star, when a blaze of intensely vivid light was observed a little to the West of North, about the height of the Equator, and which continued for perhaps a couple of seconds.

"While registering the observation, a loud report was heard nearly in the same direction, resembling that of a piece of heavy ordnance at the distance of two or three miles. The interval between the flash and the report reaching me, must have been between the limits of 2^{m} 40^{s} and 2^{m} 45^{s}, from the circumstance of my having observed the light just before the star (*g Ceti*) had come to the second wire* of the instrument, which, on referring to the transit-book, would have taken place at 23^{h} 57^{m} $47^{s}\cdot6$ nearly, and therefore the occurrence of the phenomenon may be safely referred to 23^{h} 57^{m} 45^{s}; and as, on hearing the report, I immediately consulted the Sidereal clock, which indicated 0^{h} 0^{m} 30^{s}, I think that the error in assuming the elapsed time as above cannot be supposed to amount to five seconds.

"There was little peculiar in the state of the weather or atmosphere; the day had been rather more than usually cool, the highest temperature being 68° Fahrenheit, the wind from the south, and moderate, with slight passing showers. The evening was nearly clear, with a light air from the south-west, atmosphere rather dry; the barometer standing at $30^{in}\cdot20$, and the thermometer at 52°, and both were observed to rise suddenly after the explosion, the barometer by $0^{in}\cdot01$, and the thermometer by $0^{\circ}\cdot1$, though they regained their original position in a short time afterwards.—I have, &c.,

"W. RONALD.

"By referring to my Meteorological Journal, it appears that a meteor of somewhat similar appearance was noticed in Cape Town early on the morning of the 6th November last year.—W. R."

Discovery of the Great Lake "Ngami" of South Africa.

Geographical discovery in Africa has even excited more interest than similar explorations in any other part of the world, and with reason—for, while it is one of the oldest and earliest peopled of lands; while the human race first attained there a high degree of civilization, and a high degree of knowledge in the arts of peace and war, of science and literature;

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* The Transit of *g Ceti* (2 *Ceti*) over the second wire, on this day is blank; and the word "meteor" is written in the margin. The first and third wires are 23^{h} 57^{m} $27^{s}\cdot9$ and 23^{h} 58^{m} $7^{s}\cdot4$.

with a grandeur in some things, and a skill in others never since equalled ; yet it is now the country of all others on the face of the globe concerning which we know least. In other continents there are undoubtedly parts not yet visited by Europeans, or worthy of being more fully explored ; but they are but inconsiderable spots compared with the almost boundless spaces of Central Africa, where no foot of a white man has ever yet trod, and of the greater part of which no semifabulous native accounts even have ever reached us. So that age after age the civilization of the enlightened nations of the world is gradually losing the hold which it once had, at least along the northern shores of this vast continent ; and the land of Ham is gradually reverting to a state of primeval wilderness, fenced in from all the rest of the world by the obstructive power of ignorance and position.

And yet to no other part of the world has so continued a stream of geographical explorers been poured, and is even pouring still ; but invariably either the deadly climate of the more fertile parts, or the passive but all-powerful impediments offered by the more desert portions, as well as the active opposition of natives, more savage and sanguinary than in any other part of the world, have invariably, by death or otherwise, put an untimely stop to the progress of the travellers.

Under these circumstances it must be highly encouraging to all interested in the prosecutions of African geography, to hear that an actual and tangible discovery, and one of the most important kind for the country in which it was effected, and for the prosecution of still further research, has just been made, in the fact of the Rev. David Livingston, a missionary of the London Society, having at least reached the great lake* of South Africa.

The circumstance requires perhaps something more than mere notice, and to have more names mentioned in connection with it, from its being part of a general system of cooperation in which many have borne a part, and a very im-

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* This lake must not be confounded with the smaller one, supposed by the Portuguese to exist on the coast of Zanzibar.

portant and necessary part, towards the result which has been finally achieved; and at the very least, the name of the Rev. Mr Moffat, the fellow missionary of Mr Livingston, deserves mention whenever the great lake is spoken of.

Its existence had been suspected long since, and its discovery has been a constant theme of conversation for many years past at the Cape. But yet the information of its whereabout, and size, and nature, were so very scanty, as to throw more doubt over the matter, the further that it was examined into. Up to a very recent date, the only persons who had ever been able within the colony to bear testimony to the fact of the existence of the great lake, from personal knowledge, were two young Bechuana brought down by D. A. Smith's expedition. They said, that when they were children, and their tribe was flying from their enemies, they had been at one period close to the great lake; but, after the closest cross-questioning, they left the matter more uncertain than ever, for from the length of time that their tribe was flying about in the desert in various directions, it would have been quite possible to have reached the sea either to the east or west, or the colony to the south; and nothing certain could be made out as to the mean resulting direction of the marching and countermarching.

Nevertheless, many were the ardent explorers who endeavoured to reach this consummation, so greatly to be desired, amid the arid plains of South Africa. The last which started, and by far the most important of all that were ever organized in South Africa, was that of the Cape Town "Association for Exploring Central Africa," and which started in 1834, and returned in 1836. The party consisted of about seven Europeans,as many waggons, and about thirty natives. The whole was under the direction of Dr Andrew Smith, staff-surgeon, who had admirably qualified himself for the command, by the experience of very many years spent chiefly in the interior, and amongst the natives. Among the members of the expedition, were an astronomer, well supplied with instruments, and two artists, and Mr Charles Bell for landscape, topography, and the manners and customs of the natives; and another, Mr Ford, for the natural history department.

Dr Smith took upon himself especially the zoology, the ethnology, and geology; and the others all contributed according to their powers, while the whole of their notes and journals of every kind were to be made over to the association.

The expedition started in 1834, reached at length the Rev. Mr Moffat's residence at Kuruman, then the outpost of the Missionary stations; by him it was carried on further into the Zoolah country, to the abode of the great chief Umsiligas. This seemed for various reasons the furthest northing that the expedition could make, but a small party went on in light marching order a little further, so as to be just able to say that 23° south latitude had actually been reached, before the retrograde movement was begun.

The chief result of this expedition has been the publication of Dr A. Smith's beautiful and valuable zoological work, for the publication of which the government granted a sum of money.

The personal journal, the astronomical, geographical, geological, and meteorological observations, have still to come; likewise Dr Smith's own observations touching the history, language, and other particulars of the various tribes of aborigines whom he met with; as well as Mr Charles Bell's inimitable drawings of the manners, customs, and appearances of the natives, and his expressive landscape scenery.

This degree or measure of success seemed to put the great lake further off than ever, Europeans despaired of their ever finding or beholding it, and none but traders and huntsmen subsequently traversed that part merely of the road towards it, which the expedition did pass over; while the only scientific mission which has acted since in South Africa, viz., that of Captain Sir J. E. Alexander, sent out by the Royal Geographical Society of London,—hopeless, apparently, of doing anything by following Dr Smith's route, travelled and explored along the western coast.

It was remarked long since by the North American Indians and other aborigines, that the "black-robe chiefs of the mission" had always preceded the daring hunter and the crafty trader; and in no country has the *preceding* spirit of the missionaries been more evident than in South Africa. While pushing their stations continually further and further into the interior, they christianize and civilize the tribes as they go, and so leave the way paved and open behind them; a most important condition, when it is remembered what excessive distances a traveller is there from his resources, and in what an impracticable country.

Silently, but surely, has this operation been going on, until as it were, almost by natural causes, a point has been reached, within which the lake was but at a moderate distance. Starting from Mr Moffat's advanced post of Kuruman, Mr Livingston had founded the station of Kolobeng further north; and then it only required a small advance of money to pay the expense of the long contemplated journey. That sum was furnished by two lay gentlemen, Messrs Murray and Oswell,—and this great cynosure of South African geography, fell, in the ripeness of time, an easy prize.

But if we have this much to say for the effective lever which the missionary system affords for geographical discovery, we cannot say so much as we should like in favour of the manner in which it has been worked in this instance, though it may be better than in the generality of cases.

There has been of late, it must be confessed, rather a decline of the true scientific spirit of geographical exploration; and men have too frequently been contented with filling their books with accounts merely of what they shot and what they eat; unable to give any more intelligent account of the country than the natives themselves.

Hardly any better, the Rev. Mr Rebman, who is supposed to have discovered in 5° S. lat., and 3 or 400 miles within the eastern coast of Africa, a mountain reaching above the limits of perpetual snow, and which may be the source of the Nile on the one hand, and of the rivers which feed the great lake Ngami on the other; for though he has been twice to the mountains, yet he has sent home such puerile statements, that the fact of its being snow at all which was *thought* to have been seen, is now contested; and the height, latitude, longitude, &c., of the mountain are quite uncertain.

Mr Livingston has done much better than this, though there is almost everything for the geographer, the botanist, &c., to do; but no fault is to be imputed to him, he had a higher object in view: we mention the case so prominently here, rather to incite scientific men to go and do their part. We append Mr Livingston's letter to the end of this notice, and will merely condense here the principal notabilia.

The latitude of the E. corner of the lake at its junction with the effluence the Zonga, was measured with a sextant, to be 20° 20′ S. The longitude was estimated at 24° E., consequently about midway between the E. and W. coasts. The height above the level of the sea was thermometrically determined at 2200 feet. The length and breadth were stated by the natives at 70 and 15 miles; Mr Livingston saw in the former direction an uninterrupted horizon of water.

The feeder of the lake coming down from the north was described only by the natives; but its water being very clear, even during its annual risings, and these being incomprehensible to the inhabitants of that part of the country, this course may be expected to be long, and not improbably rising from a snowy mountain.

The effluent of the lake, the Zonga, was travelled along by Mr L. for 300 miles; as the water was clear, the stream placid, the banks thickly clothed with beds of reeds, and the height above the sea 2200 feet,—it may be presumed that this river does *not* communicate with the ocean, and that it is gradually dissipated like other rivers there by evaporation and absorption.

The banyan, the palmyra, and the baobab, taking the place of the cactus, aloe, euphorbia and acacia, indicate the arrival in a better watered country and a totally different botanical region than any previously reached from the Cape.

The inhabitants of the lake "Bayeiye," seem to be a new race; their language was unknown; and they possess several remarkable habits and customs totally at variance with the characteristics of all the South African tribes, Hottentots, Bushmen, Caffres, Bechuana, Zoolahs, &c., south of the tropics; as for instance, their having *canoes*, killing the hippotami with harpoons attached to ropes, and catching fish in nets.

The head of a fish which abounds in the lake, as well as a fearful fly which stings the oxen to death, have been sent home, and are declared to be new.

In conclusion, we have the pleasure of adding that although the Geographical Society could not exactly award with propriety their Royal gold medal to discoveries in their science; made in a secondary point of view, and but indifferently described, when it should be reserved for a Bruce or a Humboldt,—yet they have with great satisfaction and alacrity awarded the value of the medal in money; and it is devoutly to be hoped that Mr L. may be spared to continue the exploration which he has thus auspiciously begun. P. S.

Letter from the Rev. David Livingston, addressed to the Rev. Arthur Tidman, Foreign Secretary, London Missionary Society.

Banks of the River Zonga, 3rd September 1849.

DEAR SIR,—I left my station, Kolobeng (situated 25° South lat., 26 East long.), on the 1st of June last, in order to carry into effect the intention, of which I had previously informed you, viz. to open a new field in the North, by penetrating the great obstacle to our progress, called the Desert, which, stretching away on our West, North-West, and North, has hitherto presented an insurmountable barrier to Europeans.

A large party of Griquas, in about thirty waggons, made many and persevering efforts at two different points last year; but, though inured to the climate, and stimulated by the prospect of much gain from the ivory they expected to procure, want of water compelled them to retreat.

Two gentlemen, to whom I had communicated my intention of proceeding to the oft-reported lake beyond the desert, came from England for the express purpose of being present at the discovery, and to their liberal and zealous cooperation we are especially indebted for the success with which that and other objects have been accomplished. While waiting for their arrival, seven men came to me from the Batavana, a tribe living on the banks of the lake, with an earnest request from their chief for a visit. But the path by which they had come to Kolobeng was impracticable for waggons; so, declining their guidance I selected the more circuitous route, by which the Bermangueato usually pass, and, having Bakwains for guides, their self-interest in our success was secured by my promising to carry any ivory they might procure for their chiefs in my waggon; and right faithfully they performed their task.

When Sekhomi, the Bermangueato chief, became aware of our intentions to pass into the regions beyond him, with true native inhumanity he sent men before us to drive away all the bushmen and Bakalihari from our route, in order that, being deprived of their assistance in the search for water, we might, like the Griquas above mentioned, be compelled to return. This measure deprived me of the opportunity of holding the intercourse with these poor outcasts I might otherwise have enjoyed. But through the good providence of God, after travelling about 300 miles from Kolobeng, we struck on a magnificent river on the 4th of July, and without further difficulty, in so far as water was concerned, by winding along its banks nearly 300 miles more, we reached the Batavana, on the lake Ngami, by the beginning of August.

Previous to leaving this beautiful river on my return home, and commencing our route across the desert, I feel anxious to furnish you with the impressions produced on my mind by it and its inhabitants, the Bakoba or Bayeiye. They are a totally distinct race from the Bechuanas. They call themselves Bayeiye (or men), while the term Bakoba (the name has somewhat of the meaning of "slaves,") is applied to them by the Bechuanas. Their complexion is darker than that of the Bechuanas; and, of 300 words I collected of their languge, only 21 bear any resemblance to Sitchuana. They paddle along the rivers and lake in canoes hollowed out of the trunks of single trees; take fish in nets made of a weed which abounds on the banks; and kill hippopotami with harpoons attached to ropes. We greatly admired the frank, manly bearing of these inland sailors. Many of them spoke Sitchuana fluently, and, while the waggon went along the bank, I greatly enjoyed following the windings of the river in one of their primitive craft, and visiting their little villages among the reed. The banks are beautiful beyond any we had ever seen, except perhaps some parts of the Clyde. They are covered, in general, with gigantic trees, some of them bearing fruit, and quite new. Two of the Boabob variety measured 70 to 76 feet in circumference. The higher we ascended the river, the broader it became, until we often saw more than 100 yards of clear deep water between the broad belt of reed which grows in the shallower parts. The water was clear as crystal, and as we approached the point of junction with other large rivers *reported to exist* in the North, it was quite soft and cold. The fact that the Zonga is connected with large rivers coming from the north awakens emotions in my mind, which make the discovery of the lake dwindle out of sight. It opens the prospect of a highway, capable of being quickly traversed by boats, to a large section of well-peopled territory.

One remarkable feature in this river is its periodical rise and fall. It has risen nearly three feet in height since our arrival, and this is the dry season. That the rise is not caused by rains is evident from the water being so pure. Its purity and softness increased as we ascended towards its junction with the Tamunakle, from which, although connected with the lake, it derives the present increased supply. The sharpness of the air caused an amazing keenness of appetite, at an elevation of little more than 2000 feet above the level of the sea (water boiled at 207½° thermometer), and the reports of the Bayeiye, that the waters came from a mountainous region, suggested the conclusion that the increase of the water, at the beginning and middle of the dry season, must be derived from melting snow.

All the rivers reported, to the north of this, have Bayeiye upon them, and there are other tribes on their banks. To one of these, after visiting the Batavana, and taking a peep at the broad part of the lake, we directed our course; but the Batavana chief managed to obstruct us, by keeping all the Bayeiye near the ford on the opposite bank of the Zonga. African chiefs invariably dislike to see strangers passing *them to tribes beyond*. Sebitoane,—the chief who in former years saved the life of Sechele *our* chief,—lives about ten days north-east of the Batavana. The latter sent a present as a token of gratitude. This would have been a good introduction; the knowledge of the language, however, is the *best* we can have. I endeavoured to construct a raft, at a part which was only fifty or sixty yards wide, but the wood, though sun-dried, was so heavy it sunk immediately; another kind would not bear my weight, although a considerable portion of my person was under water. I could easily have swam across, and fain would have done it; but, landing without clothes, and then demanding of the Bakoba the loan of a boat, would scarcely be the thing for a messenger of peace, even though no alligator met me in the passage. These and other thoughts were revolving in my mind as I stood in the water,—for most sorely do I dislike to be beaten,—when my kind and generous friend Mr Oswell, with whom *alone* the visit to Sebitoane was to be made, offered to bring up a boat at his own expense from the Cape, which, after visiting the chief, and coming round the north end of the lake, will become missionary property. To him and our other companion Mr Murray, I feel greatly indebted,—*for the chief expense of the journey has been borne by them. They* could not have reached this point without my assistance; but, for the aid they have rendered in opening up this field, I feel greatly indebted; and, should any public notice be taken of this journey, I shall feel obliged to the directors if they express my thankfulness.

The Bayeiye or Bakoba listened to the statements made from the Divine Word with great attention, and, if I am not mistaken, seemed to understand the message of mercy delivered better than any people to whom I have preached for the *first* time. They have invariably a great many charms in the villages; stated the name of God in their language (without the least hesitation) to be "Oreeja;" mentioned the name of the first man and woman, and some traditionary statements respecting the flood. I shall not, however, take these for certain, till I have more knowledge of their language. They are found dwelling among the reed all round the lake, and on the banks of all the rivers to the north.

With the periodical flow of the rivers great shoals of fish descend. The people could give no reason for the rise of the water, further than that a chief, who lives in a part of the country in the north, called Mazzekiva, kills a man annually and throws his body into the stream, after which the water begins to flow.

The sketch which I enclose is intended to convey an idea of the river Zonga and the lake Ngami. The name of the latter is pronounced as if written with the Spanish ñ, the *g* being inserted to shew that the ringing sound is required. The meaning is "Great Water." The latitude, taken by a Sextant on which I can fully depend, was 20° 20′ south, at the north-east extremity, where it is joined by the Zonga; longitude about 24° east. *We do not, however, know it with certainty.* We left our waggon near the Batavana town, and rode on horseback about six miles beyond it to the broad part. It gradually widens out into a Firth about 15 miles across, as you go south from the town, and in the south-south-west presents a large horizon of water. *It is reported* to be about 70 miles in length, bends round to the north-west, and there receives another river similar to the Zonga. The Zonga runs to the north-east. The thorns were so thickly planted near the upper part of this river, that we left all our waggons standing about 180 miles from the lake, except that of Mr Oswell, in which we travelled the remaining distance; but for this precaution our oxen would have been unable to return. I am now standing at a tribe of Bakurutse, and shall in a day or two re-enter the desert.

The breadth marked is intended to show the difference between the size of the Zonga, after its junction with the Tamunakle and before it. The farther it runs east, the narrower it becomes. The course is shewn by the arrow-heads. *The rivers not seen, but reported by the natives,* are put down in dotted lines. The dotted lines running north of the river and lake, shew the probable course of the Tamunakle, and another river which falls into the lake at its north-west extremity. The arrow-heads shew also the direction of *its* flow. At the part marked by the name of the Chief Mosing it is not more than 50 or 60 yards in breadth, while at 20° 7′ it is more than 100, and very deep.

The principal disease reported to prevail at certain seasons appears, from the account of the symptoms the natives give, to be pneumonia and not fever. When the wind rises to an ordinary breeze, such immense clouds of dust arise from the numerous dried-out lakes called salt-pans, that the whole atmosphere becomes quite yellow, and one cannot distinguish objects more than two miles off. It causes irritation in the eyes, and, as wind prevails almost constantly at certain seasons, this impalpable powder may act as it does among the grinders in Sheffield. We observed cough among them, a complaint almost unknown at Kolobeng. Musquitoes swarm in summer, and the Banyan and Palmyra give in some parts an Indian cast to the scenery.

(Signed) David Livingston.

A Brief Sketch of the Geology of the West Indies, from Dr Davy's *Lectures on the Study of Chemistry, drawn up chiefly from the Author's own Observations.** Communicated for the Philosophical Journal.

In the preceding lecture, I brought under your notice the antagonist and compensating, or correcting influences of animal life in

* Lectures on the Study of Chemistry, in connection with the Atmosphere, the Earth and the Ocean, and Discourses on Agriculture, with Introductions on the present state of the West Indies, and on the Agricultural Societies of Barbados. By John Davy, M.D., F.R.S., &c. London, Longmans. 1850.

preserving the uniformity of composition of the atmosphere. In the earth we witness influences of the like kind, as it were opposed to each other, and producing opposite effects. Water, in its operation, aided by air, may be considered as destructive, wearing away rocks and mountains, and carrying their comminuted parts to lower levels, and even into the sea, to be buried in its depths. Fire may be considered as restorative; acting below the surface, it melts and also consolidates, according to its degree of intensity, tending to reproduce crystalline rocks in one instance, and stratified in the other. Even when it appears most eminently to act according to our ordinary notions of its operation as a devastating and destroying agent, for example, in the eruption of a volcano, the ashes which are discharged into the atmosphere, and are widely scattered by the winds, even when they fall on the adjoining countries, may help to supply the place of the old surface-materials, carried away by streams and floods, and to renovate the soil with new elements of fertility. And acting in another form and manner, the same power which occasions volcanic eruptions appears to be productive of another effect, viz., the gradual elevation of the bed of the sea, tending to the formation of new land, of which we seem to have examples in the extension of certain coasts, and the appearance of rocks and dry land above the waves, preceded by a gradual diminution of the water over the spots where these remarkable phenomena occur.

Of most of the geological changes alluded to in the preceding remarks, the West Indies afford well marked instances.

From the continent of America are to be seen vast rivers flowing into the sea, turbid with the detritus of the country through which they have descended in a course of thousands of miles, and discolouring and freshening the waters with which they mix at an extraordinary distance from land. Between their mouths on the coasts and their rapids in the boundary hills of the interior, immense level, or almost level tracts occur,—marsh, morass, and sandbank, neither land nor water, covered chiefly with aquatic plants,—tracts formed by deposits from the great rivers, and commonly of materials somewhat coarser and heavier than those which are longer suspended and are carried out into the sea in consequence of their greater fineness.

In many of the islands not only are there rocks to be seen evidently of volcanic origin—columnar basalt, trachite, and many varieties of tufa, but also craters from whence eruptions have taken place, and in which the fires are hardly yet extinct that once acted, as is indicated by the hot steams and exhalations still proceeding from them.

Moreover, in some of these islands, rocks of volcanic origin, crystalline in their structure, and totally destitute of organic remains, are associated with others of a perfectly different character, stratified and abounding in organic remains,—various species of sea shells and of coral; and it is worthy of notice, that, in one of the instances in which the appearance is best observed, viz., at Brimstone Hill, in St Christopher's, the volcanic rock, flanked by the stratified rock, and the latter—an aggregate of shells, coral, and calcareous marl, has its strata highly inclined, tilted up as it were by the former.

Other islands, or parts of islands, occur, in which there are only partial volcanic traces, and these not so much of volcanic action and disturbance on the spot, as of materials, such as ashes, thrown up by volcanoes, and those distant ones. The island Barbados is an example. Composed in great parts of a calcareous aggregate, in which organic remains abound, it has very much the character, in its peculiar features, of having been raised from the bed of the ocean (where it is certain it was formed), by some mighty force, slowly acting, and which, it is probable, is acting still.

Nor is there wanting in these seas instances of islands, in which almost every variety of formation is exemplified. Barbados, in its smaller portion—the Scotland district, exhibits some interesting varieties, such as beds of chalk abounding in the remains of microscopic animalcules, strata of sandstone, some siliceous, some calcareous; the one without organic remains, containing, however, deposits of coal and bitumen; the other—the latter having included in them organic remains, and of a kind to connect them with the calcareous rock of which the larger portion of the island is formed, for instance, the spines of echini and the teeth of squali. The larger islands, Trinidad and Jamaica, Port Rico, and Cuba, yield examples, still more in point. In Trinidad I am not aware that any volcano, or crater of one, has been discovered, or any rocks evidently volcanic in their origin; but from the imperfectly crystalline rocks, destitute of organic remains and distinct stratification, to clays and marls, to mud eruptions or volcanoes as these are sometimes called, through limestones and sandstones stratified, and containing organic remains, a tolerably well-marked series may be traced. In the adjoining and smaller island Tobago some of the same series are observable, but in a broken manner, not a little interesting and instructive. There, highly crystalline rocks, destitute of organic reremains, are in juxtaposition with others abounding in these remains; coral rock is even found resting on granite; and in another situation the latter rock is contiguous to mica slate, in which quartz in mass is not of rare occurrence.

On the Differences between Progressive, Embryonic, and Prophetic Types in the Succession of Organized Beings through the whole Range of Geological Times.

It was a great improvement in our zoological investigations when the differences in their relations, according to the various degrees of affinity or analogy which exist between animals, were pointed out, and successively better understood. In earlier times, zoologists made no distinction between the different relations which existed among animals. Affinity and analogy, so dissimilar in their essential characters, were constantly mistaken one for the other; and upon the peculiarities which struck the observer most at first sight, animals were brought together, sometimes upon the ground of true affinity, sometimes, also, upon the ground of close analogy; and though comparative anatomy did put the mistakes arising from such confusion right, by showing that external appearances were sometimes deceptive, and that a more intimate knowledge of internal structure was necessary fully to understand the real relations between animals, there remained, nevertheless, a degree of uncertainty in may cases, as long as the principles of affinities and of analogies were not fully distinguished. Every naturalist now knows that true relationship—affinity—depends upon a unity in structure, however diversified the forms may be under which their fundamental structure is displayed. For instance, the affinity of whales and the other mammalia was not understood before it was shown that, under the form of fishes, these animals had truly the same structure as the highest *vertebrata*.

Again, the forms of *cetacea* exemplify the analogy there is between whales and fishes. They are *related* to mammalia; they are *analagous* to fishes; they bear close affinity to the mammals which nurse their young with milk; they have rather close analogy to the gill-breathing fishes.

Since the fossil animals which have existed during former periods upon the surface of our globe, and which have successively peopled the ocean and the dry land, have been more carefully studied than they were at the beginning of these investigations; since they are no longer considered as mere curiosities, but as the earlier representatives of an order of things which has been gradually and successively developed throughout the history of our globe, facts have been brought to light which now require a very careful examination, and will lead to a more complete understanding of the various relations which exist between these extinct types and those which still continue to live in our days. Upon close comparison of these facts, I have been led to distinguish two sorts of relations between the extinct animals, and those of our days, which seem to me to have been either overlooked or not sufficiently distinguished. Indeed, the general results derived from Palæontological investigations, seem scarcely to have gone beyond showing that the animals of former ages are specifically and frequently also generically distinct from those of the present creation; and also to establish certain graduation between them, agreeing more or less with the degree of perfection which we recognise between the living animals according to their structure.

It is now pretty generally understood that fishes, which rank lowest among the *Vertebrata*, have existed alone during the oldest periods; that the reptiles which, in the gradation of structure, rank next above them, have followed at a later period; that still later the birds, which, according to their anatomy, rank above reptiles, have next made their appearance; and that mammalia, which stand highest, have been introduced last, and even among these the lower families seem to have been more numerous, before the higher ones prevailed over them. Man, at last, has been created, only after all other types had acquired their full development. These facts which, in such generality are fully exemplified in every country in the order of succession of the different fossil characteristics of the various geological deposits, shew plainly that a gradation really exists in this succession, and constitutes one of the most prominent characters of the development of the animal kingdom as a whole.

If we investigate, however, this gradation, and the order of succession of animals more closely, we cannot but be struck with the different relations which exist between the fossils and the living animals. Many extinct types have been pointed out as characteristic of different geological periods, which combine, as it were, peculiarities which at present are found separately in different families of animals.

I may mention as such, the *Ichthysaur*, with their fish-like vertebræ, their dolphin or porpoise-like general form, and several special characters reminding us of their close relation to the Crocodilian reptiles; thus combining characters of different classes in the most extraordinary manner.

Again, the *Pterodactyli*, in which reptilian characters are combined with peculiarities reminding us both of birds and bats.

Again, the large carniverous fishes of the coal period, combining peculiarities of the *Saurians*, with true fish characters; and so on.

These relations are of an entirely different kind from those which I have pointed out between some of the older fossils and the early stage of growth of the living representatives of the same families.

For instance, the fossil fishes with a heterocercal tail, found below the new red sandstone, down to the lowest deposits, reminds us of the peculiar termination of the vertebral column in all fish embryos of species living in the present period, to whatever family they may belong, indicating a similarity of structure in the oldest representative of this class, with the earliest condition of the germs of those animals in our days.

Let us now examine whether we can properly understand the bearings of these relations, and the meaning of such differences.

In the first place, I have mentioned the gradual progress, which is observed in the succession of the different classes of *Vertebrata*. This progress is exemplified by a series of types which differ from each other, but which shew, when arranged in a series, a gradation which agrees in general with the structural gradation, which we may establish upon anatomical evidence. For instance, the salamanders, with their various forms, rank below the tailess *Batrachians*.

And where we have a succession of these animals in the tertiary deposits as they occur in various parts of Europe, we may fairly say that the fossils form, in their succession, a series of progressive types.

Another example may perhaps illustrate the point more fully. The *orthocera* of the oldest periods precede the curved lituites, which, in their turn, are followed by the circomvolute nautilus. Here, again, we have a natural gradation of a series of progressive types. Again, among *crinoids*, we find, in the older deposits, a variety of species resting upon a stem, while free crinoids begin to appear only during the secondary deposit and prevail, in the present creation, over those attached to the soil. Here, again, we have a series of progressive types developed successively, which are apparently independent of each other and seem to bear no other relation to each than that arising from the general character of the group to which they belong. Such types exemplify simply in the groups to which they belong, a real progress in the successive development of the peculiarities which characterise them as natural divisions among animals. Such forms I shall call *Progressive Types.*

The relations, however, which are exemplified in the oldest fishes, in the ichthyosaurians, in the pterodactyls or in the megalosaurians, seem to me to be clearly of a different character, and to differ from simple progressive types, inasmuch as those which appear earlier, combine peculiarities which, at a later period, appear separately in distinct forms. For instance, the reptilian characters which we recognise in the sauroid fishes, are developed at a later period in animals no longer belonging to the class of fishes, but constituting by themselves new types, provided with additional peculiarities which separate them fully from the fishes in general, as well as from those fishes in which we recognise some relation to reptiles during a period when no reptile existed.

Again, the ichthyosaurians, though true reptiles appearing long after fishes had been called into existence, and during an early period of the history of the reptiles, still shew their relation to fishes by the character of their vertebral column, and foreshadow, as it were, in their form, the cetacea of later ages, as well as many forms of the gigantic saurians of the secondary period. The same may be said of the pterodactyls, which are also true reptiles, but, in which the anterior extremity foreshadow peculiarities characteristic of birds and bats. Such types I shall call *Prophetic Types.*

To an analytic mind the examination of the peculiarities of such animals may fortell a higher progress of development, carried out in real existence, only during a later period, even if he had never seen the later ones; for in such types the germs of a future development may be recognised, and upon close examination, truly referred to the peculiarities of other higher groups, even if the intermediate links remained unknown, which, however, as the matter now stands, can leave no doubt in our mind that these prophetic types really foreshadowed that diversity of forms which has been created since they have gone by. We may also say that these prophetic types lay before us the course of thoughts which has been carried out in the plan of creation by the Supreme intelligence, who called them into existence in rich order of succession, and in so diversified relations. The recognition of this prophetic character of certain types of extinct animals is not only important in a philosophical point of view; I have no doubt it will ultimately and rapidly lead to a better, fuller, higher, and deeper understanding of the various relations which exist between animals. Let me at once point to some of these relations which might never have been understood but for this appreciation.

Among Crinoids, we have not only progressive types, as I have already quoted, but we have also prophetic ones. The Cystidæ are truly prophetic of the Echini proper. I may only mention the genus Echinocrinus to shew the link.

The Pentremites, again, are the prophetic type foreshadowing the starfishes. And often in subordinate groups we may find such close relations between genera of the same minor divisions; such, for instance, as the genus Encrinus, in which the genera Apiocrinus and Pentacrinus, are simultaneously foreshadowed. Perhaps, in this case, a distinction might be introduced between truly prophetic types and synthetic types, in which the characters of later groups are rather more combined than really foreshadowed.

As for the relation between older types and the embryos of the living representatives of the same families which are so extensively observed in almost all groups of the animal kingdom, which have existed during earlier periods, it may best be expressed if we call those fossils which exemplify, in full grown animals, forms which exist at present only in the earliest stages of growth of our living animals, *Embryonic Types*, in counterdistinction from the progressive types, and from the prophetic types. These embryonic types may be purely such, or they may be at the same time either progressive types, or even prophetic types. I shall call purely embryonic types those in which we recognise peculiarities characteristic of the embryo of the same family. For instance, the older Sauroids, which have the upper lobe of the tail prolonged, or the common Crinoids provided with a stem, which resemble the young Comatulæ, &c., &c. I shall distinguish, as progressive embryonic types, those in which we recognise simultaneously a relation to the embryo of the same family, when they form besides a link in the natural chain of progressive development. Such, for instance, as the oldest Salamanders, or the earliest Sirenoid Pachyderm. Finally, I shall call prophetic embryonic types those in which we have embryonic characters, combined with the peculiarities which stamp the type as a prophetic one, such, for instance, as the Echinoid and Asteroid Crinoids of the former ages.

The fact that these different types may thus present complications of their character, or appear more or less pure and typical, goes further to shew how deeply diversified the plan of creation is, and how many relations should be simultaneously understood before we are prepared to have a full insight into the plan of creation. There we see one type forming simply, and alone, the first link of a progressive series. There we see another which foreshadows types, which appear isolate afterwards. There we see a third, which, in its full development, exemplifies a state which is transient only in higher representatives of the same family. And then, again, we see these different relations running into each other, and reminding us that, however difficult it may be for us to see at one glance all this diversity of relations, there is, notwithstanding, an intelligence which not only conceived these various combinations, but called them into real existence in a long succession of ages.—*L. Agassiz in the American Association for the Advancement of Science*, August 1849.

On a new Analogy in the Periods of Rotation of the Primary Planets discovered by Daniel Kirkwood of Pottsville, Pennsylvania.

At the recent meeting of the Association for the Advancement of Science, an announcement was made, which, if it is found to be correct, will be regarded as relating to one of the most important discoveries which have been made in astronomy for years. It is no less than a new law of the solar system, closely resembling those of Kepler, which form the groundwork of many of the problems of astronomy. Mr S. C. Walker read to the Association a letter from Mr Daniel Kirkwood, of Pottsville, Pa., the discoverer of this new law, from which we make some extracts, omitting all that refers to the higher branches of mathematics.

" While we have in the law of Kepler a bond of mutual relationship between the planets, as regards their revolutions around the sun, it is remarkable that no law regulating their rotations on their axes has ever been discovered. For several years I have had little doubt of the existence of such a law in nature, and have been engaged, as circumstances would permit, in attempting its development. I have at length arrived at results, which, if they do not justify me in announcing the solution of this important and interesting problem, must at least be regarded as astonishing coincidences."

After stating some equations, he gives the following tables as the data on which he has proceeded :—

Planet's name.	Mean dist. from the sun in miles.	Mars.	Square root of Mars.	No. of rotations in one sid. period.
Mercury, . .	36,814,000	277,000	526·3	87·63
Venus, . . .	68,787,000	2,463,836	1·569·6	230·90
Earth, . . .	95,103,000	2,817 409	1·678·5	366·25
Mars, . . .	144,908 000	392,735	626·7	669·60
Jupiter, . .	494,797,000	953,570,222	30·879·8	10·471·00
Saturn, . . .	907,162,000	284,738,000	16·874·1	24·620·00
Uranus, . .	1,824,290,000	35,186,000	5·931·5	

From these data he deduces the following law:—" The square of the number of a primary planet's days in its year, is as the cube of the diameter of its sphere of attraction in the nebular hypothesis."

" The points of equal attraction between the planets severally (when in conjunction), are situated as follows:—

	Miles from the former.	Miles from the latter.
Between Mercury and Venus,	8,029,600	23,943,400
" Venus and the Earth,	12,716,600	13,599,400
" Earth and Mars,	36,264,600	13,540,400
" Jupiter and Saturn,	266,655,000	145,710,000
" Saturn and Uranus,	678,590,000	238,538,000

" It will be seen from the above, that the diameter of the earth's sphere of attraction is 49,864,000 miles. Hence the diameters of the respective spheres of attraction of the other planets, according to my emperical law, will be found to be as follows:—

	Diameter of sphere of Attraction.
Mercury, . . .	19,238,000
Venus, ...	36,660,000
Mars, ...	74,560,000
Jupiter, ...	466,200,000
Saturn, ...	824,300,000

" The volumes of the sphere of attraction of Venus, Mars, and Saturn in this table, correspond with those obtained from the preceding one; that of Mars extending 61,000,000 miles beyond his orbit, or to the distance of 206,000,000 miles from the sun. This is about 2,000,000 or 3,000,000 miles less than the mean distance of Flora, the nearest discovered asteroid. That of Mercury extends about 11,000,000 miles within the orbit; consequently, if there be an undiscovered planet interior to Mercury, its distance from the Sun, according to my hypothesis, must be less than 26,000,000 miles. Jupiter's sphere of attraction extends only about 200,000,000 of miles within his orbit, and leaving 89,000,000 miles for the asteroids. It is only in the most distant portion of this space, where small bodies would be likely to be detected, that none have yet been discovered."

Mr Kirkwood then modestly concludes:—

"The foregoing is submitted to your inspection with much diffidence. An author, you know, can hardly be expected to form a proper estimate of his own performance. When it is considered, however, that my formula involves the distances, masses, annual revolutions, and axial rotations of all the primary planets in the system, I must confess I find it difficult to resist the conclusion, that the law is founded in nature."

After this letter had been read, Mr Walker said, that, induced by the importance of the subject, he had at once proceeded to verify the data and conclusions of Mr Kirkwood, and had found that there was nothing in them requiring modification, except, perhaps, the substitution of some more recent values for the masses of Mercury and Uranus. This theory and that of Laplace, with reference to nebulæ, mutually strengthen each other; although the latter has been a mere supposition, while the former rests upon a mathematical basis. In a later letter, which was also read, Mr Kirkwood says that he has pursued this subject for the last ten years, it having been first suggested to him by the nebular hypothesis, which he thought could be established by some law of rotation.

Mr Walker then entered into a lengthened examination of the data on which the law rests, and seemed to come to the conclusion, that, as far as we know at present, everything is in favour of the truth of the law, except that it requires the assumption of another planet between Jupiter and Mars.

Mr Walker closed his examination by saying, "We may, therefore, conclude, that, *whether Kirkwood's analogy is or is not the expression of a physical law, it is, at least, that of a physical fact in the mechanism of the universe*. The quantity on which the analogy is based has such immediate dependence upon the nebular hypothesis, that it lends strength to the latter, and gives new plausibility to the presumption that this, also, is a fact in the past history of the solar system.

"Such, then, is the present state of the question. Thirty-six elements of nine planets (four being hypothetical) appear to harmonize with Kirkwood's analogy in all the four fundamental equations of condition for each planet.

"To suppose that so many independent variable quantities should harmonize together by accident, is a more strained construction of the premises than the frank admission that they follow a law of nature.

"If, in the course of time, the hypotheses of Laplace and Kirkwood should be found to be the laws of nature, they will throw new light on the internal organization of the planets in their present, and in any more primitive, state through which they may have passed.

"For instance, we may compute the distance from the centre at which any planet must have received its projectile force, in order to produce, at the same time, its double movement of translation and rotation.

"If the planet, in a more primitive state, existed in the form of a ring revolving round the Sun, having its present orbit for that of the centre of gravity of the ring, the momentum of rotation must, by virtue of the principle of conservation of movement, have existed in some form in the ring. It is easy to perceive that this momentum is precisely the amount which must be distributed among the particles of the ring, in order to preserve to all the condition of dynamical equilibrium, while those of each generating surface of the ring were wheeling round with the same angular velocity.

"If the planets have really passed from the shape of a revolving ring to their present state, the prevalence of Kirkwood's analogy shews a nice adaptation of parts in every stage of the transition.

"If the primitive quantity of coloric (free and latent) had undergone a very great change beyond that now indicated in the cooling of their crusts; if the primitive quantity of movement of rotation had been different from its actual value for any planet; if the law of elasticity of particles for a given temperature and distance from each other varied from one planet to another in the primitive or present state; in either of these cases, the analogy of Kirkwood might have failed. As it is, no such failure is noticed; we are authorised, therefore, to conclude, that the primitive quantity of coloric, the law of elasticity, the quantity of movement of rotation, the past and present radii of percussion, the primitive diameter of the generating surface of the rings, and the present dimensions and density of the planets, have been regulated by a general law, which has fulfilled for all of them the four fundamental conditions of Kirkwood's hypothethis.

"We may extend the nebular hypothesis and Kirkwood's analogy to the secondary system. If they are laws of nature, they must apply to both. In the secondary systems, the day and month are the same. This fact has remained hitherto unexplained. Lagrange shewed that if these values were once nearly equal, a libration sets in round a state of perfect equality; but he offered no conjecture as to the cause of the primitive equality. On the nebular and Kirkwood's hypothesis, it would only be necessary that, upon the breaking up of the ring, the primitive diameter of the generating figure and law of relative density of layers should be preserved."

Professor Peirce, whose opinions will probably be regarded as of more value on such a subject than that of any other man in this country,—especially since his successful discussion with Leverrier,—remarked, that Kirkwood's analogy was the only discovery of the kind since Kepler's time that approached near to the character of his three physical laws. Bode's law, so called, was at best only an imperfect analogy. Kirkwood's analogy was more comprehensive, and more in harmony with the known elements of the system. The diameter of the sphere of attraction, a fundamental element in this analogy, now for the first time gave an appearance of reality to Laplace's nebular hypothesis which it never had before. The positive testimony in its favour would now outweigh the former negative evidence in the case, however strong it may have been. It follows at least from Kirkwood's analogy, that the planets were dependent upon each other, and therefore connected in their origin, whatever may have been the form of the connection, whether that of the nebular hypothesis, or some other not yet imagined.

At a later period of the meeting, M. B. A. Gould junior, stated that he had gone through the necessary calculations, using different quantities, and had come to the same conclusions as Mr Walker. He expressed his opinion, that at some future day the world will "speak of Kepler and Kirkwood as the discoverers of great planetary laws."

The members generally expressed the opinion, that Laplace's nebular hypothesis, from its furnishing one of the elements of Kirkwood's law, may now be regarded as an established fact in the past history of the solar system.—*American Annual of Scientific Discovery*, p. 335.

Note.—Such, at least, is rather a representation of American opinions than of our own. We are inclined to compare it more with Bode's law than with Kepler's. The former is a mere arithmetical accident, applying indifferently well to a portion only of the planets, and having nothing of reason to advance for its establishment. The latter are essential parts of mechanics and gravitation, and precisely and perfectly, and necessarily true, not only in every part of the solar system, but through the whole universe.

The fact of axial rotations being the groundwork of Kirkwood's analogy seems fatal to it, for gravitation takes no more account of the time of rotation of a planet than it does of specific gravity; all calculations of the movement of the body in space are equally independent of the one and the other.

Under these circumstances, the degree of accuracy with which it may be found to apply is the only saving clause. Messrs Walker and Gould investigating the subject independently, and with better constants of mass and distance than Kirkwood had been able to procure, declare that it appears *perfectly!* We are sorry that the late hour at which we have received this paper has prevented us either from giving it in full, or from testing the theory rigidly.

It will be observed that, according to Kirkwood's theory, in order to compute the time of axial rotations of any planet, it is necessary to have its mass and mean distance, together with the same quantities for the planets on either side of it. Now, these quantities are only obtainable for Venus, the Earth, Saturn, and Uranus (a planet being lost between Mars and Jupiter); and the rotation of Uranus not having been obtained as yet, there remains only the three first by which the theory can be tested.

In a preliminary calculation which we have instituted, we do not find the results so accordant as we had been led to expect, but still sufficiently so to give a certain probability of the approach to truth, in a case where the quantity had not been observed.

Viewed in this light, some very interesting results are obtained.

1*st*, The idea entertained by Bianchini and other observers, that the rotation of Venus is nearly 24 times as long as hitherto supposed, is utterly untenable.

2*d*, The time of rotation of Uranus, a quantity never yet observed (but doubtless capable of being observed by a telescope of Lord Rosse's calibre, *removed to a table-land in a tropical country*) is given; and appears so very different from any other yet observed, especially so from those of its neighbours Saturn and Jupiter, being =1·396779, earth's = 0·997270 (sidereal rotation in mean solar days.)

3*d*, Knowing the rotations of Jupiter and Mars, we may supply, by using the analogy conversely, the *diameters of their spheres of attraction*, and thus get at the elements of the lost planet between Mars and Jupiter, and these appears to be;—mean distance = 2·9085111 (earth unity), mass in terms of Sun $\frac{1}{1353240}$, sidereal rotation in earth's mean solar days 2·406104, and diameter of sphere of attraction 0·830951, in terms of earth's distance. The size is thus a little larger than Mars. The slowness of rotation is remarkable, especially in the case of a planet which is supposed since to have burst into pieces: the Americans have called it Kirkwood.

P. S.

SCIENTIFIC INTELLIGENCE.

METEOROLOGY.

1. *Use of Coloured Glasses to assist the View in Fogs.*—M. Lavini of Turin, in a letter to the editor of *L'Institut* at Paris, makes the following curious observation, which, if confirmed, may prove to be of great importance:—" When there is a fog between two corresponding stations, so that the one station can with difficulty be seen from the other, if the observer passes a coloured glass between his eye and the eye-piece of his telescope, the effect of the fog is very sensibly diminished, so that frequently the signals from the other station can be very plainly perceived; when, without the coloured glass, even the station itself is invisible. The different colours do not all produce this effect in the same degree, the red seeming to be the best. Those who have good sight prefer the dark-red, while

those who are short-sighted like the light-red better. The explanation of this effect seems to depend upon the fact, that the white colour of the fog strikes too powerfully upon the organ of sight, especially if the glass have a somewhat large field. But by the insertion of the coloured glass, the intensity of the light is much diminished by the interception of a part of the rays, and the observer's eye is less wearied, and, consequently, distinguishes better the outlines of the object observed."

2. *Ozone.* — Chemists are not yet fully agreed concerning the nature or production of this singular substance, ozone. To Schonbein and Williamson we are indebted for most of our knowledge concerning it. The latter has supposed it to be a compound of oxygen and hydrogen, from the fact, that, when the ozone completely freed from moisture was passed over ignited copper, water was produced. De la Rive produced it by passing a current of electricity through pure dry oxygen gas contained in a receiver. It is also obtained in large quantities by passing oxygen gas over moistened phosphorous, and afterwards drying it. Thus prepared, it is a powerful chemical agent, possesses bleaching properties, oxidises the metals with rapidity, and destroys India-rubber. The hydrogen acids of sulphur are decomposed by it, water being formed by uniting with the hydrogen of the acid, and sulphur being set free. Professor Horsford has observed that ozone, subjected to a heat of 130° Fah., entirely loses its properties. Ozone, like chlorine, precipitates iodine, colouring a solution of iodide of potassium, and starch a deep blue colour. The peculiar smell, prevalent in the vicinity of objects struck by lightning, as well as that occasioned by the excitation of an electrical machine, and by the striking of two pieces of silica together, it is believed to be occasioned by ozone.—*Editors.*—*Annual of Scientific Discovery*, p. 219.

Method of Determining the Amount of Ozone in the Atmosphere. —At the meeting of the American Association, an instrument for determining the relative quantity of ozone in the air was presented by Professor Horsford. It consisted of a tube, containing at one end a plug of asbestus, moistened with a solution of iodide of potassium and starch. This plug within the tube, attached to an aspirator, would, as air passed over it, become blue. If much water flowed from the aspirator, and of course much air flowed over the asbestus before it became blue, the quantity of ozone indicated would be small. If but little water flowed (and this could be measured), the quantity of ozone indicated would be greater. The quantities of ozone would be inversely as the volumes of air passing through the tube before blueness is produced.—*Annual of Scientific Discovery*, p. 219.

HYDROGRAPHY.

3. *On the Phenomena of the Rise and Fall of the Waters of the Northern Lakes of America.*—At a meeting of the American Academy, February 1849, Mr Foster, of the United States Mineral Survey in the North-west Territory, presented the result of some observations, undertaken with a view of determining whether the waters of the northern lakes are subject to any movements corresponding to tidal action. The result of these observations had convinced him that these waters do not rise and fall at stated periods, corresponding to the ebb and flow of the tide, but are subject to extraordinary risings, which are independent of the influence of the sun and moon. These risings attracted the attention of the earliest *voyageurs* in these regions. Charlevoix, who traversed the lakes nearly a century ago, says, in reference to Lake Ontario :—" I observed that in this lake there is a sort of reflux and flux almost instantaneous ; the rocks near the banks being covered with water, and uncovered again several times in the space of a quarter of an hour, even if the surface of the lake was very calm, with scarce a breath of air. After reflecting some time on this appearance, *I imagined it was owing to springs at the bottom of the lake, and to the shock of their currents with those of the rivers which fall into them from all sides, and thus produce those intermitting motions.*" The same movements were noticed by Mackenzie in 1789 ; by an expedition under Colonel Bradstreet in 1764 ; on Lake Erie in 1823, and at various later periods. In the summer of 1834, an extraordinary retrocession of the waters of Lake Superior took place at the outlet of Sault St Marie. The river at this place is nearly a mile wide, and in the distance of a mile falls 18·5 feet. The phenomena occurred about noon. The day was calm, but cloudy. The water retired suddenly, leaving the bed of the river bare, except for a distance of thirty rods, and remained so for nearly an hour. Persons went out and caught fish in pools formed in the depressions of the rocks. The return of the waters is represented as having been very grand. They came down like an immense surge, and so sudden was it, that those engaged in catching fish had barely time to escape being overwhelmed. In the summer of 1847, on one occasion the water rose and fell at intervals of about fifteen minutes during an entire afternoon. The variation was from twelve to twenty inches, the day being calm and clear ; but the barometer was falling. Before the expiration of forty-eight hours, a violent gale set in. At Copper harbour, the ebb and flow of the water through narrow inlets and estuaries has been repeatedly noticed when there was not a breath of wind on the lake. Similar phenomena occur on several of the Swiss lakes. Professor Mather, who observed the barometer at Copper harbour during one of these fluctuations, remarks :—" As a general thing, fluctuations in the barometer accompanied fluctuations in the level of the water ; but some-

times the water-level varied rapidly in the harbour, while no such variations occurred in the barometer at the place of observation."

As a general rule, these variations in the water-level indicate the approach of a storm, or a disturbed state of the atmosphere. The barometer is not sufficiently sensitive to indicate the sudden elevations and depressions, recurring, as they often do, at intervals of ten or twelve minutes; and the result of observations at such time may, in some degree, be regarded as negative. Besides, it may not unfrequently happen, that, while effects are witnessed at the place of observation, the cause which produced them may be so far removed as not to influence the barometer. We are, therefore, led to infer that these phenomena result, not from the prevalence of the winds acting on the water, accumulating it at one point and depressing it at others, but from sudden and local changes in the pressure of the atmosphere, giving rise to a series of barometric waves. The water, conforming to the laws which govern two fluids thus relatively situated, would accumulate where the pressure was the least, and be displaced where it was the greatest. It has been remarked by De la Beche, that a sudden impulse given to the particles of water, either by a suddenly increased or diminished pressure, would cause a perpendicular rise or fall, in the manner of a wave, beyond the height or depth strictly due to the mere weight itself. The difference in the specific gravity of the water of the lakes and the ocean may cause these changes to be more marked in the former than in the latter.—*American Annual of Scientific Discovery*, p. 245.

4. *Water Thermometer.*—Lieut. Maury states that he has been very much assisted in developing his theory of winds and currents by means of the thermometer used by some vessels for determining the temperature of the water. It was by means of these observations on the temperature of the water that he was enabled to prove that, off the shores of South America, between the parallels of 35° and 40° south, there is a region of the ocean in which the temperature is as high as that of our own Gulf stream, while in the middle of the ocean, and between the same parallels, the temperature of the water is not so great by 22°. Now, this very region is noted for its gales, being the most stormy that the as yet incomplete charts of the South Atlantic indicate. Lieut. Maury says, however, that very few navigators make use of the water thermometer, so that he has experienced some inconvenience in his undertaking. He is the more surprised at this, from the fact that New York owes much of her commercial importance to a discovery that was made by this thermometer. At the time when Dr Franklin discovered the Gulf Stream, Charleston had more foreign trade than New York and all the New England States together. Charleston was then the half-way house between New and Old England. When a vessel, in attempting to enter the Delaware or Sandy Hook, met a north-west gale or snow storm, as at certain seasons she is apt to do, instead of

running off for a few hours into the Gulf Stream to thaw and get warm, as she now does, she used to put off for Charleston or the West Indies, and there remained till the return of spring before making another attempt. A beautiful instance this of the importance and bearings of a single fact, elicited by science from the works of nature.—*Annual of Scientific Discovery*, p. 160.

5. *On the Falls of Niagara.*—If we follow the chasm cut by the Niagara river, down to Lake Ontario, we have a succession of strata coming to the surface of various character and formation. These strata dip south-west or towards the Falls, so that, in their progress to their present position, the Falls have had a bed of very various consistency. Some of these strata, as the shales and medina sandstone, are very soft, and, when they formed the edge of the Fall, it probably had the character of rapids; but, wherever it comes to an edge of hard rock, with softer rock-beds below, the softer beds, crumbling away, leave a shelf projecting above, and then the fall is perpendicular. Such is the case at present; the hard Niagara limestone overhangs in *tables* the soft shales underneath, which at last are worn away to such an extent as to undermine the superincumbent rocks. Such was also the case at Queenston, where the Clinton group formed the edge, with the medina sandstone below. This process has continued from the time when the Niagara fell directly into Lake Ontario to the present time, and will continue so long as there are soft beds underneath hard ones; but, from the inclination of the strata, this will not always be the case. A time will come when the rock below will also be hard. Then, probably, the Falls will be nearly stationary, and may lose much of their beauty from the wearing away of the edge rendering it an inclined plane. I do not think the waters of Lake Erie will ever fall into Lake Ontario without any intermediate cascade. The Niagara shales are so extensive that possibly, at some future time, the river below the cascade may be enlarged into a lake, and thus the force of the falling water diminished; but the whole process is so slow, that no accurate calculations can be made. The Falls were probably larger, and stationary for a longer time at the "Whirlpool" than anywhere else. At that point there was no division of the cataract, but at the "Devil's Hole" there are indications of a lateral fall, probably similar to what is now called the American Fall. At the Whirlpool, the rocks are still united beneath the water, shewing that they were once continuous above its surface also.*—*Agassiz on Lake Superior*, p. 15.

6. *On the Existence of Manganese in Water.*—At a meeting of the American Academy, in January 1849, Dr Charles T. Jackson

* The data on which these and the previous remarks on the geology of the Falls are founded, are derived from Professor James Hall's investigations in the New York State Survey. A.

stated that he had discovered the presence of manganese in the water of streams, lakes, &c., almost universally. He detected it in water from the middle of Lake Superior, in Cochituate water, and in water from various sources. It has usually been regarded as iron in previous analyses. He considered the observation as having an important bearing in accounting for the deposits of bog manganese at the outlets of ponds, lakes, and in bogs, as well as for the source of the oxide of manganese in the blood.—*Annual of Scientific Discovery*, p. 202.

On the Presence of Organic Matter in Water.—The following facts relative to the presence of organic matter in water were presented to the British Association, by Professor Forchhammer, as the result of extended observations on the water, near Copenhagen.

1*st*, The quantity of organic matter in water is greatest in summer. 2*d*, It disappears, for the most part, as soon as the water freezes. 3*d*, Its quantity is diminished by rain. 4*th*, Its quantity is diminished if the water has to run a long way in open channels. The hypermanganate of potash or soda is recommended by the Professor as a most excellent test for the presence of organic matter in water.

7. *Arsenic in Chalybeate Springs.*—Since the discovery of arsenic in the deposits from certain chalybeate springs, it has been asked whether the poisonous properties of this substance are not neutralized by the state in which it is found. M. Lassaigne has finished a series of experiments connected with this subject, for the purpose of ascertaining the proportion of arsenic contained, in what state of combination it exists, and the nature of the action which these arseniferous deposits exert in the animal economy. The following are M. Lassaigne's conclusions:—1. In the natural deposits of the mineral waters of Wattviller, arsenic exists to the amount of 2·8 per cent. 2. A portion of these deposits, representing 1·76 grains of arsenic acid, or 1·14 grains of arsenic, produced no effect upon the health of a dog. 3. This non-action shews that the poisonous property of the arsenic is destroyed by its combination with the peroxide of iron, and thus confirms what has been before asserted, that peroxide of iron, by combining with arsenuous and arsenic acid, destroys their poisonous properties, and consequently becomes an antidote for them.

GEOLOGY.

8. *The Coal Formation of America.*—The coal regions of America are, from the explorations which have thus far been made, supposed to be divided into three principal masses; the great central tract, extending from Tuscaloosa, Alabama, to the west of Pennsylvania, and being apparently continued to New Brunswick and Novia Scotia; the second tract strikes north-westward from Kentucky, crosses the Ohio, and stretches through Illinois to the Mississippi River; a third

region, smaller than the others, lies between the three great lakes—Erie, Huron, and Michigan. Competent geologists affirm that, fro a comparison of the coal strata of contiguous basins, these are no more than detached parts of a once continuous deposit.

The extent of this enormous coal field is, in length, from north-east to south-west, more than 720 miles, and its greatest breadth about 180 miles; its area, upon a moderate calculation, amounts to 63,000 square miles! In addition to these, there are several detached tracts of anthracite in Eastern Pennsylvania, which form some of the most remarkable coal tracts in the world. They occupy an area of about 200 square miles.

The strata which constitute this vast deposit comprehend nearly all the known varieties of coal, from the dryest and most compact anthracite to the most fusible and combustible common coal. One of the most remarkable features of these coal-seams is their prodigious bulk. The great bed of Pittsburg, extending nearly the entire length of the Monongahela River, has been traced through a great elliptic area, of nearly 225 miles in its longest diameter, and of the maximum breadth of about 100 miles, the superficial extent being 14,000 square miles, the thickness of the bed diminishing gradually from 12 or 14 feet to 2 feet. In 1847 the anthracite coal regions of Pennsylvania furnished 3,000,000 tons, and 11,439 vessels cleared from Philadelphia in that year, loaded with the article. The produce in 1848 and the present year, is of course larger.

The bituminous coal area of the United States is 133,132 square miles, or one 17th part of the whole. The bituminous coal area of British America is 18,000 square miles, or one 45th part; Great Britain, 8139 square miles; Spain, 3408 square miles, or one 52d part; France, 1719 square miles, or one 118th part; and Belgium, 518 square miles, or one 122d part. The area of the Pennsylvania anthracite coal formations is put down at 437 square miles; and that of Great Britain and Ireland anthracite and culm, at 3720 square miles. The anthracite coal of Great Britain and Ireland, however, is not nearly so valuable an article of fuel as the anthracite coal of Pennsylvania, nor does a given area yield so much as the latter.—*New York Express. American Annual of Scientific Discovery*, p. 271.

8. *River Terraces of the Connecticut Valley.*—At the meeting of the American Association in August, President Hitchcock of Amherst College, read a paper "On the River Terraces of the Connecticut Valley, and on the Erosions of the Earth's Surface." He stated that his paper must be considered as containing a few facts and suggestions and not a finished theory. He has examined the valley from its mouth to Turner's Falls, and carefully measured the heights of the terraces. "As you approach the river you find plains of sand, gravel, or loam, terminated by a slope sometimes as steep as 35°, and a second plain, then another slope and another plain,

and so on, sometimes to a great number. I find that these terraces occur in successive basins, formed by the approaches of the mountains upon the banks at intervals. Sometimes the basin will be 15 or 20 miles in width, but usually much narrower; and it is upon the margins of these basins that the terraces are formed. I have rarely found terraces more than 200 feet above the river, which would be in Massachusetts, about 300 feet above the ocean, and at Hanover, N.U., about 560 feet. Nowhere do they exist along any river, unless that river has basins. As to the materials of which they are formed they appear exceedingly artificial. The outer or highest terrace is generally composed of coarser materials than the inner ones. They are all composed of materials which are worn from the rocks, but the outer terrace oftener is full of pebbles, some of them as large as 12 inches, while the materials of the inner seem reduced to an impalpable powder, like the soil of a meadow which is overflowed during high water. Whence did these materials originate? The materials were first worn from solid rocks, and afterwards brought into these valleys. The outer terrace appears to have been often in part the result of the drift agency. Afterwards, the river agency sorted the materials, and gave them a level surface, the successive basins having at that time barriers. The inner terrace appears to have been, at least in its upper part, the result of deposition from the river itself.

"I will now mention a few facts which I have observed. The terraces do not generally agree in height upon the opposite sides of the valley. The higher ones oftener agree, perhaps, than the lower ones. If formed, as I suppose, from the rivers, we should expect this. The terraces slope downwards in the direction of the stream. The same terrace which, near South Hadley, is 190 feet above the river, slopes until, at East Hartford, it is only 40 feet above the river, thus sloping 150 feet more than the slope of the river itself, in a distance of 40 or 50 miles. This shows that they could not have been formed by the sea or by a lake, for they would then have been horizontal. The greatest number of terraces observed is eight or nine. Generally there are but two or three." President Hitchcock then gives his view of the precise mode in which these terraces were formed, illustrating them by references to other parts of our country, and concludes by a notice of the erosions of the earth's surface.—*Annual of Scientific Discovery*, 1850, p. 229.

ZOOLOGY.

10. ***Fossil Crinoids of the United States.***—At the meeting of the American Association, 1849, a paper on the fossil crinoids of Tennessee, by Professor Troost, was read by Professor Agassiz.* The

* These fossiliferous remains were discovered in the carbonaceous and silurian strata of the State, and shew a wonderful development of that form of ani-

species embraced are not less than eighty-eight in number, of which only half a dozen have been described. It is the opinion of Professor Hall that all the silurian formations of New York, previous to the beginning of the geological survey, did not afford more than four or five. Now, about sixty species have been ascertained. Professor Hall mentioned the fact, that all the crinoids of the lower silurian rocks, with the exception of one species, have five pelvic plates, and we never find one with three, or any other number of these plates, before we reach the highest deposits. In Tennessee, the crinoids are so abundant, that Professor Troost states that he had been able to collect some 300 or 400 good specimens of seven or eight different species in a single morning. In relation to the abundance of these fossils in the United States, Professor Agassiz remarked, that it is not, perhaps, sufficiently appreciated of what importance, and of what immense value the study of these fossil crinoids may be for the progress of palæontology. American students should be proud of these materials, by which they will be able to throw so much light upon these almost extinct families by their personal investigations, which will not only render them independent of the palæontologist from abroad for information with regard to the succession of types, and the full illustration of these structures, but really afford correct standards for comparison. It is the more desirable that all these fossils should be made known, as the family of crinoids is so reduced in our days that we can form no idea of the living animals of that group, of their diversity of form, modification of character, and peculiarity of position, from the living type only. He doubted whether the number of crinoid heads of all species found in Europe, now existing in the Museums of Europe, is one-third the number of those which have been found by a single gentleman in Tennessee in one morning. Now, with such materials, consider what precise and what minute investigations could be made. And if these facts could be once fully ascertained and well illustrated, there is no doubt that the series of crinoids, and their succession in former ages, will be established from American standards, and will no longer rest upon the European evidence, which has often been derived from the examination of small fragments of those ancient fossils, found in unconnected basins for the most part, so that their geological succession could be ascertained only with great doubt and difficulty. In conclusion, Professor Agassiz would venture to say, that geologists who have had any opportunity to compare the position of the ancient rocks on this continent of North America with the corresponding deposits of Europe, would agree with him in saying that the geology proper, the stratography of North America, will afford the same precise and well authenticated standards for the appreciation of the order of succession of rocks, as fossils will for the order of succession of living beings.—*American Annual of Scientific Discovery*, p. 282.

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mal on the shores during the palæozoic period. Thirty-one genera, sixteen of which are considered by Professor Troost as new, are enumerated.

11. *Discovery of Coral Animals on the Coast of Massachusetts.*—Professor Agassiz, while on an expedition in one of the vessels of the coast survey during the past summer, obtained by means of a dredge, from a depth of seventy-two feet, in the Vineyard Sound off Gay Head, several specimens of a coral with its animals. By great care and attention they were preserved alive in glass jars for more than six weeks, and afforded an excellent opportunity for an examination and observation of their structure and habits. These corals belong to the genus *Astrangia*, and have been named by Professor Agassiz, in honour of Professor Dana, geologist of the exploring expedition, Astrangia Dana.

This species presents two varieties. Some are of a pink or rose colour, others are white. The general form of the animal is a cylinder (as of all Polypi) resting on its base, and expanded on the upper margin; thus expanded it is about two lines in diameter. The number of tentacles is definite, but it is not always the same absolute number. It never exceeds twenty-four; in earlier periods of life there are only twelve, and there is even an epoch when there are only six.

It is, perhaps, a matter of surprise that the coral animal should have been found in this latitude. They teem in the warm latitudes; but there are very few species in the more temperate regions, and but for the opportunity afforded by the coast survey, the existence of these animals could not have been suspected on these shores. For many years, however, dead fragments had been found along the shores; but whether they lived there naturally or not had not been ascertained.—*American Annual of Scientific Discovery*, p. 311.

12. *On the Circulation and Digestion of the Lower Animals.*—Professor Agassiz states, that the circulation of the invertebrata cannot be compared to that of the vertebrata. Instead of the three conditions of chyme, chyle, and blood, which the circulating fluid of the vertebrata undergoes, the blood of that class of the invertebrata which he had particularly studied, the annelida or worms, is simple coloured chyle. The receptacles of chyle in different parts of the body are true lymphatic hearts, like those found in the vertebrata; this kind of circulation is found in the articulata and mollusks, with few exceptions, and in some of the echinoderms. In the medusæ and polyps, instead of chyle, chyme mixed with water is circulated; this circulation is found in some mollusks and intestinal worms. Professor Agassiz thinks, that the embryological development of the higher animals shews a similar succession in the circulating function. As regards the connection between respiration and circulation in vertebrata, the gills are found between branches of the blood system; in invertebrata, the chyliferous system is acted on by the respiration. The gills of fishes, therefore, cannot be compared to the gills of crustacea, articulata, and mollusks. In fact, no gills are connected with

the chymiferous circulation. Animals having this circulation, have no true respiration. They have only tubes to distribute freshly aërated water to different parts of the body.—*Proc. Bost. Nat. Hist. Soc.*

13. *Distribution of the Testaceous Mollusca of Jamaica.*—The great number of species is remarkable. A few miles of coast, without the aid of storms, and without dredging, yielded 450 species. In the small bay of Port Royal, 350 marine species were found. A pint of sand, taken from a surface three yards long, contained 110 species. Probably there are 350 or 400 specimens of land shells, and two or three times as many of marine species. Extensive districts occur, however, which are nearly destitute of land or marine shells. They are accumulated in favourable stations.

The difference in the extent of the distribution of the marine and of the terrestrial species is remarkable. A majority of the marine species are known to occur in the other islands; probably not more than 10 or 15 per cent. of them will be found to be peculiar to Jamaica. But of the land shells, 95 per cent. are peculiar to the island. The limited distribution of the terrestrial species is remarkable. A few are generally distributed, but a large number are limited to districts of a few miles in diameter; and several, although occurring abundantly, could be found only within the space of a few rods. Only seventeen fresh-water species were found. Favourable stations for fresh-water species are rare.

In respect of the number of individuals of mollusca in Jamaica, as compared with more northern latitudes, the rule so obvious in the class of fishes is not applicable to the same extent. Of fishes, the species are much more numerous, but individuals much less so. Of the mollusca, the total number of individuals is about the same as in this latitude, and the number of species represented by a profusion of individuals is about the same. But the number of species not occurring abundantly is much greater, so that the average of individuals to all the species is less than in this latitude. From a comparison of the laws of distribution of the marine and terrestrial species in the Antilles, it follows that the number of the latter must exceed that of the former. With the insular distribution of the terrestrial species may be associated the fact, that the coral reefs are all fringing, for both facts are connected with the geological fact, that these islands are in a process of elevation.—Professor Adams before the American Association.—*American Annual of Scientific Discovery*, p. 334.

14. *Metamorphoses of the Lepidoptera.*—Professor Agassiz said that he had, during the past season, been studying the metamorphoses of the Lepidoptera, and, to his great surprise, he had found that one stage in the transformation of these insects has been overlooked by naturalists. We knew the Lepidoptera in three conditions,—that of the worm, furnished with jaws and jointed, the chrysalis, and the perfect insect with four wings. The change not be-

fore described, which he had noticed, is somewhat concealed under the skin of the caterpillar. The animal at a certain period swells at the thoraci region, and becomes extremely sensitive to the touch in this part, the skin being, in fact, in a state of inflammation. On cutting open the skin at this place, Professor Agassiz found beneath it a four-winged insect, before it had passed into the chrysalis state. The wings were long enough to extend half the length of the perfect insect. The posterior pair he found to be membraneous bags, somewhat flattened, like the respiratory vesicles of marine worms, with distinct ribs, which are blood-vessels. The anterior pair are also bags, with their upper half stiff and inflexible, like the elytra of coleoptera. The legs are tubular, but not joined, as in the perfect insect. The jaws are changed into two long tubes, which are bent backwards, as are also the antennæ. In the chrysalis, the wings are flattened and soldered together, as are the legs and sucking-tubes, which are bent backwards. The order of development of the different parts and the coleopterous condition at an incomplete stage, show that naturalists have been in error in placing chewing insects, as the coleoptera, above the sucking insects. The order should be reversed. Professor Agassiz said that he had confirmed his observations in many specimens, by examining them just at the moment when the skin begins to split on the back.—*American Annual of Scientific Discovery*, p. 327.

15. *On the Zoological Character of Young Mammalia.*—At the meeting of the American Association for the Promotion of Science, Professor Agassiz remarked, that zoologists have, in their investigations, constantly neglected one side of their subject, which, when properly considered, will throw a great amount of new light on their investigations. Studying animals, in general, it has been the habit to investigate them in their full grown condition, and scarcely ever to look back for their characters in earlier periods of life. We scarcely ever find, in a book of natural history, a hint as to the difference which exists in the young and old. Perhaps in birds, the colour of the young may be noticed; and it is generally known, that the young resemble the female more than the male; but as to precise investigation of the subject, we are deficient. But if the early stages of life have been neglected, there is one period in the history of animals which has been thoroughly investigated, for the last twenty-five years, —embryology. The changes which take place within the egg itself, and which give rise to the new individual, have been thoroughly examined; but, after the formation of the new being, the changes in its form which it passes through, up to its full grown condition, have been neglected. It had been his object to investigate this subject, because he had been struck with the deficiency there is on this point in our works; and in making this investigation, he had found that the young animals, in almost all classes, differ widely from what they are in their full-grown condition. For instance, a young bat, a young

bird, or a young snake, at a certain period of their growth within the egg, resemble each other so much, that he would defy the most able zoologist of our day to distinguish between a robin and a bat, or between a robin and a snake. There is something of high significance in this fact. There is something common to all these. There is a thought behind these material phenomena, which shews that they are all combined under one rule, and that they only come under different laws of development, to assume, finally, different shapes, according to the object for which they were introduced.

There is a period of life, in which, whatever may be the final form of their organs of locomotion, whatever may be the final difference between the anterior and posterior extremities, vertebrated animals have uniform legs, in the shape of little paddles or fins. This is the case with lizards as well as birds A robin's wing and a robin's leg, which are so different from a bat's wing and a bat's leg, do not essentially differ when young from the leg and arm of a bat. Wherever we observe combined fingers preserving this condition, we have a decided indication that such animals rank lower in the group to which they belong. This is all-important, as we are enabled at once to group animals which are otherwise allied, in a natural series, as soon as we know whether they have combined or divided fingers. And the degree of division to which the legs rise in their development is a safe guide in our classification. Look, for instance, at the legs of dogs and cats, in which the fingers are completely separated, and so elongated, that the animals walk naturally upon tip-toe, and compare them with others, bears, for instance, which walk upon the whole sole of the foot; and, again, with those of seals or bats, which remain united, and constitute either fins or a wing.

There are other reasons sufficient to convince us that the order of arrangement which he had assigned them, according the development of the fingers, is justified by the state of development of the other organs of the mammalia, and especially of their higher organs and intellectual faculties and instincts. And I will also add, says Professor Agassiz, that mankind are not excluded from this connection, but, in common with other vertebrata, we are all at one stage of existence provided with paddles or fins, which are afterwards developed into legs and arms.—*American Annual of Scientific Discovery*, p. 324.

16. *The Manatus or Sea Cow, the Embryonic Type of the Pachydermata?*—Professor Agassiz thinks that the Manati have been improperly considered cetaceans: they differ from them in the form of the skull, which is elongated, and in the position of the nostrils, which are in front. On the other hand, the skull resembles that of the elephant in front (particularly when seen from above), in some of the details of the facial bones, which are not like those of the cetacea, in the palatine bones, the arrangement of the teeth, and in the curve of the lower jaw. Professor Agassiz, believed

this to be the true embryonic type of the Packydermata.—*American Annual of Scientific Discovery*, p. 313.

17. *Fossil Elephant and Mastodon from Africa.*—M. Gervais communicated to the French Academy, on March 12th, that he had just received from Algiers, a drawing of the molar tooth of a fossil elephant, whose genus is very easily recognised, and which indicates a species more resembling those found in a fossil state in Europe, than the present African elephant. This tooth was found at Cherchell, in the province of Oran. Sicily has hitherto been the southernmost point on the Mediterranean where the fossil elephant has been found.

At the same time, he also mentioned the discovery, near Constantine, of some fossil remains of mastodons. Though fossil remains of this animal have been previously found in all the other portions of the world, these are the first discovered in Africa. The remains found are a tooth and a rib, and, as far as can be judged from a drawing, they belonged to an animal more resembling the *mastodon brevirostris*, or the *arvernensis*, than the mastodon angustodens.—*American Journal of Scientific Discovery*, p. 287.

18. *Cauterization in the case of Poisonous Bites.*—In the *Comptes Rendus* for January 8th, we find an article by M. Parchappe, containing the result of his observations on the question, whether the spread of poison produced by a bite can be prevented by cauterizing. He was induced to examine into this subject, because M. Renard had stated that cauterization was found to have no effect when applied even within five minutes after the bite in the cure of one sort of virus, and within one hour in that of another. These results, he was aware, though derived from experiments upon animals, would weaken the confidence of physicians and patients in the only mode that medicine possesses of preventing the bad effect of a bite from any poisonous animal, where, as is generally the case, some considerable time must elapse before the remedy can be applied. M. Parchappe, accordingly, made several experiments upon dogs, with an extract of nux vomica, all of which go to confirm him in ascribing to cauterization, a power even greater than that commonly allowed it.—"From these experiments it results, that the immediate amputation or destruction in the living portion with which the extract of nux vomica has come in contact, has the power of preventing the bad effects of the poison, even when it has been in contact for some time." The author is aware, that there is considerable difference between the virus of animals, and the substance used by him, with reference to their direct and remote effects, but thinks that every one must admit that there is a great *analogy* between them, is of the opinion, that in both cases the poison remains in the bitten part for a considerable time before it is transmitted to the rest of the body, and that cauterizing should be adopted in all cases where a poisonous bite is even suspected.

19. *Dental Parasites.*—At a meeting of the American Academy, December 1849, a paper was read by Dr H. J. Bowditch, on the animal and vegetable parasites infesting the teeth, with the effects of different agents in causing their removal and destruction. Microscopical examinations had been made of the matter deposited on the teeth and gums of more than forty individuals, selected from all classes of society, in every variety of bodily condition, and in nearly every case animal and vegetable parasites in great numbers had been discovered. Of the animal parasites there were three or four species, and of the vegetable one or two. In fact, the only persons whose mouths were found to be completely free from them cleansed their teeth four times daily, using soap once. One or two of these individuals also passed a thread between the teeth to cleanse them more effectually. In all cases the number of the parasites were greater in proportion to the neglect of cleanliness.

The effect of the application of various agents was also noticed. Tobacco juice and smoke did not impair their vitality in the least. The same was also true of the chlorine tooth-wash, of pulverized bark, of soda, ammonia, and various other popular detergents. The application of soap, however, appeared to destroy them instantly. We may hence infer that this is the best and most proper specific for cleansing the teeth. In all cases where it has been tried, it receives unqualified commendation. It may also be proper to add, that none but the purest white soap, free from all discolorations, should be used. —*American Annual of Scientific Discovery*, p. 320.

ARTS.

20. *The Steamboat New World.*—Every year sees some new steamboat constructed, which surpasses in size, magnificence, or speed those previously made. There is no doubt that the mechanics of this country excel those of any other in their inland steamboats, and it is also probable that in a few years the same can be said of our sea-going steamships, though it must be allowed that those hitherto produced are, with few exceptions, decided failures. During the present year, the new steamboat "New World" has commenced running. She is said to be the longest boat ever put on the stocks in this country, and the longest afloat in the world. Her length is 337 feet; extreme width, 69 feet; the engine is 76 feet in cylinder, 15 feet in stroke, and the wheels of iron, 46 feet in diameter. She draws 4½ feet of water. The engine is a low pressure one, and though the boat is so very long she obeys the helm with great readiness. Her decorations are all of the most superb and costly character.

If we even attain any greater speed either in our inland or sea-going steam-vessels, it will be principally by enlarging their size. Though some improvements will doubtless be made in the engines and in the models of the vessels, yet the great gain will be by increasing the tonnage, for the reason that the size, and consequent room for engines and coal, increases much faster than does the opposition caused by the water and the air.—*American Annual of Scientific Discovery*, p. 30.

21. *Use of Parachutes in Mines.*—It is well known that vertical ladders for descending into deep mines are very fatiguing, so that the miners prefer to trust themselves to baskets suspended by ropes, and in many cases the baskets are the only means provided for descending and ascending. But accidents frequently occur from the breaking of the ropes, in spite of all the precautions that can be taken to prevent it. The *Brussels Herald* states that some experiments have lately been made on a large scale in Belgium with a contrivance intended to remedy this evil. The basket or cuffert is so made, that, in case the rope breaks, it immediately springs open, forming a sort of parachute, which is held suspended in the air by means of the strong current which, it is well known, is always rushing up from mines, owing to the temperature below being higher than that above. The effect of this apparatus was shown before a numerous company, several miners entrusting themselves to the basket, which was so arranged that at a certain point the rope broke; they were sustained in the air by the open basket, so that the experiments were entirely satisfactory.

22. *Adulteration of Drugs.*—At a meeting of the New York Academy of Medicine, June 1849, an elaborate report was presented by Dr M. J. Bailey, on the practical operation of the law prohibiting the importation of adulterated and spurious drugs, medicines, &c.

The report states, that since the law took effect, July 1848, over 90,000 lbs. of drugs of various kinds have been rejected and condemned in the ports of the United States. Of these, 34,000 lbs. was included under the comprehensive title of Peruvian bark, 16,343 lbs. rhubarb root, 11,707 lbs. jalap root, about 2000 lbs. senna, and about 15,000 lbs. of other drugs. The agitation of the bill which preceded the passage of the law had its effect abroad, and the supply of adulterated drugs from foreign markets has greatly decreased. The domestic supply, has on the contrary increased. Within a recent period, quinine in considerable quantities has been found in the market, adulterated to the extent of some twenty or twenty-five per cent. These frauds were undoubtedly perpetrated by or among our own people. The material used for the adulteration of the quinine was found, on analysis, to be *mannite and sulphate of barites*, in nearly equal weights. The latter article has long been used for this purpose, but not until lately has *mannite* been detected in the sulphate of quinine. It seems to have been ingeniously substituted for salicine, and a somewhat similar substance prepared from the poplar bark; which articles have heretofore been extensively used for like purposes. The ingenuity consists in the fact, that it is much more difficult to detect the adulterations when effected by the admixture of *mannite*, than when by the admixture of salicine, &c., while the former can be furnished for less than one-fourth of the expense of the latter.

For some years past an extensive chemical establishment has been in operation at Brussels, in Belgium, built up at great expense and care, and expressly designed for the manufacture, on a large scale, of imitations of all the most important foreign chemical preparations used in medicine; while, at the same time, an agent was travelling in this country making sales, and soliciting orders in all the principal towns on our sea-board. The articles were prepared and put up with consummate skill and neatness; and the imitation was so perfect that it was impossible for the unsuspecting purchaser to distinguish them from the genuine, notwithstanding that, in some instances, they did not contain over five per cent. of the substances represented by the label. Since the law went into effect at the port of New York, not a single package has been presented for entry. Dr Bailey states, however, that he has been informed that the persons formerly connected with the Brussels firm, are now in this country engaged in the same iniquitous business; hence the adulterations spoken of.—*Annual of Scientific Discovery*, p. 188.

23. *To restore Decayed Ivory.*—Mr Layard, in his explorations among the ruins of Nineveh, discovered some splendid works of art carved in ivory, which he forwarded to England. When they arrived there, it was discovered that the ivory was crumbling to pieces very rapidly. Professor Owen was consulted to know if there was any means of preventing the entire loss of these specimens of ancient art, and he came to the conclusion that the decay was owing to the loss of the albumen in the ivory, and therefore recommended that the articles be boiled in a solution of albumen. The experiment was tried, with complete success, and the ivory has been rendered as firm and solid as when it was first entombed.

24. *Ivory as an Article of Manufacture.*—There are several sorts of ivory, differing from each other in composition, durability, external appearance, and value. The principal sources from which ivory is derived are the western coast of Africa and Hindostan: Camaroo ivory is considered the best, on account of its colour and transparency. In some of the best tusks the transparency can be discovered even on the outside. The manufacturers have a process by which they make poor ivory transparent, but it lasts only for a short time. A third kind of ivory, called the Egyptian, has lately been introduced, which is considerably lower in price than the Indian, but in working there is much waste. By an analysis, the African ivory shows a proportion of animal to earthy matter of 101 to 100; the Indian, 76 to 100; and the Egyptians, 70 to 100. The value of ivory consumed in Sheffield, where it is much used in making handles for cutlery, is very great, and nearly 500 per-

sons are employed in working it up. To make up the weight of 180 tons consumed in that place, there must be about 45,000 tusks, whose average weight is nine pounds each, though some weigh from 60 to 100 pounds. According to this, the number of elephants killed every year is 22,500; but allowing that some tusks are cast, and some animals die, it may be fairly estimated that 18,000 are killed every year merely for their ivory, which is contrary to the usual belief that the ivory used comes from the tusks cast by living elephants. These estimates, it will be seen, are for Sheffield merely.

25. *Flexible Ivory.*—M. Charriere, a manufacturer of surgical instruments in Paris, has for some time been in the habit of rendering flexible the ivory which he uses in making tubes, probes, and other instruments. He avails himself of a fact which has long been known, that when bones are subjected to the action of hydrochloric acid, the phosphate of lime, which forms one of their component parts, is extracted, and thus bones retain their original form and acquire great flexibility. M. Charriere, after giving to the pieces of ivory the required form and polish, steeps them in acid alone, or in acid partially diluted with water, and they thus become supple, flexible, elastic, and of a slightly yellowish colour. In the course of drying, the ivory becomes hard and inflexible again, but its flexibility can be at once restored by wetting it either by surrounding it with a piece of wet linen, or by placing sponge in the cavities of the pieces. Some pieces of ivory have been kept in a flexible state in the acidulated water for a week, and they were neither changed, nor injured, nor too much softened, nor had they acquired any taste or disagreeable smell.

26. *Air-Whistle.*—Mr C. Daboll, of New London, Connecticut, has invented a whistle that speaks with a most "miraculous organ" whenever its services are required for the purpose of alarm or warning. It is designed for the use of vessels at sea or on the coast, as on our eastern shores, where dense fogs prevail, and vessels are liable to come in collision before they are conscious of each other's approach. Its great advantage is its power of communicating sounds for a distance of from 4 to 5 miles, far exceeding the largest bells. An experimental one has been placed on Bartlett's Reef, and the pilot of the "Lawrence" states that he has heard it when about 4 miles off from Bartlett's Reef, *against the wind*, which was blowing quite fresh at the time. This was on a clear day, and when the whistle was blown at his request, and also by advice of the inventor, so that the distance might be marked. It is probable that, under the same circumstances, the tones of a bell could not have been heard more than from one half to three-fourths of a mile. The pilot of the steamer "Knickerbocker" reports, that he *made the whistle* during a dense fog, thirteen minutes' running-time of the steamer, before coming up with the station where it is located. He therefore must have been some four or five miles distant from it when he heard it.

This whistle consists of an air chamber or condenser, of boiler iron sufficently strong to resist almost any pressure, an air-pump, and a whistle similar to the ordinary ones used on locomotives. By means of the air-pump operating into this chamber, a pressure of air is obtained in it of any required amount,—say one, two, or three hundred pounds to the square inch. When the air is so compressed, it is made to operate the whistle by simply opening a valve, and gives a distinct clear sound.

A memorial has been presented to the Treasury Department, signed by most of the commanders and pilots of the steam-boats running through Long Island and Fisher's Island Sounds, setting forth the advantages to be derived to navigation from this whistle, and urging that it be introduced into the light vessels, and at all stations where the government intends to afford protection to navigation.—*Annual of Scientific Discovery*, p. 70.

27. *Curious Electrical Phenomenon.*—We learn from a letter from a gentleman connected with the Bay State Mills, at Lawrence, Massachusetts, some facts with reference to a new and curious application of electricity which has been introduced in those mills. The electricity is generated by the motion of the machinery, and is employed for lighting up the gas burners. It exists in large quantities in the card-rooms, where there are many belts running on iron-pulleys, and, in the cold dry atmosphere of winter, often producing serious damage to the quality of the cording. The manner in which it was discovered that this electricity could be applied to "lighting up," is somewhat curious. When the gas was first let into the pipes in the mills, one of the overseers discovered fire setting out from one of the pipes near a belt, and on examination it was ascertained that a small stream of gas was escaping. It was surmised that it had been ignited by the electricity, and to prove it, an experiment was tried. Near a large belt in the carding-room was a gas-burner, and on a bench between them there was placed a small quantity of wool, which is a non-conductor of electricity. If a person stood upon this wool, reaching one hand within two or three inches of the belt, and touching the gas-burner with one finger of the other, the escaping gas was at once ignited with an explosion like that of a percussion-cap,—the body of the operator thus being made the medium for conducting the electricity.

The writer adds,—"We shall be able to make a great saving of expense in the woollen manufacture, as soon as we can discover an effective method of conducting the electricity away from the cards, as we shall then be able to dispense entirely with the use of oil on the wool, we shall save at least $30,000 per annum, when the mills are in full operation."—*American Annual of Scientific Discovery* p. 117.

List of Patents granted for Scotland from 22*d March to* 22*d June* 1850.

1. To James Higgins, of Salford, in the county of Lancaster, machine maker, and Thomas Showfield Whitworth, of Salford aforesaid, " improvements in machinery for preparing, spinning, and doubling cotton, wool, flax, silk, and similar fibrous materials."—22d March 1850.

2. To Francais Vouillon, of Princes Street, Hanover Square, in the county of Middlesex, manufacturer, " improvements in the manufacture of hats, caps, bonnets, and other articles made of the same or similar materials."—26th March 1850.

3. To William Edward Newton, of the Office for Patents, 66 Chancery Lane, in the county of Middlesex, civil engineer, " improvements in the manufacture of knobs of doors, articles of furniture, or other purposes, and in connecting metallic attachments to articles made of glass, or other analogous materials."—26th March 1850.

4. To Jonathan Charles Goodall, of Great College Street, Camden Town, in the county of Middlesex, card-maker, " improvements in machinery for cutting paper."—27th March 1850.

5. To Charles Felton Hailsman, of Argyle Street, in the county of Middlesex, gentleman, " improvements in machinery for spinning or twisting cotton, wool, or other fibrous substances."—28th March 1850.

6. To Robert Milligan, of Harden, near Bingley, in the county of York, manufacturer, " an improvements mode of treating certain floated warp, or welt, or both, for the purpose of producing ornamented fabrics." —28th March 1850.

7. To Robert White, and James Henderson Grant, both of Dalmarnock Road, Glasgow, North Britain, engineers, " certain improvements in machinery, or apparatus to be used in mines, which improvements, or parts thereof, are also applicable to other purposes of a similar nature."—11th April 1850.

8. To William M'Lardy, of Manchester, gentleman, " certain improvements in machinery or apparatus for preparing and spinning cotton and other fibrous substances."—15th April 1850.

9. To John Scoffern, of Essex Street, in the county of Middlesex, M. B., " improvements in the manufacture and refining of sugar, and in the treatment and use of matters obtained in such manufacture, and in the construction of valves, and in such and other manufacture."—17th April 1850.

10. To James Buck Wilson, of St Helens, in the county of Lancaster, rope-maker, " certain improvements in wire ropes."—22d April 1850.

11. To Thomas Symes Prideaux, of Southampton, gentleman, " improvements in puddling, and other furnaces."—26th April 1850.

12. To Charles Cowper, of Southampton Buildings, Chancery Lane, in the county of Middlesex, " certain improvements in the treatment of coal, and in separating coal and other substances from foreign matters, and in the artificial fuel and coke, and in the distillation and treatment of tar and other products from coal, together with improvements in the machinery and apparatus employed for the said purposes," being a communication.—26th April 1850.

13. To Vidie Lucien, late of Paris, in France, but now of South Street, Finsbury, French Advocate, " improvements in conveyances on land and water."—26th April 1850.

14. To Robert Dalgleish, of Glasgow, in the county of Lanark, in Scotland, merchant and calico printer, " certain improvements in printing, and in the application of colours to silk, cotton, linen, woollen, and other textile fabrics."—27th April 1850.

15. To Ethian Campbell, of the city of New York, in the United States of America, philosophical, practical, and experimental engineer, " certain new and useful improvements for generating and applying motive power, and for propelling vessels."—30th April 1850.

16. To Robert Reid, of Glasgow, in the county of Lanark, manufacturer, " certain improvements in weaving."—3d May 1850.

17. To Maxwell Miller, of Glasgow, in the county of Lanark, coppersmith, " certain improvements in distilling and rectifying."—3d May 1850.

18. To Thomas Keely, of the town and county of Nottingham, manufacturer, and William Williamson, of the same place, frame-work knitter, " certain improvements in looped or elastic fabrics, and in articles made therefrom ; also certain machinery for producing the said improvements, which is applicable in whole or in part to the manufacture of looped fabrics generally."—8th May 1850.

19. To Peter Armand Le Comte Moreau Fontaine, of 4 South Street, Finsbury Square, in the county of Middlesex, patent agent, " certain improvements for the production of heat and light, which improvements are applicable to ventilation, and the prevention of explosions," being a communication.—9th May 1850.

20. To Ethian Baldwin, of the city of Philadelphia and State of

Pennsylvania, in the United States of America, " a new and useful method of generating and applying steam in propelling vessels locomotive, and stationary machinery."—9th May 1850.

21. To Jacob Cannon, of Hyde Park, in the county of Middlesex, gentleman, " improvements in melting, moulding, and casting sand, earth, and other substances for paving, building, and various other useful purposes."—20th May 1850.

22. To George Jackson, of Belfast, Ireland, flax-dresser, " improvements in heckling machinery."—24th May 1850.

23. To Frederick Rosenberg, Esquire, of Albermarle Street, in the county of Middlesex, and Conard Montgomery, Esquire, of the Army and Navy Club, Saint James's Square, in the same county, " improvements in sewing, cutting, boring, and shaping wood."—24th May 1850.

24. To George Ford Hayward, of St Martins Le Grand, in the county of Middlesex, " improvements in obtaining power," being a communication.—27th May 1850.

25. To Joseph Barrans, of St Pauls, Deptford, in the county of Kent, engineer, " improvements in axles and axle-boxes of locomotive engines, and other railway carriages."—27th May 1850.

26. To Samuel Fisher, of Birmingham, in the county of Warwick, engineer, " improvements in railway carriage-wheels, axles, buffer, and draw-springs, and hinges for railway carriage and other doors."—28th May 1850.

27. To Thomas Chandler, of Stockton, Wilts, " improvements in machinery for applying liquid manure."—28th May 1850.

28. To Thomas Dickson Rotch, Esquire, of Drumlamford House, in the county of Ayr, North Britain, " improvements in separating various matters usually found combined in certain saccharine, saline, and ligneous substances."—28th May 1850.

29. To Henry Columbus Hurry, of Manchester, in the county of Lancaster, civil engineer, " certain improvements in the method of lubricating machinery."—29th May 1850.

30. To Simon Pincoffs, of Manchester, in the county of Lancaster, merchant, " certain improvements in the ageing process in printing and dyeing calicoes, and other woven fabrics, which improvements are also applicable to other processes in printing and dyeing calicoes and other woven fabrics."—30th May 1850.

31. To William MacAlpine, of Spring Vale, in the county of Middlesex, general dresser, and Thomas MacAlpine, of the same place, manager, " improvements in machinery for washing cotton, linen, and other fabrics."—31st May 1850.

32. To Charles Andrew, of Compstall Bridge, in the county of Chester, manufacturer, and Richard Markland, of the same place, manager, "certain improvements in the method of, and in the machinery or apparatus for, preparing warps for weaving."—31st May 1850.

33. To James Palmer Budd, of the Ystalyfera iron works, Swansea, merchant, "improvements in the manufacture of coke."—31st May 1850.

34. To John Dalton, of Hollingsworth, in the county of Chester, calico printer, "certain improvements in and applicable to machinery or apparatus for bleaching, dyeing, printing, and finishing textile and other fabrics, and in the engraving of copper rollers, and other metallic bodies." —5th June 1850.

35. To Frederick Albert Gatty, of Accrington in the county of Lancaster, Manchester, manufacturing chemist, "a certain process, of certain processes for obtaining carbonate of soda and carbonate of potash."—5th June 1850.

36. To Jules Le Bastier, of Paris, in the Republic of France, but now of South Street, Finsbury, in the county of Middlesex, gentleman, "certain improvements in machinery or apparatus for printing."—6th June 1850.

37. To William Robertton, of Gateshead Mill, Neilston, in the county of Renfrew, in that part of the United Kingdom of Great Britain and Ireland called Scotland, machine maker, "improvements in certain machinery used for spinning and doubling cotton and other fibrous substances."—7th June 1850.

38. To Francis Tongue Rufford, of Prescott House, in the county of Worcester, fire-brick manufacturer, Isaac Marson, of Cradley, in the same county, potter, and John Finch, of Pickard Street, City Road, in the county of Middlesex, manufacturer, "improvements in the manufacture of baths and wash tubs, or wash vessels."—10th June 1850.

39. To Baron Louis Le Presti, of Paris, in the Republic of France, "improvements in hydraulic presses, which are, in whole or in part, applicable to pumps and other like machines."—10th June 1850.

40. To Arthur Elliot, machine maker, of Manchester, in the county of Lancaster, and Henry Heys, of the same place, book-keeper, "certain machinery for manufacturing woven fabrics."—14th June 1850.

41. To Charles Cowper, of Southampton Buildings, Chancery Lane, in the county of Middlesex, patent agent, "improvements in instruments for measuring, indicating, and regulating the pressure of air, steam, and other fluids, and in instruments for measuring, indicating, and regulating the temperature of the same, and in instruments for obtaining motive power from the same."—14th June 1850.

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The Natural Relations between Animals and the Elements in which they Live. By Professor Louis Agassiz.*

Among the early attempts to arrange animals in a systematic order, we find almost universally, that the natural elements in which their different tribes live, are introduced as the fundamental principle of their classification. During the sixteenth and seventeenth centuries, the great works published upon natural history by Gesner, Rondelet, Belon, Aldrovandi, and others, acknowledge this as the only basis of their arrangement of the animal kingdom. Even at a later period, when characters derived from animals themselves, rather than from the external circumstances in which they dwell, had been introduced into our systems, we still find a prevailing influence of such considerations upon the circumstances of the natural sub-divisions of animals. As soon, however, as the study of comparative anatomy had shed its brilliant light upon this question, those views were entirely abandoned, and the whole animal kingdom was finally arranged according to its internal structure. The introduction of this principle was hailed as a new era in the history of our science; and after Cuvier had applied it to a general revision of the whole animal kingdom, it was, and has been, universally acknowledged as the only safe foundation of a natural classification of animals.

* Silliman's American Journal of Science and Arts, May 1850. See also various papers by Professor Agassiz, read before the American Association for the Advancement of Science for 1849.

The recent progress in zoology, and of the various branches of natural history connected with it, has, however, opened the prospect of farther improvements, even upon the basis on which our classification at present rests. For embryology is already displaying its vast influence upon zoological questions, and the time is not far distant, when its share in the natural arrangement of animals will be as large as that of comparative anatomy itself, and when information derived from all possible quarters shall have equally its due influence upon our natural methods. A desire to investigate the various questions bearing upon classification has led me to revise the subject of the natural relations which exist between animals, and the elements in which they live. The connection between animals and the surrounding media in which they live has of late been so entirely disregarded, that it is time to reconsider this question with all the attention its importance demands, since we find in it a decided relation to the structure and functions of all animals. For though it is plain that the mere living in water or upon dry land is in itself of slight importance, as there are so many animals which dwell in the two elements, although having the same *identical* structure, it should not be overlooked that the greater number of aquatic animals have structural peculiarities common to all, and that the same is the case with the terrestial or aërial animals. For instance,. all those which live upon dry land, breathe directly the atmospheric air, and have a respiratory apparatus adopted for direct introduction of this element into their systems, while aquatic animals breathe through apparatus of a different structure, adapted to a permanent contact with aërated water. This circumstance alone would suffice to show that the natural relations of animals with the elements in which they naturally dwell, is in direct connection with at least some of their structural peculiarities. But there are other circumstances which may lead to the conviction that this connection has not merely reference to the structure of their respiratory apparatus, but influences their whole organization. The greater pressure under which aquatic animals are maintained throughout their life, modifies, in many other respects, their organization. In many of them the surrounding element has largely a direct access into the cavities of the body, or even into their tissues; so that a direct and universal influence of the surrounding media must be acknowledged throughout the animal kingdom as soon as we take into consideration all their peculiarities. This influence will be appreciated more correctly, if we consider it separately in each great group of the animal kingdom as established upon anatomical evidence.

After removing the whales from the fishes, it will be plain that the Cetacea must be considered simply as an aquatic type of the class of Mammalia, and that the connection which exists between them and the element in which they live, will not affect at all the views which we shall entertain about that class, and only allow us to consider within more natural limits, the true relation which exists between fishes and the natural element in which they are found. The circumstance that so many birds are aquatic in their habits, will no longer prevent us from considering the class of birds as a most natural group in the animal kingdom, the limits of which are well defined by anatomical evidence; and the relations of aquatic birds to the waters upon which they alight or in which they dive, will only be considered within the limits of a well circumscribed natural group. The same may be said of reptiles, and the circumstance that so many of their types are almost entirely aquatic, while others are terrestrial, will by no means prevent us from viewing them as a natural class, in which the connection with either mainland or the water shall appear as a subordinate feature.

Again, the class of insects, which is so thoroughly aërial throughout almost all its types, at least in their perfect state of development, circumscribed as it is within natural limits upon anatomical evidence, will appear to us as a type which shall bear no relation in our mind to the class of birds, although their movement through the atmosphere be apparently so similar.

But, although we remove in this manner almost completely the circumstance of animals dwelling either in water or upon mainland as influencing in any way our general classification of the animal kingdom, it were a great mistake to lose sight entirely of this most intimate relation among the natural secondary groups of animals under their different types.

The value of these considerations has become more apparent since the outlines of the leading divisions in the animal kingdom have been made in detail, by allowing the results of embryology to have their due share of influence upon our classification; and the object of these remarks is chiefly to show that there is a universal relation throughout the animal kingdom between their structure and gradation and the elements in which they live; that in all the four great types of the animal kingdom, the aquatic groups stand, in natural classification, lower than the terrestrial, and that this connection is so intimate as to extend even to the subdivisions, and so much so, that I have arrived at the conviction that in an otherwise well-defined natural division, the aquatic tribes should be placed below the terrestrial ones; that, even in narrowly circumscribed families the aquatic genera rank below the terrestrial, and that even in natural genera the aquatic species are inferior to the terrestrial ones. But, before considering those minor divisions, let us take a general glance at the four great types of the animal kingdom, beginning with the Radiata.

1. *General View of the Radiata.*—If we consider the type of Radiata as it is still circumscribed in some of our most recent works upon the animal kingdom in general, we may fail to discover this intimate connection between their natural types and the media in which they live. But, if we reduce the type of Radiata to those classes which I consider as alone truly representing that type, we shall be at once struck with the remarkable result, that all these animals are aquatic, nay, that, with one single exception, they are all marine. But, before this can be acknowledged, it must be shown that the type of Radiata should be reduced to the three classes of Polypi, Jelly-fishes, (Medusa) and Echinoderms; and that, among Polypi, there are large numbers of animals now united which do not all belong to that class. The most extensive range acknowledged by some zoologists in the type of Radiata includes Infusoria with the Rotifera, and also intestinal worms. Without

entering, for the present, into a full discussion of the natural character of all the animals which have been included in the class of Infusoria, I may limit my remarks to a few critical points, in order to show that the Polygastrica, and even the Rotifera, cannot be ranked among the Radiata.

In the first place, Rotifera constitutes a particular group among Infusoria, as Ehrenberg himself has acknowledged. They differ so completely from the Polygastrica, as to forbid entirely their union in a natural classification. The only question is, whether they can remain among Radiata, and, if not, where they should be placed. There is so little analogy between the structure of Rotifera and the structure of true Radiata, that ever since the beautiful illustration of their forms and structure, as given by Ehrenberg, most naturalists and anatomists have felt inclined to remove them to another type of the animal kingdom. Their resemblance to Articulata has appeared to some so striking as to warrant, in their opinion, their removal to the class of Crustacea, among Entomostraca, while others have considered them as more closely allied to worms; but I may say that all, or almost all, naturalists at present understand the necessity of removing them from among Radiata into the great type of Articulata. This point is no longer in question; the only remaining doubt respecting them is, whether they should rank among the lower Crustacea, or among the worms in the wider sense. As for the Polygastrica, we meet with greater difficulties in attempting to classify them; for this group, as understood by Ehrenberg, consists still of most heterogeneous beings, which do not even all belong to the animal kingdom. Recent investigations upon the so-called Anentera, including the families of Baccillaria and Volvocine Infusoria, have satisfactorily shewn, in my opinion, and in that of most competent observers, that this type of Ehrenberg's Polygastrica without gastric cavities, and without an elementary tube, are really plants belonging to the order of Algæ, in the widest extension of this group; whilst most of the Monas tribe are merely movable germs of various kinds of other Algæ. As for the other Polygastrica, which Ehrenberg combines in this division of Enterodela, I am satisfied that they also constitute still a heterogeneous group belonging to different types of the animal kingdom; and that most of them, far from being perfect animals, are only germs in an early state of development. The family of Vorticellæ exhibits so close a relation with the Bryozoa, and especially with the genus Pedicellina, that, I have no doubt, that wherever Bryozoa should be placed, Vorticella should follow, and be ranked in the same division with them.

The last group of Infusoria, Bursaria, Paramecium, and the like, are, as I have satisfied myself by direct investigation, germs of fresh-water worms, some of which I have seen hatched from eggs of Planaria laid under my eyes. This being the case, we see that, without exception, the whole class of so-called Infusoria must be dissolved into its various elements and divided partly among the Articulata, and partly among Mollusca in the widest extension of those groups (if it can be shewn that Bryozoa belongs also to the type of Mollusca), that large numbers of them belong to the vegetable kingdom, and others are simply germs of other types, and that no single one of them belongs to the type of Radiata.

If we next consider the Polypi, we find them constituting another main group and most natural class, to which, indeed, some heterogeneous types have been annexed; upon the removal of these, however, that class constitutes a very natural division of the type of Radiata, among which they form the lowest class. The natural groups which require to be removed from Polypi are,—first, the so-called Hydroid Polypi, which, though truly radiated animals, do not belong to this class, but are, as I have shewn from their structure, and as might long ago have been inferred from their development, true members of the class Medusæ, among which they constitute a type of stalk animals, as Crinoids among starfishes.*

The Bryozoa also are not constructed upon the plan of Radiata, as has long been shewn by Milne Edwards, and others. Their true position is among Mollusca, and embryonic inves-

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* See my paper upon the Homologies of Radiated Animals with reference to the classification of the so-called Hydroid Polypi, read before the American Association for the Advancement of Science, held in Cambridge, August 1849; also my lectures upon Comparative Embryology, delivered before the Lowell Institute, December 1848 and January 1849.

tigations upon Ascidia have satisfied me that Bryozoa, compound, and simple Ascidia, form a natural series of well-connected types leading to the true Acephala among ordinary Mollusca, among which Bryozoa will form a natural group of compound animals, bearing the same relation to the ordinary bivalve shells that common corals bear to the simple Actiniæ and Fungiæ. Though the doubts entertained about the Foraminifera among Bryozoa, would not affect at all the points under discussion, I may as well state at once, that I have arrived at the conclusion that Foraminifera constitute the lowest type of Gasteropoda, and exemplify, under permanent forms, the state of division of their germs in their embryonic development. Thus circumscribed, the class of Polypi constitutes a very natural group, containing only animals of an identical radiated structure, the organization of which is at present very satisfactorily known.

The class of Medusæ has been from the beginning so well characterised, and circumscribed within so natural limits, that it has undergone since its establishment only slight modifications by the removal of some few genera; and after the position of the so-called Hydroid Polypi among them shall have been generally acknowledged, I believe it will undergo scarcely any new changes in its extension, though we may still expect extensive improvements, which are indeed very much needed, in the characteristics and internal arrangement of their natural families. Considering their structure, the Medusæ rank immediately above Polypi.

The intestinal worms have long been placed among Radiata, and considered as a natural class in this great type of the animal kingdom, notwithstanding so many striking differences in the plan of their structure. This position was assigned to them upon the ground of the radiated arrangement of parts around the head, and the vascular form of some of their genera, and also upon the supposed want of a nervous system in all of them. But since the discovery of nerves in all of their types, and since the most intimate relations have been discovered between them and so many other external worms, their complete separation from Annelides as a distinct class is hardly recognised now by any modern investigator. And the necessity of combining the intestinal parasitic worms into one great natural group with the other external free worms is becoming daily more evident to all, so that whatever position be assigned to Annelides in the great type of Articulata, Helminths have to follow them, and must therefore be removed from the type of Radiata. The point is undisputed now, though there may be a difference of opinion as to the propriety of admitting, to one great class, all worms, or of subdividing them into minor natural groups.

The third class among Radiata is that of Echinoderms, which has been circumscribed within most natural limits since the reunion of Holothuriæ and Crinoids, with the common star-fishes and true Echini. Whoever is familiar with the embryonic development of Echinoderms, which has been extensively investigated of late, will acknowledge an intimate relation between them and the other two classes of Radiata, and not be willing to assent to the proposed separation of Echinoderms as one great type in the animal kingdom, placed upon an equal footing with Mollusca, and will consider their separation from Polypi and Medusæ, as proposed by Dr Leuckardt, rather as a retrograde step, than an improvement upon the general classification of animals. To me the type of Radiata, embracing the three classes of Echinoderms, Medusæ, and Polypi, constitutes, in its circumscription, illustrated above, a most natural group of the animal kingdom, all the members of which are intimately connected by a close uniformity in the plan of their structure, but present a remarkable gradation of their types in the manner in which this structure is developed in each of their classes. And the circumstance that even in the higher ones, which contain chiefly free movable animals, we have some few representatives attached permanently to the soil, upon a Polypi-like stalk, bearing the radiated animal crown, shews further the intimate connection which exists between them all. Radiata consist, therefore, of three classes only, which in their natural gradation rank as follows:—Polypi, lowest; next Medusæ; and highest, Echinoderms.

As soon as we have removed in this way all the classes or families which do not strictly belong to the type of Radiata, we cannot fail to perceive at once that all the remaining animals which must be considered as truly radiate are not only all aquatic, but, with a single exception of the genus Hydra, all strictly marine; from which we are allowed to infer that, in the plan of the creation, the radiated structure is incompatible with a terrestrial mode of life. We see that the lowest degree of development of the whole animal kingdom is entirely marine; and that it has been so throughout all ages in the history of our globe, is shewn by the large numbers of Radiata found from the earliest period through all geological epochs up to the most recent, and the entire absence of radiated animals in any of the fresh-water deposits. The circumstance that no single genus among Radiata contains fresh-water animals, further shews that this type in its main features is not better adapted for a fluviatile existence; or, we may say in other words, that the plan involved in the structure of radiated animals is chiefly adapted to the sea. We might, perhaps, even say, if, in this stage of the investigation, it would not seem premature to go so far, that the lower types of animals are not only entirely aquatic, but exclusively marine. The fact of so large a number of aquatic animals as Radiata being so exclusively marine, undoubtedly shews that the connection of organic structure with the ocean, involves peculiar circumstances, which fresh waters by no means afford to a similar extent. Whether this is especially connected with the greater density of the medium or not, I am not fully prepared to say, though I am inclined to believe that it is so, from the circumstance that Radiata are so constantly killed by the contact of fresh water, as I have ascertained by direct experiment upon Polypi, Medusæ, and Echinoderms, some of which are struck with almost instantaneous death, when brought into fresh water, and decompose with astonishing rapidity. I have seen on dropping an Ophiura into fresh water, all the articulations dismembered and entirely separated within a few minutes.

No one of the three other great types of the animal kingdom is either so exclusively marine, or even so exclusively aquatic as that of Radiata. For among Mollusca we have quite a number of terrestrial genera, and even a large number of fresh-water genera and families.

Among Articulata we notice also large numbers of fresh-water species, and a still larger number of terrestrial forms. Finally, among Vertebrata we find the most promiscuous occurrence of marine, fresh-water, and terrestrial forms. It is now important to ascertain whether we may trace, beyond Radiata, a direct relation between structure and the element in which animals live, and whether the gradation of this structure has any reference to the surrounding media as it unquestionably has among Radiata.

2. *General View of Mollusca.*—Let us first consider Mollusca, and perhaps revise their classes in a zoological point of view, before undertaking the investigation of their relations to the media in which they dwell, allowing in this revision a due influence to embryology, as far as it can influence this question at present.

The number of classes which should be admitted among Mollusca, is the first point of importance we have to consider. Since the Barnacles or Cirripedia, which Cuvier still considered as a class among Mollusca, are now known to belong to the type of Articulata, and to be most conveniently combined with Crustacea, we have five classes of Mollusca left, if we follow Cuvier's arrangement of these animals, as he distinguishes Cephalopoda, Pteropoda (Clio), Gasteropoda (Univalve), Acephala (Bivalve), and Brachiopoda (Terebratula), as so many distinct classes of the type of Mollusca, in the order of gradation just mentioned. It will hardly be necessary at present to insist upon the close relation which exists between Brachiopoda and the other bivalve shells. Indeed, anatomical investigations of these animals have shewn that they are not only constructed upon the same plan, but that the difference between Brachiopoda and ordinary Acephala, is scarcely as great as the differences which exist between Ascidia and Lamellibranchiate Acephala, (as Ostrea) which Cuvier, nevertheless, placed in one and the same class. We shall therefore consider Tunicata, Brachiopoda, and Diphyra, as one great natural class, under the name of Acephala, to which we also refer, as mentioned above, the type of Bryozoa which has been so long combined with Polypi. As to Pteropoda and Gasteropoda, though they are still generally considered as two classes, we shall, for reasons explained elsewhere,* and from embryological evidence, place Pteropoda below Gasteropoda proper; not as an intermediate type between Gasteropoda and Cephalopoda; for Pteropoda, or rather an embryonic type exemplifying, in a permanent form, that stage of development of common Gasteropoda when they are provided with large vibracula, and a thin symmetrical shell deciduous in so many of them; bearing to that state of development of the common Gasteropoda the same relation which Foraminifera bear to a still earlier period of their embryonic growth, when the yolk is undergoing its process of gradual successive division, which seems to me to be exemplified in a permanent form in the numerous cells into which the body of Polythalmia or Foraminifera is not usually divided. If this view be correct, the class of Gasteropoda would therefore consist of the three types of Foraminifera, Pteropoda, and true Gasteropoda, among which we would place the Heteropoda lowest, and the Pulmonata highest, both on account of their structure, and on the ground of the peculiar mode of development of Pulmonata.

The third class is that of Cephalopoda, which has always been circumscribed within natural limits, since Foraminifera have been removed from it. The position which I ascribe here to Foraminifera will appear very natural to those who are equally conversant with the succession of fossil types in geological periods, and with embryology, and who know, as we have seen it to be the case also among Radiata, that the higher classes reproduce in their lower forms, types analogous to the lower ones. For the great number of fossil-chambered shells, existing in earlier geological periods, is very striking when we compare those old representatives of the class Cephalopoda with their condition in the present period of the creation, and the natural gradation and analogy between Bryozoa, as the lowest type of Acephala, with the

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* See a paper upon the Homologies of Gasteropoda and Acephala, with reference to the systematic position of Pteropoda, Foraminifera, Brachiopoda, and Bryozoa, read before the American Association, &c.

Foraminifera, as the lowest type of Gasteropoda, and the chambered shells of old ages as lower types of Cephalopoda, will remind us of similar relations between Polypi, as the lowest type of the animal kingdom, the so-called Hydroid Polypi, as the lowest type of Acalephæ, and Crinoids as the lowest type of Echinoderms, which are strictly parallel cases in two of the great types of the animal kingdom.

If we now start from these modifications in the classification of Mollusca, which rest entirely upon anatomical and embryological considerations, to appreciate the relations between the three classes of this type and the media in which they naturally live, we cannot fail to be struck with the circumstance, that all Acephala, with one single exception, are aquatic, as are also Cephalopoda; and that we have only terrestrial representatives among Gasteropoda. Next, it must be obvious, that among Acephala we have fewer fresh-water representatives, than among Gasteropoda, as the fresh-water types of Acephala belong truly to two groups, one of which has very few fresh-water families, whilst among Gasteropoda we have quite a variety of fluviatile and terrestrial types.

The first thing which must strike us in this type, when contrasting it with the Radiata, is the circumstance of a far larger proportion of fresh-water forms, and of the introduction of a number of terrestrial ones. This simple fact, in itself, would go to sustain the hint thrown out above, that a higher organization in the animal kingdom is better adapted to the fluviatile and terrestrial life than a lower structure; as among Radiata we have not one single terrestrial type, and only a single fluviatile one; whilst the Mollusca, the structure of which is formed upon a plan decidedly higher than that of Radiata, present already a large increase of fluviatile types, with the addition of very many terrestrial ones. But this view will at once be sustained to a most unexpected extent, if we consider which of the Mollusca are aquatic, and marine, which are fluviatile, and which are terrestrial. Beginning with the Acephala, we have, then, in the first place, all the Polypi-like Bryozoa, and Tunicata, and the compound Tunicata entirely marine, with the exception of a few genera of fresh-water Bryozoa. And it is very interesting to notice that fresh-water animals among Mollusca are of the lowest type of their class, as also was the first and only fresh-water Radiata,—shewing thus that the types to which they belong are not adapted to rise into any of their higher developments into the forms best fitted for other elements.

Next we notice the Brachiopoda, which are all, without exception, marine. Next Lamellibranchiata, mostly marine, though some of their types are fluviatile. So the entire class of Acephala is aquatic, and chiefly marine, and its fluviatile types belong to its lowest group, and to its highest. This circumstance has raised the question with me, what is the proper position to assign to the Naiades among the Lamellibranchiata, and upon due consideration of their peculiar characters, and especially of the circumstance that their mantle is entirely open, that they have no prolonged syphons, whilst there are such even among Ascidia, I am inclined to suppose that they rank highest among Lamellibranchiata, and that Monomyarians should rank between Brachiopoda and Dimyarians. The reason for assigning to Naiades this higher rank rests upon the homology traced between the foot of Gasteropoda and that of Acephala, and between the reduction of the mantle upon the sides of the foot which it no longer encloses in Gasteropoda, and also the higher position of the gills under the margins of the mantle, all peculiarities in which Naiades bear closer resemblance to common Gasteropoda than any other of the Acephala. Thus this class of Acephala, though chiefly marine, with a few representatives of its lowest types in fresh water, would reach its highest degree of development in one family, which is entirely fluviatile.

Among Gasteropoda we have again Foraminifera as the lowest type, entirely and without exception marine; Pteropoda, which rank next, entirely and without exception marine; Heteropoda, which follow, equally marine; and among true Gasteropoda, which in their class are decidedly the highest, we find first fluviatile and then terrestrial families; and now the question is, among these, what is the respective position of the marine families, of the fluviatile families, and of the terrestrial families. There are among them such structural peculiarities as will decidedly settle the question. If we set aside for a moment the few branchiate fresh-water Gasteropoda, we have a large number left, which are pulmonate, and which live in fresh water and upon land, and which, as a whole, we may contrast with the branchiate true Gasteropoda, which are almost all marine, with the few exceptions of Valvata and Paludina and Ampullaria. Now which of these two types rank highest will not be a matter of doubt, as soon as it is remembered that Phlebenterata are among branchiate Gasteropoda, and by their general structure rank below the others. So that we shall have the marine branchiate Gasteropoda follow immediately the Heteropoda to which they are more or less closely allied through the Phlebenterata, and, above all, the Pulmonata. But here arises a new question. This family of Gasteropoda is partly fluviatile and partly terrestrial; and we may further ask, which should rank higher? No one familiar with the forms of these animals will hesitate in answering this question. We need only compare the development of their tentacles, their forms and position, the development of their organs of sense, to be satisfied that Helices and Limax rank above Planorbis and Limnæa. So that the natural gradation established by their structure among the upper groups in the class of Gasteropoda, agrees with their natural connection with the elements in which they live in the order which I have assigned to these, the types of Gasteropoda, which are lowest, being exclusively marine,—the highest, equally fluviatile and terrestrial; and among these the fluviatile, ranking immediately above the marine, and the terrestrial ranking highest, and the proportion of the fluviatile in the whole class being still larger than in the class of Acephala, inasmuch as the structure of Gasteropoda is also in a higher degree of development of Mollusca than that of Acephala, and the first terrestrial type in the animal kingdom in the gradation of its structure, making its appearance in the class of Gasteropoda.

The Cephalopoda are highest among Mollusca as a class. They rank so high, as to rival in the complication and development of their structure, even some of the Vertebrata, and, strange to say, we have among them only marine types, not a single fluviatile representative, nor a single terrestrial one. This fact would at first seem to be in direct contradiction with the statements made before, if it were not for the circumstance, that this class in itself, as represented in our days, does not seem altogether reduced in comparison with the other two, if we could not be satisfied that its perfect period of development were the former geological ages, when its numbers were far greater than at present, a circumstance which places the whole class in peculiar relations to its type, which must be rather appreciated under the point of view of the conditions which prevailed in former ages, when the ocean covered more extensively the whole surface of the globe than at present; so that the type with its high organization must be considered more with reference to its development in former ages, than to what it is now, as at present, the class is proportionally reduced, and it is well known, and it will be further mentioned with reference to other types, that in earlier periods, however high animals might have ranked by their structure, they were all marine, as we know fishes to have been the only representatives of Vertebrata in earlier periods.

At this stage of the investigation, a comparison between Mollusca and Radiata shews, that though the former advance farther in their fluviatile development, and even reach with some few of their types a terrestrial mode of existence, there is not yet a single family among them which is entirely terrestrial, nor a single class which is either entirely fluviatile or terrestrial, this connection with the higher conditions of existence being only introduced among some few of their representatives, which we are allowed from other data to consider as the highest in their respective groups.

3. *General View of Articulata.*—If we now pass to the great group of Articulata, and begin as before, by revising their zoological arrangements, as based upon anatomical and embryonic data, we shall have, at the outset, to settle the limits of their classes, and their relative positions.

The first point which we have here to investigate is the question, whether Articulata in the widest extension of this group constitute one single natural type, or whether they should be subdivided into two equivalent groups, as has been proposed by those who would restore the division of worms, in its widest sense, as a great division equal in zoological importance to the type of Mollusca, and unite the Arthropoda, Crustacea, and insects, to form another group of equal value.

The great diversity among worms, seems at first to warrant in some degree such an arrangement. But as soon as we consider the metamorphosis which insects undergo, and compare their earliest stages of growth with the structure and forms of worms, we cannot fail to perceive, that notwithstanding the many peculiarities which characterise worms, they are, after all, only one of the permanent modifications of the same type as Crustacea and insects, among which last the characters and forms of a large number of worms are reproduced as transient states of growth; so that upon the most natural view, and especially if we allow embryology to have its due weight in fixing our opinion, we must consider worms with all their diversified forms, Crustacea in all their diversity, and Lepades, Arachnidæ, and Insects, to constitute one single undivided natural type in the animal kingdom. Assuming upon the foundation alluded to, and without entering into a detailed argument upon this question, that this is the right view of this subject, the next question is about the number of classes into which these Articulata should be subdivided. Taking here again anatomical and embryological evidence as our guide, and remembering what was said above of intestinal worms, we shall find that the most natural combination of the different groups of Articulata will bring them all into three classes, one containing those in which the body is either more or less distinctly articulated, or in which indications of transverse wrinkles in the skin are scarcely marked, or wholly wanting, but in which, however developed these joints may be, they never combine in such a manner as to divide the body into distinct ridges, in which the form is always elongated and vermiform, never provided with articulated rings, however numerous and diversified the locomotive appendages may be, and in which the foremost joints hardly ever assume a peculiar structure with the appearance of a head. This class for which the name of worms is best retained, will contain the Helminths and Annelides, exclusive, however, of the vermiform parasitic Crustacea, which embryology has taught us to refer unhesitatingly to the class of Crustacea. The extraordinary diversity which exists among these animals renders it rather difficult to subdivide them into natural groups, and to assign to these a natural succession agreeing with the gradation of their structure, as there are so many the development of which is as yet very imperfectly known, and others which undergo so complicated metamorphoses as to leave great doubt respecting their natural relations to each other. However, there can be no doubt that Helminths rank lower than Annelides, for their structure indicates plainly their inferiority, and their mode of existence within other animals shews that they do not even reach that degree of independence which might allow them a free existence.

Among Annelides again, there will arise similar difficulties respecting the relative position of the branchiate types of that group, which are provided with external appendages performing simultaneously the functions of respiratory and locomotive organs, and those families which are deprived of external appendages, or which have stiff bristles upon their joints, independent of their aërial respiratory organs. Indeed, at present the position of earth worms and leeches among Annelides, has not been the subject of any direct investigation, as regards their relative position and rank. But if I were allowed to be guided by the impressions I have received from the study and comparison of the larvæ of insects, I should be inclined to consider the Annelides with external gills, as inferior to those which have no such appendages, and place the lumbricine Annelides highest in the class. So that Helminthus should be placed lowest in the class of worms; next the branchiate Annelides with external branchiæ; next those having internal branchiæ; and highest those with aërial respiratory sacks.

The second class in the type of Articulata is that of Crustacea, the natural circumscription of which can hardly be in any degree a matter of doubt, for these animals, with their distinct articulations, and aquatic mode of respiration, external appendages and particular mode of combination of the rings of their body, wherever they are combined to subdivide the body into distinct regions, are so peculiar as to determine well the natural limits of this class, to which we refer also the Cirripeda, notwithstanding their transformations, also the Lernæan parasites, though they may assume in their parasitic mode of existence so extravagant forms, and an appearance so entirely different from that of common Crustacea. In this class, again, the parasitic vermiform types rank lowest; next follow the Entomostraca, and highest the Malacostraca, in most of which the anterior rings are combined into a distinct region, assuming a peculiar appearance, differing widely from the posterior free movable rings. The circumstance that among Crustacea the organization reaches a point where the anterior part of the body assumes so peculiar an appearance, leaves no doubt as to the relative position of Crustacea among Articulata; they rank higher than worms; though they must be placed below the insects, notwithstanding their perfect circulation, and their otherwise highly developed structure; for, in every respect, insects considered as a whole class, are more highly organized, their higher types assuming a division of the body into three distinct regions,—undergoing also far more extensive metamorphosis, and assuming, finally, an aërial mode of respiration, to which the Crustacea do not reach. For these reasons, which I have illustrated more fully on another occasion, I have no hesitation in placing the class of Insects highest among Articulata, and in comprising in one class the true insects with Arachnida and Myriopoda, which are only lower degrees of development of the more special types of true insects; the Myriopoda representing, in a permanent state of development, and with the structure of true insects, the form of their caterpillars; the spiders, with their cephalic and thoracic regions united into a cephalo-thorax, representing their chrysalis in a permanent state of development; and the true insects, with their three distinct regions, the so-called head, thorax, and abdomen, ranking highest among them, as well for their more extensive metamorphosis as for the characteristic division of the body, the reduction of their locomotive appendages to a peculiar region, the complication of their chewing apparatus, and the development of their wings. The true arrangement of the different members of this class, however, is readily indicated by the remarks already made upon this class, and we shall not hesitate to consider Myriopoda as their lowest type, and to place Arachnida next above them, and then true insects, among which the sucking tribes rank highest.

If we now consider the connection of these three classes with the elements in which they are developed, and in which they permanently live, we cannot fail to be struck with the fact that two of their classes are either parasites or entirely aquatic, for even the terrestrial worms live in moist ground, or on the bark where moisture is constantly accumulating; and these two classes we have seen to be the lowest of the type, while the class of insects which, in their perfect development, are all terrestrial or aërial, constitute the highest type.

Reviewing the secondary groups of all these classes also in the same connection, we find that the lowest of all not only live in a fluid medium, but require the existence of other animals in whose cavities they find shelter and means of subsistence; and, among those which have an independent mode of life, we find that the marine worms are probably lower than the fluviatile and terrestrial,—at least, if the view expressed above respecting the relative position of Lumbrici and branchiate Annelides be correct.

In the class of Crustacea we have exclusively aquatic animals, and we find that, among them, those which live as parasites upon other animals rank lowest. The distinction, however, between fluviatile and marine types in this class does not seem to be in strict accordance with their gradation, for we have fluviatile Decapods which cannot be considered as higher than the crabs, unless it were shewn that the shortened body of the Brachyural Decapods is the result of a retrograde metamorphosis, which I am not, however, inclined to suppose, as we have some crabs which are in the habit of leaving the water to dwell upon the mainland. The occurrence of parasitic Crustacea upon fresh-water fishes again seems to indicate that here the parasitism prevails over the influence of the surrounding media; and we should not wonder at this circumstance, as a parasitic mode of development dependent upon the prior existence of organized beings, is not only a prominent feature in the mode of existence of so many worms and Crustacea, but also even of many of the insects, especially of the tribe of Arachnida and Diptera, at least in some earlier periods of their existence. In this connection it is an interesting fact to notice that the American fresh-water Crustacea, the craw-fishes, have fewer pairs of gills than the other representatives of the class.

Again, it may be, that to appreciate truly natural relations of this type of animals, it will be necessary to consider separately each of their minor divisions rather than the whole class as a unit; as we shall have to do so also among the reptiles where the peculiarities of the primary divisions overrule the influence of the media in which they are developed.

However obscure these relations may be among Crustacea owing to the parasitism of some of their types, or the peculiar metamorphosis of others, if we now consider the insects proper we shall find here again a strict accordance with the results we have already derived from the investigation of the lower classes. Having acknowledged the superiority of the sucking insects over the chewing tribes, we cannot fail to perceive that the Neuroptera, which must be considered as the lowest, inasmuch as their body still preserves the elongated form of worms, are aquatic in their larval condition and have even external gills, as their respiratory organs during that period. Next, Coleoptera, among which also we find aquatic larvæ, and a number of terrestrial types; and highest the Orthoptera which undergo a less extensive, but entirely terrestrial development, whilst Hymenoptera have a more diversified metamorphosis, and assume even in their larval condition in some of their types, the higher forms which characterise the larvæ of Lepidoptera.

Among the sucking insects we begin again with various aquatic types, or aquatic larval forms—next rise to Diptera, with other aquatic larval conditions but a constant aërial mode of life in the perfect state, and finally to the type Lepidoptera in which all larvæ are terrestrial, and even highly organized in their earliest state in the higher groups, so that the class as a whole does not only rank above Crustacea for its structure, but consists chiefly of aërial types in their perfect state of development, a large number of which are aquatic, but fluviatile in their larval condition, and comparatively exceedingly few marine. So that if we compare the whole type of Articulata, with either Mollusca or Radiata, we see that, in accordance with the higher development of its structure, it has not only proportionally a larger number of terrestrial and aërial types, but an entire class is throughout aërial in its perfect state of development; and, though aquatic in the stages of growth, these larvæ are chiefly fluviatile and not marine, so that we may conclude from zoological evidence that the more intimate connection with the mainland and aërial mode of existence indicates a higher degree of development than an aquatic mode of life; and between the animals living in water, that fluviatile types must rank higher than the marine.

These views are fully sustained by the order of succession of these great types of the animal kingdom throughout the earlier geological periods; for as it is already ascertained from zoological comparisons, that the earlier types in each class rank lower than their present living representatives, we have further evidence from the circumstances under which they live that they were all aquatic and marine in the earliest periods, and that fluviatile and terrestrial types have followed only at later periods. Without alluding to those classes in which the gradation of fossil types is less distinctly shewn, let me only recall the Crinoids among Echinoderms, which for so long time prevailed to the almost entire exclusion of all other families among Acephala; the great prevalence of Brachiopoda in the oldest deposits and the first appearance of Naiades in tertiary beds; the large number of branchiate Gasteropoda up to the time of the tertiary period, when Limnæa and Helices made their first appearance; the earlier development of Crustacea with more uniform joints, and the appearance of insects of the tribe of Scorpions anterior to that of the winged families, among which the Neuroptera seem to be the first to increase the number, and the late occurrence of the sucking tribes in tertiary beds, and there will be no doubt left that the gradation of structure is intimately connected with the extension of continental lands, and that the present connection of animals with the surrounding media in which they live, agrees also with their natural gradation. If we would study the natural relations between animals and the media in which they live, we could not begin with better prospect of success than by investigating minutely the different families of Vertebrata separately, rather than the whole class of this great type. For, though it is at once apparent that the class of fishes, as a whole, is entirely aquatic, and stands at the same time lowest among Vertebrata, as soon as we pass to the investigation of the reptiles, we find aquatic and even marine types among turtles, which rank much higher than the whole order of Batrachians, which are almost entirely fluviatile; and we find again marine and fluviatile types among birds and Mammalia, the highest of all Vertebrata. These facts shew, most conclusively, that an organization as high as that of the Vertebrata,—introducing a mode of existence so independent of the changes of the seasons throughout the year, so durable as to last for numbers of years (whilst among Invertebrata, and especially among insects, but also among many other animals of lower type, there exists the most intimate connection between their development and the course of the seasons); we say these facts shew that, with such animals which are placed so far above the influence of physical conditions, their connection with the circumstances under which they live is much weaker, so much so, that internal structure overrules greatly the foundation of those connections which are so intimate in lower animals, and reduces their limits to subordinate connections between members of the minor groups; while, in the class of fishes —the lowest—the whole type is organized in such a manner as to make it uniformly dependent upon one of the natural elements in which animals live, the three other classes present most diversified combinations, there being marine, fluviatile, and terrestrial or aërial types in these classes, under the development of as many structural types, differing almost in the same degree when contrasted with each other, and so much, that the aquatic Mammalia, even in their marine types, or the marine turtles, differ as much from each other or from bird, as they agree with their respective fresh-water or terrestrial types. These discrepancies between the great types may be owing to other motives in the plan of creation than those to which they are here ascribed. The apparent anomalies between some of the articulated types may also be the results of combinations different from those with which they are connected above. But whether these views are correct or not, I have no doubt that the study of the phenomena, which I am now contrasting, cannot fail to lead finally to a more correct appreciation of the natural relations which exist between animals and the media in which they live, than the vague views which have prevailed lately from want of investigation of the subject rather than from an especial view taken of it; I am far from supposing that, in every instance, I have hit at the outset the true view. I shall be satisfied to have called forth direct investigation upon this question, and led the way in a field which promises so ample reward.

Magnitude of Animals.—Before entering into a special investigation of the natural relations of Vertebrata and the surrounding media, it may not be out of place to call attention to some collateral facts which will appear particularly prominent in the type of Vertebrata, but which have already their value in the study of the lower types. I allude to the relative bulk of animals of the same type living in different media. We can derive no impression upon this point from the investigation of Radiata, as they are all aquatic, and almost entirely marine; but the difference is already marked between Mollusca, if we contrast their marine and their fluviatile and terrestrial types within the limits of their natural secondary groups. Among Acephala, if we consider the Lamellibranchiata, we cannot fail to observe that the marine representatives are, as a whole, and taking into consideration the proportional number of their genera and species, of larger size and greater weight than the fluviatile. We have nowhere such gigantic, bulky, and heavy fresh-water Bivalves, as are many of the marine shells; and we need only compare the large Chamas or Tridacnas and Hippopus, the gigantic Pinna, even with the largest of Anadonts; and again, the numerous species of Cyclas, &c., with the smaller marine Bivalves, among which we find but few species of so minute types. Again, among Gasteropoda, how much larger are most of the Univalve marine shells, such as Dolium, Strombus, Voluta, and others, than even the largest fresh-water Ampullariæ, and the whole lot of fresh-water and terrestrial Pulmonata, among which latter we have absolutely the smallest of all Mollusca in the innumerable varieties of Pupa and other genera. We reckon, in this type of Gasteropoda, the minute species by hundreds, while there are exceedingly few of really small size among the marine ones; and the greater number are even universally above the medium size of the larger fluviatile and terrestrial types.

Among Articulata the same rule obtains; and here we may compare classes with classes, even in their different stages of growth. Are not the Worms, taken as a whole, larger animals than the Caterpillars? Do we not find among marine Worms by far the largest types? We need only remember the gigantic Eunice, or even the parasitic Tapeworms, to be satisfied of the fact. Are not the Crustacea, as a class, composed of types exceeding far the largest insects, even with their wings spread? Are not the marine Lobsters many times larger than the fresh-water Craw-fishes? A minute investigation of the details of this numerous class might lead to very interesting comparisons, which, however, would be out of the way in this general sketch.

I shall mention only a few facts to shew that these comparisons might even be traced between the different stages of growth of these animals. It must be, for instance, a matter of surprise to see that the body of so many insects is smaller in their perfect state of development than as a pupa; and that again, this is smaller than that of the larva, though the larva be after all only the younger state of the pupa, and the pupa the younger state of the perfect Insect. But in the same ratio as we find so frequently throughout the animal kingdom, that the lower condition of structure and development of a type is manifested in a more bulky body, so we find among Insects, that their earlier state of metamorphosis which is developed under inferior circumstances, reaches its final growth in a more bulky body than that of following periods during which their successive moultings and the transformations of the substance of the body takes place; the greatest size which the larva acquires is first reduced in its transition into a chrysalis, and this again is reduced in its transition into a perfect Insect,—the development of wings only leaving them seemingly of greater size when their surface is extended, though the bulk as a whole be reduced. Weighing these animals in these different states of development will satisfy the most incredulous of the reality of what is here stated, should the appearance have deceived him before. A silkworm when it begins to spin is much heavier than the chrysalis, and this heavier than the perfect moth. Without directly weighing these animals, we might be satisfied about this fact if we should consider the amount of silk which is thrown out by the latter, and the amount of fluid which is discharged by the Moth, even before it rids itself of its load of eggs and sperm to enjoy the last moments of its complete maturity.

If we now allude to the Vertebrata, we shall find very similar facts, and perhaps, in the animals to be mentioned, inducements for the discovery of curious unnoticed connections. And here again we should be cautious, for reasons already alluded to above, not to take the classes as such, but rather to consider their different types separately; for the class of fishes as a whole cannot be said to contain the largest Vertebrates, nor even to afford any support to the view that aquatic animals in general are larger than terrestrial; for we find proportionably a much greater number of large species among Mammalia than among fishes; we find a greater number of large terrestrial reptiles than of aquatic ones.

But if we review the classes separately, and consider their secondary groups by themselves, we find that the rule holds good, but bears, at the same time, most interesting reference to the order of succession in geological times, as the respective types of any given group are the larger in the present period, whether terrestrial or aquatic; for being representatives of families which had numerous representatives in older periods. Among fishes, we find the largest in the family of Sharks and Skates, Sturgeons, and Garpikes, the first of which are exclusively marine, the second marine and fluviatile, the third entirely fluviatile; but the three types are either exclusively representatives of families largely developed in former geological periods, or so connected with extinct types as to shew that this connection has influenced their development.

Among Reptiles, we find the largest in the family of Turtles among their marine representatives; among the Lizard-like, in the fluviatile Crocodiles; among Batrachians, in their aquatic families.

In Birds, the aquatic families, Pelicans, Geese, Ducks, &c., bear a much larger proportion of heavy bulky forms than any terrestrial families; and if the Ostrich should at once occur as a striking exception, let us not forget that the giants of this family are known in a fossil state, exceeding far their living representatives.

Among Mammalia, we have the Whales as the largest class, and if we should be reminded of the great size of terrestrial Pachyderms, let us not forget that Pachyderms were the prominent type of Mammalia during the tertiary period. In connection with these facts, it might be shewn that natural families throughout the animal kingdom are constructed within limits of size, which do not admit of great differences. A comparison of Cetaceans with Rodents, of Ruminants with Bats, of Passerine with Gallinaceous birds, of Sharks with Herrings, of Cod-fishes with Blennoids, of Cuttle-fishes with Pteropods, of Crabs with Entomostraca, &c., might easily satisfy the most sceptical, that there are natural limits assigned to certain combinations of structure, and the material bulk of the animals in which they are manifested.

After this digression, let us return to our consideration of the natural connection of the secondary groups of Vertebrata, with the elements in which they live.

4. *General View of Vertebrata.*—1. *Fishes.*—Though the class of fishes is entirely aquatic, we have among these animals a greater number of marine types, and some which are partly marine and partly fluviatile, or at periods marine, or at periods fluviatile; and others which are entirely fluviatile, or almost so. And though, at present, it is not plain that fluviatile types, on the whole, are superior to the marine types, we should not lose sight of the circumstance that the only living Sauroids which have so many characters by which they may be connected with the class of reptiles, and considered as the highest among fishes, are entirely fluviatile; both Lepidosteus and Palypterus occur only in fresh waters; some of the Lepidostei only are known to reach the mouths of rivers emptying into the sea. And though the families of Sharks and Skates are chiefly marine, numbers of them, especially of those types of Skates which have numerous fossil representatives during the tertiary period, such as Myliobatis, are known to ascend freely the rivers in tropical regions. Among Cyclostoms, the lowest type Branchiostoma is marine, Petrostoma proper being both marine and fluviatile, the higher type of Ammocœtes (for we must consider Ammocœtes as higher, inasmuch as the division of the lips indicates a tendency toward a formation of a distinct upper and lower jaw), is exclusively fluviatile. The Goniodonts, which from their affinities to Sturgeons rank higher than the Siluridæ, are exclusively fluviatile, whilst there are some marine types among the latter. Among Percoids, we find in fresh water a large number of those in which the two dorsals are distinct, a character making them eminently superior to the forms with undivided fins. For the same reason, we should consider the Sparoids inferior to the Percoids, their dorsals being not only generally undivided, but even covered with scales. Among the Eels, those destitute of all fins are exclusively marine, those without pectorals also exclusively marine, and we may fairly consider the fresh-water Eels as the higher type of the family on this

ground. If there is any natural connection, as I have attempted elsewhere to shew that there is, between Scombroids and Scomberesoces, and Esoces proper, it becomes plain at once, that the latter are the higher from the abdominal position of their ventrals, and they are a fluviatile family. Even taking the Cycloids as a whole, we find among them the lower families of Thoracici and Ingulares, as the families of Cod and Scombrides, chiefly marine, whilst the family of Salmonidæ and Cyprinidæ are chiefly fluviatile. Among the Gadoids, we have those with many vertical fins, as the true Cod, marine, while those in which the dorsals and anals are reduced, such as the genus Lota, are fluviatile. Even among the Salmonidæ, in the widest extension which this family had formerly, we find the Scopelidæ, with the inferior structure of their jaws chiefly marine, while the Coracini and true Salmonidæ are chiefly fluviatile. Everywhere, in fact, in each minor group, the fluviatile representatives shew characters indicating their superiority over their marine representatives. Whatever exceptions might be found to this law, which, in the outset, appears so general, I have no doubt will lead at some future time to the discovery of some other principle as yet unknown.

2. *Reptiles.*—The class of Reptiles is one of the most interesting in the point of view under consideration; and each of their types exemplifies in itself the law of the intimate connection between animal types and the media in which they live in the most striking manner, inasmuch as here the gradation which might be inferred from structural and embryological evidence, agrees most fully with the gradation of the elements in which they live. Among Batrachians we have chiefly fluviatile and terrestrial families. The Ichthyodes, or Batrachians with permanent branchiæ, are all aquatic, and acknowledged the lowest in the class. Some of their lowest representatives occur even in the brackish swamps, and, as soon as attention is called to this subject, it cannot fail to be perceived that the frogs, with their more or less palmate fingers, and their more aquatic habits, rank lower than the toads, with their divided fingers and terrestrial mode of life. Among Ophidians we have chiefly terrestrial

families, and only a few marine and aquatic ones; but who can fail to perceive that the marine serpents, with their flattened tail, are inferior to the terrestrial genera, and that among these it is a well-known fact there are some with rudimentary posterior extremities, which assigns them a superior rank. Some objections might be drawn from the consideration of the Saurians, among which, the highest type, the Crocodiles, are chiefly fluviatile; but it has elsewhere been shewn that Crocodiles are not truly Saurians of the same type with our Lizards, but modern representatives of a large family, which was very numerous in former geological periods, when their first representatives were marine types provided with fins instead of distinct fingers; so that, far from being an exception, the Crocodiles of our days, which are either fluviatile or terrestrial, must be considered as the highest representatives of that almost extinct type of Reptiles, the earliest forms of which were marine, followed by fresh-water. Finally, among Chelonians, the gradation, in connection with the natural elements in which they live, is most striking; for the inferiority of the marine Turtles is as plain as it can be, not only in the form of their organs of locomotion, but even in the peculiarity of many of their internal organs, especially of their ovaries, which contain eggs almost as numerous as those of fishes. Next we place the fresh-water Turtles, with palmate fingers, and highest, terrestrial Testudines, with their short undivided fingers. So that we have in this class, with its various marine and fresh-water and terrestrial types, not only a full illustration of these laws, but so intimate a connection between gradation of structure and mode of living in various elements, as to lead to the conviction that the mere mode of living might, in many instances, be almost as safe a guide to ascertain the natural gradation of types, as the study of their internal structure.

3. *Birds.*—Ever since the class of Birds has been the object of regular investigation, their aquatic types have been considered as inferior to the terrestrial ones; and among the former, those which live entirely an aquatic life are decidedly the lowest. They are so, not only on account of the more imperfect development of their legs, which preserve throughout their embryonic form, but also in the less extensive development of

their wings, in the more scale-like form of their feathers, and the greater number of eggs they lay, and the less care they take of their young, which are hatched in a state of development in which they are already prepared to provide for their own food. The same is the case with the Gallinaceous and the Wading birds, which, though more advanced in many respects, are still inferior to the climbing and Passerine birds in this respect, having a heavier flight, if they fly at all, and living a more terrestrial and even aquatic life; the Wading birds coming nearer in this respect to those with palmate fingers, and the Gallinaceous birds, as well as the Ostriches, having a more terrestrial mode of life; whilst the Passerine birds rank higher in all these respects, feed their young, and take care of them for a longer time, and live almost exclusively an aërial life, few of them having aquatic habits, and those being, in their respective families, by their form, as well as by their mode of life, decidedly inferior to their loftier relations.

The classification of Birds as a whole, is still so imperfect though their minor groups are well understood, that many important relations in these respects must necessarily be more or less concealed as long as their primary divisions are not better known; so that we may expect many interesting hints from further investigations in this view.

4. *Mammals.*—The class of Mammalia is not only the most diversified in the forms of its members, but also in the diversity of their mode of life; nevertheless, this diversity is connected by the most intimate relations of structure. The Whales are as much Mammalian by their internal organization, as the most exclusively terrestrial quadrupeds. True Cetaceans constitute a natural family, all the members of which are exclusively marine, and no one of them even fluviatile—for the Sirenidæ must be considered as entirely distinct from the true Cetaceans; and those Cetaceans, at the same time that they are so exclusively marine, are also the lowest type of Mammalia, not only from the imperfection of their extremities, of which there is only one anterior pair, and from the want of hind legs, but also from the extraordinary development and bulk of their muscular tail, and the development of a caudal fin,

and sometimes even a fin-like fold of the skin upon the back. If it can be shewn that the Sirenidæ are an aquatic type of a larger group embracing Pachyderms, the direct relation of their structure and mode of life will be at once obvious, since Sirenidæ are either marine or fluviatile, while true Pachyderms are terrestrial; and should we not be justified in considering the sub-aquatic Hippopotamus as inferior to its more terrestrial relatives of the genera Rhinoceros, Elephant, and Horse? Are we not to consider the Ornithorynchus, with its pulmate hind-legs and spur, as inferior to Echidna? Are not the palmate Rodentia inferior to the terrestrial and arboreal types? Are not the aquatic Shrews inferior to the arboreal Insectivora? All these secondary questions will receive, in future, due attention, and will no doubt be satisfactorily settled. But there are families in which we can already see our way, and arrive at precise conclusions. Among carnivorous Mammalia we have three distinct types, the Pinnipoda or seals; the Plantigrada or bears, and the Digitigrada, dogs and cats. Now, even if objections were raised against the association of the Walrus with the common Seals, there can be no doubt of the inferiority of the latter when contrasted with Plantigrada and Digitigrada. Their short fin-like legs, their clumsy body, in connection with their aquatic marine life, assign them a lower position, and the Plantigrada must be considered as intermediate between them and the Digitigrada. Now, among Digitigrades, even if we take isolated genera, we are led to assign to the species with aquatic habits, an inferior position among their nearest relatives. The Polar bear comes decidedly nearer the Seals in all its habits, than any other species of that genus, and, on that ground, should be considered as inferior to the terrestrial species. Again, the others, with their palmate fingers, rank lower than their terrestrial relatives; and we may even find that such considerations will hold good among the varieties of one and the same species; for we have varieties among the Digitigrade dogs, in which the fingers are palmate, a character which is derived from the imperfect development of their legs, preserving throughout life their embryonic form; and these varieties among dogs are the most playful, and at the same time, most aquatic in their habits, preserving in their adult state, characters of the young, and habits of the lower types; this playful disposition being universal, even among the most ferocious of the cat tribe. I shall abstain purposely from tracing these comparisons higher up among Monkeys, and in the human families, from fear of alluding to exciting topics; but leave it to the philosophic observer to consider how far the idea of an aquatic Monkey is compatible with the high position which these animals hold in the class of Mammalia; and how curious it is that in the human family there are races which differ so much in their natural dispositions, mode of life, habits, and adaptation to higher civilization; and how closely these natural dispositions are connected with apparently insignificant peculiarities of structure.

Upon reviewing the facts mentioned above, and the inferences derived from the facts, no impartial observer can in future deny the importance of the study of the natural relations between animals and the media in which they live; and the close connection which exists between them and the gradation of their structure. But this being the case, it must be a matter of surprise that the views so long entertained of the importance of this connection, which led earlier naturalists, generally, to the classification of animals according to the media in which they live, should have been so completely abandoned, and even considered of no value at all in systematic classification. For my own part, I have no doubt that this negative result has arisen from the circumstance that also aquatic animals were brought together, in these earlier attempts, without reference to their structure or organic development, while we have found that structure is the ruling principle, and that natural connection with the element, is the secondary motive by which these connections are influenced. Indeed, aquatic animals, though agreeing in many respects, and though provided with analogous apparatus to perform the same functions, have, in different types of the animal kingdom, a very different plan of structure, and very different organs to perform the same functions. I shall not enter into a detailed illustration of these differences, as I have alluded to these facts in other papers, but only recall here, the great difference which exists in these connections between the different types.

Among Radiata, which are all aquatic, we find even that the adaptation to the liquid element is introduced in a plan of structure which is widely different from the plan of structure prevailing in Mollusca, though they also are chiefly aquatic; and that even the terrestial types of Mollusca present, for adaptation to an aërial mode of life, only a modification of their aquatic types. The same may be said of insects, in which the structure is mainly that of Crustacea and worms, which are permanently aquatic types, presenting simply a transformation of those peculiarities of structure which enable the lower classes to live under water, such as will enable them to rise in their adult state into an aërial condition of existence. Among Vertebrata the case is very different. The type is constructed for a terrestrial and aërial mode of life; even their aquatic representatives have rudiments of the apparatus, which acquire the highest development in the complete terrestrial types, and most of their aquatic types are truly aërial animals living in water, just as insects are aquatic types adapted to the air. Let us only contrast in this respect Cetacea with common Articulata. They have a pulmonary mode of life as much as man; they have the same mode of reproduction; only their form enables them to dive under water and to dwell permanently in the sea; but, for all their structure, they are truly aërial animals. And this is equally the case with birds and reptiles; and with the fishes I am prepared to show that there is no difference in this respect. For, though in their perfect state, Fishes are exclusively aquatic, they are completely built upon the same plan with those aërial classes of Vertebrata. The difference here is only this, that the branchial apparatus, which exists simultaneously in Reptiles, Birds, and Mammals, in their imperfect condition, is developed to be a permanent organ of respiration, while it is reduced and disappears in the higher classes in proportion as the lungs acquire a greater development. In Fishes, on the contrary, the homologue of the lung remains functionally and organically in a rudimentary state, as an air-bladder. But all classes have both apparatuses in an inverse state of development, and thus fishes are as fully constructed on the plan of the higher Vertebrata as the aërial Invertebrata are on the plan of their aquatic types. But the circumstances that fishes have the double type of respiratory organs, and that the pulmonary one which by no means exist in any Invertebrates as I have shewn elsewhere, but throughout the Vertebrata including Fishes, shew that the whole type of the Fishes, have to be viewed in the same light as Reptiles, Birds, and Mammals, and must therefore be only considered as a lower condition of these aërial types, and not the latter as a higher degree of the former. For tracheæ of Insects, and lungs of spiders, are only modified branchiæ of the type of Articulata, just as much as lungs of Pulmonata are modified branchiæ of the type of Mollusca, while gills and lungs in Vertebrata are parallel systems, both co-existing in all of them, and only acquiring respectively a different degree of development in each of their classes. These facts which I have traced in other papers through a special comparison of all the homologies of the different types of respiratory organs in Vertebrata, Articulata, Mollusca, and Radiata, shew plainly that the aquatic, marine, or fluviatile, and terrestrial mode of life are introduced throughout the animal kingdom by special adaptations of peculiar different systems of organs performing analogous functions; and that the failure of introducing the consideration of the adaptation of animals to the media in which they live, in the plan of their classification, must be ascribed to the fact that these analogous structures were in the beginning considered as identical features in the organization. But taking in future into consideration all these peculiarities, we shall rapidly proceed towards the full understanding of all the relations between the gradation of animals, and the media in which they live, as far as they are not yet fully understood.

An extensive review of the Vertebrata might long ago have led to such conclusions, but before they could be considered as a general law ruling the whole animal kingdom, it was necessary that they should be treated in a special manner through the innumerable types of Invertebrated animals; and we have seen that this agreement is as close and as complete throughout the types of Radiata, Mollusca, and Articulata, as it is plain among Vertebrata, and the slight difficulties to which we have alluded, must probably be referred to the present state of our knowledge respecting some of them, rather than to a departure from this law in any of their types.

On the Presence of Fluorine in Blood and Milk. By GEORGE WILSON, M.D., F.R.S.E. Communicated by the Author.*

In 1846 I announced to the Royal Society of Edinburgh, that after finding that fluor spar was soluble in water, and occurred in many natural waters, I thought it well to seek for it in milk and in blood, and found distinct evidence of its presence in both. The proofs, however, were not so decisive as I could have wished, and the processes followed were liable to objection from their complexity, and the possibility of fluorine being introduced in some of the reagents employed. There was reason also to suspect, that even if fluorine were present, it might be carried away by the considerable volume of liquid employed in the treatment of the blood and milk.

This summer, accordingly, I have examined both of those liquids on a much larger scale, and by a much simpler process than formerly, and the results obtained have been so satisfactory, that I have thought they would prove interesting to the Section.

In my former examination of blood, I obtained a good result only when the serum was employed. This summer, however, I have employed the fresh drawn blood of the ox, exactly as it was furnished by the butcher. About 26 imperial pints, or three gallons of blood, were made use of. This was obtained from different animals, in quantities of about nine pints at a time, as this was as much as could be conve-

* Read to the British Association, at its Meeting in Edinburgh, August 6, 1850.

niently operated on at once. The reduction of the blood to ashes was a tedious and not very pleasant process, but with the help of a powerful furnace, and the active co-operation of my assistant, Mr Stevenson Macadam, who took great pains with the whole preliminary operations, I succeeded in the course of a month in reducing the whole quantity to well-burned ashes.

These ashes contained some unburned charcoal, but not in large quantity; in greater part they presented the appearance of two distinct substances; the one a dark-red solid, owing its colour to the presence of peroxide of iron, the other a white fused salt, having a strong, pure, saline taste, and consisting in greater part of chloride of sodium. The presence of this substance interfered with the detection of fluorine, by evolving a large volume of hydrochloric acid, when the ashes were treated with oil of vitriol, which carried away the hydrofluoric acid evolved simultaneously. It was necessary, accordingly, to remove the chloride of sodium before seeking for fluorine; and to avoid the risk of introducing the substance sought for, by the employment of reagents which might possibly contain it, I effected the removal of the salt by simply digesting the powdered ashes in a minimum of distilled water. This risked the removal of a little fluoride of calcium, or any other soluble fluoride which might be present, but precluded the possibility of any such compound being added to the ashes. After being washed accordingly, they were dried, and warmed with oil of vitriol in a lead basin, covered by a square of waxed glass, which had the words, "*Blood*, 5*th July* 1850," traced upon it by a blunt style in the ordinary way. The whole of the ashes were employed with one piece of glass; but as the vessel could not contain the entire quantity in one charge, it was divided into two portions, the first of which remained for five days in the basin, and was then replaced by the other. The glass was thus exposed for ten days continuously to the vapour arising from the acidified ashes. They effervesced very slightly when treated with sulphuric acid, but evolved a sharp acid odour. The lead vessel was kept at a temperature of about 150° Fahrenheit during the day, and fresh quantities of oil of vitriol were added at considerable intervals, and the contents of the basin occasionally stirred. The glass, which was cooled on the upper surface by the frequent renewal of a stratum of cold water, slowly became dim, and slightly opalescent where the letters were traced, in consequence, no doubt, of the separation of silica, for the letters appeared deeply etched when the wax was cleaned off. From the large scale on which the experiment was conducted, and the simplicity of the process followed, the evidence in favour of the presence of fluorine in the blood of the ox seems unexceptionable; and it cannot be doubted that the blood of other animals will be found to contain the same element. I have detected it in the blood of the horse. I presume it to be present in the state of fluoride of calcium, and that its amount is very small, but I have not attempted its quantitative determination.

Milk was examined in a similar way, but its reduction to ashes was much more easily effected than that of blood. I failed, however, to obtain other than the faintest indications of fluorine from the ashes of about 20 imperial pints of cows' milk. It was from a town dairy, and left a suspiciously small residue of solid matter. The main cause of the failure, however, I believe to have been the neglect to deprive the milk-ashes of the chlorides they contained. The experiment was repeated, with nine imperial pints of rich milk from a country farm, the ashes of which were washed with a minimum of water, dried and treated like those of blood. The vapour which they evolved, etched glass distinctly. The ashes of 12 lbs. of new skim-milk cheese made this spring, treated in the same way, occasioned deep etching of glass. The ashes of four imperial pints of whey treated in the same way, have barely marked glass, so as to shew the faintest outlines when breathed upon. In all probability the fluoride of calcium is associated with the phosphate of lime present in milk, and when the latter is coagulated, separates along with the caseine.

I need not remind the Section that fluorine was long ago detected in another of the animal fluids, namely, urine, as well as in the skeletons, both external and internal, of, I may say, all classes of animals. Some difficulty was found at one time, in accounting for the presence of fluorine in the animal tissues and secretions. But when we learn that fluoride of calcium is soluble in water, and is present in many natural waters, and that it, or some other salt of fluorine, exists in the two great formative liquids of the animal organism, milk and blood, we shall cease to wonder at its presence in the animal solids and fluids, and begin to enquire what its functions may be.

I would suggest, in conclusion, to those who may wish to repeat or extend this enquiry, that—

1*st.* Substances to be tested for fluorine in the way described, should as much as possible be freed from the salts of volatile acids. Much washing, however, must be avoided, as it may occasion loss of fluorine ; and if complicated processes are followed, care must be taken that the reagents made use of, are free from fluorine.*

2*nd.* Substances examined for fluorine, should generally be left for at least twenty-four hours in contact with sulphuric acid. If they contain, as they generally do, some compound of calcium, the pasty sulphate of lime produced, will obstinately retain the hydrofluoric acid, so that unless the mass is occasionally stirred, and the glass left for some period exposed to the vapour evolved, no etching may be obtained, although an appreciable quantity of fluorine is present.

On the extent to which Fluoride of Calcium is soluble in water at 60° *F.* By George Wilson, M.D., F.R.S.E. Communicated by the Author.†

In 1846, I reported to the Chemical Section of the British Association the result of an enquiry into the extent to which

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* Chloride of sodium, and, therefore, hydrochloric acid, are liable to contain fluorine derived from sea water. Phosphorus, phosphoric acid, and phosphates are associated in nature with it ; and so, though to a much smaller extent, are the insoluble salts of lead and the alkaline earths.

† Read to the British Association, at its Meeting at Edinburgh, August 6th, 1850.

fluor spar is soluble in water at 60° F. The result of my researches at that period was, that 7000 grains of distilled water dissolve gr. 0·26 of the salt in question, at the temperature mentioned. Some objections were afterwards made by Mr Nisbet, to the method of investigation followed in some of my experiments, which seemed to imply that a doubt was entertained, whether the substance dissolved by water when it is digested on fluor spar, is fluoride of calcium, or the fluoride of silicon and calcium. I did not see the force of those objections, but I felt, nevertheless, that as all the solutions had been procured by boiling water on native fluor spar in glass vessels, which became slowly corroded if long exposed to the action of the solution, it was not impossible that silicon might have been present, in some of the solutions which were employed to determine the amount of solubility of the fluoride. I thought it well, accordingly, to repeat the results with solutions made in metallic vessels, and never allowed to come in contact with silica in any condition.

One set of trials was made last summer (1849) in the following way:—Well crystallised, transparent fluor spar, was boiled for some hours in a platinum basin, with fine hydrochloric acid, so as to secure the conversion of any silica possibly present, into fluo-silicic acid, and remove any metallic oxide, sulphate of lime, carbonate of lime, or other foreign matter present in the spar, and soluble in the acid. The purified fluor was then washed in the same vessel, by copious affusion with warm distilled water, and in this state employed for the preparation of the solutions to be evaporated. An aqueous solution was prepared by boiling distilled water on this purified salt contained in a platinum basin, and the liquid was then transferred to a pewter vessel, in which it was collected and left for some days at the temperature of 60°, that it might deposit the excess of fluor it had dissolved at 212°. The clear liquid was then filtered through a tin funnel, with the neck partially choked by zinc filings, and the filtrate was measured in a pewter vessel, which had been carefully graduated, so as to contain, when nearly full, 7000 grains of the solution at 60°. The liquid thus obtained and measured, and which had never come in contact with silica, was then evaporated to dryness in a platinum capsule, and the amount of residue ascertained. Six careful trials were made, and gave as a mean, gr. 0·25166 as the amount of fluoride of calcium soluble in 7000 grains or 16 fluidounces, *i. e.*, a pint (Old Apothecaries' Measure.)* This result approaches so closely to that previously obtained with glass vessels, that the number found must be considered as making a near approximation to the truth.

A similar series of observations was made this summer, but the fluor spar, which was of great apparent purity, as furnished to me through the kindness of Mr Tennant of London, was not subjected to any preliminary treatment with hydrochloric acid, but simply boiled with distilled water, and the solution collected and cooled as before, in a pewter vessel. The liquid was allowed thus much contact with silica that it was passed through a paper filter placed within a tin funnel. Few, however, I think, will suspect that it can have transferred to itself any silica from the saline constituents of the paper. Six trials were made in this way, the mean of which gave gr. 0·26 as the quantity of fluoride of calcium soluble in 16 ounces of water. The numbers, of which this is the mean, like those obtained in the previous determinations with metallic vessels, differ more from each other than the numbers did in the first series of experiments, where the solutions were made in glass flasks. This, however, was to be expected ; for the liquid employed in the first series was prepared at once to the extent of many pints, and the uniform composition of the whole secured, before any of the solution was evaporated. In the case of the metallic vessels, on the other hand, owing to their smallness, each pint had to be prepared separately, and its evaporation completed before another was procured. The numbers, therefore, could not but differ more in the second and third determinations than in the first. The highest number was 0·28, the lowest 0·24. We may therefore consider 0·26 as sufficiently nearly representing the true solubility of fluor spar,

* In the report of the British Association for 1846 this amount of liquid was inadvertently called the imperial, instead of the (old) Apothecaries' pint.

so that pure water may be considered as able to dissolve $\frac{1}{26923}$ its weight of this salt. The residue of 16 ounces of the solution etches glass rapidly and powerfully.

The amount of solubility observed, though comparatively small, is large for a salt reputed quite insoluble, and is plainly sufficient to occasion an appreciable error in the quantitative determination of fluorine by the ordinary process, since as much as a pint of water, and that perhaps at the temperature of 212°, must often be employed in washing a precipitate of fluoride of calcium.

Memoranda regarding an Ancient Iron Boat-Hook, found in the Carse of Gowrie. By R. CHAMBERS, F.R.S.E. and V.P.S.A.Sc. Communicated by the Author.*

In the month of August 1837, some labourers employed in digging gravel on the farm of Inchmichael, in the Carse of Gowrie, found an ancient boat-hook at the depth of about 8 feet from the surface of the ground.†

This incident excited the more attention, that there was a popular notion, long prevalent, that the Carse of Gowrie was once covered by the sea, excepting only those low eminences scattered over its surface, which are supposed to have acquired the generic appellation of *inches*, in reference to the insulated position in which they were then placed. In support of this *myth* or tale, it is affirmed that the remains of an anchor were found some years ago on the estate of Megginch. Of course, no such story could be worthy of serious notice in this place, were it not for its apparent harmony with the modern geological hypothesis regarding changes in the relative level of sea and land. That the Carse of Gowrie has once been under water, no geologist can doubt; but it is a different question,—has it been so submerged since the time when the British Island was first peopled, or when anchors and boat-hooks of iron came into use in this country? To set this question at rest, I took a considerable amount of trouble; 1*st*, to ascertain the precise local and geological circumstances of the relic, as observed at the time of its discovery; 2*d*, to decide whether the relic could have come into these circumstances in any other manner than by being lost in a sea formerly covering the Carse.

The local and geological circumstances were briefly these. The boat-hook was discovered under a slightly raised piece of ground

* Abridged from a communication to the Society of the Antiquaries of Scotland, but not hitherto published.

† The relic is preserved in the Museum of the Society of Antiquaries in Edinburgh.

near the extremity of the mount called Inchmichael. The Errol station of the Perth and Dundee Railway has since been set down within 50 yards of the spot. From pits still open, it can be observed that the ground is here composed to a considerable depth of gravel, with an appearance of stratification ; and this gravel is continued all the way to the end of Inchmichael, which is a mass of the same material. The place is a mile from the estuary of the Tay. The general surface of the argillaceous plain called the Carse, is here 25 feet above tide ; but the particular spot where the boat-hook was discovered, is three feet higher, or 28 in all ; consequently, the boat-hook was deposited fully 20 feet above the present level of the sea. The relic itself was in no respect uncommon in its appearance. It was pronounced by Rear-Admiral Sir Adam Drummond of Megginch, to be such an instrument of its kind as would be used in a man-of-war's launch, or a mercantile boat of three or four tons. The appearance of the hose gave reason to suppose that it had been fastened in the usual way to a wooden shaft.

I may here remark, that the antiquary makes at the first a decided objection to a *very great antiquity* for any relic of iron. It is now ascertained that, over all Europe, human society existed for ages without any knowledge of metals, that there succeeded an age in which copper hardened by an infusion of tin (bronze), was used for making implements, and that not till these two long periods had elapsed, and not till a time verging upon the historical era in our country, was the use of iron introduced. It is therefore certain, that this boat-hook could not have been lost or embedded at this place in one of the earliest ages of a Caledonian population. It hence becomes the more desirable to ascertain if the existence of the relic in such a situation, could not be accounted for without supposing any great geological change as occurring subsequently to its deposition. We might of course assume, with tolerable confidence, that the article is comparatively modern ; yet there must obviously be some satisfaction in knowing by what means a nautical implement had probably been embedded at so great a depth in stratified gravel, a mile from the present shore.

One important feature of the Carse in this district is now to be adverted to, namely, a trench or ditch in which a little rill crosses the plain obliquely, to join the estuary in one of those creeks locally called *pows*. The course of this rill is not more than 150 yards from the spot where the boat-hook was discovered. It is, in these days of high cultivation, a narrow ditch of well-defined sides ; but no one can doubt that, in other times, it would comprehend a wider space. Now the bottom of the ditch at this place, is so little above the level of the sea, that an abnormal tide might reach it—though I am not aware of any such event having been actually observed. Let us look, however, to the records of such events in early times.

Sir Charles Lyell, in his *Principles of Geology*, adduces a number of historical notices of inundations by the sea in Holland, causing the destruction of vast numbers of human beings and cattle, and in some instances permanently changing the face of nature. The extreme lowness of that country makes it little surprising that many such calamities should have taken place; but we are less prepared to hear of a tract 25 feet above the sea-level, and that not fronting the open sea, but bordering a confined estuary, being on any occasion submerged. It does nevertheless appear as if the sea had actually, on several occasions during the middle ages, covered large portions of the coast in this part of Scotland, as well as in other districts of the island. The Saxon Chronicle states that, in 1014, on the eve of St Michael's day, "came the great sea-flood which spread wide over the land, and ran so far up as it never did before, overwhelming many towns, and an innumerable multitude of people." Fordun describes the great flood of 1212, by which ancient Perth is understood to have been destroyed. He speaks of great river floods being on this occasion driven back by the swelling of the sea, and the waters being thus raised so much above their usual level, that not merely boats and cobles, but large ships were carried up into the streets and highways. As this was probably only a river flood overspreading the comparatively low grounds beside the Tay, near its junction with the Almond, we cannot with confidence suppose that it could have any effect upon the Carse of Gowrie; there is more likelihood of such effect from the sea-flood, commemorated by the same author as taking place in 1267, when, on the day of the eleven thousand virgins, a very great storm arose in the north; by which the sea, being roused to fury and overstepping its usual bounds in a wonderful manner, levelled houses, towns, and trees, and brought the greatest damage in many places, but particularly *between the Tay and the Tweed*. The chronicler says, that such a flood had not happened from the time of Noah; and adds, that its effects are still visible in his own day, upwards of a century and a half from its occurrence. Matthew of Westminster adverts to several inundations of the 13th century, as producing extensive damage. One on St Martin's eve, in the year 1236, was attended by a constant rise of the sea during two days and a night, the strength of the wind preventing its reflux. It carried ships with breach of anchor out of harbours, broke down shores, and destroyed a multitude of people. An occurrence in 1256, similar, except in there being no mention of the sea, is worth quoting on the present occasion, as the author states that bridges, hay-stacks, the dwellings of fishermen, with their nets and *boat-spears*, and even children in their cradles were carried away.

With such events as these on record, within the period during which iron implements have been in use, it does not appear very difficult to account for the loss and embedding of the Inchmichael boat-hook, without calling any greater geological forces into operation in the case. We may suppose the sea-flood of 1267 to have borne a small vessel or boat to this place, favoured in doing so by the natural hollow of the rill formerly adverted to. The beating of the inundation on the skirts of Inchmichael might produce that bedding of gravel in which the relic was subsequently found. As the same *quasi*-valley passes through the neighbouring estate of Megginch, it seems far from unlikely, that the anchor found in a low situation there may have belonged to the same vessel with the boat-hook. All this is of course purely hypothetical; but our purpose, it must be remembered, is only to discover a manner in which the loss and deposition of these articles *might* have occurred, since the present relative arrangements of sea and land were assumed.

On a former occasion, I enumerated a series of similar discoveries in the low sea-bordering lands of Scotland. The remains of a boat, and several nautical implements, particularly an anchor, are recorded to have been found in the Carse of Falkirk, several miles from the sea. In the Carse of Stirling, as is well known, the skeletons of two whales have been discovered in recent times, in each case accompanied by an implement of bone, denoting that the animals had been embedded there since the country was inhabited by man. In the similar plain on which part of Glasgow is built, four or five ancient canoes have been discovered; and, in one case, a flint weapon was found within the boat. Considering that the ground at Glasgow was 25 feet above the sea, while the utmost ascertained height of modern inundations in the Clyde is 21 feet, I leant, though not without due hesitation, to the hypothesis, that a change in the relative level of sea and land was required to account for these phenomena. I must now acknowledge, that the archæological considerations regarding the Inchmichael boat-hook, and those connected with ancient inundations and abnormal tides, dispose me to regard the whole phenomena as of a purely historical character.

On the Causes which Influence the Changes of Isothermal Lines. By Mr Richard Adie. Communicated by the Author.

In the following communication, I mean to endeavour to shew, that the high temperature enjoyed by European countries, when compared with others in the northern hemisphere of the same latitude, can be better accounted for when the cause of the elevated temperature is referred to heat generated in the great desert of North Africa, than when, as is more generally done, it is attributed to the influence of the gulf stream.

For isothermal lines, or lines traced through places on the earth's surface, having the same mean annual temperature, we are indebted, as the readers of this Journal are well aware, to M. Humboldt. This philosopher has traced in the northern hemisphere eight such lines, five of them confined chiefly to the opposite shores of the Atlantic, and three of them extending round about two-thirds of the earth's surface. The evidence given by these lines, together with the recent maps of monthly isothermal lines by Professor Dove, shew the north-western parts of Europe to possess a much milder climate than any other localities of corresponding latitude in the same hemisphere.

M. Humboldt found, that of two stations of equal latitude, the one in Europe and the other in North America, the mean temperature in the former was 4·1 of Fahrenheit above the mean annual temperature of the latter. The attempts which have been made to explain the reason of this great elevation of temperature in Europe have dwelt chiefly on the proximity of the Atlantic, and the influence of the gulf stream. In so far as the western shore of a continent has been shewn to be warmer than the eastern, the proximity of the Atlantic would be available to explain the superior temperatures in Europe, compared with the United States or British possessions in North America. But, if the observations which have been made on the western shores of North America can be relied on, the shore of that continent, bordered by the far-stretching Pacific, has much lower temperatures than similar latitudes in Europe, north latitude 45° being on the same isothermal line with London between 52° and 53°. Consequently, after deducting what is due to a western sea-board, there still remains an excess of temperature in Europe to be accounted for. The gulf stream which, after a course of about 4000 geographical miles, passes along the coast of the United States to the banks of Newfoundland, where it begins to cross the Atlantic to the shores of Norway, has been repeatedly urged as a reason for the high temperatures of Europe; if we look at the registers of temperature of places on the North American coast, near the banks of Newfoundland, we find them but slightly elevated by that cause, while on the coast of Norway, where the gulf stream can have far less influence, the temperature for the latitude is very great, hence another source of heat is required to account for the elevated temperatures of north-western Europe. At a distance, varying according to the localities from 1500 to 3000 geographical miles, there is in the Sahara of Africa a magazine of heat, usually considered as the greatest on the face of the globe, and composed of heated air capable of travelling with facility at ten times the velocity of oceanic currents of water.

The air on the African desert has usually the same direction as the trade-winds, namely, north-easterly, which is now admitted to be explained by the reasons given by Halley, namely, the influence of the sun rarifying the air at the equator, and the rotation of the earth on its axis. The prevailing winds of the desert taking away the air from the direction of the countries whose temperatures are so much elevated, may be thought to militate against the inference, that their climates are improved by heat from that source; but the continued stream of air in the region of the trade-winds all round the world, wherever the surface of the earth is uninterrupted by table-lands or mountain ranges, from NE., must have a counterbalancing SW. wind somewhere; for which reason it has long been held, that the south-west winds of the temperate zone compensate or restore the atmospheric equilibrium which a perpetual NE. trade-wind would disturb.

Taking, then, the SW. winds as the return currents of air carried towards the equator by a NE. trade-wind, the influence of the heated air of the Sahara should reach Europe by a SW. wind; then, if we allow that much of the heat received by the air in the desert has assumed a latent form in aqueous vapour during the transit, we should next expect to find that where the aqueous vapour is chiefly condensed, the isothermal lines tend furthest northward, a supposition which agrees well with the position of the isothermal line for 32° temperature on the coast* of Norway.

The climate of western Europe may be held to owe its favoured temperatures to two distant sources of heat. The first, and most important, from a tropical sun acting on the air over the greatest desert in the world; the second from the same tropical sun heating the waters of the Carribbean sea. The action of the sun on ground destitute of vegetation is well known to heat the incumbent air with rapidity; in dry bright weather the air over a fallow field in this country is seen agitated by the uprising currents of air; and I have seen a thermometer placed on the soil, and covered with a little powdered dry earth, stand, on 1st August, at 120° Fahrenheit. In the African desert, there is within a short aërial journey of us, a mass of heated air greater than can be found in any other place of the same magnitude. The space of time required for the transmission of this air to Europe must, I fear, remain a matter of conjecture, the probability is that it may reach the latitude of London in 100 hours. The second source of heat, the Carribbean sea, has an area nearly the same as the Sahara, so that there may be an amount of solar influence to transmit to northern regions nearly equal to that from the Sahara. The gulf stream passes for a course of 1800 geographical miles along the American coast, bathing the shores of places possessing low temperatures for their latitudes, but which are nevertheless influenced by the gulf stream; for, receding from the shore inland, the isothermal line tends to the south; while, for Europe, the gulf stream has to make another journey of 1800 miles, where its influence must be still less than on the American coast,

* *Vide* Charts by M. Humboldt and Professor Dove.

from which we must infer that very little of the temperature of Europe can be due to the gulf stream. Taking the south-west winds as the counterbalancing currents for the perpetual NE. trade-winds, they cannot derive their heat from passing over the warm water of the gulf stream, for that is not in their tract. Subsequent observation must determine whether our S. and SW. winds derive their heat from what is generated in the form of dry parched air on the African Sahara; for the reasons given, I cannot but help believing that it is so, and that the west coast of Europe enjoys a climate distinguished for its high temperature above all other lands of the same latitude through the influence of the great desert of Africa.

On British Eocene Serpents and the Serpent of the Bible. By Professor OWEN.

A few bones of serpents have been found in the superficial stalagmite, and in clefts of caves, in peat bogs, and the like localities, which bring their occurrence and deposition within the period of human history. None of these Ophidian remains, however, have offered any differences in size or other character from the corresponding parts of the skeleton of our common harmless snake (*Coluber natrix.*) As yet, no Ophidian fossils have been found in British fresh-water formations of the pre-adamitic or pleistocene period, from which formations the remains of the Mammoth, Tichorrhine Rhinoceros, great Hippopotamus, and other extinct species of existing genera of *Mammalia* have been so abundantly obtained. Between the newest and the oldest deposits of the tertiary period in geology, there is a great gap in England, the middle or miocene formations being very incompletely represented by some confused and dubious parts of the crag of fluvio-marine origin in which teeth of a Mastodon have been found.

The deposits in which the remains of the large serpents of the genus *Palæophis* occur so abundantly, carry back the date of their existence to a period much more remote from that at which human history commences. Yet, as the strange and gigantic reptiles that have been restored, and, as it were, called again to life, from times vastly more ancient, realize, in some measure the fabulous dragons of mediæval romance; so the locality on our shore of the English channel in which the Eocene serpents have been found in most abundance and of largest size, recalls to mind, by a similar coincidence, the passage cited by an accomplished and popular historian, in his masterly sketch of the rise and progress of the English nation. "There was one province of our island in which, as Procopius had been told, the ground was covered with serpents, and the air was such that no man could inhale it and live. To this desolate region the spirits of the departed were ferried over from the land of the Franks at midnight."—*Macaulay's History of England*, vol. i., p. 5.

The discovery of serpents of different genera and species, some, as *e.g. Paleryx*, terrestrial, and all manifesting the peculiar and characteristic Vertebral organization of true *Ophidia*, at a period incalculably remote from that at which we have any evidence of the existence of man, more forcibly recalls our early ideas of the nature and origin of serpents derived from annotations to Scripture which represented them as the progeny of a transmuted species, degraded from its originally created form as the consequence and punishment of its instrumentality in the temptation of Eve.

"The curse upon the serpent," say the learned Drs D'Oyly and Mant, in the edition of the Bible printed under the direction of the Society for the Promotion of Christian Knowledge, ed. 1823, "consisted, 1*st*, in bringing down his stature, which was probably, in great measure, *erect* before this time; 'upon thy belly shalt thou go,' or, 'upon thy breast,' as some versions have it: 2*dly*, In the meanness of his provision, 'and dust shalt thou eat,' insomuch as creeping upon the ground, it cannot but lick up much dust together with its food."

The idea of the special degradation of the serpent to its actual form, derived from interpreting the sentence upon it as a literal statement of fact, has been so prevalent as to have affected some of the zoological treatises of the last century. Thus, in the quaint and learned "Natural History of Serpents," by Charles Owen, D.D., 4to, 1742, p. 12, the author, treating of the food of those reptiles, writes,—"That dust was not the original food of the serpent seems evident from the sentence passed upon the Paradisaick serpent, but the necessary consequence of the change made in the manner of its motion, *i. e.*, the prone posture of its body, by which it is doomed to live upon food intermixed with earth."

Dr Adam Clark, commenting more recently upon the record in its literal sense, seeks to elude the difficulties which thence arise, by contending that the Hebrew "Nachash," may be translated "Ape," as well as "Serpent." But when we find him reduced to the necessity of glossing the text by such expositions, as that to go on the belly, means "on all-fours;" and by affirming, of the arboreal frugivorous four-handed monkeys, that "they are obliged to gather their food from the ground," we have a lively instance of the straits to which the commentator is reduced who attempts to penetrate deeper than the Word warrants, into the nature of that mysterious beginning of crime and punishment, by the dim light of an imperfect and second-hand knowledge of the divine works.

If, indeed, the laws of the science of Animated Nature formed part of the preliminary studies of the theologist, the futility of such attempts to expound the third chapter of Genesis, viewed as a simple narration of facts, would be better appreciated by him; and if he should still be prompted to append his thoughts, as so many lamps by the side of the second text, he would most probably restrict himself to the attempt to elucidate its symbolical signification.

What zoology and anatomy have unfolded of the nature of serpents in regard to their present condition, amounts to this:—that their parts are as exquisitely adjusted to the form of their whole, and to their habits and sphere of life, as is the organization of any animal which, in the terms of absolute comparison, we call superior to them. It is true, the serpent has no limbs, yet it can outclimb the monkey, outswim the fish, outleap the jerboa, and, suddenly loosing the close coils of its crouching spiral, it can spring into the air and seize the bird upon the wing; thus all these creatures fall its prey. The serpent has neither hands nor talons, yet it can outwrestle the athlete, and crush the tiger in the embrace of its ponderous overlapping folds. Far from licking up its food as it glides along, the serpent lifts up its crushed prey, and presents it, grasped in the death-coil as in the hand, to the gaping slime-dropping mouth.

It is truly wonderful to see the work of hands, feet, fins, performed by a simple modification of the vertebral column in a multiplication of its joints, with mobility of its ribs. But the vertebræ are specially modified, as I have already described, to compensate, by the strength of their individual articulations, for the weakness of their manifold repetition and of the consequent elongation of the slender column.

As serpents move chiefly on the surface of the earth, their danger is greatest from pressure and blows from above; all the joints are accordingly fashioned to resist yielding, and to sustain pressure in a vertical direction; there is no natural undulation of the body upwards and downwards, it is permitted only from side to side. So closely and compactly do the ten pairs of joints between each of the two or three hundred vertebræ fit together, that even in the relaxed and dead state the body cannot be twisted, except in a series of side coils.

Of this the reader may assure himself by a simple experiment on a dead and supple snake. Let him lay it straight along a level surface; seize the end of the tail, and, by a movement of rotation between the thumb and finger, endeavour to screw the snake into spiral coils; before he can produce a single turn, the whole of the long and slender body will roll over as rigidly as if the attempt had been made upon a straight stick.

When we call to mind the anatomical structure of the skull, the singular density and thickness of the bones of the cranium, strike us as a special provision against fracture and injury to the head. When we contemplate the still more remarkable manner in which these bones are applied one over another, the superoccipital, overlapping the exoccipital, and the parietal overlapping the superoccipital, the natural segments being sheathed one within the other, the occipital segment within the parietal one, we cannot but discern a special adaptation in the structure of Serpents to their commonly prone position, and a prevision of the dangers to which they were subject from falling bodies, and the tread of heavy beasts. I might enumerate many other equally beautiful instances of design and foresight,—the whole organization of the Serpent is replete with such—in relation to the necessities of their apodal vermiform character; just as the snake-like eel is compensated by analogous modifications amongst fishes, and the snake-like centipede amongst insects.

But what more particularly concerns us in the relation of the serpent to our own history, is the great and significant fact revealed by palæontology, viz., that all these ophidian peculiarities and complexities of cranial and vertebral organization, in designed subserviency to a prone posture, and a gliding progress on the belly, were given by a beneficent Creator to the serpents of that early tertiary period of our planet's history; when, in the slow and progressive preparation of the earth, the species which are now our contemporaries were but just beginning to dawn; these, moreover, being species of the lowest classes of animals, called into existence long before any of the actual kinds of mammalia trod the earth, and long ages before the creation of man.—*A History of British Reptiles, by Professor Richard Owen.* Part III., p. 151.

On Lamprey Eels—(Petromyzontidæ)—and their Embryonic Development and Place in the Natural History System.

There are families in all departments of nature, whose peculiarities call for an investigation of their more general relations rather than of their structural details. The Petromyzons are in this case. Closely allied together and circumscribed in a most natural family, it is a question whether they should be entirely separated from all other fishes to form a great group by themselves, or whether they belong to one of those great divisions in which the individual members differ widely from each other. In other words, should the Petromyzons stand by themselves in a natural classification of fishes, as Prince Canino and Joh. Müller have placed them, or shall we combine them with skates and sharks, as Cuvier has done? To answer such a question, it is necessary to discuss beforehand principles of the utmost importance in the study of natural history, and above all to settle the following difficulty:—Is the study of anatomical structure an absolutely safe guide in the estimation of the relations of animals to each other? Cuvier, who made the study of comparative anatomy the foundation of classification, carried out this principle in a most remarkable manner, and improved the natural arrangement of animals most surprisingly; indeed, he made zoology truly a science by it; but with a tact that characterises genius, he limited the absolute consequences of this law by a true appreciation of the relative value of characters; introducing at the same time with the principle of classification, according to the structure of animals, that of subordination of characters, without which the first great principle might mislead us, instead of helping to ascertain the true relations of organised beings. Now it seems to me as if zoologists and anatomists had of late insisted too strictly upon the absolute differences which exist between animals, instead of attempting to appreciate the relative value of the differences noticed. Of course, as this latter point rests almost within the limits of individual appreciation, it is more difficult to find the right path here, than in almost any other department of zoological investigations; but I hope to be able to introduce another great principle of zoological classification, which shall afford a safe guide to settle such doubts; I mean the study of embryonic development.

Let me now show, in the present instance, how I consider it possible to be led by anatomical evidence considered in its absolute results, to combinations strictly opposed to those which an additional acquaintance with embryonic development might indicate.

Guided by his admirable natural feeling of affinities, Cuvier placed in one and the same great division, sharks, skates, and lamprey eels. Influenced by anatomical investigation, and indeed by the most minute and admirable knowledge of their anatomical structure, derived from unparalleled investigations, Joh. Müller concluded, on the contrary, that the Cyclostomata were to be separated from the other cartilaginous fishes, and placed by themselves at the other end of the class. Who is right in this case cannot be ascertained by any further anatomical investigation; it has thenceforth become a matter of individual appreciation, unless we introduce another principle, by which we can weigh the real value of those remarkable differences. Such a principle, I think, we have in the metamorphosis of embryonic life. Indeed, if it can be shown, that besides the differences which exist in all fishes between their earliest forms and their full-grown state, there are peculiarities in sharks, skates, and lamprey eels, common to all of them, from an early period of development, which remain characteristic throughout life, it must be acknowledged that these families belong to one and the same great group, notwithstanding their extreme differences in their full-grown condition. Now, such facts exist. In the first place, it is impossible, without disturbing their true affinities, to consider an extraordinary development of pectoral and ventral fins as a standard to appreciate fundamental relations between fishes, *as in all fishes, without exception, they are both wanting in earlier life*, and as there is scarcely a family in which ventrals at least, are not wanting in some genus or other. We might just as well place Petromyzons among the eels, as their common English name purports, on the ground of the deficiency of their abdominal and thoracic organs of locomotion, as separate them from the other Placoids. Again, the peculiarities in the development of the dorsal, caudal, and anal fins in sharks and skates, and the difference which exists between them and the Petromyzons, indicate in no way their affinity or their difference ; in Petromyzon we have the embryonic condition of vertical fins, where a continuous fold in the skin of the middle line extends, as in all embryo fishes, from the back round the tail, towards the abdominal region. In the sharks we have distinct vertical fins, as they generally grow out of the continuous embryonic odd fin ; whilst in the skates these fins disappear almost entirely, or are considerably reduced. That animals in their embryonic condition are neither so elongated as many of cylindrical form in their full-grown state, nor so short as some others, is ascertained by the embryology of snakes and toads. Thus all the great external differences which exist between skates and sharks on one side, and Petromyzon on the other, do not shew that these animals do not belong to the same natural group, as we have even among the full-grown ones, what we may call transitions between the extreme forms; for instance, sharks with more elongated body than others, with more extensive vertical fins, even with two dorsals and some without ventrals. Again, the remarkable form of skates arises solely from an extraordinary development of the pectorals; they are nevertheless closely allied to sharks, notwithstanding the striking difference in the position of the gill opening.

As for the anatomical differences which exist among these fishes, and upon which so much stress is placed as to make the want of a heart, in Amphioxus, the foundation for a peculiar *class* to include that single fish, let us not forget that there is an epoch in embryonic life, when no vertebrated animal has yet a heart; when the vertebral column is a mere soft continuous cord; when the brain is scarcely subdivided into lobes; when the head, as such, is not yet distinct from the trunk; when the mouth is a mere circular opening at the anterior extremity of the body; when the gills are simple fissures on the sides of the head, or what is to be a head, without branchiostegal rays, or operculum, or protecting covering of any kind.

Whoever is familiar with the anatomy of fishes must perceive, after these remarks, that the peculiarities which characterise Petromyzon have a bearing upon the embryonic condition of their structure, even in their full-grown state, and do not, by any means, mark a difference between them and the sharks and skates, any more than between them and any other family of fishes. On the contrary, should it be possible, after these statements, to shew that there are important characters, common to Petromyzon, sharks, and skates, notwithstanding their extreme external differences, it should be acknowledged that Cyclostomata and Plagiostomata are only different degrees of one and the same great type. Now, such characters we have; in the first place, in the structure of the mouth, which differs so widely from that of the other fishes, and agrees so closely in all Placoids, as Müller himself has shewn in his Anatomy of Myxinoids. Next, the teeth also agree, in being arranged in several concentric series, and also in their microscopical structure, as well as in their mode of attachment to the skin lining the jaw, and not to the bone itself. We have other hints of the relation between Cyclostomes and Plagiostomes in their spiracles, and also in their numerous respiratory apertures, so that, after due consideration, I come to the conclusion that the Myxinoids and Petromyzons, far from being the types of peculiar sub-classes, are simply embryonic forms of the great type to which sharks and skates belong, bearing to these powerful animals, in a physiological point of view, the same relation which exists between Ichthyodes and the tailless Batrachians.

Of Cyclostomata, two species have been mentioned as occurring in the colder parts of North America, both referred by Dr Richardson to the genus Petromyzon proper, but of which I have seen no trace myself in the great lake region, though I know Petromyzons to occur below Niagara Falls. However, I am able to add a new species of this family to the fauna of those waters, which belongs to the genus Ammocætes, and was found in the mud in Michipicoton River, at the landing-place of the factory, the first specimens of which were picked up by the students, when dragging their canoes along the shore.—*Agassiz on Lake Superior*, p. 249.

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*On Fossil Rain Drops.**

Mr Desor communicated some observations made by Mr Whitney and himself in reference to the probable origin of the so-called fossil rain drops, which, in this country, we found on slabs of red sandstone, as well as Potsdown sandstone.

He said it had already been noticed by Mr Teschemacher that these so-called rain drops, when closely examined, are found to differ in several respects from the impressions made by the rain on a beach, where each drop produces an impres-

* Proc. Boston Soc. Nat. Hist., 1850.

sion surrounded by a rough crest, more or less elevated according to the force of the rain. The fossil impressions on sandstone, on the contrary, are generally flat and smooth. Besides, there is hardly a shower in which the rain drops are not numerous enough to cover the whole or nearly the whole ground, whereas the fossil impressions are generally scattered, and so few in number, that it seems almost impossible to ascribe them to rain.

Mr Desor said, that whilst encamped on the border of Lake Superior, they had several opportunities of studying the action of the waves on the beach during a heavy surf, when they are driven beyond their usual range. It was noticed that when the waves retired from the higher part of the beach, where the slope was less steep, there could be seen several kinds of impressions in the act of forming, some large and flat, others small and deep (like those which on the sea shore are generally ascribed to worms or shrimps), and others likewise deep, but surrounded by a sort of annular, smooth rim. These different kinds of impressions are all produced by the same cause, operating in the same way, namely, air-bubbles, which are formed in the waves of the surf, when rolling over the beach. If an air-bubble becomes buried in the sand, so that, in order to escape, it has to make its way through the new formed stratum of sand, it forms a deep and narrow hole. If the air, instead of escaping at once, bubbles up several times, then it raises around the hole a small and smooth rim, which may be compared to a miniature crater of a volcano. If, on the contrary, the air-bubble remains at the surface and bursts, then it causes a flat and rather large impression. According to Messrs Whitney and Desor, these different forms of impression, arising from air-bubbles, are sufficient to account for most impressions which have hitherto been considered as the effect of rain. Such impressions of air-bubbles are most perfect where the slope of the beach is very gentle. Where the slope is more or less steep, the sand becomes too much hardened, under the pressure of the waves, to allow these delicate impressions to be produced.

A sketch was exhibited, showing those different forms of impressions, and their striking contrast with impressions of rain drops from the same beach, mouth of Carp River, Lake Superior.

Mr Teschemacher said, that he had seen fossil rain drops, so called, with an elevated ridge crossing them ; an appearance easily explained by Mr Desor's hypothesis, but incompatible with the supposition that they were caused by rain.

Professor Agassiz said, that on the mud-flats at Cambridge, he had noticed impressions made in the way described by Mr Desor at Lake Superior.—*American Journal of Science and Arts*, vol. x., 2d Series, No. 28, p. 135.*

On the Fossil Crocodilia of England.

On reviewing the information which we have derived from the study of the fossil remains of the procœlian *Crocodilia*, that have been discovered in the Eocene deposits of England, the great degree of climatal and geographical change, which this part of Europe must have undergone since the period when every known generic form of that group of reptiles flourished here, must be forcibly impressed upon the mind.

At the present day the conditions of earth, air, water, and warmth, which are indispensable to the existence and propagation of these most gigantic of living Saurians, concur only in the tropical or warmer temperate latitudes of the globe. Crocodiles, Gavials, and Alligators now require, in order to put forth in full vigour the powers of their cold-blooded constitution, the stimulus of a large amount of solar heat, with ample verge of watery space for the evolutions which they practice in the capture and disposal of their prey. Marshes with lakes, extensive estuaries, large rivers, such as the Gambia and Niger that traverse the pestilential tracts of Africa, of those that inundate the country through which

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* Many of the so-called fossil foot-marks will, we believe, turn out to be imaginary.—*Edit. Ed. Ph. Journal.*

they run, either periodically, as the Nile for example, or with less regularity, like the Ganges; or which bear a broader current of tepid water along boundless forests and savannahs, like those ploughed in ever-varying channels by the force of the mighty Amazon or Oronooko;—such form the theatres of the destructive existence of the carniverous and predacious Crocodilian reptiles. And what, then, must have been the extent and configuration of the Eocene continent which was drained by the rivers that deposited the masses of clay and sand, accumulated in some parts of the London and Hampshire basins to the height of one thousand feet, and forming the grave-yard of countless Crocodiles and Gavials? Whither trended that great stream, once the haunt of Alligators and the resort of tapir-like quadrupeds, the sandy bed of which is now exposed on the upheaved face of Hordwell Cliff.

Had any of the human kind existed and traversed the land where now the base of Britain rises from the ocean, he might have witnessed the Gavial cleaving the waters of its native river with the velocity of an arrow, and ever and anon rearing its long and slender snout above the waves, and making the banks re-echo with the loud and sharp snappings of its formidably-armed jaws. He might have watched the deadly struggle between the Crocodile and Palæother, and have been himself warned by the hoarse and deep bellowings of the Alligator from the dangerous vicinity of its retreat. Our fossil evidences supply us with ample materials for this most strange picture of the animal life of ancient Britain, and what adds to the singularity and interest of the restored *tableau vivant*, is the fact that it could not now be presented in any part of the world. The same forms of Crocodilian Reptile, it is true, still exist, but the habitats of the Gavial and the Alligator are wide asunder, thousands of miles of land and ocean intervening: one is peculiar to the tropical rivers of continental Asia, the other is restricted to the warmer latitudes of North and South America; both forms are excluded from Africa, in the rivers of which continent true Crocodiles alone are found. Not one representative of the Crocodilian order naturally exists in any part of Europe; yet every form of the order once flourished in close proximity to each other in a territory which now forms part of England.—*Professor Owen's History of British Fossil Reptiles*, Part iii., p. 132.

On the Incrustation which forms in the Boilers of Steam-Engines, from a Letter addressed to Dr G. WILSON, F.R.S.E. By JOHN DAVY, M.D., F.R.S., Inspector-General of Army Hospitals. Communicated by the Author.*

On entering on this inquiry, which I did after my return from the West Indies in December 1848, and after communicating a short paper to the Royal Society "On Carbonate of Lime in Sea-water," it appeared to me desirable to collect as many specimens as possible of incrustations from the boilers of steam-vessels, now so widely employed in home and distant navigation. By application to companies and to friends in our sea-ports, as Dundee, Hull, Southampton, Hayle, Liverpool, Whitehaven, I have succeeded in procuring specimens of incrustation formed by deposition in voyages from port to port, in the British and Irish Channels and the North Sea, between Southampton and Gibraltar, in the Mediterranean and the Black Sea, and in the Atlantic Ocean, between Liverpool and North America, and between Southampton and the West Indies. I am promised specimens from the Red Sea and the Indian Ocean,—but these I have not yet received.

The character and composition of the incrustation, whether formed from deposition from water of narrow seas or of the ocean, I have found very similar—with few exceptions, crystalline in structure, and, without any exception, composed chiefly of sulphate of lime; so much so, indeed, that unless chemically viewed, the other ingredients may be held to be of little moment, rarely amounting to five per cent. of the whole. From two specimens of incrustation from the boilers of steamers crossing the Atlantic, one of which you sent me, in which you had detected a notable portion of fluorine, judging from its etching effect on glass,—I also procured it, it was in combination with silica; and procured it also so combined from two obtained from steamers navigating our own seas, one between Dundee and London, the other between Whitehaven and Liverpool. Of this I had proof, by covering with a portion of glass or platina foil a leaden vessel charged with about 200 grains of the incrustation mixed with sulphuric acid, and by keeping the glass cool by evaporation of water from its surface, and by supplying moisture for the condensation of the silicated gas by a wet band round the mouth of the vessel. After about twenty-four hours under this process, a slight but distinct deposition was found to have taken place,

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* Read to the Meeting of the British Association at Edinburgh, 1850.

corresponding to the margin of the vessel,—a deposition such as that produced by silicated fluoric acid gas under the same circumstances. Thus it was not dissipated by heat nor dissolved by water, and yet admitted of removal by abrasion, either entirely or in great part;—the former in the instance of the platina foil, the latter in that of the glass. Besides the ingredients above mentioned, I may add that, in many instances, oxide of iron, the black magnetic oxide, was found to form a part of this incrusting deposit, collected in one or more thin layers; and further, that in some, especially of steamers navigating the narrower and least clear part of the British Channel, the depositions presented a brownish discoloration produced by the admixture of a small quantity of muddy sediment. Incrustation so discoloured, I may remark, are reported to be most difficult to detach.

I have said that the incrustations, with few exceptions, were similar in their structure, and that that was crystalline;—it was not unlike the fibrous variety of gypsum of the mineralogists.—The specimens received, as might have been expected, varied very much in thickness, viz., from one line and less to half an inch. I have endeavoured, by a set of queries which I had distributed, to obtain information respecting the exact time in which the incrustations were formed, and under what circumstances; but with partial success only, owing, it may be inferred, to a want of exact observation. In one instance, that of the North American mail-ship Europa, which arrived at Liverpool on the 15th of November, at 4 P.M., having left Boston on the 7th of the same month at 9 A.M., an incrustation was found in her boiler of about one-fiftieth of an inch in thickness; and it is stated that an incrustation of about the same thickness was found on her outward voyage. This example may aid in giving some idea of the degree of rapidity with which the incrustation is produced, at least in the Atlantic, with the precaution of "blowing off" every three hours, and with the "brine pumps" kept in constant work. In other seas, especially contiguous to shores, and more especially of shores formed by volcanic eruptions, it is probable, *cæteris paribus*, the rate of the deposition of the incrusting sulphate of lime will be more rapid. The results of the trials of several portions of sea-water taken up on the voyage from the West Indies to England, noticed in the paper of mine already referred to, are in favour of this conclusion.

To endeavour to prevent the deposition of the incrusting matter or to mitigate the evil, various methods, it would appear, have been had recourse to,—some of a chemical kind, as the addition of muriate of ammonia and sulphate of ammonia to the water in the boiler,—without success, as might be expected;—others, of a mechanical kind, with partial success,—as the introduction of a certain quantity of saw-dust into the boiler, or the application of tallow, or of a mixture of tallow and plumbago to its inside, to prevent close adhesion, and the more easy separation of the incrusting matter either by percussion, using a chisel-like hammer,—or by contraction and unequal expansion, by means of flame kindled with oakum, after emptying the boiler and drying it. Of all the methods hitherto used, that of "blowing off," —that is, the discharging, by an inferior stop-cock, a certain quantity of the concentrated water of the boiler by the pressure of steam, after the admission above of an equivalent quantity of sea water of ordinary density, appears to be, from the reports made, the most easy in practice, the least unsuccessful, and the most to be relied on. But, as in the instance given of the North American steamer, it can be viewed only as a palliative.

Considering the composition of the incrusting matter and the properties of its principal ingredient—the sulphate of lime, a compound soluble in water and in sea water, and deposited only when the water containing it is concentrated to a certain degree, there appears to be no difficulty theoretically in naming a preventive. The certain preventive would be the substitution of distilled or rain water in the boiler for sea water. Of this we have proof in the efficacy of Hall's condenser, which returns the water used as steam, condensed, after having been so used:—but, unfortunately for its practical success, the apparatus is described as being too complicated and expensive for common adoption. Further proof is afforded in the fact, that the boilers of steamers navigating lakes and rivers, in the waters of which there is little or no sulphate of lime, month after month in continued use, remain free from incrustation. This, I am assured, is the case with the steamers that have been plying several summers successively on the lake of Windermere. And it may be inferred, that, in sea-going steamers in which sea water is used in the boiler,—or, indeed, any water containing sulphate of lime, the prevention of deposition may be effected with no less certainty by keeping the water at that degree of dilution at which the sulphate of lime is not separated from the water in which dissolved. From the few trials I have made, I may remark, that sulphate of lime appears to be hardly less soluble, if at all less, in water saturated with common salt than in perfectly fresh water. This seems to be a fortunate circumstance in relation to the inquiry as to the means of prevention, and likely to simplify the problem.

If these principles be sound, their application under different circumstances, with knowledge and judgment on the part of the directing engineer, will probably not be difficult. His great object will be in sea-going steamers to economize the escape of water in the form of steam, and thereby also economize heat and fuel;—also, when fresh water is available to use it as much as possible; and further, to avoid using sea water as much as possible near coasts, and in parts of seas where sulphate of lime is most abundant.

From the incrustation on the boilers of sea-going steamers, the attention can hardly fail to be directed to that which often forms, to their no small detriment, in the boilers of locomotive-railway engines, and of engines employed in mines, and in the multifarious works to which steam-power is now applied. These incrustations will of necessity be very variable, both in quantity and quality, according to the kind of ingredients held in solution in the water used for generating the steam. Hitherto I have examined two specimens only of incrustation taken from the boilers of locomotive engines, and a single one only from the boiler of a steam-engine employed on a mine—a mine in the west of Cornwall. The latter was fibrous, about half an inch thick, and consisted chiefly of sulphate of lime, with a little silica and peroxide of iron, and a trace of fluorine. The former were from one-tenth of an inch in thickness to one inch. They were laminated, of a grey colour, and had much the appearance of volcanic tufa; they consisted principally of carbonate and sulphate of lime, with a little magnesia, protoxide of iron, silica, and carbonaceous matter, the last two, the silica and carbonaceous matter, probably chiefly derived from the smoke of the engine and the dust in the air. From the engineer's report, it would appear that the thinnest—the incrustation of about one-tenth of an inch—had formed in about a week, during which time the locomotive had run about 436 miles, and consumed about 10,900 gallons of water.

Remarks on a Bone Cave near the Mouth of the North Esk. By Mr ALEXANDER BRYSON. Communicated by the Author.

This cave was discovered three years ago by Mr James Walker, the intelligent tenant of the farm of Nether Warburton, while removing alluvial debris from the north bank of the North Esk. It is situated within a mile of the confluence of that river with the German Ocean, and twelve feet above its highest spring-tides. The rock in which it occurs, is amygdaloidal trap enclosing cavities in which are found decomposing zeolites. Its distance from the nearest part of the channel of the North Esk, is about 400 yards. The mouth of the cave being laid bare by Mr Walker's operations, he found it filled with debris, containing a vast assemblage of the bones of the smaller animals (mostly rodentia.) On probing it by means of a long pole, it was found to extend upwards in a sloping direction parallel nearly with the inclination of the bank, to a height of 15 feet. Being desirous of investigating the interior of the cave, with the assistance of a friend we enlarged the opening to permit our ascent. On entering, I found the cavity presented the usual appearance of caves in trap-rocks, where the exterior crust, from the shrinkage below, forms an arched roof. The mouth of the cave on the occasion of our visit, was entirely filled with soil richly stored with the bones of the ox, deer, badger, hare, rabbit, and other smaller rodents, also with a few bones of birds. The manner in which these remains were deposited, left no doubt that the agents had been the waters of the North Esk.

Immediately at the mouth or lowest part of the cave, the bones consisted mostly of those belonging to the larger ruminants. While at the height of three feet, the remains were those of the smaller rodents, so curiously arranged as to attract our particular notice.

Although the whole mass of rich mould filling up the mouth of the cave, and extending to the height of 10 feet, teems with the remains of animals, yet a certain degree of stratification obtains. The skulls of the rat and smaller rodents, are mixed most liberally and promiscuously throughout the whole mass; not so the scapulas and the lighter bones. These are most curiously congregated in heaps, so that a spadeful could easily be obtained without the slightest admixture of earth, or foreign matter.

This fact appears easily accounted for, on the supposition that the less specific gravity of these bones made them the peculiar sport of the eddies of the North Esk, seeking a convenient and quiet resting place, only afforded by such a cave, where the waters could cease their troubling.

This is rendered more probable by a perpendicular rib of the trap projecting before the cave on its western side, and shewing at its base evident traces of attrition. Having laboured for some hours in this Golgotha, searching for varieties of bone, we were rewarded by the discovery of an inner cave, on a level with the entrance of the first.

This cave was of small dimensions, and had, before the deposition of the bony debris, been closed by a detached piece of rock from above. In this small chamber we could find no traces of bones—a slight unctuous slime covered its floor, stuck full of the buccinum, mytilus, and patella. On the walls these shells were still adherent to the slimy coating as if the sea had just left them *in situ.*

The only indications of humanity discovered in the bony debris was a vertebral bone of an ox, which bore evident traces of having been sawn or ground flat; also an amulet formed rudely from the leg bone of the ox.

When Mr Walker commenced his operations for the removal of the soil, he found, about six feet above the entrance, four chain-plate bolts, evidently belonging to a small craft of about 100 tons; lying near these he found the remains of an iron harpoon or spear, all sufficiently rusted to be interesting to an antiquary.

The secondary cave discovered below the bony debris, and only containing the remains of marine mollusca, seems certainly to indicate the presence of the German Ocean, 12 feet above its present highest spring tide. The bony deposit would seem to indicate a change of the Esk's course and a considerable addition to its waters, as this fluviatile deposit from the bottom of the cave up to the last indication of the river's action, is nearly 19 feet above the present level of the Esk. That the proof of change in the course of the Esk is not entirely dependent on this necrologic deposit is proved from the following quotation from the statistical account of Scotland.

"From the nature of the materials composing its channel, at and near the mouth of the river, its direction is subject to many changes. By one of these, two farms are at present disjoined from the parish (St Cyrus), of which they originally formed, and still, *quoad civilia*, form a part; and, in the memory of not very old persons, the river poured its waters into the sea at a point about two miles eastward of its present mouth."

These facts seem to justify the conclusion that the North Esk had, after the recession of the sea, occupied a much higher level than its present humble representative, which, in the draught of a good seed time, can scarce allow a poor salmon, troubled with sea-lice, to run beneath the magnificent bridge which spans its banks.

The finding of the chain-plate bolts and harpoon is a fact which I leave to the antiquarian's investigation; that they indicate another rising of the level of the German Ocean rests entirely on the amount of imagination possessed by the party considering the question.

On the Geography and Geology of the Peninsula of Mount Sinai and the adjacent Countries. By JOHN HOGG, M.A., F.R.S., F.L.S.; Honorary Secretary of the Royal Geographical Society, &c. Communicated by the Author.

(*Concluded from page* 52.)

And *sixthly*, in conclusion, I will add some general observations on the geological formations, the minerals and ores, mineral springs and their temperatures, the altitudes of some of the higher mountains, table-lands, and plains, and other natural features of the Sinaic Peninsula.

The great desert of *El Tyh* is vast, desolate, arid, and flat in its general aspect; but it consists in reality of several table-lands or plateaux of different elevations, and is often covered, as *Captain Newbold** describes, "with drifted sands, beds, and mounds of gravel, of quartz, flint, calcareous and jaspideous pebbles, resting on a (*secondary*) limestone." This *cretaceous* limestone is mostly "of a *chalky* texture and colour.

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* See "Visit to Mount Sinai," in the "Madras Journal," p. 47, vol. 14. *Madras*, 1847. As the author of that paper is the only English geologist who has personally visited, and then written on, this country, and as his essay is difficult to be met with in England, being recently published in *India*, I have given in the following pages several extracts from it, wherein I have at the same time made some slight corrections.

Where it is so, it generally contains imbedded nodules of *flint*, which are often black, in regular and almost horizontal layers, conforming to the stratification. In other localities, it is usually of a cream or buff colour, and close in texture. Among its numerous fossils are found ostreæ, echini, madriporæ, and pectines. Rocksalt and gypsum occur in layers." The calcareous ridges of Gebel Wardan, Hamam, Araba, Hemam, and some "ranges on the eastern coast, appear to be spurs and outliers from El Tyh."

"The central region around (the monkish) Mount Sinai presents a magnificent outburst of *granitic* and *porphyritic* rocks, which have uplifted and thrown into confusion a zone of hypogene rocks, principally *hornblendeschist* and *gneiss*, all penetrated by great dykes of *greenstone*, which present a singular feature in this extraordinary tract, passing through and over high bare mountains of *red granite* in dykes and walls.

"The nearest approach of the *granite* to the western coast is near its north-west angle to the south of 29° north latitude. At Tur it is about eight miles distant. It spreads out, breaking up the *hornblendeschist* to the eastern coast, where it forms a range from 800 feet to 2000 feet above the sea. Emerging on the north from the sandy plain of Debbet-el-Ramleh, it disappears to the south under (the *sandstone* and) the *tertiary* fossiliferous *limestone* of Ras Mohammed.

"*Sandstone* is seen resting on the borders of the *granitic* and hypogene areas, and sometimes entangled in them, the limits of which it is difficult to define. On the north, it appears to be bounded by the limestone of El Tyh, and is visible near the coast of the Red Sea, in the vicinity of Burdes, a little south of the limestone of Gebel Hamam, and forms the cliffs of Wadi Mukatteb, El Naszb, Sarbut-el-Chadem, and the Mountain of 'the Bell' El Narkus, south of which it disappears under the (secondary) limestone of Gebel Hemam and El Kaa, near Tur."

Again, further south, it is found bordering on the granitic formation, as well on the western as on the eastern sides of the extremity of the Gebel-el-Turfa.

"Near the east coast it caps the *hornblende* rock at Ograt-el-Faras (Hillock of the Horse), and thence to Wadi Murrah and El Hadhera. It caps the granite of Gebel Samghy (Gummy), and northerly it is seen occasionally resting on the granitic rocks, as at Wadi Mezarik and Wadi-el-Musry, near the head of the Akaba Gulf. In lithologic character it varies from a compact *reddish quartz* rock, as at the western mountain, near Gebel Hemam beyond Tur, to a *whitish grit* as at Gebel Narkus, and to *variegated sandstones*, as at Wadi Murrah."

"The extensive *sandy* tracts and dunes in the interior, which usually mark the vicinity of this formation, are the result of the weathering of the less consolidated beds of *this rock*." But "the drifts of fine blown *sand*, which are so remarkable on the sides of the ranges that skirt the Red Sea, have evidently been" carried thither by the winds from the sandy beach.

"The low maritime plains are usually covered with *sand*, and sometimes with *gravel*, which, as on the plain of El Kaa, has been transported a considerable distance from the granitic rocks in the interior. This *gravel* it is easy to account for in the beds of the Wadis, by the action of the mountain torrents which come down occasionally with great violence during the rains; but a considerable portion of it is now far remote from their present action. It is, however, in greatest abundance near the mouths of the Wadis, which have in many cases cut their channels through beds of it of considerable thickness, and which, on the eastern coast, as Professor Robinson informs us, reach from the base of the mountains to the sea, sometimes in beds many feet thick." Captain Newbold "examined the beds at the mouth of Wadi Hebron where it opens into the plain of El Kaa, under the impression that they might be ancient *moraines*, but found the pebbles rounded, of moderate size, or smaller, regularly inter-stratified with layers of *sand*, and *no* signs of *glacial* action on the rocks."

"Underneath the *sand*, especially near the head of the Gulf of Suez, and in many places rising in small hillocks above it, are seen (strata of *tertiary limestone* and *marl*, consisting of) thin beds of a grey and *greenish clay*, *sand*, and *marl*, often laminated, imbedding layers of lamellar crystallized *gypsum*, *rocksalt*, and sometimes existing sea-shells, also little mounds abounding in slightly-worn fragments of Egyptian pebble, jaspers, and hard calcareous stones, light coloured interiorly, but of a dark-brown exterior, evidently stained with oxide of iron."

Of course, "the *water* of the wells rising in these *saliferous* beds is usually brackish. Raised beaches of recent *coral*, a few feet high, occur" in many places along both gulfs.

Volcanic rocks are related by Burckhardt to be situate near Sherm, to the north-east of Ras Mohammed, and are described "as black and red rocks, forming *crater-like* configurations." He likewise mentions black *basaltic* cliffs and creeks on the same coast, west of the isle of Kureiyeh, and low hills of *basaltic tufa*, near the junction of Wadi Firan with Wadi Mukatteb.

On the *relative ages* of the rocks of the Sinaic Peninsula, Captain Newbold remarks,—

"It is evident that the *granite* must be of more *recent* origin than the *hypogene schists*, the strata of which he observed in the vicinity of (the present) Mount Sinai, to have undergone great disturbance, thrown on their edges, and altered by it. The *porphyries* are more recent than the *granite* which they penetrate, and the *greenstone* penetrates both the porphyries and the granite. Next in order of superposition to the hypogene schists comes the (older) *sandstone* (of the *secondary* series) which rests on them in slightly inclined and unconformable strata; it marks the era of a subsequent period of disturbance, but less violent, and was deposited while the granite peaks either formed inequalities in the ocean's bed, or appeared as small island points just above its surface, with which it rose to the heights we now see it."

"The (*secondary*) *limestone*, from its usually undisturbed horizontal stratification, appears to have been elevated slowly, without any violent paroxysms of plutonic or volcanic energy, like the more recent formations. Its *fossils* have *not* been yet scientifically described, but in general character they resemble those of the Egyptian (*secondary*) *limestones*. The mineral character of the rock, too, is much the same."

In the (older or *secondary*) *sandstone* the same author says, he "could discover *no fossils* to afford any indication of its *age*." This *sandstone* is what Herr Russegger names "Sinai sandstein" with its different marls, and he considers it to pertain to the *lower cretaceous* series (Untere Kreide-Reihe); but I think it likely, on a further examination, some of it may prove to be of a more ancient period, perhaps of the *palæozoic* epoch, like the *old red sandstone* formation. Indeed, the sandstone from Wadi Mukatteb is described by M. de Rozière ("Descrip. de l'Egypte") as being "Psammite" freestone, consisting of *quartz* grains mixed with *mica*. So also, with regard to the "Kalkstein," or *limestone*, which Russegger refers to the "Kreide-Reihe," or *cretaceous* strata, it is not improbable that some may be discovered, from a future investigation of its *fossils*, to belong to the *Oolitic*, or an older series. This last geologist* mentions some of the specimens of this *limestone* from Gebel Hamam, as compact *chalk* with

* Reisen in Europa, Asien, und Afrika, von *Joseph Russegger*, p. 285, 12th Part. *Stuttgart*, 1842.

remains of monocotyledonous *plants;* and other specimens, as compact *chalk*, from Gebel-el-Tyh, with *flints* and *fossils.* But in part of the mountains about Wadi Naszb some of the hills " are surmounted by beds of ancient *transition limestone.* The most remarkable of these is of a fine lilac colour, very compact, of great hardness, and a *crystalline texture.*"*

Many of " the *gravel* beds, and those resulting from the decay of the granite and hypogene rocks (already mentioned), are often *cemented* and consolidated by the water of springs charged with *carbonate of lime*, assisted by the *oxidation* of a portion of the *iron* contained in the rock itself."† They thus frequently present a sort of *breccia*, pudding-stone, or conglomerate of great compactness and beauty.

In some places " large *dykes* of *greenstone* can be traced for miles *over* the *granitic* rocks;" and, in others, they " rarely overlap the granite and hypogene *schist* which they penetrate, but seem to have existed in a solidified state in them at the time they were broken up. *Faults* of considerable extent may be thus traced even in the *granite* itself." And Dr Robinson says of these dykes, sometimes perpendicular veins of *grünstein* (greenstone) or porphyry were visible in Wadi Berah, projecting *above* the *granite*, and running through the rocks in a straight line over mountains and valleys for miles, and presenting the appearance of low *walls.* Burckhardt likewise noticed the same in W. Genne, near that Wadi, and in Wadi-el-Sal.

" The *strike* of the *hypogene strata* is nearly parallel with the northerly direction of the peninsula. The *dip* is nearly vertical, and towards the east, and the general direction (of the strata or rather *laminæ*) of these *hypogene schists*, forming the lower ranges around (the present) Mount Sinai, is nearly north and south, but great disorder is visible both in the dip and stratification. The *schists* are often seen on their edges."‡

Next, as to the *ores*, *minerals*, and *mineralogical* characters of the principal *rocks.*

Captain Newbold writes (p. 51):—" The great scantiness

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* Physical Geography of the Holy Land, by *J. Kitto, D.D.*, p. 81. *London*, 1848.

† *Newbold*, in Madras Journal, vol. xiv., p. 56.

‡ *Ibid.*, p. 60 and p. 69.

of *metallic ores* and *minerals*, not only in the peninsula of Mount Sinai, but in Egypt and Arabia, is a remarkable feature." *Iron* ore is met with, although not abundantly. Russegger speaks of brown ironstone (*Brauneisenstein* mit Psilomelan) as occurring in masses in the *Sinai sandstone* in Wadi Naszb; there also vestiges of *copper* mines exist, and likewise in Wadi Maghara, and near Sarbut-el-Chadem. Here, according to Dr Lepsius (p. 16), the temple dedicated to the goddess *Hathor*, mistress of *Mafkat, i. e.,* "the *Copper* Land," stands amongst great mounds of ore. He describes "a massive crust of *iron ore*, six or eight feet thick, and surrounded on all sides by blocks of *scoriæ;* the appearance of which, burnt as they are to the colour of a cinder, contrasts them very prominently with the adjacent light-brown *sandstone* hillocks." *Turquoise* is reported to be found among the rubbish at Sarbut-el-Chadem; but Captain Newbold conjectures that it is rather *malachite;* because, he says, the true *turquoise* or calaite rarely, if ever, occurs in *sandstone.*

Near Wadi-el-Naszb, the mineral called by the Arabs *Kohal* or *Kohol*, a species of *antimony*, occurs; a preparation of this is much used by the women in the East to darken the tips of their eyelids. Burckhardt has stated that native *Cinnabar* (sulphuret of mercury) is collected in Gebel *Sheyger*, to the north-east of Wadi-el-Ush; it is named by the Arabs *Rasokht*, but is rarely crystallized, and its fracture is in perpendicular fibres.

Silver does not appear to have been discovered in this peninsula, nor, indeed, *lead*, except from uncertain report. Dr Kitto (p. 109), however, writes, "*lead* is said to exist at a place called Sheff, near Mount Sinai."

The presence of *gold* is, perhaps, doubtful; yet, in the neighbourhood of *Mersa Dahab*, "Port of Gold," on the east coast, according to Lieutenant Wellsted,* the *sand* contains "yellow, shining, micaceous particles, exactly resembling that precious metal." But, whether this substance be merely *pyrites* or grains of *gold*, future examinations of that locality must determine. To the west and north-west, in Wadi-el-

* Travels in Arabia, vol. ii., p. 154.

Sal, eruptive and crystalline rocks abound; consequently their *detritus* washed down that valley by heavy rains might convey small quantities of *gold*, which may possibly be detected in the gravel or sand, near the mouth of Wadi Sal, behind Dahab.

Hœmatite, or red iron ore, has been met with in round masses in the Sinaic district. Large and beautiful *crystals* of *quartz*, or rock crystals, occur in the mountains not far from the present Convent. In Wadi Sheikh, Burckhardt describes a range of low hills of a mineral called *Tafal*, principally composed of *felspar* from *granite*, and resembling *pipe-clay;* it is brittle, and leaves a *yellow* colour on the fingers. The Arabs use it for soap, and for taking stains out of cloth. He also observed another range of *Tafal* hills, after the defile (at El Bueb) towards the west, in Wadi Firan.

Rock-salt is very abundant in many places; this, together with *sulphur*, prevents many of the springs from being of use to the traveller.

Gypsum is also frequent, as well as *selenite* or crystallized sulphate of lime, in certain argillaceous beds along the west coast.

Carbonate of soda, commonly called *Natron*, "may be found at Tur, and in the vicinity of Sherm; but we do not find it accumulated in any considerable quantities, only some efflorescences of it in places where the *calcareous* soil has been impregnated with *marine salt*."*

Saltpetre or *nitre* is seen incrusted on the surface of the earth, "in a valley between Mount Sinai and Suez,"† and in some spots in Wadi Araba.

Besides rock crystals already mentioned, Burckhardt describes the occurrence of *white* and *rose-coloured quartz:* a species of *amethyst* is said, by Pliny, to have been "found southward in Paran, whence it took the name of *Paranite*."‡

Jaspers and *Egyptian pebbles* occur in the *gravel* of the desert El Tyh, and near the extremity of the Gulf of Suez.

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* *Kitto's* Phys. Geog. of the Holy Land, p. 103.

† *Phillips'* Mineralogy, p. 189.

‡ *Kitto*, p. 111.

But the extensive and narrow plain El Kaa, in particular between Tur and Wadi Hebron, is, according to Captain Newbold (p. 55):—

"Covered with *sand* generally of a coarse *quartzose* nature, often strewn with a *gravel* composed of fragments of the granitic and hypogene rocks, both angular and rounded, from the size of a pea to that of an orange; the pebbles are principally of reddish *granite*, porphyritic and close-grained *hornblende schists*, *greenstone*, compact *felspar*, coloured green with *actynolite*,—actynolite with *quartz* and *felspar* in drusy crystals,—and *porphyry* of various descriptions, including *melaphyre*. The most prevalent variety is like that of Egypt, being composed of a brownish felspathic paste imbedding *felspar* crystals of a light reddish-brown, white, and of a pink hue; also a black *augitic* paste imbedding crystals of red, white, or pale green *felspar*."

"The rocks in Wadi Hebron are of a granitoidal *gneiss* in nearly vertical strata (or *laminæ*) penetrated by *granites*, dykes of *greenstone*, and *porphyry*."

At the east end of Wadi Firan, near Wadi Selaf, "the rocks are principally of hypogene *schist*, *gneiss*, *mica*, felspathic *actynolite*, chlorite, and hornblende *schist*." Whilst those "from Nakb Hawi to (the modern) Mount Horeb are chiefly *granite*, porphyritic granite, brown *porphyry*, in veins or dykes in granite, and *hornblende* rock. All these rocks are penetrated by enormous dykes of *greenstone*; near which veins of compact greenish felspar and *eurite* are not uncommon in the granite; also *pegmatitic* veins, and veins of felspar coloured green by *actynolite*."

"The *red granite* (of the high Sinaic group) is often porphyritic," and "penetrated by dykes of brown and black porphyry."*

But M. de Rozière and others of the French Scientific Expedition to Egypt have given the term of "*Sinaïte*" to that species of *granite*,—composed chiefly of *felspar* in confused laminæ, and of much *hornblende* (amphibole) without quartz or mica,—forming the principal rock of the higher Sinaic district.

Captain Newbold further says, "the rock composing Gebel Mineggia is principally of a *chloritic hornblende* and a white

* Newbold, *in loc. cit.*, pp. 61, 68, 69.

felspar, spotted green with hornblende. Some varieties would pass for *diallage* in hand specimens, though the rock has an obscurely stratified structure. Its weathered exterior has a dark rusty colour."

Burckhardt observes the *porphyry* of the Sinai district is usually *red;* in some specimens it has the appearance of *red felspar.* In others are imbedded small crystals of hornblende, or of mica, and thin pieces of quartz. But, at the spring Tabakat, near Gebel-um-Schomar, he discovered a beautiful *porphyry* having large slabs of *felspar*, traversed by veins of *white* and *rose quartz.* The same traveller describes the *white granite* of the summit of that lofty mountain, as appearing at a distance like chalk; this he accounts for from a great quantity of *white felspar* in it, and from the smallness of the particles of *hornblende* and *mica.* He adds, the *quartz* also in it is of a brilliant *whiteness.*

The following particulars relative to some other *varieties* of rocks, are collected from Dr Kitto's work.*

A specimen from the Sinaic peninsula, figured in a plate of the "Description de l'Egypte," is named by M. de Rozière, *talcose quartz;* it is said to form extensive beds towards the middle of the route which leads from Gebel Mousa to Ras Mohammed. This quartz offers certain slight lamellar appearances, and in some of the varieties *felspar* is associated with it. The rocks wherein the quartz most prevails, "divide themselves into cruciform fragments, the greenish surfaces of which clouded with red and yellow, are ornamented with beautiful, dark, and thickly tufted *dendrites.*"

The summit of Gebel Katherin, composed of a variety of *Sinaïte*, differs by its clear colour and neat crystallization from the coarser porphyritic and Sinaïtic rocks that constitute the chief part of that mountain. The crystallization of the *felspar* in the *Sinaïte* of the adjoining top of Gebel Mousa is more confused, the crystals of *hornblende* are less, and those of *quartz* are more numerous, but also smaller than in the other; *mica* is absent in both of these.

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* See Phys Geogr. of the Holy Land, chap. 2.

Seven or eight miles to the north of this last mountain, extensive banks of a black small grained *diabase*, much charged with *hornblende*, called *melaphyre*, occur. Strewn with crystals of grey *felspar* of various sizes, it contains small irregular masses of *pyrites*. Beds of *melaphyre* are also found in a mountain between Wadis Firan and Naszb; and among the primitive mountains near Wadi Naszb, thick and horizontal beds of a beautiful violet *Sinaïte* are seen, resting on banks of porphyry.

The highly polished surface which the *Sinaïte* often presents, "has been attributed to the action of minute particles of *quartz*, and moved over it by the winds during a long succession of ages. The alleged cause is certainly in operation, and is known to be adequate to produce the observed effect."

The huge *granitic* masses that appear isolated in the Wadis of the high Sinaic district, are considered to be of a *different* kind from any of the beds in the adjacent mountains. They consist almost entirely of *felspar*, in "distinct red crystals, intermixed with large crystals of *quartz*," with very slight *micaceous* laminæ. Of these detached masses, that related by the monks as "the rock in Horeb" which Moses smote, is remarkable. A little *mica*, associated with *quartz* and much *felspar*, places this mass amongst the true *granites*. *Epidote* constitutes a portion of many of the rocks of the peninsula, and is occasionally joined to a white *felspar*, having slight streaks of red. So combined, it is not unfrequently seen in the southern El Turfa range.

I may here refer the reader to several beautifully executed plates of different rocks from *Arabie Pétrée*, published under Napoleon's auspices, in the magnificent work of the French Scientific Commission, entitled "Description de l'Egypte," (Seconde Edition), Histoire Naturelle. *Tome* 2. *Bis. Paris*, 1826. Pl. 12, figs. 1–9, represent well-engraved specimens of "Roches *Porphyrithiques*," from Wadi Firan, and Gebel Horeb. Pl. 13 gives examples of "*Porphyres, Sinaïtes, Grès*," &c., from Wadi Naszb, Mukatteb, and Gebel Mousa. Pl. 14, *granites* from Gebel Mousa and Gebel Horeb; and Pl. 15, different *primitive* rocks from the coasts of the Ælanitic or Eastern Gulf.

Descriptions of these engraved specimens will be found in the letter-press accompanying the plates.

Dr Kitto moreover writes (p. 99) :—

"In the deserts bordering on the Isthmus of Suez, and particularly in those parts where the hills are of friable strata, the soil is principally of a *quartzose gravel*, produced by their detrition. In this gravelly soil, which envelopes the foot of the mountains, are found many fragments, and even entire trunks, of *petrified trees*, of upwards of ten or twelve feet in length. It is readily perceived that these trees belong to different species ; but the palm-tree and the *seyal*, or desert *acacia*, alone can be identified ; all the others offering, in their petrified state, characteristics too equivocal to allow their species to be determined. The perfect preservation and the size of the petrified trunks, thus found enveloped in the sands, not embedded in, or forming part of any rocks, as well as various other circumstances enumerated by M. de Rozière, appear very clearly to intimate that they were not brought from any distance, but that they pre-existed in those spots."

The chief and most considerable *mineral springs* (as previously noticed), are found at Gebel Hamam, and near the town of Tur ; they are *thermal*, or naturally warm, in both situations.

Russegger describes the former, or *Pharaoh's Baths*,—El Hamam Faroun,—"as breaking out from the strata of *lower chalk*, nearly on the sea level at the foot of the mountain. The largest was 55°·7′ *Reaum.* (about 156° *Fahr.*), whilst the temperature of the air was 26°·3′ *R.* (near 91° *F.*) The water deposits much common *salt* with *sulphur*. The latter is sublimated on the sides of several caverns adjacent to the springs wherein the hot vapours ascend."* Wellsted learnt from his guides, "that pilgrims affected with leprosy, and other cutaneous disorders, sometimes use them ; and, notwithstanding the heat of the water is so great that the hand can with difficulty be borne in it, these patients are said to bear immersion for several hours."†

The latter springs, called by some Hamam Mousa, *Moses' Baths*—are situated in El Wadi, about two miles to the north-west of Tur, but on the east side of the plantation of date

* Robinson's Biblical Researches, vol. i.

† *Wellsted*, Travels in Arabia, vol. ii., p. 35.

trees, and under their shade. The last author observes, (*ibid.* p. 14), "the water is beautifully clear, but it has a slight *sulphureous* smell, with a strong *saline* and bitter taste. On immersing a Fahrenheit's thermometer, it rose to 86°." But Captain Newbold says (p. 71), he found the temperature of this well, "90°·5′, at the surface, and 91°·6′, where the water bubbles up from the *limestone*—(temperature of air in shade = 84°). A few gaseous bubbles escape from the bottom, which have but a very slight odour of sulphuretted hydrogen, yet the water has very little *saline* taste."

Again, he continues,—"the temperature of two wells which lie on the other side of the town, viz.,—Bir Eshesh, and Bir Mussact, did not quite reach 80°."

Other *mineral springs* have been noticed in Wadi Araba, which appear to contain *salt* and *sulphur*, but their waters, as far as I can ascertain, have never been analysed.

Whilst the wells in a great part of the peninsula afford extremely bad water, being so frequently impregnated with *common salt*: those, according to the testimony of Captain Newbold, "which rise in the *granite* regions, are usually pure and good. The water of the Mount Sinai district is deliciously cool and refreshing;" it is, moreover, very abundant throughout the entire year.

The following are the *heights* of some of the principal mountains, table-lands, plains, and valleys, or *Wadis*, chiefly taken from Russegger's work:—

	English feet above Sea.
Gebel Jaraf in north of the desert El Tyh,	1300
Level of Wadi Khereir on south side of the preceding mountain,	1080
Gebel Eshrim,	1700
W. el Agaba, at south-west foot of do.,	1264
Station of Nakhl about half-way across the desert El Tyh on the pilgrim route,	1488
W. Woalechan, about 10 miles SSW. of Nakhl,	1889
Elevation of the plain east of G. Heiyalah, and at nearly half of the distance between Nakhl and G. el Egmeh,	2010
Regimm, situate 15–20 miles north-west of the Pass of Mureikhi,	2656
El Tyh summit nearly adjoining to Gebel-el-Egmeh,	4615
Convent on the present Mount Sinai,	5451
Gebel Mousa,	7564
Gebel Katherin,	8705
Gebel Masrud,	8700
G. um Schomar,	8850

	English feet above Sea.
Highest peaks south of last mountain, . . .	9300
G. um Khesin, in El Turfa chain, . . .	5000
Gebel Serbal, ...	6759
Plateau of Debbet-el-Ramleh, north of Sarbut-el-Chadem,	1606
Same Plateau at Alahadar, about half-way across, at its south extremity, and about 5 miles north of W. el Sheikh, .	4042
Wadi Barak, ...	3036
Mountains just south of Sarbut-el-Chadem, . .	4800
1st Plateau north of G. el Egmeh, . . .	2010
2nd Do. north-east of the former, . . .	2250
3rd Do. east of do., and somewhat south of Bir-el-Themed,	2550
Gebel Harun (Mount Hor), ...	5300

The annexed *altitudes* I have inserted from Rüppell (R.), Schubert (S.), and Wellsted (W.) The measurements of the first and third travellers, are respectively founded upon corresponding observations made on the sea-coast at Tur on the Gulf of Suez, and upon some taken on the coast of the Gulf of Akaba.

	Paris feet above Sea.
Second peak from west of Mount Serbal, from (R.), .	6342
Highest summit of G. Egmeh, from (S.), . .	5000
Extreme top of G. Hamam, from (S.), . . .	1000
Gebel Mousa, according to (R.), ...	7035
G. Katherin summit, or G. Horeb of (R.), . .	8063
Convent of El Arbain, from (R.), about . . .	5365
G. Mousa, above the last, from (R.), . . .	1670
G. Katherin, above do., from (R.), . . .	2700
G. Mousa, according to (S.), ...	6796
The same above the present Convent, from (S.), . .	2071
Same above do., according to *Russegger*, . . .	1982
Convent on present Mount Sinai, from (S.), . .	4725
The same according to *Russegger*, . . .	5115
Same from (R.), about, ...	4966
	Eng. feet above Sea.
Same from (W.),—(mean of two observations), . .	5005
Summit of G. Mousa from mean of (W.)'s observations, .	7505
Same above the present convent, according to (W.), at the most,	2500

These *elevations* are principally derived from Dr Robinson.

	Eng. feet.
The range of Mount Seir above the Wadi-el-Araba,	2000 to 2500
The mountains on west of the Araba above that Wadi,	1500 or 1800
Wadi Mousa (*Petra*) above the same Wadi, near .	2200
North-east peak (*the highest*) of G. Harun above W. Mousa, about	2700
The Nabathæan Chain on east, above W. el Araba, about	3000
G. Araif-el-Naka cone above El Tyh desert, . .	600

The general *form* of the Peninsula of Mount Sinai, strictly so called, is that of a *scalene* or inequilateral *triangle;* but if we include that space of Arabia Petræa as given in our accompanying map, it may be defined as a *Trapezium placed upon a scalene triangle.* Two arms of the Red Sea (*Sinus Arabicus*), named in Hebrew "Yam Suph," bound two sides of this peninsula: the *first,* or Gulf of Suez, the ancient *Sinus Heroopolites,* and the modern Bahr-el-Kolzum of the Arabs is much the longest, being nearly 200 English miles in length, whilst its breadth varies a good deal: this, from the coast of Egypt to Birket Faroun, exceeds thirty miles; but, as an average, it may be considered as about twenty miles.

The length of the *second* arm, called the Gulf of Akaba, formerly *Sinus Ælanites,* and at this day by the Arabians Bahr-el-Akaba, is about 118 English miles, computing it from the supposed site of Aila, or Ælana, at its north-east extremity to the southern side of the Isle of Tiran; and its average breadth may be taken at about twelve miles.

The most important features of the Sinaic peninsula may be divided into two: the enormous desert of El Tyh on the north, which occupies its greatest portion, and the southern or alpine region of lofty mountains. These have been already shortly described; but I may, however, observe in general terms, that the *former* is a vast central *plateau,* or elevated table-land, descending rapidly from the chain called Gebel-el-Tyh, which bounds it on the south, towards the north. Two or three smaller plateaux that slope to the north-east, extend from the Gebel-el-Egmeh. Immediately south of the El Tyh mountains, the sandy plain or table-land of El Ramleh descends to about 3000 or 4000 feet; and thence commences the *second* great feature of the peninsula, in that magnificent group of the modern Sinaic mountains, consisting of naked, sharp, and numberless peaks of schist, granite, and porphyry, and their varieties, the highest of which rise to an altitude of above 9000 English feet above the sea-level. This alpine group, known to the Arabs under the appellation of *Gebel-el-Tur,*—"Mountains of Tur,"—slopes down and terminates in the southern extremity by the granite chain Gebel-el-Turfa.

Messrs Burckhardt and Robinson mention the following peculiar conformation of the lower mountain ranges;—an ascending valley, or *wadi*, reaches to the very summit, where it forms a plain, and then another wadi descends upon the other side. Such is likewise the present general feature of the extensive Wadi-el-Araba. And Captain Newbold observes (p. 47) that "the longitudinal and transverse valleys by which the southern or mountain region is strangely fissured, form the natural routes and lines of drainage—the *wadis* of the Arabs." Through these valleys no continually flowing rivers descend to either gulf; but in the rainy season, after occasional storms, and during the melting of the snows on the more lofty mountains, winter-streams, or rather *torrents*,—the χείμαῤῥοι of the ancients—carry down their temporary waters to the sea. Still it appears to me, from the descriptions of some travellers, that four or five small rivulets in some of the valleys, as in Wadi Firan, W. Hebron, El Wadi, W. Kyd, El Ain, &c., continue to flow through the greatest part, if not the entirety, of the year.

The Gulf of Akaba has been compared to a very long ravine or lake; and as its shores are mostly skirted by precipitous and lofty mountains, the navigation throughout its length is exceedingly dangerous for small vessels, because squalls and violent north winds so frequently arise and prevail for some time. Indeed, from Wellsted's account, the surveying ship Palinurus was in great danger of being wrecked in it. Having already described this gulf, I will only observe that the same intelligent officer did *not* consider that it would prove *too* boisterous for *steam-vessels*, if it ever became necessary to establish communication by them to these coasts of Arabia. And I will here omit any delineation of the other wider and more extensive, but less hemmed in by mountains, and consequently less dangerous branch of the Red Sea—the Gulf of Suez, because it is now so well known by reason of such numbers of English annually passing over its waters, either in going to or returning from our Indian empire. The *north* wind also prevails in this gulf, and the trees and bushes along the coasts of it, especially on the Egyptian side, bend from it and extend their branches in the opposite direction.

Having before noticed the probable passage of the river Jordan through the Wadi-el-Araba, and its flowing into the Red Sea beyond the Strait of Tiran at a former but remote period, as well as some of the physical causes which very possibly put a stop to its further conflux, and latterly confined it to the present limits of the Dead Sea, I will now alone mention the following fact, as an additional proof that the *Dead Sea* may once have formed either a *continuation* of the Ælanitic Gulf, or that it may have been directly *connected with* the same, by the Jordan having poured its waters into it, at an antecedent date.

Baron A. von Humboldt writes, in his "Views of Nature,"*—

"In opposition to the hitherto generally-adopted opinion respecting the *absence* of all organisms and living creatures in the *Dead Sea*, it is worthy of notice that my friend and fellow-labourer, M. Valenciennes, has received, through the Marquis Charles de l'Escalopier, and the French consul Botta, beautiful specimens of Porites elongata (of Lamarck†) from the *Dead Sea*, which is supersaturated with salt. This fact is the more interesting, because this species is *not* found in the Mediterranean, but *only* in the *Red Sea*, which, according to Valenciennes, has but few organisms in common with the Mediterranean."

Of the natural phenomena connected with *Meteorology*, two or three deserve to be enumerated.

The *first* is, the great purity or *clearness* of the *atmosphere*, so much so, that Wellsted ‡ speaks of the outlines of the hills in Egypt, distant 105 miles from his anchorage, a few miles from Ras Furtak on the west coast of Arabia, appearing "as clearly defined as if they had been but ten." See also his accounts of a glimpse of *Moweilih* high peak (p. 74), when at a vast distance from it in the Peninsula of Sinai; and (p. 97) of the hills and mountains, both in Arabia and Egypt, being visible from the summit of Gebel Mousa. I ought, however, to observe, these appearances of the atmosphere, all occurred in the *winter*, and in the same month, *January;* and that they cannot be expected to present themselves with the like distinct-

* P. 260. Edit. *Bohn.* Lond. 1850.

† See Tom. ii., p. 437, No. 7, Hist. Nat. des Anim. sans Verteb. 2d Edit. *Par.* 1836.

‡ Travels in Arabia, vol. ii., p. 108.

ness during the other seasons of the year, since the sun would then generally produce, from its intense heat, much mist and haze. Indeed Wellsted states (p. 179), "This extraordinary clearness, or purity of the atmosphere, is mostly observed in December, January, and February; and during this period, the outline of any object on the horizon, however distant or small, may be seen with the utmost distinctness; the *brilliancy* of the *nights* is also very great," and affords to the sailor facilities for navigating the gulfs.

The *second*, or the *Mirage*, is very common; and its various appearances are occasioned by the refraction of light through the lower strata of air of different density, caused most frequently, in the arid desert, by *heat*. This illusion, as is well known, presents to the traveller a phantom tract of water, or a lake, often with an undulating surface, and is called by the Arabs *Serab*, which word is of great antiquity, for it occurs in Hebrew in *Isaiah* xxxv. 7, and is incorrectly translated in our Bible, "the parched ground," instead of "the *Mirage*," or "mock water."*

Of the other phenomena I need only mention the *Simoom*, or hot wind of the desert, which brings with it a quantity of fine sand, and penetrates through everything; the air being very hot, and perhaps laden with excess of electricity, every animal is severely affected by parched mouth, difficulty of breathing, fever, and other distressing symptoms. Rounded or twisted columns of sand, whirlwinds, and showers of dust or minute sand, carried on with the force of a hurricane, sometimes produce vast destruction to man and beast. Allusion is made to the *sand-storm* in Deuteronomy xxviii. 24,—"The Lord shall make the *rain* of thy land *powder* and *dust:* from heaven shall it come down upon thee, until thou be destroyed." So Lucan† :—

> "At, non imbriferam cum torto pulvere nubem
> In flexum violentus agit, pars plurima terræ
> Tollitur, et numquam resoluto vertice pendet."

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* Confer Diodor. Sic., Lib. iii., p. 219.—*Wessel.*

† Pharsal. Lib. xi., v. 453–7. And see the following verses for a further and excellent description of a *sand-storm* in the Libyan Desert.

"The whirling dust, like waves in eddies brought,
Rising aloft, to the mid heaven is caught;
There hangs a sullen cloud; nor falls again,
Nor breaks, like gentle vapours, into rain."*

In this country little *rain* falls during the year; and for nine months, generally, none at all.

At the Convent in Wadi Shueib, on the base of Gebel Mousa, "The thermometer may be 75°, while in the low country, and particularly near the sea-shore, it will be at from 102° to 105°, or even 110°. In winter, all the upper Sinai is deeply covered with *snow*, which chokes up many of the passes, and often renders the mountains of Moses and St Catherine inaccessible. Upon the whole, the climate is so different from that of Egypt, that fruits are nearly two months later in ripening there than at Cairo."†

The *vegetable* productions of the Peninsula, whether *wild* or *cultivated*, are but few: of the former are the *Turfa*, or manna—bearing tamarisk, Tamarix gallica, *var.* mannifera; the gum or *manna* of which is named *men*, or *mun*. Gum Arabic, called formerly *Gumma Torræ*, the product of several Acacias, but chiefly of A. Nilotica, the *Talh*, and A. Seyal. Peganum retusum, or *Gharkad*, whose berries are grateful. Coloquintida, *Handhal* in Arabic, Cucumis Colocynthis. *Nabek* or *Nabk*, the fruit of Rhamnus, or Zizyphus, Lotus. A few trees here and there occur of the *Doum* Palm, Hyphœne Thebaica, but its fruit is not eaten. Some Cruciferæ, and many dwarf thorny Leguminosæ are frequent.

Pasturage on several of the mountains of lower elevation and in some valleys, in certain parts of the year, is abundant: and the turf, often scented with Thymes and other Labiatæ, is then quite verdant. The *cultivated* productions are, for the most part, the common Date Palms, *Nakhl*, which to the Arabs are the most useful of trees: olives, figs, limes, oranges, almonds, caroubs, and grapes, are also found; the latter more especially in the Convent Gardens of the present Sinai, and

* Rowe's Lucan, Book ix., v. 777–80.
† *Kitto's* Phys. Geogr. of the Holy Land, p. 57.

in Wadi Firan. Tobacco, a few cereales, legumes, and pot-herbs, are likewise grown in the last fertile valley.

In some districts, though particularly at Noweibia, a great deal of charcoal is prepared from the Acacia trees.

The *domestic* animals are camels or dromedaries, dogs, goats, and small sheep; but no cows, or oxen.

Among the *wild* animals may be named, leopards, hyænas, the *Wober* or marmot; the *Beden*, alpine goat or Ibex; antelopes, gazelles; the Egyptian vultures, eagles, partridges, quails, pigeons; the *Dhob* or large lizard, serpents, scorpions, and locusts. The gulfs abound in a variety of fishes, shells, and corals; and Burckhardt mentions pearls, as well as mother-of-pearl being obtained near the Isle of Tiran. The *mineral* products have been sufficiently noticed; but, concerning the *mountains*, which have really the best claim to the identity of the *true Sinai*, it is not in this place to discuss; and especially as my remarks on this subject—derived from early history—are already published in another work.* Yet, I fully concur with Dr Kitto (p. 54), that "there is no question that this region is the scene of the wondrous transactions recorded in the sacred books; that *these* are the *mountains* which quaked when the Lord came down in fire upon them; and that *these* are the *valleys* which then heard His voice."

Neither will I here enumerate the *Amalekites*, *Midianites*, or other ancient nations, to whom the Peninsula once belonged; nor will I give any account of the present *Arab* tribes which dwell therein; but it is worthy of note that many of these dwellers in tents, retain at this day their primitive and scriptural customs.

Traces of *Egyptian* colonists are still apparent in the monuments at Sarbut el Chadem, and in the very ancient tablets and hieroglyphics sculptured on the rocks in Wadi Maghara. Some of these contain, as Dr Lepsius writes,† "the oldest effigies of kings in existence, without excepting

* Transactions of the Royal Society of Literature, vol. iii. 2d Series. Part 2.

† Tour to the Peninsula of Sinai, p. 17.

the whole of Egypt and the pyramids of Gizeh." Here upon one is seen the cartouche of *Suphis,* king of Memphis, and it is identical with that in the Great Pyramid which was built by him. This king is related to have conquered this portion of the Peninsula, which was about the time of Abraham.

The chief people now inhabiting this country are the Bedawyun or *Bedouin* Arabs, whose entire population Burckhardt estimated, some years ago, at about four thousand souls; and I apprehend, that little or no increase has taken place in their numbers since that traveller visited them.

Notwithstanding that of late years the Sinaic Peninsula has become better known to us from the reports of its recent travellers, yet there remains much to be more perfectly investigated in it: so likewise with regard to its adjoining countries, and of these none requires more examination than the north of Arabia Proper. I can therefore only express an ardent wish that a party of English scientific men, geologists and naturalists, would undertake the exploration of it; for I am satisfied that great benefits would accrue to science from their researches, and that they would obtain for themselves much lasting honour from such an investigation.

Finally, in composing this hasty account of a portion of Arabia and Egypt, but little known to us in a scientific view, I have principally made use of the accurate works of Burckhardt, Robinson, Wellsted, Lepsius, Newbold, J. Wilkinson, and Russegger—all able travellers, who have personally visited the countries here attempted to be described.

PROCEEDINGS OF THE BRITISH ASSOCIATION AT EDINBURGH, IN JULY AND AUGUST 1850.

OFFICERS FOR 1850.

President.—Sir DAVID BREWSTER, K.H., D.C.L., LL.D., F.R.S., V.P.R.S.E., Principal of the United College of St Salvador and St Leonard, St Andrews.

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Treasurer for the Meeting.—WILLIAM BRAND, Esq.

The General Meeting,

Wednesday, 31*st July*,

IN THE MUSIC HALL—EVENING.

The meeting was opened at eight o'clock in the evening, by the President of the former year. The Rev. Dr Robinson of Armagh, on retiring from the office of President of the Association, on this occasion, said—

"The time has come, when, by our rules, I must lay down the authority which last year you honoured me with. I trust that, from the way in which I have employed it, I have not altogether proved myself unworthy of the confidence which you then reposed in me. I have at least this to boast of—which it is not every Sovereign who can congratulate himself upon at the close of his career—that I shall deliver to my successor my dominion in a more prosperous and in a more flourishing state than I received it. But more: I have this additional consolation, in entering again among your ranks, that at least I shall not be visited by the affliction which pressed so heavily upon the mind of Solomon, that when he had laboured in the pursuit of wisdom and in the advancement of knowledge, he should leave his portion to one who had not laboured therein; for I deliver my authority to one, in comparison of whose achievements, whatever I myself may, by the partiality of my friends, be supposed to have effected, fades into nothing. There is not a spot in the world to which the light of physical investigation has pierced, where his name has not become known. There has been no period in the course of this Association, prosperous and successful as it has been from its origin, in which we have not been enlightened by his discoveries and aided by his counsel. There is not a department in that multifarious lore with which we have employed ourselves, on which he has not, in the course of his investigations, thrown a brilliant light; and what I prize beyond all that he has achieved—as the distinction or the fame of the whole of that career, which has been so brilliant, is, that there has not been any stain or any cloud to obscure the moral purity, the religious veneration, the upright and conscientious spirit, which, more than all knowledge, and more than all genius, is the noblest prerogative of man. When I resign my throne of office to Sir David Brewster, I know that that act is perhaps the greatest service which, in the course of my connection with the Association, I have ever rendered to it."

Dr Robinson then moved that, in accordance with the resolution of the General Committee of last year at Birmingham, Sir David Brewster do take the chair. Sir David Brewster having taken the chair, addressed the audience nearly in the following terms:—

"The kind and flattering expressions with which Dr Robinson has been pleased to introduce me to this chair, and to characterise my scientific labours, however coloured they are by the warmth of friendship, cannot but be gratifying even at a time when praise ceases to administer to vanity or to stimulate ambition. The appreciation of intellectual labour by those who have laboured intellectually, if not its highest, is at least one of its high rewards. When I consider the mental power of my distinguished friend, the value of his original researches, the vast extent of his acquirements, and the eloquence which has so often instructed and delighted us at our annual reunions, I feel how unfit I am to occupy his place, and how little I am qualified to discharge many of those duties which are incident to the chair of this Association. It is some satisfaction, however, that you are all aware of the extent of my incapacity, and that you have been pleased to accept of that which I can both promise and perform—to occupy any post of labour, either at the impelling or the working arm of this gigantic lever of science. It has been the custom of some of my predecessors in this chair, to give a brief account of the progress of the sciences during the preceding year; but however interesting such a narrative might be, it would be beyond the power of any individual to do justice to so extensive a theme, even if your time would permit, and your patience endure it. I shall make no apology, however, for calling your attention to a few of those topics, within my own narrow sphere of study, which, from their prominence and general interest, may be entitled to your attention. I begin with astronomy, a study which has made great progress under the patronage of this Association; a subject, too, possessing a charm above all other subjects, and more connected than any with the deepest interests, past, present, and to come, of every rational being. It is upon a planet that we live and breathe. Its surface is the arena of our contentions, our pleasures, and our sorrows. It is to obtain a portion of its alluvial crust that man wastes the flower of his days, and prostrates the energies of his mind, and risks the happiness of his soul; and it is over, or beneath, its verdant turf that his ashes are to be scattered, or his bones to be laid. It is from the interior, too—from the inner life of the earth, that man derives the materials of civilization—his coal, his iron, and his gold. And deeper still, as geologists have proved—and none with more power than the geologists around me—we find in the bosom of the earth, written on blocks of marble—the history of primæval times, of worlds of life created, and worlds of life destroyed. We find there—in hieroglyphics as intelligible as those which Major Rawlinson has deciphered on the slabs of Nineveh, the remains of forests which waved in luxuriance over its plains; the very bones of huge reptiles that took shelter under their foliage, and of gigantic quadrupeds that trod uncontrolled its plains—the lawgivers and the executioners of that mysterious community with which it pleased the Almighty to people his infant world. But though man is but a recent occupant of the earth—an upstart in the vast chronology of animal life, his interest in the Paradise so carefully prepared for him is not the less exciting and profound. For him it was made; he was to be the lord of the new creation, and to him it especially belongs to investigate the wonders it displays, and to learn the lesson which it reads. But while our interests are thus closely connected with the surface, and the interior of the earth, interests of a higher kind are associated with it as a body of the solar system to which we belong. The object of geology is to unfold the history and explain the structure of a planet: and that history and that structure may, within certain limits, be the history and the structure of all the other planets of the system—perhaps of all the other planets of the universe. The laws of matter must be the same, wherever matter is found. The heat which warms our globe, radiates upon the most distant of the planets; and the light which twinkles in the remotest star, is in its physical, and doubtless in its chemical, properties, the same that cheers and enlivens our own system; and if men of ordinary capacity possessed that knowledge which is within their reach, and had that faith in science which its truths inspire, they would see in every planet around them, and in every star above them, the home of immortal natures—of beings that suffer and of beings that rejoice—of souls that are saved and of souls that are lost. Geology is, therefore, the first chapter of astronomy. It describes that portion of the solar system which is nearest and dearest to us, the cosmopolitan observatory, so to speak, from which the astronomer is to survey the sidereal universe, where revolving worlds, and systems of worlds, summon him to investigate and adore. There, too, he obtains the great base lines of the earth's radius to measure the distances and magnitudes of the stairry host, and thus to penetrate, by the force of *reason*, into those infinitely distant regions where the imagination dare not follow him. But astronomy, though thus sprung from the earth, seeks and finds, like Astræa, a more congenial sphere above. Whatever cheers and enlivens our terrestrial paradise is derived from the orbs around us. Without the light or heat of our sun, and without the uniform movements of our system, we should have neither climates nor seasons. Darkness would blind, and famine destroy everything that lives. Without influences from above, our ships would drift upon the ocean, the sport of wind and wave, and would have less security of reaching their destination than balloons floating in the air, and subject to the caprice of the elements. But while the study of Astronomy is essential to the very existence of social life, it is instinct with moral influences of the highest order. In the study of our own globe we learn that it has been rent and upheaved by tremendous forces—here sinking into ocean depths, and there rising into gigantic elevations. Even now geologists are measuring the rise and fall of its elastic crust, and men who have no faith in science often learn the truth to their cost, when they see the liquid fire rushing upon them from the volcano, or stand above the yawning crevice in which the earthquake threatens to overwhelm them. Who can say that there is a limit to agencies like these? Who could dare to assert that they may not concentrate their yet divided energies, and rend in pieces the planet which imprisons them? Within the bounds of our own system, and in the vicinity of our own earth, between the orbits of Mars and Jupiter there is a wide space which, according to the law of planetary distance, ought to contain a planet. Kepler predicted that a planet would be found there—and strange to say, the astronomers of our own times discovered at the beginning of the present century four small planets, Ceres, Pallas, Juno, and Vesta, occupying the very place in our system where the anticipated planet ought to have been found. Ceres, the first of these, was discovered by Piazzi, at Palermo, in 1801; Pallas, the second of them, by Dr Olbers of Bremen, in 1802; Juno, the third, by Mr Harding, in 1804; and Vesta, the fourth, by Dr Olbers, in 1807. After the discovery of the third, Dr Olbers suggested the idea that they were the fragments of a planet that had been burst in pieces; and, considering that they must all have diverged from one point in the original orbit, and ought to return to the opposite point, he examined these parts of the heavens and thus discovered the planet Vesta. But though this principle was in the possession of astronomers, nearly forty years elapsed before any other planetary fragment was discovered. At last, in 1845, Mr Encke of Driessen, in Prussia, discovered the fragment called Astræa, and in 1847 another, called Hebe. In the same year, our countryman, Mr Hind, discovered other two, Iris and Flora. In 1848, Mr Graham, an Irish astronomer, discovered a ninth fragment, called Metis. In 1849, Mr Gasparis of Naples, discovered another, which he calls Hygeia; and within the last two months, the same astronomer has discovered the eleventh fragment, to which he has given the name of Parthenope.* If these eleven small planets are really the remains of a larger one, the size of the original planet must have been considerable. What its size was would seem to be a problem beyond the grasp of reason. But human genius has been permitted to triumph over greater difficulties. The planet Neptune was discovered before a ray of its light had entered the human eye; and by a law of the solar system just discovered, we can determine the original magnitude of the broken planet long after it has been shivered into fragments; and we might have determined it even after a single

* Ceres,	1801, January 1st,	Piazzi.
Pallas,	1802, March 28th,	Olbers.
Juno,	1804, September 1st,	Harding.
Vesta,	1807, March 29th,	Olbers.
Astræa,	1845, December 8th,	Encke.
Hebe,	1847, July 1st,	Encke.
Iris,	1847, August 13th,	Hind.
Flora,	1847, October 18th,	Hind.
Metis,	1848, April 25th,	Graham.
Hygeia,	1849, April 12th,	Gasparis.
Parthenope,	1850, May 11th,	Gasparis.

fragment had proved its existence. This law we owe to Mr Daniel Kirkwood of Pottsville, a humble American,* who, like the illustrious Kepler, struggled to find something new among the arithmetical relations of the planetary elements. Between every two adjacent planets there is a point where their attractions are equal. If we call the distance of this point from the Sun the radius of a planet's sphere of attraction, then Mr Kirkwood's law is, that in every planet the square of the length of its year, reckoned in days, varies as the cube of the radius of its sphere of attraction. This law has been verified by more than one American astronomer, and there can be no doubt, as one of them expresses it, that it is at least a physical fact in the mechanism of our system. This law requires the existence of a planet between Mars and Jupiter, and it follows from the law that the broken planet must have been a little larger than Mars, or about 5000 miles in diameter, and that the length of its day must have been about 57½ hours. The American astronomers regard this law as amounting to a demonstration of the nebular hypothesis of Laplace; but we venture to say that this opinion will not be adopted by the astronomers of England. Among the more recent discoveries within the bounds of our own system, I cannot omit to mention those of our distinguished countryman, Mr Lassell of Liverpool. By means of a fine 20-feet reflector, constructed by himself, he detected the satellite of Neptune, and more recently an eighth satellite circulating round Saturn—a discovery which was made on the very same day, by Mr Bond, Director of the Observatory of Cambridge, in the United States. Mr Lassell has still more recently, and under a singularly favourable state of the atmosphere, observed the very minute, but extremely black, shadow of the ring of Saturn upon the body of the planet. He observed the line of shadow to be notched, as it were, and almost broken up into a line of dots—thus indicating mountains upon the plane of the ring—mountains, doubtless, raised by the same internal forces, and answering the same ends, as those of our own globe. In passing from our solar sys-

* For account of Kirkwood's analogy in the Periods of Rotation of the Primary Planets, *vide* Edinburgh New Philosophical Journal, vol. xlix. p. 165.

tem to the frontier of the sidereal universe around us, we traverse a gulf of inconceivable extent. If we represent the radius of the solar system, or of Neptune's orbit (which is 2900 millions of miles) by a line two miles long, the interval between our system, or the orbit of Neptune, and the nearest fixed star will be greater than the whole circumference of our globe—or equal to a length of 27,600 miles. The parallax of the nearest fixed star being supposed to be one second, its distance from the Sun will be nearly 412,370 times the radius of the Earth's orbit, or 13,746 times that of Neptune, which is 30 times as far from the Sun as the Earth. And yet to that distant zone has the genius of man traced the Creator's arm working the wonders of his power, and diffusing the gifts of his love—the heat and the light of suns—the necessary elements of physical and intellectual life. It is by means of the gigantic telescope of Lord Rosse that we have become acquainted with the form and character of those great assemblages of stars which compose the sidereal universe. Drawings and descriptions of the more remarkable of these nebulæ, as resolved by this noble instrument, were communicated by Dr Robinson to the last meeting of the Association, and it is with peculiar satisfaction that I am able to state that many important discoveries have been made by Lord Rosse and his assistant, Mr Stoney, during the last year. In many of the nebulæ the peculiarities of structure are very remarkable, and, as Lord Rosse observes, "seem even to indicate the presence of dynamical laws almost within our grasp." The spiral arrangement so strongly developed in some of the nebulæ is traceable more or less distinctly in many; but "more frequently," to use Lord Rosse's own words, "there is a nearer approach to a kind of irregular, interrupted, annular disposition of the luminous material, than to the regularity observed in others;" but his lordship is of opinion that those nebulæ are systems of a very similar nature, seen more or less perfectly, and variously placed with reference to the line of sight. In re-examining the more remarkable of these objects, Lord Rosse intends to view them with the full light of his six feet speculum, undiminished by the second reflection of the small mirror. By thus adopting what is called the *front view*, he will doubtless, as he himself expects, discover many new features in those interesting objects. It is to the influence of Lord Rosse's example that we are indebted for the fine reflecting telescope of Mr Lassell, of which I have already spoken; and it is to it, also, that we owe another telescope, which, though yet unknown to science, I am bound in this place especially to notice. I allude to the reflector recently constructed by Mr James Nasmyth, a native of this city, already distinguished by his mechanical inventions, and one of a family well known to us all, and occupying a high place among the artists of Scotland. This instrument has its great speculum 20 feet in focal length, and 20 inches in diameter; but it differs from all other telescopes in the remarkable facility with which it can be used. Its tube moves vertically upon hollow trunnions, through which the astronomer, seated in a little observatory, with only a horizontal motion, can view at his ease every part of the heavens. Hitherto, the astronomer has been obliged to seat himself at the upper end of his Newtonian telescope; and if no other observer will acknowledge the awkwardness and insecurity of his position, I can myself vouch for its danger, having fallen from the very top of Mr Ramage's 20 feet telescope when it was directed to a point not very far from the zenith. Though but slightly connected with astronomy, I cannot omit calling your attention to the great improvements—I may call them discoveries—which have been recently made in *Photography.* I need not inform this meeting that the art of taking photographic *negative* pictures upon paper was the invention of Mr Fox Talbot, a distinguished member of this Association. The superiority of the Talbotype to the Daguerreotype is well known. In the latter the pictures are reverted, and incapable of being multiplied, while in the Talbotype there is no reversion, and a single negative will supply a thousand copies, so that books may now be illustrated with pictures drawn by the sun. The difficulty of procuring good paper for the negative is so great, that a better material has been eagerly sought for; and M. Niepce, an accomplished officer in the French service, has successfully substituted for paper a film of albumen, or the white of an egg, spread upon glass. This new process has been brought to such perfection in this city by Messrs Ross and Thompson, that Talbotypes taken by them, and lately exhibited by myself to the National Institute of France, and to M. Niepce, were universally regarded as the finest that had yet been executed. Another process, in which gelatine is substituted for albumen, has been invented, and successfully practised by M. Poitevin, a French officer of engineers, and by an ingenious method, which has been minutely described in the weekly proceedings of the Institute of France, M. Edmund Becquerel has succeeded in transferring to a Daguerreotype plate the prismatic spectrum, with all its brilliant colour, and also, though in an inferior degree, the colours of the landscape. These colours, however, are very fugaceous: yet, though no method of fixing them has yet been discovered, we cannot doubt that the difficulty will be surmounted, and that we shall yet see all the colours of the natural world transferred by their own rays to surfaces both of silver and paper. But the most important fact in Photography which I have now to mention, is the singular acceleration of the process discovered by M. Niepce, which enables him to take the picture of a landscape, illuminated by diffused light, in a single second, or at most in two seconds. By this process he obtained a picture of the sun on albumen so instantaneously, as to confirm the remarkable discovery, previously made by M. Arago, by means of a silver plate, that the rays which proceed from the central parts of the sun's disc, have a higher photogenic action than those which issue from its margin. This interesting discovery of M. Arago is one of a series on photometry, which that distinguished philosopher is now occupied in publishing. Threatened with a calamity which the civilized world will deplore—the loss of that sight which has detected so many brilliant phenomena, and penetrated so deeply the mysteries of the material world, he is now completing, with the aid of other eyes than his own, those splendid researches which will immortalize his own name and add to the scientific glory of his country. From these brief notices of the progress of science, I must now call your attention to two important objects with which the British Association has been occupied since their last meeting. It has been long known, both from theory and in practice, that the imperfect transparency of the earth's atmosphere, and the unequal refraction which arises from differences of temperature, combine to set a limit to the use of high magnifying powers in our telescopes. Hitherto, however, the application of such high powers was checked by the imperfections of the instruments themselves; and it is only since the construction of Lord Rosse's telescope that astronomers have found that, in our damp and variable climate, it is only during a few days of the year that telescopes of such magnitude can use successfully the high magnifying powers which they are capable of bearing. Even in a cloudless sky, when the stars are sparkling in the firmament, the astronomer is baffled by influences which are invisible, and while new planets and new satellites are being discovered by instruments comparatively small, the gigantic Polyphemus lies slumbering in his cave, blinded by thermal currents, more irresistible than the firebrand of Ulysses. As the astronomer, however, cannot command a tempest to clear his atmosphere, nor a thunder storm to purify it, his only alternative is to remove his telescope to some southern climate, where no clouds disturb the serenity of the firmament, and no changes of temperature distract the emanations of the stars. A fact has been recently mentioned, which intitles us to anticipate great results from such a measure. The Marquis of Ormonde is said to have seen from Mount Etna, with his naked eye, the satellites of Jupiter. If this be true, what discoveries may we not expect, even in Europe, from a large reflector working above the grosser strata of our atmosphere. This noble experiment of sending a large reflector to a southern climate has been but once made in the history of science. Sir John Herschel transported his telescopes and his family to the south of Africa, and during a voluntary exile of four years' duration, he enriched astronomy with many splendid discoveries. Such a sacrifice, however, is not likely to be made again; and we must, therefore, look to the aid of Government for the realization of a project which every civilized people will applaud, and which, by adding to the conquests of science, will add to the glory of our country. At the Birmingham meeting of the Association, it's attention was called to this subject, and being convinced that great advantages would accrue to science from the active use of a large reflecting telescope in the southern hemisphere, they resolved to petition Government for a grant of money for that purpose. The Royal Society readily agreed to second this application ; and as no request from this Association has ever been refused, whatever Government was in power, we have every reason to expect a favourable answer to a memorial from the pen of Dr Robinson, which has just been submitted to the Minister. A recent and noble act of liberality to science on the part of the Government justifies this expectation. It is, I believe, not yet generally known that Lord John Russell has granted £1000 a-year to the Royal Society for promoting scientific objects. The Council of that distinguished body has been very solicitous to make this grant effective in promoting scientific objects, and I am persuaded that the measures they have adopted are well fitted to justify the liberality of the Government. One of the most important of these has been to place £100 at the disposal of the committee of the Kew Observatory. This establishment, which has for several years been supported by the British Association, was given to us by the Government as a depository for our books and instruments, and as a locality well fitted for carrying on electrical, magnetical, and meteorological observations. During the last six years the Observatory has been under the honorary superintendence of Mr Ronalds, who is well known to the scientific world for his ingenious photographic methods of constructing self-registering magnetical and meteorological apparatus. On the joint application of the Marquis of Northampton and Sir John Herschel, Her Majesty's Government have granted to Mr Ronalds a pecuniary recompense of £250 for these inventions; and I am glad to be able to state, that Mr Brooke has also received from them a suitable reward for inventions of a similar kind. Under the fostering care of the British Association, the most valuable electrical observations have been made at Kew, and Mr Ronalds has continued, from year to year, to make those improvements upon his apparatus which experience never fails to suggest;—but I regret to say that, in consequence of our diminished resources, the Association, at its meeting in 1848, came to the resolution of discontinuing the observations at Kew, appropriating, at the same time, an adequate sum for completing those which were in progress, and for reducing and discussing the five years' electrical observations which had been published in our annual reports. I trust, however, that means will yet be found to maintain the Observatory in full activity, and carry out the original objects contemplated by the Committee. Having had an opportunity of visiting this establishment a few weeks ago this summer, after having inspected two of the best conducted Observatories on the Continent where the same class of observations are made, I have no hesitation in speaking in the highest terms of the value of Mr Ronalds' labours, and in recommending the institution which he so liberally superintends to the continued protection of the Association, and the continued liberality of the Royal Society. From the facts which I have already mentioned, and from many others to which I might have referred, the members of the Association will observe, with no common pleasure, that the Government of this country have, during the last twenty years, been extending their patronage of science and the arts. That this change was effected by the interference of the British Association, and by the writings and personal exertions of its members, could, were it necessary, be easily proved. But though men of all shades of political feeling have applauded the growing wisdom and liberality of the State; and, though various individuals are entitled to share in the applause, yet there is one statesman, alas! too early and too painfully torn from the affections of his country, whom the science of England must ever regard as its warmest friend and its greatest benefactor. To him we owe new institutions for advancing science, and new colleges for extending education; and, had Providence permitted him to follow out in the serene evening of life, and in the maturity of his powerful intellect, the views which he had cherished amid the distractions of political strife, he would have rivalled the Colbert of another age, and would have completed the systematic organization of science and literature and art, which has been the pride and the glory of another land. These are not the words of idle eulogy, or the expressions of a groundless expectation. Sir Robert Peel had entertained the idea of attaching to the Royal Society a number of active members, who should devote themselves wholly to scientific pursuits, and I had the satisfaction of communicating to him, through a mutual friend, the remarkable fact, that I had found among the MSS. of Sir Isaac Newton a written scheme of improving the Royal Society, precisely similar to that which he contemplated. Had this idea been realized, it would have been but the first instalment of a debt long due to science and the nation, and it would have fallen to the lot of some more fortunate statesman to achieve a glorious name by its complete discharge. It has always been one of the leading objects of the British Association, and it is now the only one of them which has not been wholly accomplished, 'to obtain a more general attention to the objects of a science, and removal of any disadvantages of a public kind which impede its progress.' Although this object is not very definitely expressed, yet Mr Harcourt, in moving its adoption, included under it the revision of the law of patents and the direct national encouragement of science, two subjects to which I shall briefly direct your attention. In 1831, when the Association commenced its labours, our patent laws were a blot on the legislation of Great Britain; and though some of their more obnoxious provisions have since that time been modified or removed, they are a blot still, less deep in its dye, but equally a stain upon the character of the nation. The protection which is given by statute to every other property in literature and the fine arts, is not accorded to property in scientific inventions and discoveries. A man of genius completes an invention, and after incurring great expense, and spending years of anxiety and labour, he is ready to give the benefit of it to the public. Perhaps it is an invention to save life—the life-boat; to shorten space and lengthen time—the railway; to guide the commerce of the world through the trackless ocean—the mariner's compass; to extend the industry, increase the power, and fill the coffers of the State—the steam-engine; to civilize our species, to raise it from the depths of ignorance and crime to knowledge and to virtue—the printing-press. But, whatever it may be, a grateful country has granted to the inventor the sole benefit of its use for fourteen years. But what the statute thus freely gives, law and custom as freely take away, or render void. Fees, varying from £200 to £500, are demanded from the inventor; and the gift thus so highly estimated by the giver bears the great seal of England. The inventor must now describe his invention with legal precision. If he errs in the slightest point,—if his description is not sufficiently intelligible,—if the smallest portion of his invention has been used before,—or if he has incautiously allowed his secret to be made known to two, or even to one individual, he will lose in a court of law his money and his privilege. Should his patent escape unscathed from the fiery ordeal, it often happens that the patentee has not been remunerated during the fourteen years of his term. In this case the State is willing to extend his right for five or seven years more; but he can obtain this extension only by the expensive and uncertain process of an act of Parliament—a boon which is seldom asked, and which, through rival influence, has often been withheld. Such was the patent law twenty years ago; but since that time it has received some important ameliorations; and though the British Association did not interfere as a body, yet some of its members applied energetically on the subject to some of the more influential individuals in Lord Grey's Government, and the result of this was, two acts of Parliament passed in 1835 and 1839, intituled 'Acts for amending the law touching letters patent for inventions.' Without referring to another important act for registering designs, which had the effect of withdrawing from the grasp of the patent laws a great number of useful inventions, depending principally on form, I shall notice only the valuable provisions of the two acts above mentioned,—acts which we owe solely to Lord Brougham. By the first of these acts the patentee is permitted to disclaim any part either of the title of his invention or of the specification of it, or to make any alteration on the title or specification. The same act gives the Privy Council the power of confirming any patent, or of granting a new one, when a patent had been taken out for an invention which the patentee believed to be new, but which was found to have been known before, but not publicly and generally used. By the same act, too, the power of letters patent was taken from Parliament, and given to the Privy Council, who have, on different occasions, exercised it with judgment and discrimination. By the second act of 1839, this last privilege was made more attainable by the patentee. There are doubtless valuable improvements which inventors will gratefully remember; but till the enormous fees which are still exacted are either partly or wholly abolished, and a real privilege given under the great seal, the genius of this country will never be able to compete with that of foreign lands, where patents are cheaply obtained and better protected. In proof of the justness of these views, it is gratifying to notice, that, within these few days, it has been announced in Parliament that the new Attorney-General has accepted his office, on the express condition that the large fees which he derives from patents shall be subject to revision. The other object of the British Association, mentioned by Mr Harcourt, the Organization of Science as a National Institution, is one of a higher order, and not limited to individual, or even to English interests. It concerns the civilized world; not confined to time it concerns eternity. While the tongue of the Almighty, as Kepler expresses it, is speaking to us in His word, his finger is writing to us in His works; and to acquire a knowledge of these works is an essential portion of the great duty of man. Truth secular cannot be separated from truth divine; and if a priesthood has in all ages been organized to track and exemplify the one, and to maintain, in ages of darkness and corruption, the vestal fire upon the sacred altar, shall not an intellectual priesthood be organized to develop the glorious truths which time and space embosom,—to cast the glance of reason into the dark interior of our globe, teeming with what was once life,—to make the dull eye of man sensitive to the planet which twinkles from afar, as well as to the luminary which shines above,—and to incorporate with our inner life those wonders of the external world which appeal with equal power to the affections and to the reason of immortal natures? If the God of Love is most appropriately worshipped in the Christian temple, the God of Nature may be equally honoured in the Temple of Science. Even from its lofty minarets the philosopher may summon the faithful to prayer; and the priest and the sage may exchange altars without the compromise of faith or of knowledge. Influenced, no doubt, by views like these, Mr Harcourt has cited the opinions of a philosopher whose memory is dear to Scotland, and whose judgment on any great question will be everywhere received with respect and attention; I refer to Professor Playfair, the distinguished successor in our Metropolitan University of the Gregorys, the Maclaurins, and the Stewarts of former days, who, in his able dissertation 'On the Progress of the Mathematical and Physical Sciences,' thus speaks of the National Institute of France:—

"'This institution has been of considerable advantage to science. To detach a number of ingenious men from everything but scientific pursuits,—to deliver them alike from the embarrassments of poverty or the temptations of wealth,—to give them a place and station in society the most respectable and independent, is to remove every impediment, and to add every stimulus to exertion. To this institution, accordingly, operating upon a people of great genius, and indefatigable activity of mind, we are to ascribe that superiority in the mathematical sciences which, in the last seventy years, has been so conspicuous.'—*Diss. 3d*, *Sec.* 5, p. 500.

"This just eulogy on the National Institute of France, in reference to abstract mathematics, may be safely extended to every branch of theoretical and practical science; and I have no hesitation in saying, after having recently seen the Academy of Sciences at its weekly labours, that it is the noblest and most effective institution that ever was organized for the promotion of science. Owing to the prevalence of scientific knowledge among all classes of the French population, and to their admirable system of elementary instruction, the advancement of science, the diffusion of knowledge, and the extension of education, are objects dear to every class of the people. The soldier as well as the citizen,—the Socialist, the Republican, and the Royalist,—all look up to the National Institute as a mighty obelisk erected to science, to be respected and loved and defended by all. We have seen it standing unshaken and active amid all the revolutions and convulsions which have so long agitated that noble but distracted country,—a common centre of affection, to which antagonist opinions, and rival interests, and dissevered hearts, have peacefully converged. It thus becomes an institution of order, calculated to send back to its contending friends a message of union and peace, and to replace in stable equilibrium the tottering institutions of the State. It was doubtless with views like these that the great Colbert established the Academy of Sciences in Paris, and that the powerful and sagacious monarchs on the Continent of Europe have imitated his example. They have established in their respective capitals similar institutions,—they have sustained them with liberal endowments,—they have conferred rank and honours on their more eminent members, and there are now here present distinguished foreigners who have well earned the rewards and distinctions they have received. It is, therefore, gentlemen, no extravagant opinion that institutions which have thus thriven in other countries should thrive in ours,—that insulated societies, which elsewhere flourish in combination, should, when combined, flourish among us,—and that men ordained by the State to the undivided functions of science should do more and better work than those who snatch an hour or two from their daily toil, or from their nightly rest. In a great nation like ours, where the higher interests and objects of the State are necessarily organized, it is a singular anomaly that the intellectual interests of the country should, in a great measure, be left to voluntary support and individual zeal,—an anomaly that could have arisen only from the supineness of ever-changing administrations, and from the intelligence and liberality of a commercial people,—an anomaly, too, that could have been continued only by the excellence of the institutions they have established. In the history of no civilized people can we find private establishments so generously fostered, so energetically conducted, and so successful in their objects, as the Royal Societies of London, Edinburgh, and Dublin, and the Astronomical, Geological, Zoological, and Linnæan Societies of the metropolis. They are an honour to the nation, and will ever be gratefully remembered in the history of science.

But they are nevertheless defective in their constitution, limited in their operation, and incapable, from their very nature, of developing and directing and rewarding the indigenous talent of the country. They are simply subscription societies, which pay for the publication of their own transactions, and adjudicate medals entrusted to them by the beneficence of others. They are not bound to the exercise of any other function, and they are under no obligation to do the scientific work of the State, or to promote any of those national objects which are entrusted to the organized institutions of other lands. Their President and Council are necessarily resident in London; and the talent and genius of the provinces are excluded from their administration. From this remark we must except the distinguished philosophers of Cambridge and Oxford, who, from their proximity to the capital, have been the brightest ornaments of our metropolitan institutions, and without whose aid they never could have attained their present pre-eminence. It is, therefore, in the more remote parts of the empire that the influence of a national institution would be more immediately felt, and nowhere more powerfully than in this its northern portion. Our English friends are, we believe, little aware of the obstructions which oppose the progress of science in Scotland. In our five Universities there is not a single Fellowship to stimulate the genius and rouse the ambition of the student. The Church, the law, and the medical profession hold out no rewards to the cultivators of mathematical and physical science; and were a youthful Newton or Laplace to issue from any of our universities, his best friends would advise him to renounce the divine gift, and to seek in professional toil the well-earned competency which can alone secure him a just position in the social scale, and an enviable felicity in the domestic circle. Did this truth require any evidence in its support, we find it in the notorious fact, that our colleges cannot furnish Professors to fill their own important offices; and the time is not distant when all our chairs in Mathematics, Natural Philosophy, and even Natural History, will be occupied by Professors educated in the English Universities. But were a Royal Academy or Institute, like that of France, established on the basis of our existing institutions, and a class of resident members enabled to devote themselves wholly to science, the youth of Scotland would instantly start for the prize, and would speedily achieve their full share in the liberality of the State. Our universities would then breathe a more vital air. Our science would put forth new energies, and our literature might rise to the high level at which it stands in our sister land. But it is to the nation that the greatest advantages would accrue. With gigantic manufacturing establishments, depending for their perfection and success on mechanics and chemistry; with a royal and commercial marine almost covering the ocean; with steam ships on every sea; with a system of agriculture leaning upon science as its mainstay; with a network of railways demanding for their improvement, and for the safety of the traveller, and for the remuneration of their public-spirited projectors, the highest efforts of mechanical skill, the time has now arrived for summoning to the service of the State all the theoretical and practical wisdom of the country; for rousing what is dormant, combining what is insulated, and uniting in one grand institution the living talent which is in active but undirected and unsupported exercise around us. In thus pleading for the most important of the objects of the British Association, I feel that I am not pleading for a cause that is hopeless. The change has not only commenced, but has made considerable progress. Our scientific institutions have already, to a certain extent, become national ones. Apartments belonging to the nation have been liberally granted to them. Royal medals have been founded, and large sums from the public purse devoted to the objects which they contemplate. The Museum of Economic Geology, indeed, is itself a complete section of a Royal Institute, giving a scientific position to six eminent philosophers, all of whom are distinguished members of this Association. And in every branch of science and literature the liberality of the Crown has been extended to numerous individuals, whose names would have been enrolled among the Members of a National Institution. The cause, therefore, is far advanced; and every act of liberality to eminent men, and every grant of money for scientific and literary purposes, is a distinct step towards its triumph. Our private institutions have, in reality, assumed the transition phase, and it requires only an electric spark from a sagacious and patriotic statesman to combine in one noble phalanx the scattered elements of our intellectual greatness, and guide to lofty achievements and glorious triumphs the talents and genius of the nation. But when such an institution has been completed, the duties of the State to science are not exhausted. It has appreciated knowledge, but in its abstract and utilitarian phase. It would be of little avail to the peace and happiness of society if the great truths of the material world were confined to the educated and the wise. The organization of science thus limited would cease to be a blessing. Knowledge secular and knowledge divine, the double current of the intellectual life-blood of man, must not merely descend through the great arteries of the social frame. It must be taken up by the minutest capillaries before it can nourish and purify society. Knowledge is at once the manna and the medicine of our moral being. When crime is the bane, knowledge is the antidote. Society may escape from the pestilence, and may survive the famine, but the demon of ignorance, with his grim adjutants of vice and riot, will pursue her into her most peaceful haunts, destroying our institutions, and converting into a wilderness the paradise of social and domestic life. The State has, therefore, a great duty to perform. As it punishes crime, it is bound to prevent it. As it subjects us to laws, it must teach us to read them; and while it thus teaches, it must teach also the ennobling truths which display the power and the wisdom of the great lawgiver, thus diffusing knowledge while it is extending education; and thus making men contented, and happy, and humble, while it makes them quiet and obedient subjects. It is a great problem yet to be solved to determine what will be the state of society when man's physical powers are highly exalted, and his physical condition highly ameliorated, without any corresponding change in his moral habits and position. There is much reason to fear that every great advance in material civilization requires some moral and compensatory antagonism; but however this may be, the very indeterminate character of the problem is a warning to the rulers of nations to prepare for the contingency by a system of national instruction, which shall either reconcile or disregard those hostile influences under which the people are now perishing for lack of knowledge."

Thursday, 1st August.

MORNING—IN THE UNIVERSITY.

The different sections having been organized, business commenced in each of them at 11 A.M. The following abstract will convey to our readers a short, but pretty correct general account of their proceedings.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

President.—Professor JAMES D. FORBES, Sec. R.S.E.

Vice-Presidents.—Sir T. M. BRISBANE, Bart.; Bishop TERROT; Professor W. THOMSON; Lord WROTTESLEY.

Secretaries.—Professor STEVELLY; Professor G. G. STOKES; Mr W. J. MACQUORN RANKINE; Professor SMYTH.

Committee.—Mr J. C. Adams; Sir David Brewster; Mr J. A. Broun; Professor Gray; Mr J. P. Gassiot; Rev. Dr Hincks; Rev. Professor Kelland; Dr Lee; M. Otto Struve; Follet Osler; Professor Phillips; Rev. Dr Scoresby; Professor Wilson; J. Scott Russell; the Rev. J. B. Reade; Mr F. Ronalds; Col. Sykes; Lieut. R. Strachey, R.E.

At this meeting, Mr Ronalds' Report on the Kew Observatory was read; also a Report by the Rev. B. Powell, on Luminous Meteors; Mr W. J. M. Rankine communicated a paper on the Laws of the Elasticity of Solids.

The Rev. Dr Scoresby communicated an interesting memoir "On Atlantic Waves, their Magnitude, Velocity, and Phenomena," nearly in the following terms:—"During *two* passages across the Atlantic in 1847–8, I had opportunities for investigating certain elements respecting deep-sea waves more favourable than had ever before occurred within my experience in navigation. These observations, it should be noted in the outset, and the results deduced from them, were entirely uninfluenced by, and separate from theory. They form but a contribution to this interesting branch of natural phenomena; but I offer them the more readily from the circumstance of their entire independency and speciality. It was in our return voyage from America that the highest seas occurred, when the circumstances adapted for interesting observations were singularly favourable; for, whilst the magnitude and the peculiar construction of the upper works of the ship—the Hibernia—afforded various platforms of determinate elevation above the line of flotation for observations on the height of the waves, the direction of the ship's course, with respect to that of waves, was generally so nearly similar as to yield the most advantageous agreement or accordance for observations on their width and velocity. These observations I shall extract, in their order, from my Journal kept during the homeward passage. My first observation worth recording is under the date of March 5, 1848, when the ship was in latitude about 51°, and longitude (at noon) 38° 50′ W.—the wind then being about WSW., and the ship's course, true, N. 52° E. At sunset of the 4th the wind blew a *hard gale*, which, with heavy squalls, had continued during the night; so that all sail was taken in but storm-staysail forward. The barometer stood at 29·50 at 8 P.M., but fell so rapidly as to be at 28·30 by 10 the next morning. In the afternoon of this day I stood some time on the saloon deck or cuddy roof,—a height, with the addition of that of the eye, of 23 feet 3 inches above the line of flotation of the ship,—watching the sublime spectacle presented by the turbulent waters. I am not aware that I ever saw the sea more terribly magnificent. I was anxious to ascertain the height of these mighty waves; but found almost every wave rising so much above the level of the eye, as indicated by the intercepting of the horizon of the sea in the direction in which they approached us, as to yield only the *minimum* elevation, and to shew that the great majority of these rolling masses of water possessed a height of considerably *more* than 24 feet (including depression as well as altitude), or reckoning from the mean level of the sea, of *more* than 12 feet. Exposed as the situation was, I then adventured to the larboard paddle-box, which was about 7 feet higher, where the level (as ascertained afterwards at Liverpool, allowance being made for the alteration in the draught of water of the ship), was 24 feet 9 inches above the sea. This position, with 5 feet 6 inches, the height of my eye, gave an elevation altogether of 30 feet 3 inches for the level of the view then obtained,—a level, it should be remarked, which was very satisfactorily maintained during the instants of observation, because of the whole of the ship's length being occupied within the clear '*trough* of the sea,' and in an even and upright position, whilst the nearest approaching wave had its maximum altitude. Here, also, I found at least *one half* of the waves which overtook and passed the ship were far above the level of my eye. Frequently I observed long *ranges* (not acuminated peaks) extending 100 yards, perhaps, on one or both sides of the ship,—the sea then coming nearly right aft,—which rose so high above the visible horizon, as to form an angle estimated at two to three degrees (say $2\frac{1}{2}°$) when the distance of the wave summit was about 100 yards from the observer. This would add near 13 feet to the level of the eye. And this measure of elevation was by no means uncommon,—occurring, I should think, at least once in half a dozen waves. Sometimes peaks of crossing or crests of *breaking* seas would shoot upward at least 10 or 15 feet higher. The *average wave* was, I believe, fully equal to that of my sight on the paddle-box, or more,—that is, $\frac{30}{2} = 15$ feet, or upwards; and the *mean highest waves*, not including the broken or acuminated crests, about 43 feet above the level of the hollow occupied at the moment by the ship. Illuminated as the general expanse not unfrequently was by the transient sunbeam breaking through the heavy masses of the storm-cloud, and contrasting its silvery light with the prevalent gloom, yielding a wild and partial glare, the mighty hills of waters rolling and foaming as they pursued us, whilst the gallant and buoyant ship—a charming 'sea-boat'—rose abaft as by intelligent anticipation of their attack, as she scudded along, so that their irresistible strength and fierce momentum were harmlessly spent beneath her and on her outward sides,—the storm falling fiercely on the scanty and almost denuded spars and steam-chimney raised aloft, still indicated its vast, but as to us innoxious, power, in deafening roarings,—altogether presented as grand a storm-scene as I ever witnessed, and a magnificent example of 'the works of the Lord,' specially exhibited to sea-going men, 'and his wonders in the deep.' In the afternoon of the same day the gale again increased, blowing, especially during the continuance of a much protracted hail-shower, terrifically,—roaring like thunder whilst we scudded before it, causing the ship to vibrate as by a sympathetic tremor, and the tops of rolling waves, too tardy, rapid as was their actual progress, for the speed of the assailing influence, to be carried off and borne along on the aërial wings in a perfect drift of spray! But during the period of these most vehement operations of nature, I was fortunately enabled from familiarity with sea enterprise, to pursue my observations with entire satisfaction. The next day—March 6—added to the interest of these investigations, by developing the character of the Atlantic waves under a long and fiercely-continued influence of a little varying wind. It had blown a heavy gale, violent in showers, from the north-westward, from Saturday evening the 4th, to the evening of Sunday, from 26 to 30 hours; during the night, too, of Sunday, it had again blown hard (abating towards the morning of Monday), and making a total continuance of the storm, in *its violence*, of about 36 hours.* I renewed my observations on the waves at 10 A.M. —the storm having been then subdued for several hours, and the height of the waves having perceptibly subsided. Soon I observed, when standing on the saloon-deck, that ten waves, in one case, came in succession, which all rose above the apparent horizon,—consequently they must have been more than 23 feet, probably the *average* might be about 26 from ridge to hollow. At this period I also found that occasionally (that is, once in about four or five minutes) three or four waves in succession, as seen from the paddle-box,

* The barometer on Saturday, at 8 P.M., was 29·50; at 6 A.M. of Sunday it had fallen to 28·30, being 1·2 inches in 10 hours. At 6 P.M. of the latter day it had risen to 30·00 inches.

rose *above* the visible horizon,—hence they must, like those of the preceding day, have been 30 feet waves. But one important *difference* should be noted,—viz., that they were of no *great* extent on the ridge, presenting, though more than mere conical peaks, but a moderate elongation. Another subject of consideration and investigation, on this occasion, was the period of the regular waves overtaking the ship, and the determination, proximately, of the actual width or intervals, and their velocity. 1. The ship was then going *nine* knots only, the free action of the engines being greatly interfered with by the heavy sea running, and the lines of direction of the waves and the ship's course differed about 22½ degrees, the sea being two points on the larboard quarter,—in other words, the true course of the ship was east; the direction *from* whence the sea came was WNW. 2. The period of regular waves, in incidental series, overtaking the ship were observed as follows:—

Waves.		Min.	Sec.	Mean.
20	occupied	5	30	16″·5
10	,,	2	35	15 ·5
10	,,	2	50	17 ·0
10	,,	2	45	16 ·5
8	,,	2	16	17 ·0
		General average		16″·5

3. The length of the ship was stated to be 220 feet. The time taken by a regular wave to pass from stern to stem appeared, on a mean of several observations, to be about six seconds. Hence 6″ : 220 feet (the width passed over in that time) : : 16·5 feet to 605 feet (the width passed over betwixt crest and crest.) But this extent, by reason of the obliquity of the direction of the waves to the course of the ship, is found to be elongated about 45 feet, reducing the probable mean distance of the waves to 559 feet. Independently of this process, I had previously estimated the distance of the wave crests, ahead and astern when the ship was in the hollow, as I stood near the centre of the ship's length on the paddle-box, at 300 feet each way, by comparing the intervals betwixt my position and the place of the wave-crest with the known length of the ship. This comparison frequently re-

considered and repeated, subsequently yielded, in much accordance with the former, a total width, in the line of the ship's course, of about 600 feet. 4. But the total distance betwixt the crests of two waves, then reckoned at 550 feet, a distance passed by the wave in 16·5 seconds of time, by no means indicates, it is obvious, the real velocity of the wave, as the ship meanwhile was advancing merely in the same direction at the rate of nine knots, that is, nine geographical miles, or (6,075·6 feet × 9 =) 54,680·4 feet per hour, or 15·2 feet per second. During the time, therefore, of a wave passing the ship = 16·5″, the ship would have advanced on its course 16·5 × 15·2 = 250·6 feet. Reducing this for the obliquity of two points, we have 231·5 feet to be added to the former measure, 559 feet, which gives 790·5 feet for the actual distance traversed by the wave in 16·5 seconds of time, being at the rate of $\left(\frac{3{,}600'' \times 790{\cdot}5}{16{\cdot}5} = \right)$ 17,251·7 feet, or 32·67 English statute miles per hour. To know how far this result is but proximate, it should be considered that, of the several elements employed in the calculation, all but one might be deemed accurate. The interval of time occupied by the transit of a wave with respect to the position of the ship, the *direction* of the ship's motion with relation to that of the waves, and the speed of the ship through the water,—may all be recorded as essentially accurate. The element in doubt is that of the average distance from summit to summit of the waves. This distance, it has been seen, was, by a twofold process of observation or comparison accordantly assumed. The value of the judgment derived from rapid comparison of measures by an eye accustomed to such estimations is, it should be observed, far higher than might be generally considered. The practical military commander or engineer officer is able to make, by mere inspection of the ground before him, remarkably close estimates of spaces and distances. When engaged in the Arctic whale fishery, I was enabled, from habit and comparison of unmeasured spaces with known magnitudes, to estimate certain distances with all but perfect accuracy. Thus, as to a circumstance in which we were most deeply interested—the near approach of a boat to a whale—I found it quite practicable, whenever the pursuing boat approached within twice or thrice its length (except when the position was near end on) to estimate the distance to less than a yard. Now, the means of comparison by the eye as to the estimation of the breadth of the Atlantic waves, was that of the ship's length of 220 feet. When the ship was fairly in the middle of the depression betwixt two waves, it was assumed, with reference to this known measure, that something obviously less, but not greatly so, than the ship's length, was the distance of each of the two waves then contemplated,—giving a total width of 600 feet. But the comparison of the time required by a wave to pass from stem to stern, with the average time of transit of an entire wave, yielded a much better result; and, on much consideration of the subject, I am inclined to believe that the estimate is a tolerably close approximation to the truth. It should be observed, too, that as the headway of the ship, in the direction of the course of the wave—being a known quantity—it was favourable to the accuracy of the estimate. For, assuming an error in the width of the waves to have occurred, say to the amount of one-twelfth of the whole, or 49 feet,—the effect upon the calculated velocity of the wave would have been only about a sixteenth, or 2·16 miles per hour. The form and character of these deep-sea waves became at the same time interesting subjects of observation and consideration. In respect to form, we have perpetual modifications and varieties, from the circumstance of the inequality of operation of the *power* by which the waves are formed. Were the wind perfectly uniform in direction and force, and of sufficient continuance, we might have, in wide and deep seas, waves of perfectly regular formation. But no such equality in the wind ever exists. It is perpetually changing its direction within certain limits, and its force too, both in the same place and in proximate quarters. Innumerable disturbing influences are therefore in operation, generating the varieties more or less observable in natural sea-waves. In regard to my own observations of the actual forms of waves, nothing particularly new could be expected from an inquiry of this kind, in regard to phenomena falling within the perpetual observation of seagoing persons; yet, at the risk of stating what might be deemed common, I will venture to transcribe from my notes made with the phenomena before me the leading characteristics which engaged my attention. During the height of the gale (March 6th) the *form* of the waves was less regular than after the wind had for some time begun to subside. Though in many cases when the sea was highest the succession of the primary waves was perfectly distinct, it was rather difficult to trace an identical ridge for more than a quarter to a third of a mile. The grand elevation in such case sometimes extended by a straight ridge, or was sometimes bent as of a crescent form, with the central mass of water higher than the rest, and not unfrequently with two or three semi-elliptic mounds in diminishing series, on either side of the highest peak. These principal waves, too, it should be noted, were not continuously regular, but had embodied in their general mass many minor, secondary, and inferior waves. Neither did the great waves go very prevalently in long parallel series, like those retarded by shallow water on approaching the shore, but every now and then changed into a bent cuneiform crest with breaking acuminating peaks. On the following morning (March 7), after a second stormy night, wind SSW. (fine), we had a heavy and somewhat cross sea (from the change of wind from WSW. to SSW.) But the almost unabated magnitude of the more westerly waves indicated a continuance of the original wind at some distance astern of us. The gale had moderated at daylight, and the weather became fine; but as the sea still kept high, its undulations became more obvious and easily analyzed. At three in the afternoon, when about a third part of the greater undulations averaged about 24 feet from crest to hollow, in height, these higher waves could be traced right and left as they approached the ship to the extent of a quarter of a mile on an average, more or less. Traced through their extent, the ridge was an irregular roundbacked hill, precipitous often on the leeward side of waters. The undulations, indeed, as to primary waves, consisted mainly of these roundbacked masses, broken into or modified by innumerable secondary and smaller waves within their general body. The time in which these waves passed the ship was now, on an average, about 15 seconds, the ship's speed being increased from 9 to 11 knots, and the obliquity of the ship's course to the direction pursued by the waves was three points. On the 9th, two days after the above condition of the waves—whilst the sea yet ran high—few waves could be traced continuously above 300 or 400 yards in extent along the same ridge. The crests often curled over, but none so as to reach the height of a 30 feet wave, and broke for a wide space, estimated at 50 to 100 yards in continuity.

Miscellaneous Notes and Suggestions.—The mode adopted in these researches of finding the *height* of waves is, said Dr Scoresby, I believe, quite satisfactory, and, observed with care and with relation to numbers or proportion of waves, as accurate as need be. The depression of the horizon, in respect to the elevation of the observer, is too small to form even a correction. As the horizon from the paddle-box $\frac{30}{2} = 15$ feet, had only a depression of 3′ 49″, the distance of the visible horizon, as seen from this elevation, would be 4·45 statute miles, and the actual depression in feet due to the distance of the summit of the wave when the ship was in the midst of the hollow, could only be 0·18 foot, or 2·16 inches. Other modes of determining the width of a wave—or the extent betwixt summit and summit—much preferable to that described (the only available one I could devise) might easily be adopted, where the management of the ship was in the hands of the observer. In steam-ships, the simplest mode for high seas, perhaps, would be, altering the speed of the ship when going in the direction of the wave or against the wave; the ratios of the times of transit of wave-crests, under different rates of sailing of the ship, might yield results very close to the truth. In moderate-sized waves the plan adopted by Captain Stanley—whose observations I met with before this meeting—seem satisfactory. But in calms, or moderate weather after a storm—that is, for the determination of the velocities of less elevated waves—a variety of processes might be available."

The author referred, in conclusion, to the *forms* of wave-crests, and heights, modified by crossings, interferences, and reflections.

Mr Scott Russell said he felt a familiar interest in the results of Dr Scoresby's observations. The Section was aware that great doubts existed as to the actual heights of the waves of the open ocean. It was now past all doubt that waves 24 feet high, 30 feet high, 43 feet high, and with the swelling crest even exceeding 45 feet high, actually existed and were observed. From the observations which he had conducted many years since, he had ventured to draw up a table predicting the velocities of sea waves up to even 1000 feet from trough to crest in length. Although the apparatus which he had used did not enable him to experiment on waves which exceeded 16 inches in length,—yet from these pigmy waves it was most interesting to see how accurately the law was obtained; for in his table the velocity of a wave whose length was 600 feet was set down at 30 or 31 miles per hour, Dr Scoresby's actually observed velocity for this wave was 32 miles and a fraction.

Lord Northampton begged to remark, that this was one of the many instances of the value of the British Association as a handmaid to science. It brought together two such gentlemen as Mr Russell and Dr Scoresby, and showed the accuracy of the laws deduced by one from experiments conducted on a microscopic scale, by the test of others observed amid the sublime scene of the great Atlantic.

Professor G. G. Stokes read a memoir "On Metallic Reflexion," and another "On a Fictitious Displacement of Fringes of Interference."—Rev. Professor Powell "On the Refractive Indices of several Substances."

Section B.—Chemistry, including its application to Agriculture and the Arts.

President.—Dr Christison, V.P.R.S.E.

Vice-Presidents.—Dr Gregory, Dr Traill, Dr Daubeny.

Secretaries.—Mr R. Hunt, Dr G. Wilson, Dr T. Anderson.

Committee.—Dr L. Playfair, Mr J. P. Gassiot, Professor Johnston, Dr J. Stenhouse, Mr J. P. Joule, Professor Voelcker, Professor Blyth, Messrs S. Ward, T. Pearsall, Professor Penny, Dr Gladstone, Mr A. Kemp, Dr D. Maclagan, Messrs J. Tennant, J. Young, H. L. Pattinson, H. C. Sorby, Dr Schunck, Professor Williamson, Dr R. D. Thomson, Dr Andrews, Professor A. Fleming, The Marquis of Northampton, G. Gladstone, Professor Chapman, Dr De Vry.

Dr George Wilson read a paper containing a few particulars concerning the late Dr Black.

This paper is too long to be given in full, and cannot well be abridged. It will be acceptable to those who take an interest in the biography of our men of science, and we perceive that it has been reported at length by the Literary Gazette for August 10, 1850. We shall only, therefore, mention that the paper contained the account of several curious particulars concerning Dr Black's habits and character not previously published. It also corrected two erroneous dates in the history of our celebrated chemist; the one that of the publication of his views on fixed air, which Dr Wilson proved, by the production of the copy of Black's inaugural dissertation, from the library of the Edinburgh University, to be 1754; the other that of his death, which, as Mr Muirhead has shewn, was in December, not November, 1799, when Black was in his 72d, not in his 71st year, as has generally been stated. In illustration of this paper, Dr Wilson shewed to the Section Black's blowpipe and balance, as well as the trough in which he prepared fixed air before his class.

Dr Daubeny read a Report "on the influence of carbonic acid on the growth of ferns." This was merely a statement that the inquiry on this subject was still in progress, and that no satisfactory results have as yet been arrived at. The ferns were now growing in an atmosphere containing one per cent. of carbonic acid in excess above that ordinarily contained in air; and although it was thought similar ferns growing under the same conditions, but without carbonic acid in excess, were the most luxuriant, it appeared that they thrived well in this artificial atmosphere. Mr R. Hunt stated that he found the diversified influences of light materially to affect the quantity of carbonic acid which the plants could absorb without immediate injury.

Professor Voelcker read a paper on "the per-centage of nitrogen as an index to the nutritive value of food," which was highly important, as shewing the objections which apply to the present method of determining the nutritive value of food by chemical analysis. The nature of the paper, however, does not admit of abstract.

A paper was then read from Mr Henry Taylor, on "the chemical composition of the rocks of the coal formations;" and another by Mr J. P. Joule, F.R.S., "on some amalgams."

Mr J. P. Gassiot, F.R.S., the well-known electrician, read a paper on "a peculiar form produced in a diamond under the influence of the voltaic arc." He exhibited to the Section a diamond which had been exposed to the intense heat produced by the voltaic battery when arranged as in the device for the electric light. The diamond had apparently been fused, but instead of changing into coke, as in such circumstances diamonds generally do, it had become a glassy mass, and seemed to consist of a multitude of small crystals adhering to each other. The diamond was examined with much interest and curiosity.

The last paper read was by Mr H. C. Sorby, F.G.S., on "the trimorphism of carbon," the object of which was to establish the fact that coke was in reality crystallised when very hard, and in the same form as the diamond, from which, however, it was stated to differ in crystallographic volume. Mr Sorby stated that he had also observed anthracite or blind-coal in the form of crystals, belonging to the square prismatic system.

SECTION C.—GEOLOGY AND PHYSICAL GEOGRAPHY.

President.—Sir RODERICK I. MURCHISON.

Vice-Presidents.—Professor JAMESON, Sir PHILIP DE GREY EGERTON, Mr C. M'LAREN, Professor SEDGWICK.

Secretaries.—Professor NICOL, Mr HUGH MILLER, Mr A. KEITH JOHNSTON.

Committee.—The Duke of Argyll, Captain Sir G. Back, Messrs R. Allan, Binney, Dr Black, Mr J. Bryce, Count Breunner, The Earl of Cathcart, Mr R. Chambers, The Earl of Enniskillen, Sir C. Fellows, Professor E. Forbes, Professor Hitchcock, Messrs Hopkins, J. Hogg, J. B. Jukes, Sir C. Lemon, Sir C. Malcolm, Mr M'Adam, Dr Mantell, Mons. Martins, The Marquis of Northampton, Mr J. B. Pentland, Professor Oldham, Professor Phillips, Messrs S. P. Pratt, G. W. Ormerod, Professor Owen, Professor Ramsay, Major Rawlinson, Mr Smith.

Sir R. I. Murchison gave an account of " the discovery of carboniferous fossils in the crystalline chain of the Forez, France, and on the age of lines of dislocation between the lower and upper carboniferous deposits of France and Germany." He stated that no French geologist had noted the occurrence of a fossil in the crystalline chains of the Forez, but that on his first visit to the banks of the Sichon—a tributary of the Allier—he (Sir Roderick) discovered that certain peculiar and hard grits of the tract contained encrinites; and in a second examination he farther detected in the schists a few remains of bivalves, univalves, trilobites, and corals. The form of one of the best preserved of these bodies has a resemblance to a Silurian Leptœna or Chonetes; but the occurrence of a productus, of a form very nearly allied to *P. fimbriatus* (Sow.)—so identified by M. de Verneuil—leaves no doubt that the deposit belongs to the lower part of the carboniferous epoch. Another fossil resembles the palæozoic cypricardia, but approaches nearest to the *Pleurophorus costatus* (King) of the Permian system. A portion of the head of a Trilobite belongs to the genus Phillipsia (Portlock), so characteristic of the British mountain limestone; and thus the age of these rocks may be considered to be determined. In the geological map of France these rocks are placed as old transition and crystalline; and for such, or for the lower Silurian rocks, they might unquestionably very well have passed, if lithological structure and aspect alone determined their age. The schists, porphyritic grits, and other varieties of the sedimentary portions of these rocks, as well as the various porphyries by which they are penetrated, are indeed well depicted by M. Dufrenoy, in the *Memoires pour Servir;* and the very locality in question was specially described by M. Visquesnel. These authors never observed fossils; and hence, judging from mineral character only, they have assigned much too high an antiquity to the rocks. Sir Roderick having ascended the Sichon from the Castle of Busset, for some leagues, to near its source (Ferrieres), found that the eruptions of the porphyry (often very granitiferous) and the schistose rocky grits were unusually so metamorphosed and dislocated, that he was wholly unable to attempt to define anything like a descending series from the above-mentioned lower carboniferous rocks to others, which might be considered Devonian and Silurian. Besides fossils, he observed two thin bands of scaly, hard, subcrystalline limestone associated with the schists of Busset. In truth, the limestones increase in volume near Ferrieres, where they are in the state of marble, of grayish, reddish-veined, and even of white colours. In order to satisfy himself whether the loftier and bolder portions of the chain of the Forez belonged to the same class of rocks as those he had examined in its lower and northern end (though they are distinguished in the map of France), Sir Roderick made an excursion to Thiers. There he recognised precisely the same phenomena, but on a grander scale, and in broken and picturesque gorges, as he had witnessed along the banks of the Sichon and around the Castle of Busset. Towering masses of dark gray and reddish quartziferous porphyry, with veinstones of quartz (occasionally very like granite), have there penetrated in every direction the mutilated schists and grits, which can, notwithstanding, be recognised as fragments of the very same strata as those of the Sichon; although the greywacke, like schist, has in many parts become a sort of crystalline amphibolic schist, and the grit has been converted into quartz rock. In examining the granitic and schistose chain of the west of the Limagne, Sir Roderick was disposed to think that parts of it (particularly near Ebreville), will eventually be assigned to the palæozoic deposits also; but the engagement to return to the meeting of the British Association prevented the completion of researches to establish this point. In the meantime, he calls attention to the importance of the discovery of lower carboniferous fossils in rocks of so crystalline a nature as those of the chain of the Forez. It has long been known that small but true coal fields occur in many parts of central France, some of which the author described long ago, in conjunction with Sir Charles Lyell. But at that time no geologist could have dared to think that any portion of the crystalline or slaty schist on which these coal-fields reposed *unconformably* could also pertain to the carboniferous system. Yet such is the fact; for independent of this discovery in the chain of the Forez, M. de Verneuil had long ago observed that the "producti," and other fossils found at Regny, near Roanne, in a system of hills parallel to the Forez, and of very similar composition, unquestionably placed such rocks in the carboniferous or mountain limestone group of the carboniferous system. These facts, as well as the occurrence of numerous true carboniferous producti at Sable, in Brittany—where these rocks are also unconformable to overlying coal-fields—have induced M. Elie de Beaumont to renounce an opinion which he formerly entertained in considering the inclined formations as belonging to a different natural group from those which are horizontal. In their exploration of the palæozoic rocks of Germany, Professor Sedgwick and Sir R. Murchison long ago indicated, that the true carboniferous limestone, with large producti, near Hof, had been raised up conformably with underlying Devonian and Silurian rocks—(*see Trans. Geol. Soc.*)—the adjacent Bohemian coal being horizontal. Although this indisputable fact—since confirmed by a subsequent visit to the tract—was at the time received incredulously, it is now sustained by independent evidences in France. The conclusion, therefore, is, that very powerful continental dislocations have operated, both in Germany and France, after the close of the deposits of the mountain or carboniferous limestone, and before the accumulation of the great overlying coal-fields. Seeing the facts now in this light, and M. Elie de Beaumont having introduced a new epoch of disturbance into his classification, Sir Roderick considered the subject to be one eminently meriting discussion at a meeting of the British Association, in order to test the application of such periods of dislocation to the carboniferous series of England, Scotland, and Ireland,—it being understood that in many tracts of Britain no apparent unconformability had yet been observed between the carboniferous limestone and the overlying coal-fields. The existence of such dislocations in some regions, and their non-occurrence in others, bear out, he maintains, the view he has long contended for, that all *dislocations are local only*, when viewed in a general sense. Phenomena, for example, which are true in France and central Germany, do not apply to Russia or the British Isles.

The Chairman, Professor Jameson, made some remarks on these interesting phenomena.

Professor Phillips, addressing the Chairman, said, that the ideas that had been put forth by Scotchmen on the subject of geology were felt in all parts of the world, and that his (the Chairman's) teaching was still felt and gratefully acknowledged; and he accounted it an honour to fight under the banner that was carried by his hand. Although he desired to be accounted a palæontologist, yet he would remind them that there were other considerations to be taken into account than the nature of the fossils, viz., the geological formations. He had been asked a question respecting the relation of the carboniferous limestone to the coal measures. In England there was such an easy gradation that they could not well be separated. But the type in England was useless for Scotland. General inferences could not be drawn from limited data.

Prof. E. Forbes read an account of "the Succession of Strata and Distribution of Organic Remains in the Dorsetshire Purbecks."—These observations were made in the autumn of 1849, in conjunction with Mr Bristow. The formation had been previously described in various memoirs by Prof. Webster, Dr Fitton, Dr Buckland, and Dr Mantell, but not very minutely;

and only twelve species of mollusca and crustacea had been determined,—whereas more than seventy were now enumerated. The strata examined occur along the coast between Weymouth and Dorchester, at Durlestone Bay, near Swanage, and in the quarries at Swindon, Wilts, where the bar of the Purbeck series is exposed, and corresponds exactly with the Dorsetshire beds. After describing these strata, Prof. Forbes said:—It is very remarkable that, whilst the Purbeck can be divided into upper, middle, and lower, each with its peculiar assemblage of organic remains, the lines of demarcation between them are not lines of disturbance, or physical or mineral change. The features which attract the eye, such as the dirt-beds, the dislocated strata at Lulworth, and the cinder-bed, do not indicate any breaks in the distribution of organized beings. The causes which led to a complete change of life three times during the deposition of these freshwater and brackish strata must be sought for, not simply in a rapid or sudden change of their area into land or sea, but in the great lapse of time which intervened between their epochs of deposition. A most striking feature of the mollusc Fauna of the Purbecks is this, so similar are the generic types to those of tertiary freshwater strata and those now existing, that had we only such fossils before us, and no evidence of the position of the rocks in which they are found, we should be wholly unable to assign them a definite geological epoch.—A comparison of these fossils with the collections from the Hastings sand and Weald clay leads the author to believe that the Fauna of the middle and upper Wealden series is almost entirely distinct, as far as species are concerned, from those of the lower or Purbeck division. Some of the species reputed identical prove to be distinct; and others are derived from certain anomalous beds near Tonbridge Wells, believed to be true Purbeck strata by the author. The excellent monograph on the Wealden of N. Germany by Dunker and V. Mayer, affords the strongest confirmation of these views, showing that the Fauna of the German Wealden essentially corresponds with the British, and that the organic contents of the Purbecks of the Continent correspond with ours and differ almost entirely from those of the upper beds.

Sir R. Murchison remarked on the small physical extent of the Purbeck strata compared with their palæontological importance, confirming the belief that a whole epoch may be represented by a few feet of deposit.—Professor Owen confirmed the inference of Professor Forbes respecting the connection of the Wealden with the oolites; of the large Wealden Reptilia, all except the Iguanodon were oolitic and not cretaceous.—Professor Ramsay stated that the whole oolitic series had been deposited in a diminishing area, with the land rising to the west, and the last of the series, the Wealden, had been deposited in the estuary of a great river, which must have flowed from the north-west at a time when what is now Wales and Derbyshire was very high land.—Professor Forbes observed, that no inference as to the age of the Purbecks could be drawn, without the evidence of geological position; the freshwater mollusca and Cyprides differ less from living British species than the living species differed from those of other countries; the Wealden of Scotland was not identical with that of England, but probably belonged to an older period.

Mr Ormerod next read a paper "On the Gradual Subsidence of a Portion of the Surface of Chat Moss, in Lancashire, by Drainage."—This was the continuation of a paper read at the Swansea meeting. It was shown by a series of levellings made in the last four years, over an extent of about 200 acres, where drainage was carried on, that a subsidence had taken place to the amount of one foot per annum.

Mr Bryce described "the Lesmahago and Douglas Coal Field," and exhibited maps and sections.—This coal-field forms a distinct barrier from all the rest, being separated by a barrier of old red sandstone; it measures about ten miles by five or six, and contains twelve or fourteen beds of coal, amounting in all to sixty-five feet, one bed being fifteen feet thick, and another nine. In some of the deep valleys the coal is worked on a level. Several beds of clay-ironstone occur, averaging eight inches thick, and one black band (bituminous ironstone) eleven inches thick, is found throughout the northern part. Fire-clays have been noticed under some of the coal-beds; the largest fault is one of twenty-five fathoms, running north-west and south-east.

Mr Landell was of opinion that this coal-field was connected with the Ayrshire coal-field and not separated by old red sandstone as described; throughout the Scotch coal-fields the carboniferous limestone was split up into a number of beds and intercalated with the coal.—Mr Bryce, in reply to a question, stated that he considered all the Scotch coal-fields had once been continuous, but had become more or less separated by the outburst of the trap, and in this one instance by an upheaval of the old red sandstone.—Mr Hugh Miller said there were beds of *red* sandstone with coal fossils overlying the coal, and that it was extremely difficult to determine the exact line of junction of the two systems, but such a line did exist, and he believed Agassiz was right in asserting that no species of fish was common to the old red and carboniferous series.—Professor Nicol stated that Mr Bryce's sections were exceedingly like Mr Milne's Berwickshire sections; he thought that all the red sandstone on the north flank of the Lammermuir hills might with more propriety be referred to the carboniferous series.—Dr John Fleming described some instances in which there were true old red sandstone, with scales of the Holoptychius, followed by numerous alternations of very thin coal seams with carboniferous limestone; some of the trap rock after its ejection appear to have been arranged by water.

SECTION D.—NATURAL HISTORY, INCLUDING PHYSIOLOGY.

President.—Professor GOODSIR.

Vice-Presidents.—Sir J. G. DALYELL, Sir J. RICHARDSON, Dr R. K. GREVILLE, Mr G. BENTHAM.

Secretaries.—Dr LANKESTER, Professor J. H. BENNETT, Dr D. MACLAGAN.

Committee.—Professor Allman, Mr C. C. Babington, Professor J. H. Balfour, Dr Black, Mr G. Busk, Dr H. Cleghorn, Rev. Professor Fleming, Mr W. Gourlie, Rev. L. Jenyns, Dr W. H. Lowe, Mr R. M'Andrew, Professor W. Macdonald, Dr M'William, Mr R. Patterson, Rev. J. Reid, Messrs W. Spence and Wyville Thomson, Professor Walker-Arnott, Mr J. Wilson, Dr P. Neill, Professor Parlatore, Professor E. Forbes, Professor W. Carpenter, Sir W. Jardine, Mr Hugh E. Strickland, Professor A. Fleming, Professor Dickie, Professor Daubeny, Dr Redfern, Dr Tilt, Professor Owen, Dr Fowler, Mr R. Strachey, Professor Van der Hoeven, Mr J. E. Winterbottom, Professor Hyrtl, Messrs T. C. Eytyn, P. J. Selby, Prof. Buchanan, Professor Sharpey, Mr C. W. Peach, Dr D. Mackay, Messrs Joshua Clark, Hamlyn Lee, Dr George Johnston.

"On the Hedge Plants of India, and the Conditions which adapt them for Special Purposes and Particular Localities," by Dr Cleghorn.—The author first made some remarks on the low condition of agriculture generally throughout India, and stated that his remarks more particularly applied to the south of that continent, in the district of Mysore. Having referred to the importance of hedges in any well-developed system of agriculture, he pointed out their especial importance in a country infested with wild animals, and where the crops needed especial protection. The following plants were named as those which might be used with advantage for hedges in various parts of India. Most of these plants are characterized by possessing spines, prickles, and thorns, which render them dangerous to animals.—*Opuntia Dillenii.* This plant was originally introduced from America, but grew very abundantly, was easily propagated, and required little or no soil. It might be used for military defences. Its fruit is eaten. It, however, harbours vermin, and is to be used only when other plants cannot be obtained.—*Agave Americana,* another introduced plant. It is propagated by suckers, grows easily, and when decayed the leaves may be used as fuel.—*Euphorbia antiquorum.* This, combined with other species of Euphorbia, forms an excellent fence. Its juice is very acrid, and care must be taken in pruning it. Several species of plants belonging to the divisions Mimoseæ and Cæsalpinieæ, were also mentioned as thorny shrubs adapted for the purposes of inclosure. Many of these have elegant flowers.—*Acacia Arabica* yields gum, and the pods and seeds are eaten. They are all plants easily cultivated.—The Bamboo (*Bambusa arundinacea*) is also a plant highly recommended for forming inclosures. Several other species of Bambusa have been employed for the same purpose.—Other plants used for hedges are *Pandanus odoratissimus*, the lime, the mulberry, species of Hibiscus, &c. The paper was illustrated by drawings of the species of plants described by the author.

"On Exuviation, or, the Changes of Integuments by Animals," by Sir J. G. Dalyell.—The observations of the writer were confined to the family of Crustacea. He described minutely the changes undergone by crabs during the process of moulting, and, in several instances, counted the number of days from one moult to another. These varied from 60 to 194 days. In all cases he found that no reparation of wounded, mutilated, or destroyed parts took place till after the moult which succeeded the injury. He described minutely several cases in which injuries of various kinds had been repaired. In one case of the moult of a crab only the two claws of the dermal skeleton were developed, whilst the eight legs were entirely suppressed. At the next moult the animal produced its usual number of legs.

Professor Owen wished to express the obligations under which naturalists were to Sir J. Dalyell for his numerous observations in natural history. The subject of the present paper was one of great interest and demanded further investigation.—Professor Van der Hoeven stated that the remarks of Sir John confirmed those of Mr Newport on the change of skin and the reproduction of lost members in the family of spiders.—Mr Peach said that the white colour of the young crabs mentioned by Sir John was owing to confinement. He believed that limbs were only reproduced after exuviation, from his own observations. Amongst the Crustacea which he had observed, the hermit crabs shed their skin most frequently:—sometimes as often as five or six times in a month.

"Notes on Crustacea, accompanied by Drawings," by Dr T. Williams.—The notes were, first,—on the development of the shell. Under this head the author gave an account of the changes observed in the shell during its growth when examined by the microscope. In the first place a production of cells was observed over the region of the heart. This gradually spread and formed the upper layer of the dermal skeleton. Under this was formed a layer of pigment cells, and below this again layers of smaller cells till the whole integument was formed. The younger the animal the oftener this process went on,—till at last it went on very slowly or ceased altogether. Second,—the shedding of the exuviæ. This process seemed in a great measure under the control of the animal; as when watched it frequently suspended this operation, or when excited, hastened it. It seems to be attended with excitement of the nervous system,—as at this period the animal was more pugnacious than at any other. Third,—the reproduction of limbs. This process only took place after the exuviation of the old skin, although a reparative process was evidently set up in the injured part. At the moult immediately subsequent to the loss of a limb, the new limb was not so large as those which represented uninjured limbs.

"A Notice of the Distribution of the Herbaria of the Honourable East India Company," was read by Dr Royle.—The collections in the possession of the Company consisted of the plants collected by Royle, Griffiths, Falconer, Harris, Stocks, and others. Duplicates of the specimens contained in these collections had been sent to various public bodies.

"On the Anatomy of the Doris," by A. Hancock and Dr Embleton.—The paper contained a description of the different internal organs and embraced several new points, namely:—Some hitherto unnoticed modifications of the digestive organs. A full account of the complicated organs of reproduction and their varieties:—these organs have long been matter of dispute.

"On the Vertebral Homologies of the Basicranium," by Professor W. Macdonald.

"Remarks on the *Anacharis Alsinastrum*," by Mr C. C. Babington,—who exhibited specimens.—The plant was gathered in a river in Berwickshire where it had been seen by Dr Johnston ten years ago. It was not, however, till recently that it had been recognized as a British plant. It appears now to be very generally diffused,—and where once introduced, to grow with the greatest possible rapidity. In some places where it had not been introduced more than two years it had already quite filled up the reservoirs or parts of canals in which it was growing. A species of Anacharis grew in North America; but Mr Babington considered the British species peculiar, and had named it accordingly. It belonged to the same order of plants as Vallisneria, and produced its flowers in the same way. Although filaments had been seen in the staminiferous flowers, no anthers had yet been discovered in the British species.

Ethnological Sub-Section.

President.—Vice-Admiral Sir Charles Malcolm, K.C.B.

Vice-Presidents.—Professor J. Y. Simpson; Dr R. G. Latham; Rev. Dr Edward Hincks; Major Rawlinson.

Secretary.—Daniel Wilson, Esq.

Committee.—Rev. W. L. Alexander, D.D., Professor Buckman, Professor Christison, Sir Charles Fellows, Joseph Fletcher, Esq., Professor Goodsir, Dr William Jones, J. Hogg, Esq., Professor R. Lee, D.D., Dr Meyer, Dr D. Skae, W. F. Skene, Esq., William Spence, Esq., William Walker, Esq.

Dr Edward Hincks read a paper on the Language and Mode of Writing of the Ancient Assyrians; and Professor Rangabe of Athens read Notices of some additions made to our knowledge of the Ancient Greeks by recent discoveries in Greece.

The communication next laid before the Section by Mr Daniel Wilson, was entitled an "Inquiry into the Evidence of the Existence of Primitive Races in Scotland, prior to the Celtæ." Mr Wilson commenced by furnishing a slight sketch of the previous labours of continental ethnologists, and especially of Professors Retzius, and Nillson, the latter of whom has carefully explored the primitive barrows of Sweden, and, by the comparison of their crania, has arrived at the conclusion that four successive races have occupied that country. Mr Wilson shewed, by a series of results established on carefully sifted data, that evidence may be produced to prove the existence of two primitive races in Scotland, differing decidedly in cranial characteristics from the Celtæ, but also differing in a remarkable manner from the two earliest races of Scandinavia, the primitive race of the north of Europe, apparently corresponding to the second race of the Scottish Tumuli.

An interesting collection of crania was exhibited from various Scottish cairns and barrows, and a large diagram was shewn in illustration of their measurements and relative capacities. The communication excited much interest, and led to an animated discussion on various points referred to, in which the author was acknowledged to have opened up an entirely new field of inquiry, in relation to primitive Scottish Ethnology.

SECTION F.—STATISTICS.

President.—Dr J. LEE.

Vice-Presidents.—Rev. Dr GORDON, Dr H. MARSHALL, Professor W. P. ALISON, Mr G. R. PORTER.

Secretaries.—Professor HANCOCK, Messrs J. STARK, J. FLETCHER.

Committee.—Mr T. Tooke, Colonel Sykes, Sir J. P. Boileau, Messrs F. G. P. Neison, G. L. Finlay, W. T. Thomson, J. Finlaison, F. Sopwith, W. Jerdan, W. Felkin, J. Shuttleworth, R. Christie, W. Chambers, Sir C. Lemon, Messrs J. Gibson, J. W. Orpen, J. Ball.

"On the Self-imposed Taxation of the Working Classes in the United Kingdom," by Mr G. R. Porter.—The writer referred, of course, to that self-imposed taxation which consists in the use of articles from which we could very well abstain, which are of little or no use to us either bodily or intellectually, and by foregoing the consumption of which we should become, individually and nationally, better able to bear the necessary expenses of Government. The particular instances to which he called attention, were the consumption of ardent spirits, beer, and tobacco; the yearly expenditure for which articles in the United Kingdom amounts to a sum which must appear perfectly fabulous until the reasonableness of the result be shewn by means of calculations adopted and formed on good authority. The quantity of spirits of home production consumed in 1849 within the kingdom was—

In England . . .	9,053,676	imperial gallons.
Scotland . . .	6,935,003	...
Ireland . . .	6,973,333	...
Together .	22,962,012	

the duty upon which quantity amounted to £5,793,381. The wholesale cost, including the duty, would probably amount to about £8,000,000, a sum which would, however, be very far short of that paid by the consumers. In all trades which, like that of the distillation of spirits, are carried on for the supplying of very numerous customers, and where the sum paid at any one time by each individual is very small, the retail profits must necessarily be great, in order to reimburse the expenses attendant on the trade, and to afford a living to those engaged in it. It may likewise be fairly assumed, that something greater than the average rate of profit would be required in order to induce persons with the necessary capital to embark in a business accompanied by, or at least liable to, circumstances of an unpleasant character. It is not possible to make any precise calculations of those expenses and profits; but a good deal of trouble has been taken in order to make as near an approximation as possible to the truth, and it has been given as the opinion of several distillers who have been consulted, that the consumer pays for every gallon of spirits used three times the amount of the duty. Assuming this estimate, it would appear that the cost of British and Irish distilled spirits to the people of England, Scotland, and Ireland respectively, in 1849, was £17,381,643, thus divided:—

England	£8,838,768
Scotland	5,369,868
Ireland	3,173,007
	£17,381,643

To this must be added the sum spent for rum, nearly the whole of which is used by the same classes as consume the gin and whisky, of which the cost is here estimated. The consumption of rum in 1849 amounted to 3,044,758 imperial gallons, the duty paid on which was £1,142,855. The class of consumers being the same, and the means of distribution nearly, if not wholly, identical, it may fairly be assumed that the cost to the consumer bears an equal relation to the duty with that assigned to British spirits, in which case the expenditure for this kind of spirit will reach £3,428,565, making the whole outlay of the people for these two descriptions of ardent spirits £20,810,208, thus locally divided—

England	£8,205,242
Scotland	6,285,114
Ireland	6,319,852
	£20,810,208

If, for the purpose of the calculation, we assume that the population of the three divisions of the United Kingdom was the same in 1849 as it was found to be at the enumeration of 1841, the consumption per head in the year was—

In England	. . . .	0·569 gallons.
Scotland	. . . .	2·647 ...
Ireland	. . . .	0·853 ...

These proportions are such as would fall to the share of each man, woman, and child, throughout the land; but it must be evident that many, and especially the women and children, can count for very little in the calculation, if indeed they should not be wholly discarded from it. Adopting this latter view, and dividing the quantity consumed among the adult males in all ranks of life, as they were ascertained in 1841, the following portions would fall to the share of each—

In England	2·330 gallons, or about	$2\frac{1}{3}$	gallons.
Scotland	11·168	$11\frac{1}{6}$	...
Ireland	3·469	$3\frac{1}{2}$	...

Brandy is for the most part drunk by persons not of the working class, as that term is generally, but somewhat arbitrarily, understood. The quantity consumed in 1849 was 2,187,500 imperial gallons—

The first or wholesale cost of which was about	£546,875
And the duty paid amounted to . .	1,640,282
Together . .	£2,187,157

The system of distribution is, for the most part, quite different from that used with respect to British and colonial spirits,—a large proportion being purchased in quantities of two gallons and upwards for use in private families, so that a much smaller rate of gross profit will be required by the dealers. Some part is, however, sold at inns and public houses by the glass, and for this portion a very high profit will be received, so that it cannot be considered an over-estimate if we assume that each gallon costs, on the average, to the consumers, 30s. or 50s. per cent. advance upon the import cost and duty. This would exhibit an expenditure for brandy of £3,281,250, which, added to the sum formerly stated, gives a total expenditure within the year for ardent spirits of the enormous sum of £24,091,458. The data at command by means of which to estimate the money spent for beer in its various forms, is not so satisfactory as that used in regard to spirits, but is sufficiently precise to enable us to approximate to the truth within a reasonable degree of accuracy. The number of bushels of malt subjected to duty in 1849 was 37,999,032, or 4,749,879 quarters, but of this quantity only 3,719,145 quarters is set down as having been used by licensed brewers. Of the remaining 1,030,734 quarters, the greater part was, no doubt, used by private families, and the remainder was worked up by the distillers. In order to be on the side of moderation, let us assume that only the quantity (3,719,145 quarters) used in licensed breweries was employed in making beer, and we shall find, upon the usual calculation of 3¼ barrels of beer, of average quality and strength, as the product of each quarter of malt, that the number of gallons brewed from the above-mentioned quantity was 435,139,965. The price at which porter is retailed to the consumer varies with the circumstances attending the sale. When it is taken away in the jugs of the buyers for consumption elsewhere, the charge is 3d. per quart, or 1s. per gallon, but when drunk on the premises of the seller, the charge is one-third more, viz., 4d. per quart, or 1s. 4d. per gallon; a difference of price which, considering the check upon exorbitant profits offered by the great amount of competition among the sellers, affords good evidence of the necessity for a large advance upon the actual cost, in order to meet and cover the expenses of retail dealers. The prices here mentioned are for porter. Ale is higher in price, and is retailed at 4d., 6d., or 8d. per quart, according to its quality, which mainly depends upon the proportion of malt and hops used in its production. On the other hand, table-beer, which is very largely drunk in families, is frequently sold at a lower price than 1s. per gallon, but in such cases a smaller or a larger quantity is produced from a like quantity of ingredients. As no means can be found for determining the quantities of each kind and quality of beer consumed, let it be assumed, as very fairly it may be, that taking all qualities into the account, the price to the consumer is a mean between the two prices above stated for porter, viz., 1s. 2d. per gallon, and we arrive at the sum of £25,383,165 annually spent by the population of this kingdom, and chiefly by the labouring portion, for beer. It is shewn by a statement recently presented to the House of Commons, that the number of persons who are engaged as producers and distributors of beer in England and Wales, is as follows:—

Brewers,	2,507
Victuallers,	88,496
Persons licensed to keep beer-houses,	38,070
	129,073

The quantity of manufactured tobacco upon which duty was paid in 1849 was 27,480,621 lb., and of manufactured tobacco and snuff, 205,066 lb., yielding a revenue of £4,408,017, 14s. 11d. The retail price ranges from 4s. to 14s. per lb., 17-20ths, or 85 per cent., of the whole being of the lowest price here named, and only about 2 per cent., being of the highest quality, proportions which were stated by several respectable manufacturers who gave evidence before a committee of the House of Commons in 1845. On the same authority we are told that an addition is made of other ingredients in the processes of manufacture, amounting to 15 per cent. upon the

85 per cent., which consists of cut or shag, and roll tobacco, while the snuff, which comprises 13 out of 15 parts of the remainder, admits of an increased weight to the extent of from 50 to 60 per cent. Applying these per-centages to the quantity taken for consumption in 1849, we arrive at the following results:—

	Pr. ct.	Lb.		Pr. ct.	Lb.
Shag and Roll Tobac.,	85	23,358,529	adding increase	15	26,862,308
Snuff of various kinds,	13	3,572,480		55	5,537,344
Segars, . .	2	549,612	no increase		549,612
		Lb.27,480,621			Lb.32,949,264
Manufactured when imported, ...					205,066
So that the quantity for which the public pays as Tobacco and Snuff is, ...					Lb.33,154,330

The retail prices, obtained from a respectable shop in a leading thoroughfare in London, at this time (June 1850) are:—

	Per oz.		Per oz.
Good Shag, . . .	3*d*.	Princes' Mixture, . .	6*d*.
Best do.	3½	Brown Rapee, . . .	4½
Bird's Eye, . . .	3½	Pale Scotch, . . .	4
Returns, ...	3½	Do. best, ...	4½
Cavendish, . . .	4	Black Rapee, . . .	4
K'naster, ...	6		

The average price of the six qualities of tobacco here given is at the rate of 5s. 2d. per lb., and that of the five qualities of snuff is 7s. 6d. per lb. The great bulk of the consumption falls upon the lowest priced quality of tobacco, which is 3d. per oz. or 4s. per lb. It cannot therefore, give an exaggerated view of the sum expended for this article if we assume that lowest price as being paid for the whole. In regard to snuff a larger proportion of the whole than in the case of tobacco is used by the middling and easy classes, to whom the difference of a penny in the price of an ounce of snuff cannot be any object, and who rarely, if ever, will buy the most inferior quality. The prices, it will be seen, run from 5s. 4d. to 8s. per lb.; if we take the mean of these two prices as the average of the whole, *i. e.* 6s. 8d. per lb., we shall probably be within the mark. At these rates, the cost to the consumers generally will be as follows:—

26,862,308 lb. of Tobacco, at 4s. per lb., ...	£5,372,461
5,537,344 lb. Snuff, at 6s. 8d., ...	1,845,781
549,612 lb. English made Segars, at 9s., . .	247,325
Total for British-manufactured, ...	£7,465,567
205,066 Foreign-manufactured, at 12s., . .	123,040
Total value as paid by consumers, . .	£7,588,607

which amount would yield 50 per cent. above the cost of the tobacco as imported, and the duty paid thereon,—a moderate increase to defray all the expenses of manufacture, and the charges attendant upon the retailing of an article nearly the whole of which is paid for in copper coins. There can be no reason to suspect that the amount can be at all overcharged, which leaves no larger margin than this for the gross profits of 209,537 persons, the number which, in the year 1848, took out and paid for licenses to deal in tobacco and snuff, in addition to 642 persons licenced to manufacture those articles. It must be remembered, that with regard to two of the three articles the expenditure for which Mr Porter had endeavoured to estimate, an indefinite sum should be allowed for the quantities illicitly produced and imported, but as to the amount of which it is altogether impossible to form any trustworthy estimate. We know, however, from the seizures and discoveries that are continually made, that a very large additional amount must be drawn from the pockets of the people in order to compensate for the risks of the smuggler and the illicit distiller.

If it be conceded that the sums here brought forward are justified by the facts and calculations on which they are based, it would appear, that the people, and chiefly the working classes of England, Scotland, and Ireland, voluntarily tax themselves for the enjoyment of only three articles, neither of which is of any absolute necessity, to the following amount:—

British and Colonial spirits . . .	£20,810,208
Brandy, ...	3,281,250
Total of spirits, ...	£24,091,458
Beer of all kinds, exclusive of that brewed in private families, ...	25,383,165
Tobacco and Snuff, ...	7,588,607
	£57,063,230

At the beginning of this paper it was remarked, that the amount of money expended upon articles which, like spirits, beer and tobacco, are not of first necessity, forms a measure of the prosperity of the nation and of the ability of the community to bear those national burthens which cannot be avoided,—a remark the justice of which hardly admits of question; but it would by no means follow that the diminished use of the three articles named would afford proof in itself of lessened means of comfort on the part of the working people, and of diminished prosperity in the nation generally. On the contrary, if it were seen that, as respects gin and whisky, the two and one-third gallons consumed in the year in England—the eleven and one-sixth gallons so consumed in Scotland—and the three and a-half gallons consumed in Ireland, by each adult male, were diminished to one-half those proportions, while a larger sale should be effected of sugar, of tea, of articles of decent clothing, and of other matters whereof the females and children should be partakers, there can be no disputing about the advantageous nature of the change, and but little ground for asserting that the general sum of prosperity were lessened. The probability, on the contrary, is, that money thus expended would afford greater means for employment throughout the country in other branches of industry, and thus open additional sources of prosperity to all. There is one consideration arising out of this view of the subject which is of a painful character, and which, if it were hopeless of cure, would be most disheartening to all who desire that the moral progress of the people should advance at least at an equal pace with their physical progress—it is, that among the working classes so very large a portion of the earnings of the male head of the family is devoted by him to his personal and sensual gratifications. It has been computed that, among those whose earnings are from 10s. to 15s. weekly at least one-half is spent by the man upon objects in which the other members of the family have no share. Among artisans, earning from 20s. to 30s. weekly, it is said that at least one-third of the amount is in many cases thus selfishly devoted. That this state of things need not be, and that, if the people generally were better instructed as regards their social duties, it would not be, may safely be inferred from the fact that it is rarely, if ever, found to exist in the numerous cases where earnings not greater than those of the artisan class are all that are gained by the head of the family when employed upon matters where education is necessary. Take even the case of a clerk, with a salary of £80 a year, a small fraction beyond 30s. a week, and it would be considered quite exceptional if it were found that anything approaching to a fourth part of the earnings were spent upon objects in which the wife and children should have no share. The peer, the merchant, the clerk, the artisan, and the labourer, are all of the same nature, born with the same propensities and subject to the like influences. It is true they are placed in very different circumstances—the chief difference being that of their early training—one, happily, which it is quite possible in some degree to remedy, and that by means which would in many ways add to the sum of the nation's prosperity and respectability.

Section G.—Mechanical Science.

President.—Rev. Dr Robinson.

Vice-Presidents.—Mr George Buchanan, Professor Gordon, Mr Thomas Grainger, Mr John Scott Russell.

Secretaries.—Dr Lees and Mr David Stevenson.

Committee.—Mr John Taylor, Mr James Nasmyth, Mr Robert Napier, Mr Roberts, Mr James Leslie, Professor Fischer, Major-General Pasley, Mr Thomas Stevenson, Mr Whitworth, Mr J. G. Appold, Mr F. Osler, Mr S. Downing, Mr J Miller.

The President, Dr Robinson, in taking the chair, offered a few observations explanatory of the objects of the Section. These were in fact the application of science to human purposes. The Section was formerly in connection with Mathematics and Physics; in consequence, however, of the vast advances of our mechanical progress, it was found necessary to separate them, and to devote an entire section of the Association to the development of mechanical science.

Mr Scott Russell read a communication from Thomas B. Dogson of the Brazils, who had constructed several vessels in the wave principle; the results thus furnished showed an advantage over the common build of seven to eight in speed; while in a sailing vessel, the Titania of 100 tons, constructed in England on the same principle, the great power in withstanding a storm had been satisfactorily established.

The President, while he expressed the pleasure which he had in finding these wave principles carried out on the Continent, regretted that the great amount of information offered to the Admiralty on this subject in Mr Russell's reports had not yet been accepted. It certainly would save much fruitless expenditure.

Mr Stokes then read a communication from Homersham Cox, Esq., on the Hyperbolic Law of the Elasticity of Cast-Iron. The paper went into great detail on this interesting question.

Mr Ruthven's communication on his new mode of propelling steam-vessels was then read by Mr David Stevenson. The paper was illustrated by a large model. This led to a desultory conversation on the principle, some contending that there would be a great loss of power, as much as 30 per cent., while Mr Ruthven contended that so far as his experiments went, they only indicated a loss of 15 per cent.

Mr Macpherson read a communication on a method of preventing the bursting of water-pipes during frost. The only method he regarded as effectual was that of emptying the pipe. This he proposed to do by causing the expansion consequent upon freezing, to work a linn so as to shut the service pipe and open the waste-pipe.

Several members expressed their opinion as favourable to the means which Mr M. proposed to employ to obviate the great expense and inconvenience of such occurrences.

Mr James Nasmyth then explained to the Section his improvements in forging iron. In forging shafts for the paddle-wheels of steamers, for example, it was of most essential importance that the shaft should be sound from the surface to the centre. The common plan by which the section was alternately elongated in different directions, could not effect this object. It did, in fact, effectually cripple or disintegrate the central parts of the shafts, just as one by heating a rod of wood would separate the central fibres and thereby weaken it. To prevent this elongation Mr Nasmyth forged his shafts in a hollow wedge, thereby giving rise to three forces converging upon the centre, and thus securing a complete consolidation of the metal.

Mr Nasmyth then explained his method of welding, shewing that a weld was in general so much weaker than the other parts, because of the weld being made from the extremities towards the centre, thus enclosing within it all those omdated and disintegrated portions which, in fact, kept the solid forces of the metal from coming in contact. He proposed that one of the surfaces to be welded together should be slightly convex, that the welding should begin at the centre when the surfaces were in contact and proceed outwards, thus squeezing out those loose portions, and allowing the two surfaces to come in complete contact with one another.

Several members having expressed their high opinion of these excellent improvements,

Dr Robinson said that they bore upon them the impress of mechanical genius, addressing themselves as all such things did, at once to the understanding and approbation of all, and each wondering that they were not found out before.

Friday, August 2.

Section A.—Mathematical and Physical Science.

Mr Follet gave notice of the working of the new Integrating Anemometer. He had now adopted Dr Robinson's plan for quantity, which he considered superior to his own. The distance the paper passes over now shews the quantity of air which passes in a given time. For example, one inch of paper represents ten miles of air. A clock strikes off the hour on the paper. By these improvements we are enabled, by one line, to observe the direction of the wind, the length of the current passing, and the time of passing. It is very desirable to have observations on larger areas, or over greater ranges. On arriving in Edinburgh, he found different currents indicated at the Calton Hill from those at Birmingham on Tuesday last. The great currents of the atmosphere should be first traced all over the earth's surface, and afterwards those more local.

Mr John Tyndell then read a paper on the Magneto-Optic Properties of Crystal.

Mr J. A. Broun presented four papers on magnetic forces.

Mr Broun next read a paper on the construction of the suspension threads of the declinometer.

Sir D. Brewster gave a short notice on the polarising structure of the eye. He referred to the phenomenon called Haidinger's Brushes. These discoveries prove three different polarising structures in the eye,—in fact that the eye may be a polariscope. It was difficult to see the brushes. Neither he nor Haidinger can explain the cause of this property.—Professor Stokes had also a communication on the same subject. He had seen the brushes with great facility; and he described their appearances as seen under various circumstances, and at various positions of the spectrum, having traced them over several of Fraunhofer's lines.

Rev. C. F. Lyon on some phenomena of Mirage on the East Coast of Forfarshire.

Mr Roberts detailed some experiments on the expansion of glass, wood, and metals, from changes of temperature.

Section B.—Chemistry.

"On a new and ready Process for the Quantitative Determination of Iron," by Dr F. Penny.—The author recommends the employment of the chromate and bichromate of potash for the estimation of iron in the common ores of the metal, and especially for the analysis of the clay-band and black-band ironstone of this country. He was led to the application of these salts, in the course of some recent investigations on the materials and products of the manufacture of alum from "alum-shale," in which he was much retarded by the want of a ready method for estimating the oxides of iron. The chromates of potash give very exact results, and possess the great advantage that a much larger quantity of material may be operated on than can be conveniently treated by the usual methods. For practical purposes, the bichromate is to be preferred. The process requires no other apparatus than that commonly used for centigrade testing, which is familiar to all persons engaged in chemical pursuits. It may be easily and rapidly executed, occupying only a fraction of the time required for the process of estimating iron by precipitation as the sesquioxide; and it is not interfered with by the presence of alumina and phosphates which usually exist in the ore. The method is based on the well-known reciprocal action of chromic acid and protoxide of iron, whereby a transference of oxygen takes place, the protoxide of iron becoming converted into sesquioxide and the chromic acid into sesquioxide of chromium.

Mr Hunt then read an elaborate and interesting communication on the present state of our knowledge of the chemical action of solar radiations. The paper, which occupied nearly two hours in reading, cannot possibly be given in brief compass. We may state, that it contained a very clear historical sketch of all that had been done in the investigation of the action of light in producing chemical changes, and that it entered at great length into the theory of the daguerreotype, calotype, and other photogenic processes, which are now so much objects of popular interest.

Dr L. Playfair then read a paper on the condensation of volume in highly hydrated minerals. This paper contained the explanation of a very remarkable law, in virtue of which it appears, that in many solid bodies, which contain water in a state of chemical combination, such a condensation occurs, that they occupy no greater space than the water in them would if frozen into ice.

Dr Anderson then announced the results of some important observations on the action of nitric acid upon the vegetable alkalis, which he is engaged in prosecuting.

"On the Influence of Sunlight over the Action of the dry Gases on Organic Colours," by Dr George Wilson. The object of this communication was to report the result of a series of experiments made this summer, on the effect of daylight in modifying the chemical action of eight different dry gases, viz., chlorine, sulphurous acid, sulphuretted hydrogen, carbonic acid, a mixture of sulphurous and carbonic acid, oxygen, hydrogen, and nitrogen on organic colouring matters. All of these gases were found to act more powerfully in changing colours when exposed to sunlight than when left in darkness. The effect was greatest in the case of the bleaching gases, especially chlorine, which the author shewed, may be left for three years in contact with colouring matter without bleaching occurring, provided moisture is excluded, whereas the same gas, though equally dry, was found to bleach dry colouring matter in six weeks, if exposed to sunshine, so that a fortnight of sunshine is more than equal to a year of darkness in determining the decolorising action of dry chlorine. These researches are to be continued and extended at the request of the Chemical Section.

Professor Williamson communicated a paper on the Theory of Etherification, which excited much interest, and led to considerable discussion.

SECTION C.—GEOLOGY AND PHYSICAL GEOGRAPHY.

Robert Chambers, Esq., read a paper "On the Glacial Phenomena around Edinburgh." The paper opened with a description of the local phenomena, partly with a view to the gratification of the strangers present on this occasion, who might otherwise remain ignorant of them. Mr Chambers described the Corstorphine Hill as a stratum of trap dipping to the west, and with a cliff in a line north and south. In its crest, which rises to 470 feet above the sea, are three or four transverse clefts. On the west surface of the hill, the rock, wherever it is exposed, is found to be rounded (*mon-*

tonnée), smoothed, and grooved. The grooves, and the clefts in the crest of the hill, all lie in one direction, viz., directed to a point to the north of east. There are also long hollows, with rounded intervening swells; and these run precisely in the same direction. At various places between the hill and the sea are seen sandstone surfaces, worn down to a remarkable flatness and smoothness, and in several instances marked with striæ, all pointing in the same direction.

Throughout the valley of the Forth, from the Pentlands on the one side to the Fife hills on the other from Linlithgow to Dunbar, the sandstone surfaces, wherever they come up, are likewise smoothed, and in many instances striated, the striæ all pointing to the ENE., or thereby. The trap hills rising in this valley are all long and narrow, generally free from abruptness on the sides, often abraded on the west, and generally sloping away gently to the east; the direction here also is always to ENE. Surfaces on the Pentlands and in Fife exhibit striation precisely conformable. In short, if a deep ice-flow passed through this valley, it might be expected to produce precisely the phenomena which have been observed.

The similar markings on other districts of Scotland were shewn for the most part, though not without striking exceptions, to be directed towards the east and south.

Mr Chambers adverted to the theory of debacles, which was started to account for these appearances, as now nearly given up. Ice was generally acknowledged as concerned in producing them, because the appearances were precisely those which the existing glaciers produce. But there was great room for speculation as to the circumstances under which the presumed glacial agent was applied. Mr Chambers declined theorising on the subject, but pointed out various conditions which any theory on the subject must explain. (1.) How ice could move over so large a portion of the North American continent, in a direction admitted to be tolerably uniform, allowing for slight deviations easily explicable, as owing to inequalities in the original surface, and without any mountain chain to give it forth. (2.) How this ice was capable of ascending slopes and topping mountains many hundred feet high. It must explain how, in such a valley as that of the Forth, there could be an ice-torrent of undeviating flow for many miles, and deep enough to envelope hills many hundred feet high.

Mr H. Miller read a communication on peculiar scratched pebbles and fossil specimens from the boulder clay in Caithness.

Mr Miller, when examining, a good many years ago, the boulder clay of Ross and Cromarty, in the vain hope, as it proved, of finding in it organic remains belonging to itself, was struck by a peculiarity in the dressing of the smaller pebbles which he had not seen described or adverted to by any writer on the subject. He was aware that many of the larger boulders which it contains are scratched and polished like the rocks on which it rests, but he was not prepared to find the smaller pebbles scratched, and not less deeply than the large ones, in every case in which they were not of too coarse a grain to retain the markings, or of too hard a quality to receive them originally. If of limestone, or of a coherent shale, or of a close, finely-grained sandstone, or of a yielding trap, they are scratched and polished—invariably on one, most commonly on both their sides; and it is a noticeable circumstance, that the lines of the scratchings occur, in at least four cases out of every five, in the lines of their longer axes. Though in many cases, as on the western coasts of the mainland of Scotland,—in the islands of Skye and Rum, with several of the other Hebrides,—in Sutherlandshire, and in various localities in the neighbourhood of Edinburgh, he had found the scratched and polished surfaces dissociated from the boulder clay, in no instance had he ever found the boulder clay, if not, as in the case of our common brick clays, a re-formation—dissociated from the scratchings and polishings. Now, from these data the inference seems unavoidable, first, that the rock on which the clay rests was scratched and polished either at the time when it was receiving its first coating of the clay, or so immediately before, that the markings were not in the slightest degree effaced when it was covered up; and, second, as the pebbles in the entire thickness of the deposit are also scratched and polished, that it was not before, but at the time; seeing that the process of scratching and polishing went on during the entire period of the formation, beginning with its lowest layers, and not terminating until its uppermost were cast down. The dressed surfaces and the boulder clay are contemporary phenomena. The smaller stones must have been fastened ere they could have been scratched. Even, however, if the force of water could have scratched and furrowed them, it would not have scratched and furrowed them longitudinally, but across. Simple water could not have been the agent here; nor yet an eruption of mud propelled along the surface by some wave of translation produced by the sudden upheaval of the bottom or shore of the sea. When a large raft of wood, floated down a river, grates heavily over some shallow bank of gravel and pebbles resting on the rock beneath, it communicates motion, not of the rolling, but of the launching character, to the flatter stones with which it comes in contact. It slides ponderously over them; and they, with a speed diminished in ratio from that of the moving power, in proportion to the degree of friction below or around, slide over the stones or rocks immediately beneath; and thus, to borrow my terminology from our Scotch law courts, they are converted at once into *scratchers* and *scratchees.* For rafts of wood we have but to substitute rafts of ice, a submerged land, covered by many fathoms of sea, for the shallows of the river, and some powerful ocean-current, such as the Gulf or Arctic Stream, for the river itself, as we at once arrive at a theory of the boulder clay and its origin, which seems to account more satisfactorily for the various phenomena of the deposit than any of the others.

Mr Maclaren described certain ridges and mounds of soil in Glenmessan (Argyleshire), which bore a resemblance to the moraines of glaciers. They rise abruptly from the bottom of the valley, are composed of materials similar to those of moraines, consisting of confused piles of gravel, clay, and blocks of stone, and they occupy similar positions. The rocks forming the sides of the valley are also smoothed to a great height, and exhibit well marked striæ and groovings. He remarked that the deep glens of Scotland often presented shapeless masses of clay and gravel at their lower ends, which might be the materials of moraines modified subsequently by the action of water.

Mr Hopkins made a statement on "the Dispersion of Granite Blocks from Ben Cruachan." He stated that he had detected them on the beach about Oban; in considerable mass to the northern extremity of the island of Kerrera, and across nearly the summit of the island. He also found many blocks on the shores of Loch Lomond, Loch Long, and Lochfine, which he thought might be traced to Ben Cruachan as their original source. His observations were as yet imperfect, but he hoped, in the course of the present summer, to complete them. He argued that glaciers must have been effective in transporting the blocks from some of the higher parts of the mountains to those of the lower levels, when they might be subject to other causes, such as floating ice and diluvial currents; and he conceived it highly probable that the surface of the land of this region had, during the glacial epoch, been submerged considerably beneath the surface of the sea; and that a complete transport of the blocks had been effected by a combination of the actions of the glaciers, floating ice, and currents.

The Rev. Mr Longmuir, of Aberdeen, then read a paper on the Flints and Greensands of Aberdeenshire, in which he gave a view of the geological structure of Aberdeen and its vicinity, illustrating his observations by reference to the geological map. He then described the district in which the flint nodules abounded, as stretching between Peterhead and the Hill of Dudwick.

Professor Hitchcock then read a paper on the Terraces in New England, and another on Erosion from river action. Dr Becker made some remarks on the constant increase of Elevation of the Beds of Rivers; and was followed by Mr Bryce on Scratched Surfaces in the Lake District of Westmoreland.

After the various papers had been read, a general discussion was invited. The President having stated his opinion, that Mr Chambers had attributed too much to one set of causes, whereas he was inclined to take them all together.

He had handed a note to Sir John Richardson, asking what, in his opinion, was the strongest power, when he had immediately answered, that, in the region with which he was conversant, North America, he did not believe that the glaciers had any effect at any time. He (the President) believed the last action had been that of floating ice. An animated and amusing, but unsatisfactory discussion, followed the invitation of the President.

SECTION D.—NATURAL HISTORY INCLUDING PHYSIOLOGY, ETC.

Professor Owen gave an exposition of his views upon the nature of the segments of the vertebrate skull. His remarks were illustrated by a series of preparations of the skulls of the various forms of vertebrate animals.

Dr Lankester read a letter from Mr G. Newport, "On the reciprocal Relations of the Vital and Physical Forces."

Professors Kelland and Goodsir successively addressed the Meeting on the subject of Mr D. R. Hay's views of the geometrical principles of Beauty in general, and more particularly as applied to architecture and the human form.

Professor E. Forbes gave an account "of the Infra-littoral Distribution of Marine Animals on the Southern, Northern, and Western Shores of England and Scotland."—In the year 1839, a Committee of the British Association was formed for the purpose of investigating the natural history of the British seas by means of the dredge. A chief object of the research proposed was the ascertaining of the exact relation of the Fauna of the British seas at the present epoch, to that of the same area during the epoch of the so-called northern drift. A vast body of accurate observations and carefully stated facts has been obtained. This Report consisted chiefly of tables of two kinds. 1st, Tables systematically arranged of the species of animals dredged, all the depths at which they were taken during the inquiries, and the mineral character of the seabeds on which they were found, being stated in each species. These tables are extremely full, so far as Mollusca and Echinodermata are concerned, less so respecting other tribes of animals, but nevertheless more extensive than any yet made known. 2nd, Tabulated abstracts of the dredging papers, each separately abstracted; the year and place of observation, the distance from shore, the depth, the ground, the number of species of univalve testacea taken alive, and of those taken only dead; the same as regards bivalves. The number of species of Echinodermata, and remarks under which the creatures taken most abundantly in each instance are recorded. More than a hundred papers, all relating to the district under report, are so abstracted. In these tables the region so explored is divided into ten provinces, five upon the English coasts and five on those of Scotland. These provinces are not arbitrary sections, but represent areas, each presenting peculiar geological features. The five English provinces are:—1. The coasts of Dorset and Hants, a region peopled from the general Fauna of the English Channel, but deficient in many of the species which give a character to the second province, the coasts of Devon and Cornwall, where we have the most southern type of the Fauna of Great Britain, and the greatest number of Lusitanian forms appearing. 3. The Bristol Channel and Southern shores of Wales, where we have a southern character still presented by the Fauna, but less intense. 4. The coast of North Wales, where we have the characteristic Fauna of the Irish Sea, marked more by deficiencies than by many peculiar species. 5. The seas around the Isle of Man, where the northern and southern types of the British marine Fauna, each faintly indicated, meet as it were in the middle of a region markedly of the British or Celtic type. 6. The region of the Clyde, and the lochs which branch from it, an area of great interest, for in these great sea-lakes we find as it were imprisoned assemblages of marine creatures which remind us of the inhabitants of the Arctic Seas, and strikingly of the population of the British Seas during the glacial epoch. 7. The seas of the inner Hebrides, presenting similar phenomena, but influenced by the currents of the North Atlantic. 8. The seas of the outer Hebrides and the district around Cape Wrath. 9. The Orkneys, where the peculiarities of the northern part of the German Ocean come in contact with those of the Atlantic regions; and 10. The Shetland Isles where we find the marine races of Britain mingled abundantly with creatures of unquestionably Scandinavian and Arctic parentage, not isolated or straggling, as those of similar character in the western provinces are, but seated at the true bounds of the great boreal province which here intersects the British Seas. The dredge has been used within the area reported on in all depths between four and a hundred fathoms. Everywhere do we find the distinction of Littoral, Laminarian, and Coralline zones maintained, and in the Scottish provinces, that deeper region to which Professor E. Forbes had previously given the name of "deep-sea coral," on account of the numbers and abundance of calcareous, zoophytic and bryozoic polypedons procured from the greater depths. Between the coasts of Cornwall and Ireland, Mr MacAndrew has dredged and carefully noted the Mollusca inhabiting the region of fifty fathoms; and it is very curious and interesting to observe that only at such depths, and in peculiar localities, in the southern part of the British Seas, do we find those species of Scandinavian origin which give a feature to even the shallower zones in the sea-beds of North Britain. The tables now presented shew that whilst certain species of marine creatures are absolutely restricted to defined provinces of depth, those of the Littoral and Laminarian zones, being especially limited in range, alter; and not a few have a power of enduring all the various conditions between the coast line and 100 fathoms, but in every case of wide range there is some portion in each region where the individual of each species attains a maximum in number. The higher zones of our sea are distinguished by the presence of peculiar genera as well as species, but in the lower zones, the peculiarity is maintained almost entirely by peculiar species of genera, which have a wide bathymetrical range. According to the nature of the sea-bottom the proportion of species and of individuals of particular tribes of Mollusca and Radiata is determined. Among the former, the Acephalous species prevail over the Paracephalous in proportion to the more sandy or muddy character of the soundings, whilst the latter equal or exceed the former when the bottom is of mullipore, or hard, or abounding in stones of any size. A comparison of the species of Mollusca and Radiata, in the several provinces before enumerated, shews beyond question that there is a distinct distribution of them horizontally, and that the elements of our marine Fauna are derived from opposite directions, mingled, however, with a general assemblage, of which the British Seas may be regarded as the centre. To the influence of the Rennell's current we may attribute much of the southern element in our marine Fauna; to that of currents setting in from the north, the Scandinavian and Arctic elements. But when all the cases of distribution clearly to be attributed to such influences are enumerated, there remains a residue which we can only explain by going back to epochs anterior to our own, and to a different conformation of the coast of Europe, and a different set of currents from those which now prevail.

"On the European Species of Echinus, and the Peculiarities of their Distribution," by Prof. E. Forbes.—When the author published his account of the British Echinodermata, he laid great stress on the distinctive character furnished by the sculpture of the spines in each species. In this communication he endeavoured to shew that these characters bear definite relations to the more important features of the organization of the test, and that through them we are enabled easily to recognise even the most aberrant varieties of each species.

Ethnological Sub-Section.

The following interesting memoirs were read :—

On the Sicilian and Sardinian Languages, by Mr J. Hogg.

Remarks on the Present State of the Natives of New Zealand, by the Rev. J. F. H. Wahlers of Otago.

Observations on the Religious Rites, and the affirmed Practice of Cannibalism, of the New Zealanders, by Dr T. Hodgkin.

Remarks on the Scottish Picts, and on that remarkable event in our national history known as the "Scottish Conquest," by Mr D. Wilson. Mr Wilson went into an investigation of evidence which indicated, first, that the Picts were the earlier native Celtic race; that the Scots were also a

Celtic race of later intrusion, and probably, as he shewed, passing from Spain to Ireland about the second century B. C.

Section F.—Statistics.

Mr G. R. Porter read a long paper, being an inquiry into the question, whether, under our existing social system, there is a tendency for the increasing of capital in the hands of those already possessing riches? The result of his paper was, that he came to the conclusion, that the fears entertained and expressed by many as to the probable disappearance of the middle classes from among us are unfounded; that it is far from being true that the rich are growing richer, and the poor are becoming poorer; but that, on the contrary, those who occupy a middle station (perhaps the safest station as regards personal respectability, and that which offers the surest guarantee for the progress and continued well-being of the country), are progressively increasing in number, and in the proportion which they bear relatively to the population of the kingdom.

Mr Joseph Fletcher, London, next read a paper "On the relation of Crime and Ignorance in England and Wales." The paper stated, that in every light, whether under industrial or political agitation, the more instructed localities shew the most buoyant and favourable character. A discussion took place on the subject of this paper, which was participated in by Colonel Sykes, Mr G. R. Porter, Mr F. G. Neison, and Professor Hancock. Colonel Sykes said, he hoped, in the consideration of this question, that they would guard against assuming that an increase of crime was necessarily and entirely to be attributed to defective education, for, in his opinion, there were many other elements to be considered.

Section G.—Mechanics.

Mr Nasmyth gave an account of his new arrangement of the reflecting telescope, by which great additional comfort was afforded to the observer. This consisted in having the centering or trunions at the centre of gravity, through one of which, in a tubular form, the rays from the reflector within were thrown into the eye thus placed, as in the Newtonian telescope at the side. The advantage from this elegant arrangement is, that the eye does not require to move upon a movement of the telescope. Mr Nasmyth then described his plan of casting specula, by which all unsoundness was avoided.

Mr Lassell, to whom so much is due in the polishing of specula, observed, that if Mr Nasmyth could give an equatorial movement, his instrument, he thought, would be perfect.

Dr Robinson observed, that if any mechanical arrangement were desired, and this was certainly one, he had no doubt that in Manchester could be found the men to achieve it.

Professor Smyth then gave an account of a new form of equatorial at present constructing for the Edinburgh Observatory, and a folding dome for extra meridian instruments. Professor Smyth in another communication explained a mode of cooling the air in tropical climates. This was, in the first instance, to condense air by mechanical means. Then to allow the air thus condensed, and consequently heated, to fall to the common temperature. The condensed air thus let loose, and allowed to flow into a room, would, by its expansion, lower all the air with which it comes in contact. He had tested the principle on a large scale, and found it to answer his expectations.

Mr Taylor knew of men working in one of the Cornwall mines at a temperature of 110°. It would now be possible to send them down a treat of cold air.

Mr Rankine said,—In reference to the power required, that he had made the calculation, and the result was, that one horse working for one hour lowers 9000 cubic feet of air 20°; and, of course, in this proportion for all other cases. This was exclusive of friction.

Mr Appold then explained the arrangements in his hydrametric instrument for regulating the atmospheric moisture of houses, which seemed to answer well.

Mr Sykes Ward gave an account of his improved gas stove.

Monday, 5th August.

Section A.—Mathematical and Physical Science.

"Report of the Committee on the Instruments for the Measurement of Earthquake Waves" was given in.

"Report of the Meteorology of the Azores," by Mr J. C. Hunt, communicated by Col. Reid, was laid before the meeting.

Dr Martins addressed the meeting in French, "On the six Climates of France."—He commenced by stating, that France partook of the climates both of continental and sea-girt countries. He wished at present to consider six climatoreal subdivisions, viz.,—1. The North-east or Vosgien.—2. The North-west of Séquanien.—3. That of the West or Armoricain.—4. The South-west or Girondin.—5. The South-east or Rhodanien.—6, and finally, the Mediterranean or Provençal climate. Upon each of these subdivisions he enlarged; detailing the features of the country, the rivers, mountain-ranges, sea-coasts, geological structure, differences of level, and state of cultivation in each case, with the prevailing and most important features in the actual climate of each. Dr Martins exhibited a map of France with these six regions distinguished. He stated, that hitherto the labours of the Meteorologists of France had no channel of publicity at their command, but that a journal devoted exclusively to Meteorology was about to be established.

Dr Lee made a communication "On the Meteorological Register kept at Alten and Christiania—and some Observations on the British Meteorological Society."

"The Report of a Committee appointed to examine the Effects produced by Lightning on a Tree near Edinburgh," was read by Professor Phillips.—The tree in question stands in the grounds of Mr Wauchope, at Edmonstone, about four miles from Edinburgh, on the Dalkeith road. The surface slopes gently to the north; the substrata are part of the coal formation, and contain at a small depth an abundance of the rich "black band" ironstone. The locality appears remarkably liable to lightning strokes; several other trees having been destroyed there since 1834. The tree examined by the Committee was struck on the 11th of June 1849, on a still sultry day. It is an oak tree. It stood in rather a clear space—the surrounding trees being chesnut, elm, &c. It was a large tree (14 feet in girth), but there were others as high, and of rather greater diameter. When struck it was full of sap. The mechanical effects of the lightning were violent. The main trunk of the tree, which appears to have stood about 12 feet high before sending off branches, was rent from top to bottom; some of the branches were broken off; all were thrown down and implicated together, and for some distance upward fissured and twisted; some of the roots were split for a yard or more from the stem. A large mass from the northern side of the tree was driven out, and carried through the air 127 feet, in the direction of the magnetic meridian to NNW. Its weight was 2½ cwt. The main stem was entirely denuded of the bark, which was scattered widely around, but most abundantly in a direction opposite to that in which the log of wood was conveyed. Shreds of wood were scattered to the north-west, and left hanging in the trees. What remained standing of the stem, as well as the parts which had been displaced, was cleft into wedges, by vertical radiating fissures parallel to the laminæ of medullary rays; and these wedges were again cleft by other vertical fissures concentric to the axis of the tree, and coinciding with the annual bands of large vertical vessels, which are conspicuous in cross sections of the oak. Where these cleavages produced the fullest effect, the wood was divided into long slender prismatic shreds like lucifer matches. The smaller split masses were much twisted. For all these phenomena a simple mechanical cause appears sufficient, viz., an internal expansion and bursting of the main stem of the tree along the surfaces, which, by the structure of the tree admitted of the most easy separation, and contained at the time abundance of liquid sap capable of assuming the form and force of elastic vapour. Hence, in the first place, the destruction of the main stem by explosion—the projection of the bark and woody fragments, and the minute and regular cleavage of the fibres. The stem being destroyed as a support, the branches fell in ruinous aggregation round it. It appears that a laburnum tree situated about 12 yards to the east had been twice struck by lightning, first (I believe) in 1834, and again in 1844. It was split, but not barked. An elm situated about 100 yards to the north was struck, and in like manner split, but not barked. These differences may, perhaps, be due to the difference of structure in the wood; but in all cases before attempting to explain the phenomena observed as the effects of lightning, it is desirable to be informed of the times of year when the trees were struck. The precise points of entrance and exit of the lightning cannot be stated. A small quantity of black powder was found in the fissured part of the wood, at the base of the twisted branches; but nothing was observed which could determine the course or the chemical effects of the electrical agent.*

"On the Climate of the Valley of the Nile," by Mr T. S. Wells.—The observations extend from the 6th of December 1849 to the 16th of March 1850. The instruments were kept in a cabin in the boat of an invalid. The cabin was six feet high, 12 feet broad, and 10 feet deep. Its floor was from 1 to 2 feet above the level of the river. The dry and wet bulb thermometers, and the barometer were fixed to a beam in the centre of the cabin, where they were not exposed either to the direct or reflected rays of the sun. There were six glass windows to the cabin, provided with open blinds. Some of these windows were always open during the day, so that the morning and afternoon observations may be considered to represent the temperature of the open air in the shade. Sometimes a window was open until after the evening observations, but more frequently this was not the case, and to this I ascribe the fact that the mean of the evening observations is above that of the morning. A register night thermometer was fixed outside one of the windows, and the lowest temperature observed each day is recorded. These daily observations were made at the hours of 9 A.M., 3 P.M.,

* Since the Report was presented, Mr Wauchope has cleared a larger portion of the roots, and has found them split and *blackened* considerably.

and 11 P.M., and an abstract of these daily observations was exhibited.

The *mean temperature of the air* for the period of my observations at Greenwich, was 39° 3′, on the Nile it was 61°. Thus there was a difference of 22 degrees in the mean temperature of Egypt over that of Greenwich during these months.

The *mean temperature of evaporation* at Greenwich, was 37° 4′, in Egypt 55°, being 18 degrees above the mean at Greenwich for the same period.

The *mean temperature of the dew-point* at Greenwich, was 34° 1′, in Egypt 50° 8′. Thus in England the air was saturated by the quantity of vapour contained in it at a temperature 16 degrees below that at which saturation occurred in Egypt.

The *mean elastic force of vapour* in Egypt, was 0·384, at Greenwich 0·214. In other words, the pressure of the watery vapour mixed with the air was capable of supporting a column of mercury higher by $\frac{17}{100}$ of an inch in Egypt than in England.

The mean weight of water in a cubic foot of air in England was 3 grains, in Egypt 4 grains and $\frac{3}{10}$, but still, owing to the higher temperature, the air was much drier in Egypt. When the temperature of the air is considerably above that of the dew-point, the air is dry, dissolving or absorbing aqueous vapour without any tendency to precipitation in the form of rain, and it is dry in proportion to the difference between the two temperatures. Thus, although the mean weight of water in a cubic foot of air was greater last winter in Egypt than in England, yet the air was much more nearly saturated with moisture in England than in Egypt. At Greenwich the mean additional weight of water required to saturate a cubic foot of air was only $\frac{4}{10}$ of a grain, while on the Nile it was 1 grain and $\frac{3}{4}$. If we represent air completely deprived of moisture by Zero, and air completely saturated as unity, the *mean degree of humidity* on the Nile was 75 per cent., while at Greenwich it was 85 per cent.

The mean readings of the barometer in the two countries very nearly approach each other; in Egypt being 29·99, at

Greenwich 29·87. A glance at the table, however, shewed how very small the extreme range of the instrument was on the Nile.

The *average weight of a cubic foot of air* at Greenwich was 549 grains, in Egypt 527 grains.

Rain fell in various districts of England on averages from 31 to 61 days, while in Egypt it only fell on 5 days, and on three of these a shower was of but a few minutes' duration. On two days rain fell heavily at Cairo for several hours.

The mean daily range of the temperature of the air at Greenwich was 11·37, in Egypt 10·31; but while the mean extreme range in Egypt was 38, at Greenwich it was but 29; the mean extreme range in the cabin being only 7 degrees below that on the grass at Greenwich in the open air.

Fog was occasionally but rarely observed. It was general in the Delta in the early morning; but above Cairo was only observed on three occasions.

"On the Causes of the Rise of the Isothermal Lines in the Winters of the Northern Hemisphere," by Mr T. Hopkins.—Mr Hopkins examined some of the isothermal lines exhibited in the maps recently constructed by Professor Dove, and objected to the theory which is put forward to account for the irregular rise of the winter isothermals in the Northern Pacific, Atlantic, and Arctic Oceans, through the warming influence of the water of those oceans.

"On the Daily Formation of Clouds at Makerstoun," by Mr T. Hopkins.—The author went into an examination of the meteorological registers kept at Makerstoun, for the year 1844, to prove that the facts registered were in harmony with and tended to establish the theory he had advanced, that the horary fluctuations of the barometer were attributable to the daily vaporization of water by the sun, and the daily condensation of a portion of that vapour into cloud. The great difficulty being to account for the fall of the barometer from ten in the morning till four in the afternoon. At Makerstoun, the state of the atmosphere as to cloud was registered by noting an overcast sky by 10, and a cloudless sky by 0, and intermediate states by intermediate numbers. The state of the wet and dry bulb thermometers was also regularly noted, shewing both the activity of vaporization and the tension of vapour.

"On the Passage of Storms across the British Islands," by Mr R. Russell.—The views of the writer were illustrated by reference to the storm in October last.

"On Meteorological Phenomena at Huggate, Yorkshire, for 1849," by the Rev. T. Rankine.

Section B.—Chemistry.

An interesting communication was read from Professor Matteucci of Italy, announcing the law determining the way in which the earth conducts electricity, when used instead of a wire as part of the electric telegraph.

The second communication was by Dr Scoffern, on a new process for the Manufacture of Sugar from the Sugar-cane, as it is practised in the south of Spain. In this process, sugar-of-lead is used to purify the juice of the cane; and an immense saving attends its use. Professor Gregory spoke in favour of the process, and pointed out the freedom of the sugar so produced from any compound of lead, except occasionally a little sulphite, which he stated was innocuous. Professor Christison, on the other hand, cautioned the Section against accepting as a fact the statement which had been made, that the presence of a small quantity of sulphite of lead in sugar would not prove injurious to health. Various other members joined in the discussion.

Dr J. H. Gladstone and Mr G. Gladstone read the third paper, which detailed some curious and important experiments on the growth of plants in atmospheres of the different gases. These are to be continued at the request of the Section.

Much interest was excited by Dr Lyon Playfair's paper on the relative values of the dietaries in use by the different classes of the population. This gentleman has, at an enormous expenditure of time and trouble, classified and analyzed, in a very satisfactory way, the tables of diet used all over the country, by every class of the people. The result, as Dr Playfair shewed, is that we are as yet, in spite of all the improvements of chemistry, in almost total ignorance of the exact nature and quantity of the food required for the maintenance, in a healthy condition, of any of the classes of our population. He established this by a variety of most valuable tables, the importance of which was acknowledged by various members of the Section.

"On the Air and Water in Towns, and the Action of Porous Strata on Water and Organic Matter," by Dr R. A. Smith.—It is a matter of great importance to find from what source it is best to obtain water for large towns, and how it is to be collected. To these points Dr Smith particularly directs attention. Regarding the conditions of many springs, which never become muddy, but possess a constant brilliancy and a very equal temperature at all seasons of the year, the author thinks that there is a purifying and cooling action going on beneath. The surface water from the same place, even if filtered, has not the same brilliancy; it has not the same freedom from organic matter, neither is it equally charged with carbonic acid or oxygen gas,—there are other influences therefore at work. The rain which falls has not the purity, although it comes directly from the clouds; it may even be wanting in cleanness, as is often the case. Springs rise through a great extent of soil, and collect a considerable amount of inorganic salts; and it is shown by Dr Smith that their purity is due entirely to the power of the soil to separate all organic matter, and at the same time to compel the absorption of carbonic acid and oxygen. The amount of organic matter removed in this way, by its combination with oxygen, is surprising, and it is a most important and valuable property of the soil. The change even takes place close to cess-pools and sewers; at a very short distance from the most offensive organic matter there may be found water having little or none in it. As an agent for purifying towns, this oxidation of organic matter is the most extraordinary, and we find the soil of towns which have been inhabited for centuries still possessing this remarkable power. St Paul's Churchyard may be looked upon as one of the oldest parts of London, yet the water from the wells around it is remarkably pure, and the drainage of the soil is such that there is very little of any salts of nitric acid in it. If the soil, says Dr Smith, has such a power to decompose by oxidation, we want to know how it gets so much of its oxygen. We must, however, look to the air as the only source, and see how it can come from it. When water becomes deprived of oxygen, it very soon takes it up again,—as may be proved by experiment. This shows us, that as fast as the oxygen is consumed by the organic matter it receives a fresh portion, conveyed to it by the porous soil. Several experiments of the following character were given, to show the filtering power of the soil. A solution of peaty matter was made in ammonia; the solution was very dark, so that some colour was perceived through a film of only the twentieth of an inch in thickness. This was filtered through sand, and came out perfectly clear and colourless. Organic matter dissolved in oil of vitriol was separated from it by a thickness of stratum of only four inches. A bottle of porter was by the same process deprived of nearly all its colour. The material of which this filter is made is of little importance. One of the best, according to Dr Smith, as far as clearing the water is concerned, being of steel filings,—oxide of iron, oxide of manganese, and powdered bricks all answering equally well. This shows that the separation of the organic matter is due to some peculiar attraction of the surfaces of the porous mass presented to the fluid.—This paper was a continuation of Dr Smith's Report, published last year; and he purposes continuing the inquiry.

" On the Incrustations which form in the Boilers of Steam-Engines," in a letter addressed to Dr G. Wilson, F.R.S.E., by Dr J. Davy. This communication will be found at page 250.

Professor Voelcker then read a paper on the proportion of phosphoric acid present in natural waters; and the concluding one was by Professor Chapman on the isomorphous relations of silica and alumina.

Section C.—Geology and Physical Geography.

The first paper read was by Professor Hitchcock of N. America, on the effects of river action in wearing down strata, and on the raised sea margins of New England. The Professor took a general view of the effects of river action as contrasted with the waters of the ocean in eroding the terraqueous surface, and pointed out the various kinds of action as illustrated by the rivers of America, as well as those of other parts of the world. His general conclusions were, that the hollowing out of river channels, as well as that of valleys through which they flowed, was in a considerable degree owing to the eroding effects of their waters, and that the time required for their erosion was in the ratio of the hardness of the rocks over which they flowed. He was of opinion, too, that the various kinds of terraces, and the so-called sea margins, might be accounted for by the gradual operations of rivers and the ocean, without having recourse to the supposition of our sudden catastrophes. The Professor also entered into an explanation of the diluvium or drift, and the various layers of firm mud, gravel, and larger pebbles of which it was composed,—stating that, where the drift was found separated into these three states, he was inclined to believe that the separation was effected by an aqueous agency posterior to its original deposition, and that this upper or newer portion might be characterised by the name of modified drift.

Professor Sedgwick was compelled to some extent to differ from the opinions of the learned American geologist, and maintained that the general course of rivers was entirely dependent on the nature of the surface over which they flowed, and that from the natural laws of hydraulics their waters sought the readiest and easiest outlets for the currents, instead of wearing down and scooping out those channels, and argued that one great and marked peculiarity of the present surface of the earth, whereby it was elevated into mountain and depressed into valleys, was due to the great and sudden igneous convulsions to which this surface had been subjected. In respect to elevated sea-beaches, too, he stated that these owed their origin to upraising of the land, not to recession of the sea. He did not deny that local and limited effects were being produced by river action in the present time; yet these, in respect to the magnitude of the effects attempted to be attributed to them, were but insignificant; and, indeed, nothing was more difficult in geology than to attempt to connect present events with the past.

Colonel Portlock supported the views of Professor Sedgwick; while the statements of Sir C. Lyell were advanced by others in favour of the erosive agency of rivers.

Professor Hitchcock, in reply, disclaimed that the purport of his statements went to establish the erosion of rivers as the only cause of the formation of valleys.

Dr Becker then read a paper "On the Constant Increase of Elevation of the Beds of Rivers."

An interesting account of the discovery of "A Tertiary Fossiliferous Deposit underlying Trap in the Island of Mull," was communicated by the Duke of Argyll.—The island, according to Professor Jameson, consists chiefly of trap, granite, gneiss, and mica slate, all of which are seen in the small bay near Ardtun, and at this place are some small layers of brown coal interstratified with columnar trap. A little north of the bay is Ardtun Head, a perpendicular cliff of 130 feet, intersected by a deep fissure or ravine, accessible from the moor above. The cliff, the Duke remarked, consists of the following horizontal beds:—1. At the top, 20 or 30 feet of rudely columnar trap; 2. A thin laminated stratum containing fossil leaves; 3. Volcanic ashes; 4. A second leaf-bed; 5. A second bed of volcanic ashes; 6. A third leaf-bed; 7. Amorphous trap; 8. Columnar trap, occupying the base of the cliff. The volcanic ash-beds are undistinguishable from some modern formations at Vesuvius, and from the tuff at Madeira and Auvergne. The second leaf-bed is 1½ to 2 feet thick, and in its lower part is a mere mass of vegetation. In the third bed the leaves are less numerous, and imbedded in a volcanic mud, which now forms a hard trap; the leaves are black and look charred, but this is not necessarily the case: no trunks, boles, or even small twigs were found. From these appearances the Duke concluded that the leaves had accumulated from autumn to autumn in a shallow lake, and had been overflowed by soft mud, in which they were preserved. The only indication of living animals found with the leaves was the track of a worm. Chalk flints were found entangled in the trap. The Duke also mentioned that the first recorded visit to this spot was paid by Dr Johnson in 1773. In 1790 Mr Mills (Phil. Trans.) visited the ravine, but did not notice the leaf-beds ; and subsequently Professor Jameson and Dr Maculloch had coasted the island and described its general geognosy.

Professor Edward Forbes stated that the leaves were in a very beautiful state of preservation, and belonged to species of plane, alder, pine, equisetum, and some others. From the presence of flints the deposit appeared to be newer than the chalk, whilst in the latest tertiaries only vegetable remains of a more boreal character were found. The leaves most resembled some eocene specimens from Styria, figured by Dr Unger, and those found in the (eocene) pipe-clay beds of the Isle of Wight. Sir John Richardson had also discovered leaves of similar character at Mackenzie River, in Arctic America. Fossil leaves and brown coal occur with layers of trap in Iceland, an island composed chiefly of trap and tertiary rocks. Professor Oldham mentioned the occurrence of similar fossil vegetable remains associated with trap in Ireland—but the merit of proving the tertiary nature of the brown coal in the Island of Mull is due to the Duke of Argyll.

Sir R. I. Murchison exhibited and explained a " Geological Sketch-map of Spain," communicated by M. E. De Verneuil.

Professor Nicol, of Cork, read some observations on the Promontory of Cantyre, in Argyllshire. This communication will be found at page 385.

Mr R. Harkness read some observations on " the Representatives of the Mountain Limestone as they occur in the south and east of Dumfriesshire," also on " the so-called Fossil Footsteps in the variegated sandstone of Dumfriesshire and Cheshire."

Sir William Jardine exhibited specimens of these footprints from Dumfriesshire.

SECTION D.—NATURAL HISTORY, INCLUDING PHYSIOLOGY, BOTANY, AND VEGETABLE PHYSIOLOGY.

Professor A. Voelcker.—On the influence of Salt on Vegetation.

Dr Lankester.—On the Epidermal Appendages of the order Halorageæ.

J. T. Mackay, LL.D.—On Dracæno Draco.

Professor Royle, F.R.S.—On the species of Gossypium, and the effects of climate in altering the characters of Cotton.

Mr George Read.—Observations on Ropy Bread. Communicated by Dr Lankester.

Zoology.

Professor Van der Hoeven.—On the genus Perodicticus of Bennett, and its relation to Stenops.

Dr H. Lowe.—Report on the Progress of Entomology in Scotland during the last few years.

Professor Allman.—Report on the present state of our knowledge of the Fresh-water Polyzoa.

C. W. Peach, Esq.—A list of Zoophytes from the vicinity of Peterhead, with a notice of three new to the British list.

Professor E. Forbes, J. Gould, and G. Busk, Esqs.—Notices of the Zoological Researches of the Naturalists under the late Captain Owen Stanley, in H.M. Ship Rattlesnake.

Geo. Busk, Esq.—On Zoophytes from the shores of Africa.

Ethnological Sub-Section.

Rev. Dr Edward Hincks.—Observations on the Language and mode of Writing of the Ancient Assyrians.

Major-General Briggs.—On the Aboriginal Tribes of India. *With illustrative Map and Drawings.*

Physiological Sub-Section.

Dr Tilt.—On the period of First Menstruation in different Countries.

Dr M'William, R.N.—On the use of the Bofareira (*Ricinus communis*) of the Cape de Verd, as a means of exciting Lactation.

Dr Laycock.—On the relation of Consciousness to Reflex or Automatic Action.

Dr Carpenter, F.R.S.—On the Relative Functions of the Cerebral Hemispheres, and Sensory Ganglia in Intellectual Operations.

Dr J. Dalziel.—On Hysteria, Hydrophobia, and other Convulsive Affections, containing an Analysis of the Phenomena of Water-dread.

Section F.—Statistics.

G. R. Porter, Esq., F.R.S.—Remarks suggested by an examination of the recent Statistics of the Cotton Manufacture in Great Britain.

F. G. P. Neison, Esq.—On the rate of Mortality among the Provident Classes in Germany, and in Great Britain.

Professor W. P. Alison.—Account of the system of Croft-husbandry adopted at Gairloch in Ross-shire, chiefly on waste lands, since 1846, and its result, as illustrating the conditions under which the labour of Paupers and Criminals may safely be made productive.

Mr A. Keith Johnston read a paper "on the Geographical distribution of Health and Disease, as indicated by natural phenomena," which was illustrated by numerous very interesting maps and diagrams:—

Since the time of Hippocrates a belief has existed that the development of the moral and physical faculties of man is dependent, not on original organization only, but also on the atmosphere by which he is surrounded, and the nature of the soil on which he is reared; and modern researches in physical geography, combined with statistical investigations in medical science, have confirmed this opinion. Sweden furnished the first tables of mortality, since then England, France, Prussia, and the United States of America, have each contributed systematic statistical returns, and thus a vast mass of material has been accumulated, from which valuable conclusions may be deduced, especially since it is known that, during a similar series of years, the same diseases reappear with the most astonishing regularity, both as to periodicity and extent, and with reference to moral as well as physical causes.

The charts exhibited showed that endemic fever, including remittent and intermittent fever, prevails in North America, the West India Islands, the west coast of Africa, Syria, South Italy, the Ionian Islands, and in general in the low marshy districts of warm countries. Yellow fever is endemic in North America and the West India Islands, between latitude 5° and 40° N., its northern limit in Europe being the latitude of Gibraltar. Diseases of the digestive organs are most prevalent in India, West and East Africa, the Cape of Good Hope, England, Guiana, &c. Disease of the liver greatly predominates in the East Indies; while consumption is most conspicuous in Great Britain, Newfoundland, Canada, and Jamaica. Dropsy is most prevalent in West Africa, Great Britain, and Guiana. Among the different countries the most striking contrasts are sometimes exhibited; thus the west of Africa is to Europeans the most fatal; while the south-east is the most healthy country in the globe.

Although many causes besides that of climate contribute to produce these results, yet generally, both in countries and in cities, the chances of longevity are greatly in favour of northern latitudes. Of the former we find near the bottom of the scale, Java, as indicated by Batavia; some of the West India Islands, Sicily, Naples, &c.; and near the top, Norway and Sweden, and portions of England. In all cases cities are less healthy than rural districts. Of these the lowest is Vienna and the highest London. From these results it appears that a cool or cold climate near the sea is the most favourable situation for health and longevity. Among the causes of mortality not dependent on climate may be noted: 1. Poverty and want among the lower classes of a community; 2. Close and ill-ventilated lodgings, whether in hospitals, prisons, or private dwellings; 3. Unhealthy or excessive labour, especially in youth; 4. Intemperance and dissolute habits; and, 5. War.

The proportion of deaths from consumption in different countries indicates how little mere climate has to do with the extent of this disease; since, while it is almost unknown in the Madras Presidency of India, it is more frequent at the Cape of Good Hope than in the northern States of America, nearly even in Britain and in British North America, nearly the same at Gibraltar as in the West Indies generally, and more fatal among European troops in Jamaica. Remittent fever shows an almost regularly progressive increase with the increase of temperature from the North States of America to Jamaica, where the deaths, among Europeans, amount to 102, and among the black troops, only 8 per 1000. Of diseases in the digestive organs, in the United States the number of cases is 526, and deaths 14 per 1000; while in Britain the cases are 95 per 1000, and the deaths only 1 in 2000 of the population.

Rheumatism is most prominent in Britain and least in Malta. In Asia it is least among Europeans in the Tenasserim provinces, and greatest in the Madras.

The influence of climate is most powerfully evinced in the mental and physical degradation produced by malaria on the inhabitants of the moor and marshy districts of tropical regions; but, even in Europe, its effect on the amount of mortality is much greater than is generally understood. Thus in the smiling plains of southern Italy the rate of mortality is nearly twice as great as in the cold region of Scandinavia; and this proportion appears to be held in all countries.

Temperature alone has a great effect on the production of disease; the Registrar-General calculates that a fall of the mean temperature of the air from 45 deg. to 4 or 5 deg. below zero, destroys from 300 to 500 of the population of London.

In order to judge of the effects of the climate it is necessary to compare the amount of sickness and mortality among the indigenous population of a country with that of strangers to the soil. Now, we find that in all India the average amount of mortality among European troops is nearly three times as great as among natives, that while seventy-five per cent. of the European troops died at the Gamola, the mortality among the black troops was little more than two per cent.; that the number of deaths from cholera in India is twice as great among Europeans as among natives, that the native troops in Bombay are as healthy as the British troops are in England. These comparisons will be found to be confirmed in all the other colonies.

Perhaps the most striking result exhibited by the tables or diagrams is the great amount of mortality among the military as compared with the naval service, or with the civil population of a country. When it is remembered that the former are selected with a special view to health, while the latter are taken promiscuously, an opposite result might have been anticipated. In Britain the number of deaths among the troops, generally, is 15 per 1000, while among officers and the civil population it is only 9 per 1000. In France the returns of the army of the interior show a mortality of 18 per 1000, while among the civilians it is 10 per 1000; and this is exceeded in all the colonies. In the island of Barbadoes the mortality among civilians is not more than 14 per 1000, while among European troops it is 58 per 1000.

As compared with the mortality in the navy the crews in the Mediterranean, South American, and Home Station, are all greatly more healthy than any European troops, the average mortality being 9 per 1000. In the East Indian command the average is 15 per 1000, corresponding with that of the troops in Britain. In the West Indian and North American command it is 18 per 1000, being the same as among the British troops at Malta, and in the Cape of Good Hope, and West Africa command, where the mortality among the troops is 450 per 1000, or 45 per cent., in the navy it is only 25 per 1000, or 2½ per cent.

The effect of the means adopted for checking disease in the three great countries of England, France, and Germany, during the past century, are such that while formerly one out of every 30 of the population died each year, now the average is one in 45—reducing by one-half the number of deaths in these countries. In the year 1700 one out of every 25 of the population died in each year in England. In 1801 the proportion was one in 35, in 1811 one in 38, and in 1848 one in 45, so that the chances of life have in England nearly doubled within 80 years. In the middle of last century the rate for Paris was one in 25, now it is one in 32.

Section G.—Mechanics.

Mr Lassell gave an explicit account of his new method of supporting a large speculum free from sensible flexure in all positions. This he proposed to do, when in a horizontal position, by supporting it at eighteen different points, on which the weight might bear equally ; and by casting the speculum with ribs, he proposed to adapt levers, that when the telescope is elevated they might bear the weight among them, and thus prevent it from disturbing the true form of the speculum.

Dr Robinson said that it appeared to him that the suggestions of Mr Lassell would remedy the annoying evils which every astronomer had to contend with.

Mr Whitworth's communication on a new Duplex Turning-Lathe was then made by Mr Scott Russell. The improvement suggested not only doubled the quantity of work, but did it in a much better style.

Mr George Beattie then gave an account of his new Door-spring, the motive power of which is the pressure of the atmosphere. The principle of this excellent contrivance is simply this—to cause the opening of the door to move an air-tight piston from the closed end of the cylinder to the open end ; the atmosphere then acting upon the piston, forces it back, and thus closes the door. Several members expressed themselves in terms of high approbation of Mr Beattie's contrivance.

Mr Stevenson made a statement of the result of certain observations made by him on the force of the waves with reference to the construction of marine works. The result of the experiments hitherto made may be stated to be a force of about 1½ tons per square foot for the German ocean, and of 3 tons for the Atlantic ocean ; the experiments from which these results were obtained being made at the Bell Rock and Skerryvore Lighthouses.

Mr Swan then brought forward his communication on the "Limits to the Velocity of Revolving Lighthouse apparatus, caused by the time required for the production of Luminous Impressions on the Eye."

Dr Robinson, the President, in introducing Mr Budd to the Section, said, the subject on which that gentleman was about to speak was one of very great importance to the iron trade of this country. According to the present system, an iron founder, in melting a ton of iron, sent out into the atmosphere about four tons weight of gaseous products, all of which were entirely lost. Now, Mr Budd had satisfactorily proved, by actual experiment, that the heat which escaped from the tops of blast furnaces was a matter which the iron manufacturer might turn to material account in the way of increasing his own profit, as well as in diminishing the price to the purchasers of that commodity.

Mr Budd stated that, since the meeting of the Association at Swansea, he had continued, and with increased success, to apply the waste gases that escaped from the top of blast furnaces, to the manufacture of iron; and it was the result of his farther experience applied to the whole of his furnaces (nine in number) since that period, that he now wished to submit to the Section. He considered that he could not have fallen on a better locality for this purpose than Scotland, where the iron trade has been developed with a rapidity that is quite surprising and quite characteristic of the enterprise of Scotchmen. Twenty-five years ago, Scotland was of no importance in the iron trade, but, since then, the produce of iron in Scotland had increased to between 600,000 and 700,000 tons a year. In that short period Scotland had accomplished a production which Staffordshire and other places in England took two hundred years, and South Wales a hundred years to accomplish—the make of iron in Scotland being now equal to that of either England or Wales. This great accession to the produce of iron has had a most sensible effect on its price; but as he believed that necessity was the mother of invention, and that nature had in store for us an immense reservoir of riches to be yet developed, he was of opinion that the tendency of all this cheapness was to teach us that nothing should be wasted, and that we should look forward to the time when the smoke that at present contaminated the atmosphere, and the filth that polluted our streets, would be regarded as too valuable to be wasted.

When we considered the utility of iron, its low price, and its general distribution in the deposits of every age, we could not but look upon it otherwise than as the great agent in modern civilisation. Mr Budd then referred to his mode of applying the gaseous escape, and said it was well known that there were two descriptions of furnaces used for metallurgic purposes. The one was the blast furnace, into which air was injected by mechanical means at a great density, so as to penetrate upwards of 40 feet of dense materials; and the other was the reverbatory furnace, where the fire was produced by means of the draft of a chimney stack. What he had accomplished was by combining these two so that the gaseous products of the furnace, instead of escaping through the tunnel head, were drawn sideways by a high stack, and passing through the stoves and boilers, leave behind the necessary temperature of the blast and of the steam. In a blast furnace the ores are smelted before the *tuyères* by the conversion of the solid carbon into carbonic acid, which, passing up through the middle region of the furnace into a bath of carbon, was reconverted into carbonic oxide, capable of combining with a farther dose of oxygen. It would be thus seen that the whole of the carbon of the fuel should be present at the top of the furnace in a gaseous form. When the British Association met at Swansea, he had not used the gaseous escape at any great distance from the furnace, his stoves and boilers being very closely contiguous. Further experience, however, had proved that by the aid of a stack at the end of the chain of sufficient dimensions, the gaseous escape from the furnace might be made to travel in the most tortuous directions, descending to the stoves built for heating by the usual fire-places, and traversing the boilers; the only condition absolutely necessary being that there should be an unbroken communication with the high stack at the end, into which the gaseous escape might at last pass, and by which it was drawn forward, instead of passing off wastefully at the tunnel-head. When, however, the draft was carried downward, and to long distances, he had found it necessary to drop into the top of the furnace a hopper or funnel, made of sheet-iron, which acted as a shield at the mouths of the horizontal flues, and prevented them from either being affected by high winds, or from being choked up by materials thrown into the furnace. The reason, no doubt, why this funnel was not applied before was the great apparent temperature at the tunnel-head. In practice, however, it was found that until the gaseous escape mingled with the atmosphere, its heating power was not such as to injure sheet-iron, or even to make it red-hot. In fact, so long as there was an escape upwards, the iron funnel would not be injured. The damage arose during and after stoppages of the furnace, when the blast was obstructed in its passage upwards by the settlement of the materials in the furnace, so that the atmosphere rushed down to meet the ascending gases, and, of course, caused a very high local temperature. His practice was to exclude the atmospheric air as much as possible. The affinity of the gases for oxygen was so great that the air leakage raised the temperature quite sufficient for safety, whilst the full combustion of the gaseous escape would melt down the bricks in the flues, and destroy the texture of the iron tube. It was not possible for him to say what combinations took place at high temperatures, where carbonic oxide, carbonic acid, hydrogen, and nitrogen, were mixed in such proportions. At any rate, he found a smothered combustion to be the most suitable and economical for the purposes in view. He was happy to say that, at length, the application of the gaseous escape had been tried in Scotland; and that at Dundyvan and elsewhere it was now in successful operation. The peculiar quality of the furnace coal of Scotland being what was called in South Wales "free burning," which, when put into the furnace raw, coked sufficiently in its descent, gave out an enormous escape, so much so, that, upon a rough estimate, he calculated that the waste from one furnace in Scotland was sufficient to heat the blast, and to raise the steam for three. With anthracite coal, the minimum effect was obtained, as it was a dense fuel of nearly 95 per cent. of solid carbon; but in Scotland there would be an enormous surplus at the tunnel-head. He expected, from the well-known sagacity of the Scottish people, that when truly embarked in this mode of operation, the greatest possible use would be made of it: and he would not be surprised to see heat let out, like mill-power, for burning bricks and other similar purposes. He felt, however, anxious that the application should be made under the superintendance of competent parties, as he had known several instances where the plan had been abandoned from difficulties that might easily have been surmounted under proper directions. He was quite aware that, by the plan he had pursued, the utmost heat was not extracted from the gases; and that, by different means, a temperature might be obtained capable of performing all the operations of the forge; and if it be true that the solid carbon of the furnace in its escape, as carbonic oxide, would unite with another dose of oxygen for saturation, there could be little doubt that, with properly constituted gas furnaces, there was enough at present passing off to convert the pig iron into bar iron. He hoped some of the iron-masters of Scotland would follow up this hint effectually with regard to the remaining processes required for making malleable iron. He observed that the saving at the Dundyvan Iron Works was stated to be about 1¼ tons for each ton of iron produced. Supposing, therefore, 600,000 tons of iron to be the produce of Scotland, and supposing the value of the coal used to be 3s. a ton, the saving that would thus be effected on the make of Scotland would amount to £112,500 a year; to which might be added £20,000 a year of saving in wages and repairs, which would make a total saving of £132,500, or about 4s. 5d. a ton on the produce of Scotland, which, on the present price of 44s. per ton, was about 10 per cent. on the value. If the gaseous escape could be extended to the uses of the forge, a farther saving of three tons of coal would be effected—thus making, at least, a saving of 20s. a ton on all the iron manufactured into bars, sheets, and rails.

Tuesday, 6th August.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

Professor Phillips made a communication on Isoclinal lines in Yorkshire, a contribution to our knowledge of terrestrial magnetism on a point not much investigated,—a point, though small perhaps, yet certainly interesting. There are certain lines, as is well known, on magnetic maps called Isoclinal curves, corresponding to the different angles shown by the needle when freely suspended in different places. The investigations of Professor Phillips related to those lines within a limited track, where the inclination of the needle is the same. The general isoclinal lines have been ascertained, but these are only the mean—the resulting lines, and observations in individual places may, and often do, vary not a little from these, and Professor Phillips wished to find the variation of the lines with reference to the surface of the country. He exhibited a sketch of part of Yorkshire, having elevations to the height of 600 and 400 feet on the east, and rising as high as 2600 feet to the west. It was a portion of country free from trap rocks, and therefore from one great source of irregular action of the needle. He had made investigations on the west part sixteen years ago with a dipping needle made by himself, but the Association had thought that the instrument might have been inaccurate in its indications. He had since obtained one of Mr Charles Robinson's dipping needles, whose instruments of this kind he thought the best. In his new investigations, he had taken four parallel lines of observation north and south, and observed at different latitudes, and he had every reason to conclude that his observations were correct. With a good dipping needle, all that is required for accuracy is due time and care, and his instrument he found could generally be depended to within a minute of a degree. His method of observation was to turn the needle in azimuth all round the circle, 30°, 60°, 90°, &c., and read off the dip each time, and do the same with two other needles. Two hours were required for a good observation. He had observed the magnetic dip all the hours of the day, particularly in summer, and found the maximum to be at 9 A.M., the mean at 3 P.M., and the minimum at 9 P.M. M. Kupffer had obtained results of the same general character, so that we may thus apply to observations a correction for the hour of the day. Now, he (Professor Phillips) had found as the result of his observations regarding the point he had in view, that the isoclinal curve in individual cases, and within a limited track, tends towards the high ground. Whenever we come to a mountain country, there we come to great flexures.

Professor Airey, the Astronomer Royal, laid before the Section a question of Probabilities which had occurred to him in the use of a fixed collimator for the verification of the constancy of position of an azimuth circle.

Mr Nasmyth made an interesting communication on the lunar surface.

James Dennison, Esq., read a notice on a Tissue spun by Caterpillars. Specimens were exhibited, one a veil, 46 by 24 inches, seeming almost to realize the figurative epithet of the ancient "*textilis ventus*," and another, a picture drawn on a portion of a similar tissue, 7 by 5 inches.

Sir David Brewster shewed to the meeting the beautiful Talbotypes by Messrs Adamson and D. O. Hill, Ross, and Thomson, Edinburgh.

The Rev. J. B. Reade made a communication regarding a new Solid Eye-piece.

Sir William Rowan Hamilton read a paper on "Polygons inscribed on a Surface of the Second Order," which will appear in the Mathematical Journal.

Professor W. Thomson read a paper on the Theory of Magnetic Induction.

Professor Nichol made a communication on the winds in the west of Scotland, as observed at the Glasgow Observatory by Mr Osler's Anemometer, giving the reduction of observations for six years in a tabular form.

Professor Smyth read a paper on Cometary Physics. The motions had been reduced to mathematical calculation, but the addition to, and arrangement of, the facts regarding comets which observation furnishes, have been too little attended to. Having had an opportunity of seeing a number of comets, he had endeavoured to arrange such facts respecting them as observation made known. These were: 1. A comet consisting of a nucleus, and one or more gaseous envelopes. 2. The nucleus is solid and material, but exceedingly small. 3. The nucleus is eccentrically situated in the gaseous body. 4. Comets of the longest period have the largest bodies. 5. The more eccentric the orbit, the more eccentric the body of the comet. 6. The comet rotates on its shorter nucleoid axis in the same time that it takes to move round the sun. 7. This axis is not always at right angles to the plane of the orbit. 8. There is also a quicker rotation round the longer axis. 9. A comet shines by reflected light, and shows a sensible phase. 10. In proportion to the eccentricity of the orbit a comet increases in density, and decreases in size in approaching the perihelion, and *vice versa*. 11. The longer axis of a comet is straight at the perihelion and aphelion, but between these points is concave towards the latter, the curvature being inversely as the eccentricity of the orbit. 12. (Sir John Herschel's.) The component molecules of a comet are only held together by their mutual gravitation, each constituting an almost separate projectile, and describing its own parabola round the sun. Professor Smyth adverted particularly to the 9th and 10th axioms. Arago had proved that comets shine by reflected light, but as to their showing a sensible phase, a contrary opinion had hitherto been held. He shewed, however, by several diagrams, that they had phases, and how this was caused. The atmosphere being eccentrically disposed of by the force of gravitation to the nucleus, the greater part of the light will fall on the denser part of the atmosphere exposed directly towards the sun. Behind the atmosphere and the nucleus there will be an axial darkness, while the exterior parts of the atmosphere above and below will present the form of a double tail, with the light growing dimmer towards its extremities. With regard to the 10th axiom stating a decrease rather than increase in bulk of comets near the sun, this had been explained by Sir John Herschel, and was verified in a remarkable manner by the great comet of 1843, which had a far less perihelion distance than had ever been known before,—only about 60,000 miles.

Sir D. Brewster read a notice of very powerful magnets made by the process of M. Elias, and, under his direction, by M. Logemon, optician, Haerlem. By this process a magnet 1 lb. weight will, with due precaution, support 28½ lbs., and the power does not sensibly diminish though the armature be suddenly detached several times. It has twice the power of magnets commonly made in Britain. Magnets capable of raising 400 lbs. are made in this way. Sir David exhibited two of M. Elias's magnetic horse-shoe combinations of bars, one of about 17 oz. weight, and another 12½ lbs., the latter capable of supporting 150 lbs. It was necessary, for their perfect action, to polish the ends of the armature with two pieces of wood covered with emery and lead. The line joining the poles must be as perfectly horizontal as possible. The bars are magnetized by being moved several times through a helix of copper wire, along which the galvanic current passes.

Short communications were made by Sir D. Brewster, on the Optical properties of Cyanuret of Magnesia and Platina; on a New Membrane investing the Crystalline Lens; and on some phenomena of the Polarisation of the Atmosphere. By Professor Stevelly—On an attempt to explain the occasional distinct vision of revolving coloured sectors. By Professor Stokes—On the mode of disappearance of Newton's Rings in passing the angle of total internal reflection. By Professor Hennessy—On the distribution of Shooting Stars in the Interplanetary spaces. By Mr J. A. Broun—On Electrical Figures of Dust on Plate Glass; and by Mr Beswick, in Explanation of a Magnetic Chart on which the lines had been drawn by a theoretical formula.

Section B.—Chemistry, including its Applications to Agriculture and the Arts.

"On the action of the Soap Test upon Water containing a salt of magnesia only, and likewise upon water containing a salt of magnesia and a salt of lime," by Mr D. Campbell.*

"Remarks on some Chemical Facts connected with the

* This paper published in the 37th Vol., p. 171, of the Philosophical Magazine for 1850.

Tessellated Pavements discovered at Cirencester (the Roman Corinium)," by Professor Buckman.—In this paper it was shown that the materials of which pavements are composed are of two kinds:—The first derived from rocks of the district and termed natural, the second composed of clay, fictilia and glass, artificial tessellæ. The natural tessellæ, many of which are so altered by chemical manipulation as to cause them to be referred to foreign rocks, consist of bits of stone from the chalk, oolite, lias, and red sandstone formations, and were clearly referred to their origin, and the processes by which they were prepared for pavements were pointed out. Thus a grey colour was produced from a cream coloured oolite, the change of colour being caused by a process of roasting. This is dependent upon the fact that the oolite bed of which they are made contains iron and organic matter, the latter of which prevented the iron peroxidizing, and thus the grey was due to a protoxide of that metal. The artificial tessellæ from pottery consist of shades of red and black; the reds all being due to a peroxidation of the iron in the clays from which they were made,—whilst the blacks were the result of baking in "smother furnaces," as long since pointed out by Mr Artis, so that the carbonaceous matter of the fuel with which the baking was effected was prevented from escaping, and, as he would lead us to infer, the black smoke penetrated the clay and thus blackened it. The author, however, showed that this smoke acted chemically, by preventing the oxidation of the iron, and thus the change from the dark colour of the clay to red which usually occurs in burning pottery and bricks was prevented. Reference was then made to a medallion in the pavement representing Flora, in the first drawing of which the head-dress and flowers held in the hand were coloured verdigris green, the hue these objects presented on being exhumed; but as this was unsatisfactory in chromatic arrangement, the author suspected some chemical change had occurred since the pavement was put down,—and on scraping away the green from the surfaces of the tessellæ in question, a beautiful ruby glass presented itself. New drawings (which were also exhibited) were then made with ruby instead of green colour: the result of which was, that what was before inharmonious in colour and grouping, at once resumed harmony in these respects, and became perfectly intelligible. An analysis of the glass made by Professor Voelcker showed the cause of change from ruby to green to have been due to the fact that the antique ruby glass had derived its colour from suboxide of copper, and that the tessellæ had become covered with carbonate of copper from a decomposition of their surfaces.

On the "Phosphorescence of Potassium," by Mr W. Petrie.

"On the presence of Fluorine in Blood and Milk," by Dr G. Wilson. This communication is given in full, page 227.

"On the presence of Carbonates in Blood," by Professor G. J. Mulder, of Utrecht.—The intention of Professor Mulder was to show experimentally that blood contains carbonic acid not merely in solution, but also in chemical combination with bases and organic substances, as globulin, albumen, &c.

"On a compound of Iodine and Codeine," by T. Anderson, M.D.—The compound of Iodine and Codeine which formed the special subject of this communication is obtained by mixing together alcoholic solutions of equal quantities of Codeine and Iodine, and leaving the mixture to spontaneous evaporation, when the new compound is deposited in crystals. The compound is insoluble in water, sparingly soluble in cold alcohol, but readily in boiling, and it is again deposited in small triangular plates as the solution cools. Its crystalline form has been determined by Professor Haidinger, of Vienna, who finds it to belong to the doubly oblique system. The crystals have a fine diamond lustre and a deep purple colour by reflected, and ruby red by transmitted light. In powder its colour is cinnamon brown.

"On a direct method of separating Arsenious from Arsenic Acid, and on its application to the estimation of Nitric Acid," by Mr J. Stein.

Section C.—Geology and Physical Geography.

Professor Ramsay read a paper on the position of the black slates of the Menai Straits.

Professor Nicol then read a translation of a communication from M. Martins on "Parallele entre les Terrains superficiels du basin Suisse et de la Plaine du Po."

Professor Oldham made some additional remarks on the temperature of mines in Ireland, to the effect that, in the very same lode, they had in the shallow portion one degree for every fifty-two feet; but at a depth of twelve hundred feet, they had a rise of one degree for every eighty-five feet.

Mr Hugh Miller then made a communication on certain peculiarities of structure in the more ancient ganoids. Mr Miller began by stating that it was his purpose to introduce to the notice of the Association a curious suite of fossils from the Lower Old Red Sandstone of Scotland, many of which were still without duplicate in the public museums of the empire, and but imperfectly represented in those of Russia. In one important respect there attached to them a peculiar interest. They belonged to the earliest animals of the vertebral division, of which our knowledge was rather inferential than direct. The most ancient fishes known to the geologist were the Placoids of the Silurian System; the next most ancient the Placoids and Ganoids of the Lower Old Red Sandstone. Of the placoids, however, little comparatively could be known; from their perishable cartilaginous structure an entire species might be represented by but a few spines, teeth, or shagreen points; whereas the ganoids, from the peculiar armature of solid bone in which they were enveloped, continued to exist, not as mere ichthyic fragments, but as ichthyolites. Hence our absolute knowledge of the ancient forms and mechanism of ichthyic life was mainly to be derived from the study of the first ganoids. Mr Miller submitted to the Society several specimens. In a Dura Den specimen of *Pterichthys*, for example, the very capsules of the eyes were preserved; and we had evidence of at least the three senses with which these earliest of the ganoids took note, in an incalculably remote period, of the sights, sounds, and odours of the material world.

Dr Anderson read a paper on the Fossil Fishes and the Yellow Sandstone of Dura Den.

Dura Den is situated in the upper part of the Old Red Sandstone, which is now interesting in a paleontological view, on account of the fossil fishes with which it abounds. Dr Anderson laid before the meeting a beautiful collection of these fossils, and stated it as his opinion, that among the specimens exhibited, there were several species, and even genera new to paleontologists. The accuracy of this opinion was questioned by some of the members of the Association, but minute examination we understand was not gone into for want of time.

Professor Sedgwick then described the Palæozoic Rocks of the south of Scotland. After referring to the formations which surrounded them, and to the deposits which occupy a higher geological position, the Rev. Professor said he had endeavoured to ascertain the axis of the great mountain chain which traversed the south of Scotland. He believed that the axis was at the centre—that was to say, that newer rocks were to be found on the north and south sides of it. He then went on to say, that in this great mountain chain beds exist which are nearly equivalent to the Caradoc sandstone of the Chairman (Sir R. Murchison), and also to the Conniston limestone of the high part of Lancashire, where it adjoins Cumberland. These beds were marked by the fossils which characterized the Silurian of his friend the Chairman. Such deposits occurred at Girvan, Colmonell, in Ayrshire, and in some parts of Wigtonshire, and at Balmea, in Kirkcudbright. Below these beds Graptolites are found, and these Graptolites are of such a nature as to connect them with the black slates of New York, in which fossils of a similar nature occur. He had figured in a work, which would appear before long, thirteen different species found here, which were described only in American works. In Scotland these Graptolites are most abundant about Moffat—the so-called alum slate being full of them. This portion of the palæozoic formation the learned Professor conceived to be much below any beds which have hitherto afforded fossils, and he believed that his friend (the Chairman's) system would have to undergo some change before the palæozoic rocks of the south of Scotland could find a place in that arrangement.

The Professor then alluded to the relative position of the lower beds, which he conceived are much better developed on the south portion of the range than on the north, and concluded by observing, that we must refer to the palæozoic rocks of America, before we can obtain a correct idea as to the position of these beds as they occur in the south of Scotland.

Professor Nicol mentioned his having met Graptolites in Peeblesshire, and Mr Harkness, his discovery of them abundantly near to Moffat, in Dumfriesshire.

The President then explained the progress made in M. Barrande's great and beautiful work on the Silurian or Transition Rocks of Bohemia.

Professor Edward Forbes read Notices of some remarkable forms of Fossil Radiata.

Lieutenant Strachey, Bengal Engineers, noticed some Recent Researches in the Himalaya.

Lieutenant-Colonel Portlock described the intrusion of the Trap Rocks into the conglomerate on the shore between Tantallon and North Berwick.

Mr Nasmyth.—On the Structure of the Lunar Surface, and its relation to that of the Earth.

Dr Mantell.—Notice of a Specimen of an Upper Jaw of the Iguanodon.

Mr William Stevenson.—On a Quartz Formation in the South of Scotland.

Notices of Earthquakes in South America in the years 1844–5–6–7. By Mathie Hamilton, M.D., formerly Surgeon of the Potosi Mining Company.

Section D.—Natural History, including Physiology, Zoology, and Animal Physiology.

Dr Mantell.—On the Dental Organs of Iguanodon.

W. Thomson, Esq., of King's College, London.—On the Lingual Teeth of the British Pulmono-branchiate Mollusca. Communicated by Professor Edward Forbes.

Mr James Hardy.—On an Acaris and Vibrio, that attack grasses. Communicated by Dr Douglas Maclagan.

H. E. Strickland, Esq.—On the Development of the Tail Feathers of Vidua paradisea.

J. Gould, Esq., F.R.S.—Notice of the Ornithological Collections made by Mr J. M'Gillivray, on the North Coast of Australia.

A. Strickland, Esq.—On the Changes of Colour of British Birds.

R. M'Andrew, Esq.—Record of the Distribution of Marine Animals according to depth, in a cruise from Vigo to Tunis.

Dr Lankester.—Report on the Registration of Periodic Phenomena.

W. T. C. Thomson, Esq.—Notice of the application of Photography to the Compound Microscope.

Rev. T. Rankine.—Zoological Memoranda.

Dr Carpenter gave a very interesting account of the reparation of the species of the echinida, and also an anatomical description of the foraminifera of the tertiary strata.

Dr Mantell gave an exposition of the dental organs of the iguanodon of the Wealden formation, exhibited teeth and portions of the lower jaw of that reptile, and also a portion of an upper jaw lately found, which completely confirmed his previous conjectures regarding the position of the teeth of the upper jaw. He also exhibited a drawing of the humerus of a gigantic lizard called Pelorosaurus, which had been also recently found in the Wealden.

Dr Hugh Cleghorn read a paper on the grass cloth, the produce of Bohmeria nivea, a kind of nettle. The first mention he found of it was in 1698, afterwards in a history of Japan, and by the great botanist Thunberg. The plant occurred in India and China, and a coarse cloth was made from it for the summer dress of the poorer classes, while a much finer was made for the use of the rich.

A paper was read by J. Wolley, Esq., on the birds of the Faroe Islands, as observed by the author on a visit there last year. He gave a sketch of the relative situation, geological structure, and climate of the group, with a reference to their organic productions, as far as these had any bearing on the presence or absence of various kinds of birds. In illustration of the abundance of certain kinds of food, was mentioned the phenomenon of the sudden rise of a compact shoal of small marine animals, which, on the testimony of an intelligent native, has given origin to Pontoppidan's story of the kraken, or large flat sea-monster, called in Faroe kraka, or teara-bue. The snow bunting and the purple sandpiper, both of which frequent the tops of mountains, were the only species of bird not known to breed in Britain. The fulmar, about ten years ago, began to establish itself on the cliffs of Faroe for the first time. Many species reported to breed there by other authorities were not to be found. Several traditionary particulars about the great auk were given. After many observations on the habits of the different birds, their relative numbers, and the etymology of their names, Mr Wolley concluded by deducing a lesson from the mode in which the birds are treated by the human inhabitants. Although numbers are caught at stated times, yet as a whole they rather increase than diminish, for they are not constantly annoyed as they are round the coasts of Britain. Both the established rights of the bird-climbers and the interest of our coast navigation require that the sea-birds should be protected. In foggy weather they warn vessels of their approach to the dangerous headlands which they chiefly frequent. Already they are very greatly diminished in numbers, and the persecution is constantly increasing. On the Yorkshire coast slaughtering parties arrive by trainsful. It is a matter well worthy the attention of the Legislature. The protection afforded to them in the vicinity of one or two lighthouses on the west coast, and also round the Bass Rock and Ailsa Craig, are pleasing exceptions to the general rule, and shew what may be done.

Ethnological Sub-Section.

E. Norriss, Esq.—Notice of a Vocabulary of the Mandrawe Language (African.) Communicated by Dr R. G. Latham.

Dr R. G. Latham.—Remarks on Mr Norriss's Paper.

E. Norriss, Esq.—Notice of a Vocabulary of a Sudama Language (African.)

F. Newman, Esq.—Notice of a Dialect of the Berber Language. Communicated by Dr Latham.

Professor P. A. Munch of Christiania.—Ethnological observations suggested by the Philological Characteristics of the remarkable Anglo-Saxon Runic Inscription at Ruthwell, in Galloway.

Dr R. G. Latham.—On the Distribution of the Germanic, Lithuanic, and Slavonian Tribes, at the beginning of the Historic Period.

Physiological Sub-Section.

Professor Bennett read a communication " On the Molecular Element of Growth in Plants and Animals." He pointed out that the generalisation of Swan was, that all living textures originated from cells. Since he wrote, numerous physiologists, especially Henle, Barry, and Goudin, had directed attention to the influence of the nucleus. He (Dr B.) conceived that there now existed many parts which indicated that neither the cell nor nucleus was the primary element, but rather the molecular from which each of these was originally produced.

" On some Facts in relation to Pathological Cell-Development," by Dr W. T. Gairdner.

" On the supposed Relation of the Spleen to the Development of the Coloured Blood Corpuscle in the Adult," by Mr Sanderson.

" On a Physiological Mode of Investigating the Metaphysical Difficulties in regard to the Origin of the Notions of Space, of Motion, of the External, of Substances, &c., in connection with the Laws of Nervous Action," by Dr Seller.

" On the influence which our Instinctive Propensities have on our Intellectual and Active Powers,—that is, on Acting in consequence of Thinking," by Dr Fowler.

" On the Reproduction of Limbs after Amputation in the Human Subject," illustrated with specimens, by Dr Simpson. —Dr Simpson shewed that the power of reproducing and repairing lost parts was greatest in the lowest classes of animals, and decreased as we ascended higher and higher in the scale of animal life. He then pointed out that the human embryo approached in this, as in other respects, the physiological life and powers of the lower animals; and, consequently, when the arm or leg was amputated during embryonic existence, as not unfrequently happened from bands of coagulable lymph, and the results of disease, the stump structures reproduced a small rudimentary hand or foot—as the crab or lizard does. He shewed various casts and drawings of cases of hands thus reproduced; and two living examples were exhibited.

There was read an interesting memoir "On the laws regulating the Development of Monstrosities," illustrated with specimens, by Dr A. Wood.

"Important Suggestions regarding the Expediency of ascertaining the Extent to which Infantile Idiocy prevails in Great Britain and Ireland generally, and of inquiry into the causes of its Prevalence in certain Quarters, with a view to the adoption of some means of deliverance from it," by Dr Coldstream.

Concluding General Meeting.

MUSIC-HALL.

The proceedings of the Association terminated by a General Meeting held in the Music Hall, on Wednesday the 7th of August, at three o'clock, which was very numerously attended,—Sir David Brewster in the chair.

Dr Royle reported, in a very lucid manner, the transactions of the General Committee, which were approved.

Thanks to the Lord Provost and Magistrates of Edinburgh.

Sir R. I. Murchison said, he rose with great pleasure to move a resolution entrusted to him, viz., that the cordial thanks of the British Association be given to the Lord Provost and Magistrates of Edinburgh. This Sir Roderick did in his usual felicitous and animated manner. The distinguished Admiral Sir C. Malcolm said, it was a gratifying task imposed on him, as a Scotchman, to second this motion.

The Lord Provost returned thanks, in very courteous terms, for the honour thus conferred on the Town-Council and himself by the vote of thanks of the British Association.

Thanks to the University of Edinburgh.

Professor Sedgwick said, that he rose to propose the thanks of the British Association to the University of Edinburgh for the hospitality which they had returned to its members, and the kind manner in which, in every respect, they had co-operated in carrying out the objects of the Association. The subject of his resolution, he said, was linked with the history of Scotland in the most enduring form; with the history of great intellectual benefits; and also with the history of civilized Christendom. In one of the little excursions which he had made the other day, he passed by a venerable monument, though very different, indeed, from the numerous noble architectural structures that adorn the neighbourhood of Edinburgh,—he meant that old crumbling kind of castle in which the old family of Napier lived at Merchiston. Napier was associated with the history of this great intellectual capital, and his name was associated most intimately with the history of the University of Edinburgh; for if it had not been for his discoveries, the progress of scientific discovery must have been clogged by the enormous labour connected with those operations which he facilitated by a kind of intellectual steam-power by the production of those great treatises which pass under his name. He hoped, therefore, amidst the improvements that were going on in the neighbourhood of Edinburgh, that great intellectual monument would never have one sentence of its record obliterated, but that it would stand as long as its crumbling walls would hang together—(applause.) It was not, indeed, the fortune of the illustrious University of this city to produce Newton; and it is not the University of Edinburgh, or of Oxford, or any university in the world, that can make men of this kind. It is such men that make the universities, because they themselves give a soul and an embodied intellect to the university, which called forth the aspirations and the hopes of feeble men—(loud applause.) But though this University had not the honour of producing Newton, yet Scotland had the very great distinction of producing—aye, and before almost any other university in Christendom—a good Newtonian philosophy, and admirable original commentators on the Newtonian philosophy; and through those channels which Scotland supplied, that Newtonian system of philosophy has been diffused through Europe. But coming down to our own days, in every branch of science Edinburgh has contributed most nobly. He might speak of a series of great mathematical teachers who have in succession filled its chairs; but he would pass them over. Who was the great leader in that branch of science so important in its bearings upon the civil welfare of men? He was a man most intimately connected with Edinburgh—Adam Smith—one of the glories of this University. Then, again, with regard to the discoveries in chemistry—another comparatively modern science—who takes a higher philosophical place than the illustrious Black, one of the grandest, most intellectual, and crowning decorations of the University of Edinburgh?—(applause.) The learned Professor then expressed his fervent gratitude for having been privileged in his younger days to peruse the works of such men as Reid and Dugald Stewart; and, speaking of such illustrious names, he thought it a most glorious privilege in a University like that of Edinburgh to have such a grand intellectual ancestry to connect the present with the past—not to induce them to stand up as mere *parvenus*, as mere mushrooms in literature and science, springing up in a night; but, on the contrary, as men who believed in the vast services of an intellectual ancestry, to shew what can be done, not by the labours of one man, but by that accumulation arising from the labours of generation after generation, and that no man who belongs to the University of Edinburgh, or any other similar seat of learning, ever dare to dissociate the present from the past, or cut off that connection with our intellectual ancestry which is not only our pride and boast, but also an element of our intellectual strength—(applause.) But, after all, it would be but a petty and sorry matter if we were merely to boast of those who are gone: but it is not so. They have not carried away their mantles, but have cast them upon the shoulders of their successors, who are now filling their offices to the best of their power. For while we have such men as our Chairman—who has shewn the greatest analytical skill in dissecting the most complicate or difficult of all physical phenomena; while we have such a staff of intellectual men as are now engaged in carrying on the work of the University of Edinburgh; while we have men who—he dared not speak of individuals—but he must name the distinguished veteran (Professor Jameson) who wielded a hammer before he was born—(great applause), —and seeing a gentleman near him who holds a Professorship (Professor Forbes of Edinburgh), whose essay connected with Geology, he (Professor Sedgwick) did not hesitate to declare, was adorned as much by admirable good taste as by its spirit of sound philosophy,—while he could not pass over a gentleman now before him, adorned with such moral and intellectual qualities as distinguished Dr Alison—(applause.) With such men, therefore, filling the highest ranks in exact science, and adorned with the highest moral and intellectual qualities, they could entertain no more doubt of the future success, than of the past prosperity, of the University of Edinburgh—(loud applause.) The ladies, also, were members of the British Association; and he was certainly rejoiced to see that they had not only partaken of their intellectual banquet, but had even condescended to share in those cruder and less promising banquets in another room in Edinburgh. He rejoiced in that kind of half celestial vision; but he must mention the name of one lady, and of all the ladies who had decorated the history of man, there was none who stood higher than one most intimately connected with Edinburgh—that most accomplished philosopher, that admirable domestic woman, gifted with all the qualities that adorned the elegancies of life along with the very sternest of those powers which belonged to high philosophy—of course he meant the name of Mrs Sommerville—(loud applause.) The learned Professor then expressed the regret he felt in leaving so many kind friends, and he trusted that the intellectual communions they had enjoyed was not merely an offering to personal vanity, but that they had co-operated for a common end—for what Bacon called "constructing something for the glory of God and the good of man's estate"—(applause.) That was the great object of their meetings; and he trusted that they would not end merely in the teaching of new laws, or the gratification of their imagination, or in any of those little accompaniments which belong to such occasions, but that they would result in high moral and intellectual profit, and not only make them wise in the knowledge of this world, but in wisdom of a still higher kind, so that it might produce fruit which, by the blessing of God, might enable them to meet hereafter in a place where the regret of parting would be unknown, and where they would live for ever, and in happiness—(applause.)

Major Rawlinson seconded the motion, and remarked that, as a lover of science, he yielded to none in his admiration of that great and splendid educational establishment, the University of Edinburgh—an establishment which, if its merits were tested by the number of great men who had been trained within its walls, including, in the present day, Lord Brougham, the Marquis of Lansdowne, Lord Palmerston, and Lord John Russell,—it would yield to no other University, not only in Great Britain, but in the world—(applause.)

Principal Lee said,—It happens very inopportunely that I am present on this occasion, and therefore can hardly avoid the duty, as being at present the Chairman of the University, of returning thanks for the compliment which has been paid us, in terms so eloquent that it would be vain for me to attempt to rival them. Facts have been referred to by the able and accomplished gentleman who made the motion, to which, if your time were not so valuable, I would very willingly advert, namely, the illustrious names which have shed glory on this country. Your chairman and myself had the good fortune to study at the University of Edinburgh at a time when Black, Dugald Stewart, Playfair, and a great many other distinguished names carried on the instructions of the different departments; but though I claim no share in the credit which has been rendered to the University of Edinburgh, I think myself entitled to say that, in point of zeal, energy, and efficiency, both in investigating the foundations of science, and in adding to its domains, and in the various branches of literature—the different faculties (medicine and law in particular) never had the advantage of abler or more efficient teachers—(applause)—and I am sure that those who now study within the walls of our University will be quite ready to agree with me in the opinion, that the studies as now conducted in the very best style of didactic composition, are such as are calculated to impart incalculable benefit to those who attend the University, whatever may be the department in which they study, from that presided over by my venerable and excellent friend, Professor Jameson, the father of the University, to the youngest of our Professors—(loud applause.)

Vote of Thanks to the Royal College of Physicians and Surgeons for their Hospitality.

Professor Airey, Astronomer-Royal, said, that from his earliest youth he had derived more benefit from books written by distinguished parties in Edinburgh than from any other class of books whatever; and that he valued most highly his acquaintance with the distinguished men who now adorned its chairs. He then expressed the obligations of the Association to the medical profession in Edinburgh, for the kindness and cordiality of their welcome; and concluded by proposing a vote of thanks to the Royal College of Physicians and Surgeons for hospitality.

Sir C. Pasley seconded the motion.

Vote of Thanks to the Royal Society of Edinburgh, the Board for the Encouragement of Arts and Manufactures, and other Literary and Scientific Societies in Edinburgh.

The Marquis of Northampton moved a vote of thanks to the Royal Society of Edinburgh, the Board for the Encouragement of Arts and Manufactures, and the other literary and scientific bodies which had contributed to the comfort of the members of the British Association. They had come to a town where science not only flourished, but where literature and art existed in a high degree of perfection. Architecture, also, had achieved many triumphs in this splendid metropolis; and he could not help feeling great satisfaction that within a few months he had enjoyed the opportunity of comparing the childhood of architecture—when it was most vigorous, it is true—as it is displayed in Egyptian Thebes, and as it exists in its manhood here—(applause.) One of the great objects of the British Association was to enable the philosophers of

London to form an acquaintance with those in other parts of the empire, whence, after all, the ranks of science must be recruited, and that was one reason why they were delighted to visit such great cities as that in which they were then assembled, where, he was sure, it was impossible not to feel they had been received, not only as brothers, but as very selves—(applause.)

Thanks to the Commissioners of Northern Lights.

Dr Robinson of Armagh said, nearly in the following terms,—I have been entrusted with a task which I accepted very cheerfully, the more so as I was enabled to profit by the opportunity, which my friend Professor Sedgwick has told you he unfortunately missed. The Secretary has been kind enough to entrust me with a vote of thanks to be given by the British Association to the Commissioners of the Northern Lights for the liberality with which they placed their resources at the disposal of the Association, especially on the occasion of the excursion to the Bell Rock Lighthouse on Saturday last. To speak of the kindness with which we were received—to speak of the splendid hospitality with which we were entertained is nothing here, for there is no individual nor public body who has not heaped on us, even in profusion, this sort of kindness. I take on myself this office with particular pleasure, because of the excessive enjoyment which I, in common with about fifty other members of the Association, derived from an excursion, in the course of which we were led to an object which, almost from the days of my childhood, has engrossed my attention, and which I have ever regarded as one of the wonders of the world, of which we read and which we regard with almost mythological idolatry—a thing in whose existence I believed, but of which I never had any very clear experience—I mean the Bell Rock Lighthouse.* When I visited that marvellous, beautiful structure, rising up in its strength and loneliness out of the deep, I found that though the sea was calm and the wind was still, yet there

* This dangerous rock was named "*The Bell Rock*," because in former times *mariners were warned from it by the lugubrious tones of a bell, tolled by the action of the waves.*

was quite enough of danger in the enterprise of approaching it. Under these circumstances it enabled the mind to call up for itself the terrors which must in former years have beset those who were unhappily entangled in that wilderness of rocks which that noble structure now crowns as a beacon. When I looked down from the summit of the lofty tower, and traced the perils which, under the smooth surface of the ocean, lay stretching far and wide on every side like the snare of death, it was impossible not to feel admiration for the beneficent courage and the mechanical skill of the late distinguished engineer, Robert Stevenson of Edinburgh, which surmounted these difficulties, and turned into a source of security that which had been long the cause of danger and destruction. When I had satiated myself with the contemplation of the mechanical skill displayed in the construction of the Lighthouse—when I thought of the extraordinary resources both of wealth and talent that must have been accumulated to overcome such a tremendous difficulty, I naturally looked to the nature of the power by which such marvels had been achieved, and I found not a mere unenlightened body of what are called practical men, of persons who followed the road of experience, going always in some old track, and incapable of availing themselves of the progress of the age to perfect their feeble endeavours. I found I was among men who were able to teach me in many important facts regarding which I had sought in vain for information for years, and which I learned in the course of that excursion. In a conversation I held with the engineers of the Northern Lights, I learned much that was highly interesting, and much I know that will be valuable to me for future research; and when I was led to ask the question, "who are the controllers of this admirable system," I learned with surprise that the Commissioners of Northern Lighthouses are not a set of salaried functionaries, not a set of men whose professional habits might have led them to interest themselves in these pursuits, but a body of lawyers and municipal magistrates; and when I saw the unexampled perfection of their administrative system—when I saw the order and method that pervade all the details of their establishment, above all, the scrupulous integrity, and the diligent exactness of their administration, and the patriotic feelings which made them take from their own avocations so much time and labour to devote to public objects, then I felt more than ever I had done before, that you are the natives of a great and noble country—that this is not a common nation, and that such results can be experienced in no other portion of the world, nor often in this empire is this phenomenon to be found. And why? That was to me a matter of deep thought. What was the system—what were the circumstances that made it possible that from the bosom of society could be taken, as it were indiscriminately, a body of men capable of such achievements as these? In the answer, Sir, I found the source of the nation's glory and the nation's power. Hold by that source, and your nation's glory and power shall never pass away. Pursue, as you have ever done, knowledge in all its branches, inspired from the heart by a love for such pursuits of knowledge, and guided, as it has been till now, by a deep, profound, and all-pervading sense of religion. Join these two, and Scotland will never fail to be a great nation, and shall go on increasing in glory to the end of time,—(great applause.)

Professor Phillips moved the thanks of the meeting to Professors Kelland and Balfour, Mr James Tod, the local secretaries, and to Mr Brand, the local treasurer, from whose exertions, in a great measure, the meeting had passed off with a degree of harmony and satisfaction, which, he was sure, would prove an ample recompense for their labours.

Professor Kelland returned thanks.

The President's Concluding Address.

Sir David Brewster then said,—In closing the twentieth meeting of the British Association, I must congratulate you on the great success which has attended it. In order that a meeting for the advancement of science may be a successful one, many circumstances must concur. When the attendance is numerous, as on the present occasion, we obtain the pecuniary means of carrying on new investigations, in which, from their expense, philosophers cannot be expected to embark. In this way science is directly promoted, and new paths of research are opened up and made accessible to humble and unsupported inquirers; but, however important a numerous attendance may be, the character of the Association mainly depends on the number and value of the reports and communications made to the Sections. Both these causes had been happily combined in making our present meeting one of very considerable interest. Discoveries, indeed, of no small value, have been communicated for the first time at this meeting; and the most important of these by some of the younger members of the Association. To us older members, whose term of labour is about to expire, it is no slight gratification to mark the living genius which is now luxuriant around us, and promising by the fruit which it bears to maintain and extend the scientific and literary glory of the empire. Nor is it less interesting to us who live in a portion of the kingdom less favoured than the rest in point of wealth and endowments, to observe how actively science is often pursued under difficulties and embarrassments; and how minds of a high order put forth new energies in resistance to the very power which would otherwise crush and destroy them. In taking a retrospect of the intellectual condition of the past, there is a natural and commendable tendency to exaggerate, in any comparative estimate, the merits of our more immediate predecessors. This, doubtless, arises from the affectionate relation which exists between the teacher and the taught,—from the absence of all those rival feelings from which our prostrate nature is seldom wholly free; and from the respect which is always due, and ever paid to the illustrious dead. But without taking into account this influence over our judgment, I have no hesitation in saying, that however brilliant be the names, and glorious the memories of those eminent men who have adorned the Universities of our eastern and western metropolis, there never was a period in our history when their chairs were better filled,—their youth better instructed,—and science and literature more energetically advanced, than by the distinguished Professors who have taken such an active part in the business of the British Association. Among the bodies connected with the University of Edinburgh who especially merit this praise, I cannot avoid mentioning the College of Physicians and the College of Surgeons. Edinburgh has long been celebrated throughout the world for its medical school. During the last 50 years I have enjoyed the society of many of its most distinguished physicians and surgeons. I have received from them assistance and encouragement in my own researches when that encouragement was of much value; but I am bound to say, that at no period of the history of the medical art have the members of these two Colleges taken such a high place in their own profession, and in the allied sciences of Chemistry, Natural History, and Botany, as in the present day. The active part which they have taken in the proceedings of this Association, and the noble hospitality which they have extended to it, will never be forgotten while our Institution places upon record the generosity of its friends. In the distribution of praise, it is often unwise, and sometimes unjust, to dispense it individually; but I feel that my eminent colleagues around me, and even those whom it may personally affect, will excuse the error I may thus commit, if I name the distinguished President of the College of Surgeons, Professor Syme, who has earned our gratitude by the generous combination of hospitality and science. Scotland had lately occasion to lament his absence from her sanitary sphere, but she now welcomes him back from his brief but voluntary exile, to pursue with new ardour the profession which he adorns, and to enjoy in his Tusculan villa the enviable blessings of social and domestic life. From the present let us now look to the future. From Edinburgh we pass to Ipswich, in the vicinity of the metropolis, where a peculiar combination of circumstances cannot fail to make the next meeting of the British Association one of high interest. Great numbers of British and of Foreign philosophers may be expected on that occasion; and we are confident that, under the able Presidency of Mr Airey, our illustrious Astronomer Royal, to whom every branch of the physical science owes much deep obligation, the meeting at Ipswich will be one of the most successful that has yet been assembled.

After a cordial and unanimous vote of thanks to Sir David Brewster, the chief of this eminently successful session of the British Association, the meeting adjourned to Ipswich in 1851.

Conclusion of the Proceedings of the British Association for 1850.

Excursions.

During the meeting of the British Association several excursions to interesting localities were made, chiefly with a view of inspecting the geognostical phenomena near to Edinburgh. The parties were much gratified and instructed by what they saw.

Lectures.

Two lectures were given, one by Dr Bennett on the evening of Thursday, 1st of August, "On the passage of the Blood through the minute vessels of animals in connection with Nutrition:" the other by Dr Mantell "On the Extinct Birds of New Zealand." Both lectures were listened to with deep attention by very numerous audiences. Mr Nasmith also exhibited very beautiful drawings and relief representations of the surface of the moon, which he described in a very interesting manner.

Promenades and Conversations.

Two evenings, viz., the 2d August and Tuesday evening the 6th of August, brought together brilliant and very numerous assemblages of the members of the Association in the Music Hall and great Assembly Room.

Notes on the Geology of the Southern Extremity of Cantyre, Argyllshire. By James Nicol, F.R.S.E., F.G.S., Professor of Geology, Queen's College, Cork. Communicated by the Author.*

The peninsula of Cantyre is very remarkable both for its geographical and geological peculiarities. Its general direction from north to south differs greatly from the usual range of the Scottish mountains from NE. to SW. At Tarbet, it is connected with the mainland by an isthmus only a mile in breadth, and were the land depressed a few feet, it would be changed into several islands. The great formation of mica slate, which runs nearly SW. along the border of the Grampians, through the whole of Scotland, in this place seems to turn to the south, whilst the clay slate resting upon it disappears on the east side of the granite of Goatfell in Arran. The geology of this district has, however, been scarcely noticed, ex-

* Read to the British Association in 1850.

cept in some incidental remarks in the works of Professor Jameson and Dr Macculloch.

The oldest or fundamental rock of the district examined is mica slate, forming the wild country round the Mull of Cantyre, the mountain Bengollion, near Campbeltown, and the high ground north of that town. It is generally a light grey arenaceous rock, often more resembling a micaceous sandstone than the typical mica slate of the northern Highlands. The beds are also less contorted, and dip at a low angle, or about 30° on an average, to the east, or a few degrees south of east. Occasionally it is connected with a dark-coloured large-granular crystalline limestone in numerous beds. In Knock Scalbert, north of Campbeltown, this limestone series seems to differ in direction from the mica slate, the beds running NE. by N., and hence may probably form a distinct, perhaps newer part of the series. The primary rocks are followed by red sandstone and conglomerate which often rest almost conformably on the older strata. This is seen in Knock Scalbert, on the north shore of the harbour, very markedly in Glenramskill Burn, and at the south of the peninsula near Keills. In all these places the dip and direction of the two formations approximate as closely as that of the separate beds of each. The conglomerate is often of immense thickness, and consists of rounded blocks, varying from three feet or more to a few lines in diameter, imbedded in a red sandy basis. The blocks have a very local character, being in some places almost exclusively a clove-brown porphyry—in others hard sandstone or hornstone—in others quartz or trap rocks. It is remarkable that no fragments of the mica slate on which they rest, or of other primary rocks, were observed in these conglomerates. The red sandstone, especially on the east and south-east coast, is often almost a tufa, composed of the same materials with the claystone porphyries, with which it is, in part at least, contemporaneous. The coal formation occurs chiefly to the west of Campbeltown, in the low tract named the Laggan of Cantyre. The true character of this formation, as a detached portion of the central coal-field of Scotland, was pointed out by Professor Jameson in his travels in Scotland. Dr Macculloch, in his Western Isles, seems to have adopted the same opinion, but afterwards in his map coloured it as lias. The impressions of *Lepido-dendron*, *Sigillaria*, *Stigmaria*, and other plants found in the coal, and in the connected shales and sandstones, prove its true age, and no trace whatever of the lias has been found in this part of Scotland. The coal deposits are broken through by dykes of trap, and are also overlaid by igneous rocks on the shore near Losset and in Tirfergus burn. The igneous rocks are principally claystone and felspar porphyries, which form a broad band across the country from Kilkivan and Losset on the west, to Macharioch on the east, in the region coloured by Macculloch as mica slate. In this tract fragments of altered limestone and sandstone of the coal formation often occur, imbedded in the porphyry. Augitic trap rocks are common, especially in the high ground to the east of Southend church, and associated with the limestone series north of Campbeltown harbour. These rocks are of very different ages, veins of one variety of trap often penetrating beds of another kind, as near Losset and at Kilchousland. At the latter a vein of dark greenstone, divided into columns nearly horizontal, intersects a mass of light grey trap, in some places highly concretionary and divided into verticle columns, separated from each other by thick veins of hæmatite and green carbonate of copper. In the Laggan of Cantyre west of Campbeltown, a tertiary deposit occurs, consisting of peat, with large trunks of trees, covered by beds of red and white clays and gravels. The wood is chiefly oak or birch, and the peat contains leaves of forest trees and hazel nuts. It seems a lacustrine deposit drained during the recent elevation of the land. It rests in the hollows of the red boulder clay with striated blocks, which is in part overlaid by shingle beds, formed of round water-worn stones, gravel, and sand. This deposit much resembles the lignite and drift deposits seen on the coast of Norfolk, and is probably of the same age. The last change of level in the sea and land is marked by a line of cliff surrounding the whole peninsula, and in many places hollowed out into immense caves—some in the hard porphyries of Davar island, measuring 130 feet in length.

Some of the general results of this investigation seem very interesting. The peculiar arenaceous character of the mica slate, intermediate between the crystalline rocks of the more northern Highlands, and the silurian beds of the south of Scotland. The amount of limestone beds in some parts of the series—the diversity in its dip and direction from the mica slate series in the north, would indicate that this rock belongs to a different group. In a paper read to the Geological Society of London, the author formerly stated that the mica and clay slates on the southern border of the Grampians were probably the northern synclinal of the great trough in which the central coal formation was deposited, and of which the silurian rocks in the south were the other limb. The latter are chiefly of lower silurian age. Hence he concludes that the metamorphic slates of Cantyre are probably altered upper silurian or Devonian beds, and that the great mica slate formation of Scotland will eventually require to be broken up into several divisions. The introduction of the great overlying mass of trap and sandstone into the region coloured by Macculloch as mica slate, renders this part of Cantyre closely analogous to the south of Arran. It also completes the band of igneous rocks, which, commencing on the shore of the German Ocean, near Montrose, is now shown to extend across the whole of Scotland to the Atlantic, and even into the north of Ireland.

Notes of Professor Edward Forbes' Excursion to the Hebrides. Communicated by the Author.

We visited Loch Staffin in Skye, to examine the fresh, or brackish water strata, discovered by Sir Roderick Murchison, and supposed to be equivalents of the English Wealdens. Favourable circumstances enabled me to determine their exact position. They rest upon the great sheet of columnar basaltic trap, which covers the oolitic sandstones, limestones, and shales (the uppermost portion of which beds have been referred to the cornbrash), of the coast of Skye, from Portree to Loch Staffin. They are covered by beds of shale and clay abounding in Belemnites and Ammonites, all characteristic Oxford clay species, and in beautiful preservation. The Oxford clay underlies the great mass of amygdaboidal and other traps, which form the picturesque line of hills from the Stove to the Guiraing, above Loch Staffin. The brackish-water beds of the latter locality are consequently exactly equivalent to similar beds observed by Mr Robertson at Brora.

The dredge did not bring up any new testaceous mollusca during our cruise. Near Croulin Island, however, when dredging on the pleistocene clay or mud bed at a great depth, among other fossils we procured a broken shell of the *Nucula thraciæformis* of Gould, hitherto known only as a recent North American species. In the same neighbourhood we dredged a magnificent addition to our marine molluscous fauna, in the shape of a gigantic compound Ascidian of the *Clavelina* group.

In the Minch and at Croulin, we dredged a very fine Holothurian of the genus *Fistularia*, quite distinct from any known British species. Also a second species of *Sarcodictyon*.

With the tow-net we were very fortunate. In the sound of Mull we procured a new species of *Slabberia*, a new genus allied to *Sarsia*, three new species of *Hippocrene*, two species of *Diphyes* (*D. truncata*, and *D. biloba* of Sars), and two forms of Physograde medusæ.

In the Minch we met with several examples of a beautiful and very large *Equorea*, a genus new to Britain, also the *Arachnactis albida*, a remarkable swimming Actinea, discovered by Sars in the Norwegian seas, and now added to the British fauna. EDWARD FORBES.

Observations on Three Skulls of Naloo Africans. By RICHARD OWEN, F.R.S., Hunterian Professor of Comparative Anatomy in the Royal College of Surgeons.* Communicated by the Ethnological Society.

These skulls have belonged to mature but not aged individuals: two (A and B) are male; the third (C) appears to be a female. They shew no trace of disease. According to Camper's method the facial angle of the skull B is 70°, that of C is 67°, while that of A does not exceed 65°. All exhibit the prognathic character in its extreme degree, but it is less marked in B, owing to the minor development of the incisive alveoli, to which also the difference in the facial angle is chiefly attributable.

By the "vertical" or Blumenbachian method of comparison, the oval is long, narrow, much contracted anteriorly; but in this respect the skull B has the advantage, and shews a greater fulness of the frontal region.

In the anterior comparison, or by "Pritchard's method," the two tangential lines carried from the malar prominence upwards meet much sooner in A, than in B or C. The individual differences in this respect being so great, especially in A and C, as to affect the value of this mode of comparison in its relation to the characteristics of race.

The comparison, according to the basal method, shews the same degree of posterior position of the foramen occipitale, as compared with the Indo-European or American races which the majority of Ethiopian skulls manifest; and also the same advanced position of the alveolar area, in relation to the zygomatic arches. The extent to which the latter arches are occupied by the outline of the cranium behind, is rather greater in B than in A and C, but is in

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* Read before the Ethnological Society, 25th April 1849.

a marked degree less in all than in the Indo-European family. The basi-occipital is long and straight; this inferior character is well marked in A.

The molar teeth have the characteristic superiority of size of the lower Ethiopic races in A and C, but they are smaller in B; and it is interesting to find this approach to the higher races accompanying the more open facial angle and the fuller oval contour of upper region of the cranium; the teeth are also less worn, which would lead to the conjecture that the individual had been of higher rank than A.

The par-occipital processes (marked with a + in ink) are unusually clearly developed in A and C, on both sides; when present in Europeans it is a rare anomaly and usually on one side only. It is an interesting manifestation of a character common in the skulls of brutes, where the par-occipitals generally take the function of the mastoids, and are called mastoid by Cuvier and De Blainville.

The par-occipital process is to be distinguished from that angle of the occipital which completes the foramen jugulare, and which Bourgery depicts as the "processus jugularis" of the French school of Anthropotomists.

The superior occipital ridge is well marked in the two male skulls; in all the supra-occipital swells out behind or beyond that ridge.

The malar bones are protuberant, and the orbital boundary is less sharply defined than in higher races of mankind, they are more rounded off, which is an approach to the large apes.

The internal nasal suture is obliterated in A. The glabella is prominent in all, but less so than in the Australian skulls, from which likewise the Naloo skulls differ in the larger proportion in which the ali-sphenoid unites with the parietal.

As in all Ethiopian skulls the cranial sutures are less complex, and more obliterated considering the age of the specimens. Again, however, this character is less marked in the skull B.

There is a trace of the frontal suture above the nasal bones in C; and in the female skulls of other races this immature character is more frequently retained than in the males. As individual peculiarities there may be noticed the deep and almost symmetrical grooving of the frontal bone by the supra-orbital nerves and vessels in A. The same character is more feebly repeated in C.

The general cranial characters of the Ethiopian race are manifested in all, by the narrow anteriorly contracted oval cranium, by the prognothic jaw, and by the protuberant cheek-bones; but they are most strongly marked in A and C, except that the cheek-bones shew the sexual inferiority of development, together with the weaker zygomata in the female skull C.*

On the Succession of Strata and Distribution of Organic Remains in the Dorsetshire Purbecks. By Professor EDWARD FORBES, F.R.S.† Communicated by the Author.

During the autumn of 1849, Professor E. Forbes was deputed by the Director-General of the Geological Survey, Sir Henry De la Beche, to examine the organic remains of the Purbeck strata in Dorsetshire, and to investigate their distribution *in situ*, acting in co-operation with Mr Bristow, the officer engaged in constructing the geological map of the district. The results of this enquiry were so novel and curious, that it was thought by the Director-General desirable, before publication in an extended form, to lay them before the British Association, in the hope that, by such a course, attention may be directed to similar phenomena in freshwater formations in other districts.

Our knowledge of the Dorsetshire Purbecks has been derived chiefly from the memoirs by Professor Webster, Dr Fitton, Sir H. De la Beche, Dr Buckland, and Dr Mantell. With the exception of certain Vertebrata (reptiles and fishes) we owe to Dr Fitton our information respecting their fauna. No minute investigation of the strata in connection with their organic contents had, however, been undertaken, nor had the latter been collected to any extent, as may be seen when the published lists, including about 12 species of Mollusca and Crustacea from these beds, are compared with those now submitted to the section, in which more than 70 members of those classes are enumerated. This increased catalogue is not merely of

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* Dr Cull's Observations on the Naloo Skulls will appear in our next Number.

† The above is a more particular account of the Dorsetshire Purbecks delivered at the late meeting of the British Association, and already noticed in a very general way at page 311.

value on account of the great number of species; it is remarkable on account of the new and interesting light it throws on the distribution of freshwater creatures during the oolitic period.

The points at which these observations were made were Lulworth Cove and the neighbouring bays, Warbarrow Bay, on one side of which, at Meup's Bay, is the clearest and most complete of all the Purbeck sections, Osmington, Upway, and Ridgeway, between Weymouth and Dorchester and Durlestone Bay, near Swanage. Subsequently the base of the Purbecks, as exposed in the great Portland quarries at Swindon, a section which had previously been examined and accurately described by the Rev. J. Brodie, was visited and found to correspond exactly in mineral characters and organic contents, with the beds at the base of the Purbecks in Dorsetshire. From all these localities ample collections were made, in which the author had the constant assistance, for several months, of Mr J. Gapper, of the Geological Survey.

The results of these researches, whether new, or confirmatory of older observations, may be stated briefly as follows:—

1*st*. There is no passage from the Portlands into the Purbecks. The top beds of the Portland stone are purely marine: the lowermost beds of the Purbeck are purely freshwater, containing *Cyprides*, and species of *Valvata* and *Limneus*. At Meup's Bay these lowest freshwater beds, forming the "Cap," occupy a thickness of a little more than 8 feet, and are surmounted by the great dirt-bed, containing the stools of Cycadaceæ. A little above the great dirt-bed is another less developed, and a similar one occurs in many places below it.

Above the highest dirt-bed, the cypridiferous shales, which follow, are strangely contorted and broken up in all the sections at the west end of the isle of Purbeck. These are capped by undisturbed beds full of Cyprides, succeeded by 20 feet or more of shales, calcareous slates, marls, and limestones, with occasionally siliceous bands, all for the most part deposited in brackish water, and filled in many places with *Rissoæ*, of the subgenus *Hydrobia*, and a little *Cardium*, of the subgenus *Protocardium*. Many of these beds abound in a species of *Serpula*, closely allied to, if not identical with, *Serpula coacervites* of the German Purbecks. There are above 30 feet of these brackish-water beds at Meup's Bay. They are capped by purely freshwater marls, containing the same species of *Cypris*, *Valvata*, and *Limneus*, as occur in the lowest bed of the Purbecks.

Suddenly, without any disturbance, a change takes place. A very thin band of greenish shales, full of impressions of leaves like those of a large *Zostera*, and with traces of marine shells, cuts off the freshwater strata. Immediately, however, new freshwater beds succeed, filled in many places with fossils, species of Cypris, Valvata, Paludina, Planorbis, Limneus, Physa, and Cyclas, all different from any he had previously seen in the lower beds. Thick bands of cherty stone, filled with these fossils in a beautiful state of preservation, occur, and among them are, for the first time, in the oolitic series, *Gyrogonites*, the spore-capsules of Charæ. Immediately above these interesting bands (in which many remains of fish were also found) is the great and conspicuous stratum, long familiar to geologists under the local name of "Cinder-bed," formed of a vast accumulation of the shells of *Ostrea distorta*. On the summit of this bed, the author discovered the first Echinoderm ever seen in the Purbecks. It proved to be a species of *Hemicidaris*, a genus characteristic of the oolitic period. It was accompanied by a species of *Perna*. The cinder-bed is succeeded by limestones and shales, partly of freshwater, partly of brackish-water origin. In these, the same species of Cypris occur, which mark the shaly bands near the chert below the cinder.

Many fish, especially species of *Lepidotus* and *Microdon radiatus* are found in these sands; and in the fine collection of Mr Wilcox of Swanage, are the heads of two magnificent species of the reptile *Macrorynchus*, resembling, but distinct from that described by Von Mayer, from this horizon in the Purbecks. Among the Mollusks, a remarkable ribbed *Melania*, of the section *Chilina*, is found here. After the deposition of these strata, there came another powerful influx of the sea, introducing marine species, *Pectens*, *Modiolæ*, *Aviculæ*, and *Thraceæ*, all undescribed forms. Brackish-water strata full of *Cyrena*, and traversed by bands abounding in *Corbulæ* and *Melaniæ* are next in order: in them is a *Protocardium*, a large species quite distinct from its representative species in the lower portion of the Purbecks. Limestones with Cyprides, Turtles and fish, crown these brackish-water bands, and are specifically connected with the beds of the middle Purbecks below them.

Lastly, a third series of freshwater strata commences with a new series,—*Cyprides*, *Paludinæ*, *Physa*, *Limneus*, *Planorbis*, *Valvata*, *Cyclades*, and *Unio*, and new forms of fish. These continue until they merge into the base of the Hastings sands, and the Purbeck series is completed. The total thickness of all the Purbecks at Meup's Bay is about 155 feet. Of this, one-half is occupied by the lower portion of the series, and the remainder is divided between the middle and upper portions, the former being rather the more extensive.

It is very remarkable, that whilst we can strictly divide the Purbecks into upper, middle, and lower, each marked by a peculiar assemblage of organic remains, the lines of demarcation between these sections are not lines of disturbance, nor indicated by striking physical characters or mineral changes. The features which attract the eye in the Purbecks, such as the dirt-beds, the dislocated strata at Lulworth, and the cinder-bed, do not indicate any breaks in the distribution of organized beings. The causes which led to a complete change of life three times during the deposition of the fresh-water and brackish strata of the Purbeck series, must be sought for, not simply in either a rapid or a sudden change of their area into land or sea, but in the great lapse of time which intervened between the epochs of deposition at certain periods during their formation.

A most striking feature of the Molluscan fauna of the Purbecks is this;—so similar are the generic types of these Mollusca to those of tertiary freshwater strata and those now existing, that, had we only such fossils before us, and no evidence of the infra-position of the rocks in which they are found, we should be wholly unable to assign them a definite geological epoch.

An examination and comparison of these Purbeck fossils with the collections from the Hastings sands, and Wealden in the Museum of the Geological Society (to which they were chiefly presented by Dr Fitton), and in the cabinet of Dr Mantell, leads the author to believe that the fauna of the middle and upper divisions of the Wealden series is, so far as species are concerned, almost entirely distinct from that of the lower or Purbeck division. Many of the species reputed to be common to the whole series, are found on inquiry to include more species than one under one name, whilst some other forms recorded as Wealden, but, so far as the author has observed, peculiar to the upper Purbecks, and occupying only a limited horizon in that part of the series, are derived from certain anomalous strata near Tunbridge Wells, which the author believes will prove, on closer examination and accurate survey, to be Purbeck strata brought up among the true Wealden by faults. The excellent monograph on the Wealdens of North Germany by Dunker and Von Mayer, in which a vast number of species of animals and plants are described and accurately figured, affords the strongest confirmation of this view, and shows that while the fauna of the German Weald clay and Hastings sands corresponds in essentials with that of the same formations in Britain, the Purbecks of the Continent, just as here, differ from the superior beds almost entirely in their organic contents, and correspond with similar beds in our own series.

The marine or brackish-water bands in Germany, containing *Ostrea Fittoniana*, appear to be represented in England by corresponding bands with the same fossils, and accompanied by species of *Corbula*, *Cardium*, and *Melania*, in the upper part of the Hastings sand at Swanage. All the investigations of the author so far, have gone to indicate the probability of the presence of several distinct assemblages of organic remains (similar to those which he has shewn to exist in the Purbecks), in the higher portions of the Wealden series of formations, whilst the true position of these strata is shewn, without a question, to be in connection with the Oolitic or lower, and not with the Cretaceous or upper division of the secondary rocks.

Classification of Mammals, Birds, Reptiles, and Fishes, from Embryonic and Palæozoic data.

The principle, says Agassiz, which has regulated our classifications in zoology for the last half century, is that which Cuvier worked out by his anatomical investigations; I mean the arrangement of the whole animal kingdom according to the natural affinities of animals as ascertained by the investigation of their internal structure. This fruitful principle, applied in various ways, has produced a series of classifications, agreeing or differing more or less in their outlines, but all resting upon the idea, that a certain amount of anatomical characters may be easily ascertained, expressing the main relations which exist naturally among animals, and affording a natural basis for classification. Structure, therefore, internal as well as external, is, according to the principles of Cuvier, the foundation of all natural classifications; and, undoubtedly, his researches, and those of his followers, have done more in the way of improving our natural methods, than all the efforts of former naturalists put together, and this principle will doubtless regulate, in the main, our further efforts.

Nevertheless, so much is left in this method to the arbitrary decision of the observer, that it would be in the highest degree desirable to have some principle by which to regulate the internal details of the edifice.

We may indeed form natural divisions simply from structural evidence, bring together all fishes as they agree in the most important details of their structure, and combine all reptiles into one class, notwithstanding the extreme differences in their external form. We may also recognise the true affinity of whales, and bring them together with other mammalia, notwithstanding their aquatic habits and their fish-like form; we may even subdivide those classes into inferior groups upon structural evidence, and thus introduce orders, like the Quadrumana, Carnivora, Rodentia, Ruminantia, &c., &c., among Mammalia. But we are at once at a loss how to determine the relative value of those groups, and to find a scale for the natural arrangement of further subdivisions. After having, for example, circumscribed the Carnivorous Mammalia into one natural family, how are we to group the minor divisions like that of the swimming Carnivora, the Plantigrada, and the Digitigrada; or, after circumscribing the reptiles into natural groups like those of Chelonians, Saurians, Ophidians, and Batrachians, how shall we, for instance, arrange the various types of Batrachians? To those who have been familiar with our proceedings in all these attempts, it must be evident that the grouping of our subdivisions have been almost arbitrary and entirely left to our decision without a regular guide. We have, it is true, subdivided the Batrachians into the more fish-like forms which preserve their gills and tails, or at least their tails; and into another group containing those which undergo a complete metamorphosis; but it has not yet occurred to naturalists to take this metamorphosis as the regulating principle of classification, to arrange genera according to their agreement with certain degrees of development, in the natural order of changes which the higher of these animals undergo. Now, it is my firm belief, that such a new principle can be introduced into our science; that methodical arrangement may be carried into the most minute details, without leaving any room for arbitrary decision. Proteus, Menobranchus, Amphiuma, Triton, Salamandra, will hereafter have a natural place in our classification, which will be commanded by embryology, and no longer be left to a vague feeling, that aquatic animals are lower than amphibious and terrestrial ones, and that the retaining of the gills indicates a lower position than their disappearance.

Of course, in the outset, we do not find sufficient data to trace this arrangement throughout the animal kingdom, and to make the principle which I have just mentioned the ruling law of classical arrangement. But until such sufficient knowledge is acquired, let me shew that my principle does in fact apply to all classes of the animal kingdom, and will at once contribute to improve all their subdivisions. Among Mammalia, for example, we shall continue to give the aquatic carnivorous animals a lower position among Carnivora, but no longer simply because they are aquatic, but because they are web-footed, as the web-foot is the earlier form of the limbs in all mammalia whose embryonic development has been traced. We shall be led, for similar reasons, to deny the Bats the high position which has been assigned to them, and to combine them closer with the Insectivora. We shall separate the Manatees from their present relations, and combine them with tapirs, elephants, &c., as they are rather web-footed Pachyderms, than true Cetaceans.

Among birds we shall also avail ourselves of the discovery I made last year, that embryos of birds have web-feet and web-wings, and no longer consider Palmipedes as forming a natural group by themselves, but allow the possibility of having several natural groups of birds, beginning each with web-footed forms. Every one who is conversant with the natural history of birds, must have been struck with the great diversity of features in birds united in our systems under the head of Palmipedes. Taking all birds together, we hardly notice among them greater differences than those which exist between the various families of Palmipedes, which are, confessedly, brought together upon no other character than the webbed form of their feet; though among them we have birds of prey, such as the gulls, and others, which seem to stand by themselves unconnected, and without any analogy with any other family, such as the swans, geese, and ducks; and again, the pelicans and the genera allied to them, and also the divers. It can hardly be understood why birds so widely different should be brought together; and, indeed, their reunion would long ago have been given up, had it not been for the difficulty of finding characters to separate them, and for the strong impression that the similarity of the structure of their feet should overrule the other characters.

But now, since it is known that birds of the most heterogeneous character in the structure of their legs, in their adult form, have, when very young, identical legs, whether they belong to the tribe of hawks, or to that of crows, or to that of sparrows, or to that of swallows, or to that of pigeons, or to that of hens, or to that of waders, or to that of true Palmipedes,—when we know all these types to have an identical development of their legs, and, I may add also, of their wings,—for the young wing is equally a small webbed fin,—there can be no longer any doubtless upon the impropriety of combining any two families of adult birds solely on the ground of their legs having webbed feet.

It is a fact too well known in zoology, that different families will repeat, in the same class, the characteristic changes which are peculiar to the whole family, to require any further argument to shew that Palmipedes are not necessarily a natural division ; and though we may fail for the present in re-arranging the families of this class into natural orders, I trust after these remarks, more importance will yet be attached, and more attention paid in future, to the fact that Palmipedes, as they are now characterized, have very different types of wings and bills. I have, for my own part, been strongly impressed with the resemblance which exists between gulls and frigate birds, and the birds of prey of the hawk and vulture families, in which the toes are by no means so completely distinct as they are among other birds. And, far from considering birds of prey as the highest family amongst birds, I would only consider them as highest in the series which includes simultaneously Procellaridæ and Laridæ. Whether the family of pelicans belongs to this group or not, I am not prepared to say ; but, at all events, the fact of their possessing their four toes in one continuous web shews them to rank lowest among birds.

Again, among reptiles there will no longer be a foundation for any arrangement resting merely upon impressions ; thus the terrestrial turtles will stand higher than the freshwater, and those again higher than the marine ; and among Batrachians, which are best known in their embryology, we can already arrange all the genera in natural series, taking the metamorphosis of the higher as a scale, and placing all full-grown forms in successive order, according to their greater or less resemblance to these transient states. Even the relative position of toads and frogs may be settled with as much internal evidence as any other question of rank in wider limits, merely upon the difference of their feet.

In my researches upon fossil fishes I have, on several occasions, alluded to the resemblance which we notice between the early stages of growth in fishes, and the lower form of their families in the full-grown state, and also to a similar resemblance between the embryonic forms and the earliest representatives of that class in the oldest geological epochs; an analogy which is so close, that it involves another most important principle, viz., that the order of succession in time, of the geological types, agrees with the gradual changes which the animals of our day undergo during their metamorphoses, thus giving us another guide to the manifold relations which exist among animals, allowing us to avail ourselves, for the purpose of classification, of the facts derived from the development of the whole animal kingdom in geological epochs, as well as the development of individual species in our epoch. But to this most fruitful principle I shall have hereafter an opportunity of again calling attention.—*Agassiz on Lake Superior*, p. 191.

SCIENTIFIC INTELLIGENCE.

GEOLOGY.

1. *First Geological Appearance of Coniferæ.*—Coniferæ (Pine family), remarkable for the apparently whorled arrangement of their branches, and for their evergreen leaves; in most cases they form hard *cones*, but one has soft, berry-like fruit. The seeds are naked, winged, resting on the scales. The leaves are peculiar, the nerves not being spread, but often gathered into compact bundles. The Coniferæ existed at a very early geological epoch. This was the first family that became numerous after the ferns. Their remains are easily recognised under the microscope by the circular disks on their wood cells.

2. *A Proof of the Correctness of the Glacial Theory.*—Professor Agassiz, before starting, showed us a rock at the south entrance of the bay, which he considered a proof positive of the correctness of the glacial theory. Its surface was a couple of hundred yards in extent, sloping regularly north to the water's edge. The whole was polished and scratched, except where disintegrated. The scratches had two directions, the prevailing one north 10° to 30° west, the other north 55° west. The scratches on the outer or lake-side, seemed to have a rather more westerly direction than the rest. Great numbers of these striæ could be traced below the water's edge, from which they ascended in some places at an angle of 30° with the surface, showing, as the Professor remarked, that they could not have been produced by a floating body. The rock is granitic, with an astonishing number of veins and injections of epidotic felspar, granite, and trap, often crossing each other so as to form a complicated net-work. Wherever exposed, it was ground down to an even surface.—*Agassiz on Lake Superior*, p. 50.

ZOOLOGY.

3. *New Fishes from Lake Superior.*—Professor Agassiz gave an account of two new fishes obtained by him at Lake Superior, which he regarded as types of two new genera. The first is an entirely new type in the class of fishes. It is a small fish, five or six inches long, which, in some respects, resembles several families, but is most like the Percoids, though distinct from them. Fossil species with similar characters are found in the cretaceous formation. This is the second, Professor Agassiz remarked, of the "old fashioned" fishes, so to speak, corresponding in their structure to a fossil species, which has been observed in this country. The other fish is the only living representative of a large family of fossil species. The existence of these two species has undoubtedly reference to the fact, that America is the oldest extensive continent which has been upheaved above the level of the sea. In New Holland, two genera exist bearing similar relations to older families, a fish and a shell, which have their analogues among the oolitic deposits.—*Proc. Boston Nat. Hist. Society. American Annual of Scientific Discovery*, p. 310.

MISCELLANEOUS.

4. *Resources of Russia.*—The metallic produce of the Russian empire in 1848 was, according to the official returns, as follows, viz.:—1826 poods of gold; ¼ pood of platinum; 1,192 poods of silver; 254,569 poods of copper; and 8,513,673 poods of wrought iron. The pood is equivalent to a little more than 36 lbs. avoirdupois. The gold from Russia, therefore, represents a value of £3,944,832, making allowance for the English alloy.

5. *Use of Anæsthetic Agents during Surgical Operations at an early period, by the Chinese.*—Stanislas Julien has found, in examining the Chinese books in the National Library at Paris, the proof that the Chinese have been long acquainted with the use of anæsthetic agents during surgical operations. The extract which he gives is from a book published about the commencement of the sixteenth century, in fifty volumes quarto, and entitled, "Kou-Kin-i-tong"—*General Account of Ancient and Modern Medicine,*—and refers to the practice of a celebrated physician, Ho-a-tho, who flourished between the years 220 and 230 of our era. It states that, when about to perform certain painful operations, "he gave the patient a preparation of hemp" (Hachich), and that at the end of a few moments "he became as insensible as if he had been drunk or deprived of life." After a certain number of days the patient was cured, without having experienced the slightest pain during the operation. In a subsequent notice, he also shews that the same physician used the hydropathic system as a cure for certain diseases; among others chronic rheumatism.

6. *Analogy between Alpine and Arctic Vegetation.*—There is no animal, and no plant, which in its natural state is found in every part of the world, but each has assigned to it a situation correspond-

ing with its organization and character. The cod, the trout, and the sturgeon, are found only in the north, and have no antarctic representatives. The cactus is found only in America, and almost exclusively in the tropical parts. Humboldt, to whom the earliest investigations on this subject are due, extends the principle not only to the distribution of plants according to latitude, but also according to vertical elevation above the surface of the earth in the same latitudes. Thus an elevation of 14,000 feet under the tropics corresponds to 53° north latitude in America, and 68° in Europe. The vegetation on the summit of Mount Etna would correspond with that of Mount Washington, and this again with the summits of the Andes and the level of the sea in the Arctic regions. In the ascent of a high mountain, we have, as it were, a vertical section of the strata of vegetation which "crop out," or successively appear, as we advance towards the north over a wide extent of country.

But in dwelling on the resemblances between the plants of high latitudes and those of high mountains, we must not lose sight of their not less constant differences. In the northern regions in general, we find the number of species comparatively small. Thus, in the region through which we have passed, and which has already a northern character, we find vegetation characterized by great vigour; the whole country covered with trees and shrubs, and lichens and mosses in great profusion, but the species few, and the proportion of handsome flowering shrubs small. In the Alps, on the other hand, vegetation is characterized by great beauty and variety, and the number of brilliantly flowering plants, of Gentianaceæ, Primulaceæ, and Compositæ, is very great. The plants, however, are dwarfish, and vegetation comparatively scanty; the lichens and mosses much less abundant. There is, then, not an identity, but an analogy only, and an imperfect though very interesting one, between Alpine and Arctic vegetation.—*Agassiz on Lake Superior*, p. 89.

7. *The Kirkwood Analogy.*—The following letter to Professor Piazzi Smyth from Mr S. M. Drach of Hampstead, we insert as received, deferring, from want of space, any observations on this important topic until a future opportunity:—

"Dear Sir,—My attention having been directed to an article in the last part of the Edinburgh New Philosophical Journal, signed P. S., on Kirkwood's new presumed analogy of the planetary rotations and limits of gravitating influence, I beg to refer to the London 'Philosophical Magazine' for January 1841, especially paragraph 5, page 40, wherein I shewed that the period of rotation of a primary planet supposed to extend to the surface where its attraction—centrifugal force—is precisely that of a satellite moving at the same distance as deduced from the actual satellites. There are several other curious analogies in this paper which may possibly repay perusal.

"By noticing this communication in the next number of the Edinburgh New Philosophical Journal, you will much oblige, yours truly,

"S. M. Drach.

"To Professor Piazzi Smyth."

List of Patents granted for Scotland from 22d June to 22d September 1850.

1. To William Watson, the younger, of Chapel Allerton, in the parish of Leeds, in the county of York, manufacturing chemist, "improvements in the preparation and manufacture of various materials to be used in the processes of dyeing, printing, and colouring."—18th June 1850.

2. To William Edward Newton, of the Office of the Patents, 66 Chancery Lane, in the county of Middlesex, civil engineer, "improvements in rotary engines;" being a communication from abroad.—21st June 1850.

3. To James Ward Hoby, of Blackheath, in the county of Kent, engineer, "certain improvements in the construction of parts of the permanent way of railways, and in shaping iron."—21st June 1850.

4. To William Wood, of Over Darwen, Lancashire, carpet-manufacturer, "improvements in the manufacture of carpets and other fabrics."—24th June 1850.

5. To Moses Poole, of the Patent Office, London, gentleman, "improvements in machinery for punching metals, and in the construction of springs for carriages and other uses;" being a communication from abroad.—28th June 1850.

6. To Peter Armand le Comte de Fontaine Moreau, of 4 South Street, Finsbury, in the county of Middlesex, patent agent, "certain improvements in the manufacture of sulphate of soda, muriatic, and other acids;" being a communication from abroad.—3d July 1850.

7. To Thomas Dickason Rotch, of Drumlamford House, in the county of Ayr, Esquire, "an improved mode of manufacturing soap;" being a communication from abroad.—3d July 1850.

8. To Robert Andrew Macfie, of Liverpool, in the county of Lancaster, sugar-refiner, "improvements in manufacturing, refining, and preparing sugar, also improvements in manufacturing and treating animal charcoal."—10th July 1850.

9. To William Cormack, of No. 60 King Street, Danston Road, Haggerstone, in the county of Middlesex, chemist, "certain improvements in purifying gas, also applicable in obtaining or separating certain products or materials from gas-water and other similar fluids."—10th July 1850.

10. To Richard Roberts, of Manchester, in the county of Lancaster, engineer, "improvements in the manufacture of certain textile fabrics, in machinery for weaving plain, figured, and terry or looped fabrics, and in machinery or apparatus for cutting velvets and other fabrics."—12th July 1850.

11. To James Thomson, of Glasgow, in the county of Lanark, civil engineer, "improvements in hydraulic machinery, and in steam-engines."—17th July 1850.

12. To John Stevenson, of Roan Mills, Dungannon, county Tyrone, flax-spinner, "certain improvements in machinery for spinning flax and other substances."—17th July 1850.

13. To Tempest Booth, of Ardwick, in the county of Lancaster, gum-

manufacturer, "certain improvements in the method of, and apparatus for, obtaining and applying motive power."—17th July 1850.

14. To Peter William Barlow, of Blackheath, in the county of Kent, civil engineer, and William Henry Barlow, of Derby, civil engineer, "improvements in the permanent ways of railways."—22d July 1850.

15. To Richard Archibald Brooman, of the Patent Office, 166 Fleet Street, in the city of London, patent agent, "improvements in types, stereotype plates, and other figured surfaces for printing from."—26th July 1850.

16. To Donald Beatson, of Stepney, in the county of Middlesex, mariner, "certain improvements in instruments, for taking, measuring, and completing angles."—29th July 1850.

17. To Joel Spiller, of Battersea, in the county of Surrey, engineer, "improvements in cleaning and grinding wheat and other grain."—29th July 1850.

18. To William Edward Newton, of the Office for Patents, 66 Chancery Lane, in the county of Middlesex, civil engineer, "improvements in machinery or apparatus for making hat bodies, and other similar articles;" being a communication.—30th July 1850.

19. To John Gwynne, of Lansdowne Lodge, Notting Hill, merchant, "improvements in obtaining motive power, and in applying the same to giving motion to machinery."—31st July 1850.

20. To Walter Neilson, of Hyde Park Street, in the city of Glasgow, North Britain, engineer, "an improvement or improvements in the application of steam, for raising, lowering, moving, or transporting heavy bodies."—2d August 1850.

21. To George Gwynne, of Sussex Square, in the county of Middlesex, Esquire, "improvements in the manufacture of sugar."—7th August 1850.

22. To William Cox, of Manchester, in the county of Lancaster, cigar-merchant, "certain improvements in machinery or apparatus for manufacturing ærated waters or other such liquids;" being a communication from abroad.—7th August 1850.

23. To William Edward Newton, of the Office for Patents, 66 Chancery Lane, in the county of Middlesex, civil engineer, "improvements in obtaining, preparing, and applying zinc, and other volatile metals, and the oxides thereof; and in the application of zinc, or ores containing the same, to the preparation or manufacture of certain metals, or alloys of metals;" being a communication from abroad.—8th August 1850.

24. To Matthew Gray, of 3 Morris Place, in the city of Glasgow, in the county of Lanark, practical engineer, "an improved method of supplying steam boilers with water."—9th August 1850.

25. To William Watt, of the city of Glasgow, North Britain, manufacturing chemist, "certain improvements applicable to inland navigation, which improvements or parts thereof are also applicable, generally, to raising, lowering, or transporting heavy bodies."—13th August 1850.

26. To George Augustus Huddart, of Brynkir, in the county of Caernarvon, Esquire, "certain improvements in the manufacture of cigars, and certain improved apparatus for smoking cigars."—14th August 1850.

27. To James Rennie, of Gowan Bank, Falkirk, in the county of Stirling, in the kingdom of Scotland, gentleman, "a certain improve-

ment or improvements in the construction of gas retorts and furnaces and in apparatus or machinery, applicable to the same."—14th August 1850.

28. To Charles William Bell, of Manchester, in the county of Lancaster, "improvements in apparatus connected with water-closets, drains, and cesspools, and gas and air traps."—14th August 1850.

29. To Henry Meyer, of the Strand, in the county of Middlesex, gentleman, "certain improvements in power looms for weaving."—14th August 1850.

30. To Read Holliday, of Huddersfield, "improvements in lamps."—14th August 1850.

31. To William M'Naught, of Rochdale, in the county of Lancaster, engineer, "certain improvements in steam engines, and also improvements in apparatus for ascertaining and registering the power of the same."—16th August 1850.

32. To Alfred Holl, of Greenwich, in the county of Kent, engineer, "improvements in steam engines."—16th August 1850.

33. To William Edward Newton, of the Office for Patents, 66 Chancery Lane, in the county of Middlesex, civil engineer, "improvements in the construction of ships or vessels, and in steam boilers or generators;" being a communication from abroad.—20th August 1850.

34. To Edward Highton, of Clarence Villa, Regent's Park, in the county of Middlesex, engineer, "improvements in electric telegraphs, and in making telegraphic communications."—21st August 1850.

35. To Charles William Lancaster, of New Bond Street, in the county of Middlesex, gunmaker, "improvements in the construction of fire arms, cannon and projectiles, and in the manufacture of percussion tubes."—21st August 1850.

36. To William Dick, of the city of Edinburgh, professor of veterinary medicine in the Edinburgh Veterinary College, "improvements in the manufacture of steel and gas."—22d August 1850.

37. To Thomas Lucas Paterson, of the city of Glasgow, North Britain, manufacturer and calico printer, "certain improvements in the preparation or manufacture of textile materials, and in the finishing of woven fabrics, and in the machinery or apparatus used therein."—22d August 1850.

38. To Robert Westmoreland Hutchinson, of Camberwell, in the county of Surrey, gentleman, "certain improvements in saw sets, mallets, and other tools, and in apparatus and machinery for manufacturing the same."—28th August 1850.

39. To James Hall, of Gercross, near Stockport, in the county of Chester, machine maker, "certain improvements in looms for weaving."—28th August 1850.

40. To Henry Houldsworth, of Coltness House, in the county of Lanark, North Britain, iron-master, "improvements in the manufacture of iron and other metals."—28th August 1850.

41. To Charles Lamport, of Workington, in the county of Cumberland, ship-builder, "certain improvements in machinery or apparatus for lifting and moving weights, working chains, and pumping, which improvements are more especially adapted for ship's use."—2d September 1850.

42. To Astley Paston Price, of Margate, in the countyof Kent, and James Heywood Whitehead, of the Royal George Mills, Saddleworth, near Manchester, "improvements in filters."—2d September 1850.

43. To Frederick Woodbridge, of Old Gravel Lane, in the county of

Middlesex, engineer, "improvements in machinery for manufacturing rivets, bolts, and screw blanks."—3d September 1850.

44. To Wakefield Pim, of the town or borough of Kingston-upon-Hull, in the county of the same town or borough, engine and boiler maker and builder of iron steam ships, "certain improvements in the construction of the boilers and funnels of steam engines."—4th September 1850.

45. To William Joseph Horsfall, and Thomas James, both of the Mersey steel and iron works, Toxteth Park, Liverpool, in the county of Lancaster, "improvements in the rolling of iron and other metals."—6th September 1850.

46. To George Attwood, of Birmingham, in the county of Warwick, copper roller manufacturer, "a new or improved method of making tubing of copper or alloys of copper."—6th September 1850.

47. To Thomas Priestly, of Shuttleworth, in the county of Lancaster, manager, and Richard Hurst, of Rochdale, in the same county, cotton spinner, "certain improvements in the machinery or apparatus to be used for preparing, spinning, and doubling cotton, wool, flax, silk, and similar fibrous materials, and also in machinery or apparatus for preparing, balling, and winding warps, or yarns."—7th September 1850.

48. To George Thompson, of No. 12 Park Road, Regent's Park, in the county of Middlesex, gentleman, "certain improvements in machinery and apparatus for cutting, digging, or turning up earth, applicable to agricultural purposes."—16th September 1850.

49. To Christopher Cross, of Farnworth, near Bolton, in the county of Lancaster, cotton spinner and manufacturer, "certain improvements in the manufacture of textile fabrics, also in the manufacture of wearing apparel and other articles from textile materials, and in the machinery or apparatus for effecting the same."—16th September 1850.

50. To Joseph Long and James Long, of Little Tower Street, in the city of London, mathematical instrument makers, and Richard Pattenden, of Nelson Square, in the county of Surrey, engineer, "an improvement in instruments and machinery for steering ships, which is also applicable to vices and other instruments and machinery for obtaining power."—17th September 1850.

51. To John James Greenough, of George Street, Hanover Square, in the county of Middlesex, gentleman, "improvements in obtaining and applying motive power;" being a communication from abroad.—17th September 1850.

52. To John Sidebottom, of Broadbottom, in the county of Chester, manufacturer, "improvements in looms for weaving."—18th September 1850.

53. To George Robbins, of Forest Lodge, near Hythe, in the county of Southampton, gentleman, "improvements in the construction of railway carriages."—20th September 1850.

54. To James Scott, of Falkirk, in the county of Stirling, North Britain, shipwright, "certain improvements in docks, slips, and apparatus connected therewith."—20th September 1850.

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