A MANUAL OF ZOOLOGY

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FOR THE USE OF STUDENTS.

WITH A

General Introduction on the Principles of Zoology.

BY

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PART II.

VERTEBRATE ANIMALS

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CHAPTER LIII.

GENERAL CHARACTERS AND DIVISIONS OF THE VERTEBRATA.

THE five sub-kingdoms which we have previously considered—viz., the *Protozoa*, *Cœlenterata*, *Annuloida*, *Annulosa*, and *Mollusca*—were grouped together by the French naturalist Lamarck to form one great division, which he termed *Invertebrata*, the remaining members of the animal kingdom constituting the division *Vertebrata*. The division *Vertebrata*, though including only a single sub-kingdom, is so compact and well-marked a division, and its distinctive characters are so numerous and so important, that this mode of looking at the animal kingdom is, at any rate, a very convenient one.

The sub-kingdom *Vertebrata* may be shortly defined as comprising *animals in which the body is composed of a number of definite segments, arranged along a longitudinal axis; the nervous system is in its main masses dorsal, and the neural and hæmal regions of the body are always completely shut off from one another by a partition; the limbs are never more than four in number, and are always turned away from the neural aspect of the body; mostly there is the bony axis known as the "spine" or "vertebral column," and in all the structure known as the "notochord" is present—in the embryo, at any rate.* These characters distinguish the *Vertebrata*, as a whole, from the *Invertebrata;* but it is necessary to define these broad differences more minutely, and to consider others which are of little less importance.

One of the most obvious, as it is one of the most fundamental, of the distinctive characters of *Vertebrates* is to be found in the shutting off of the main masses of the nervous system from the general cavity of the body. In all *Invertebrate* animals, without exception, the body (fig. 115, A) may be regarded as a *single* tube, enclosing all the viscera; and consequently, in this case, the nervous system is contained within the general cavity of the body, and is not in any way shut off from the alimentary canal. The transverse section,

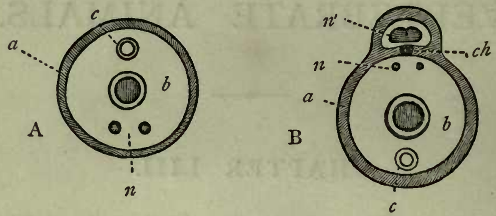


Fig. 115.—A, Tranverse section of the body of one of the higher *Invertebrata: a* Body-wall; *b* Alimentary canal; *c* Hæmal system; *n* Nervous system. B, Transverse section of the body of a *Vertebrate* animal: *a* Body-wall; *b* Alimentary canal; *c* Hæmal system; *n* Sympathetic system of nerves; *n'* Cerebro-spinal system of nerves; *ch* Notochord.

however, of a *Vertebrate* animal exhibits *two* tubes (fig. 115, B) one of which contains the great masses of the nervous system —that is, the "cerebro-spinal axis," or brain and spinal cord —whilst the other contains the alimentary canal and the chief circulatory organs, together with certain portions of the nervous system, known as the "ganglionic" or "sympathetic" system. Leaving the cerebro-spinal centres out of sight for a moment, we see that the larger or visceral tube of a Vertebrate animal contains the digestive canal, the hæmal system, and a gangliated nervous system. Now this is exactly what is contained in the visceral cavity of any of the higher Invertebrate animals; and it follows from this, as pointed out by Von Baer, that it is the sympathetic nervous system of Vertebrates which is truly comparable to, and homologous with, the nervous system of Invertebrates. The cerebro-spinal nervous centres of the *Vertebrata* are to be regarded as something superadded, and not represented at all amongst the *Invertebrata*.

The tube containing the cerebro-spinal centres is formed as follows:—At an early period in the development of the embryo of any Vertebrate animal, the portion of the ovum in which development is going on—the "germinal area"—becomes elevated into two parallel ridges, one on each side of the middle line, enclosing between them a long groove, which is known as the "primitive groove" (fig. 116, A, B). The ridges which bound the primitive groove are known as the "laminæ dorsales;" and they become more and more raised up, till they ultimately meet in the middle line, and unite to form a tube, within which the cerebro-spinal nervous centres are developed. It follows from its mode of formation that the inner wall of the tube formed by the primitive groove, which remains as the septum between the cerebro-spinal canal and the body-cavity, is nothing more than a portion of the primitive wall of the body of the embryo. And there appears to be little doubt, as believed by Remak and Huxley, that the cerebro-spinal nervous centres are "the result of a modification of that serous layer of the germ, which is continuous elsewhere with the epidermis" (Huxley).

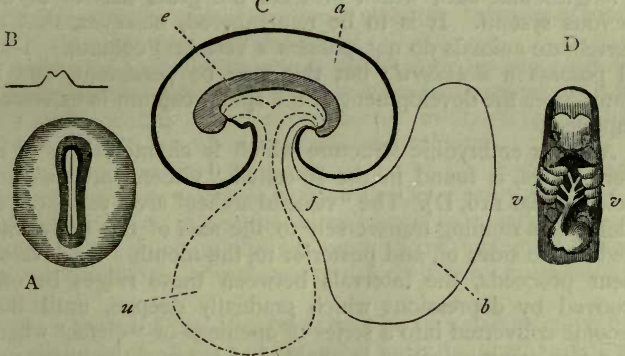


Fig. 116.—Embryology of Vertebrata. A, Portion of the germinal area of the ovum of a Bitch, showing the primitive groove (after Bischoff). B, Profile view of the same. C, Diagram representing the amnion and allantois: *e* Embryo; *a* Amnion; *u* Umbilical vesicle; *b* Allantois; *f* Pedicle of the allantois, afterwards the urinary bladder. D, Head of an embryo, showing the visceral arches (*v v*).

Another remarkable peculiarity as regards the nervous system is found in the fact that in no Vertebrate animal does the alimentary canal pierce the main masses of the nervous system, but turns away to open on the opposite side of the body. In most Invertebrates, on the other hand, in which there is a well-developed nervous system, this is perforated by the gullet, so that an œsophageal nerve-collar is formed, and some of the nervous centres become præ-œsophageal, whilst others are post-œsophageal.

Furthermore, the floor of the "primitive groove" in the embryo of all Vertebrates has developed in it at an early period the structure known as the "notochord" or "chorda dorsalis" (fig. 115, B, *ch*). This structure, doubtfully present in any Invertebrate, is a semi-gelatinous or cartilaginous collection of cells, forming a rod-like axis, which tapers at both ends, and extends along the floor of the cerebro-spinal canal, supporting the cerebro-spinal nervous centres. In some Vertebrates, such as the Lancelet (*Amphioxus*), the notochord is persistent throughout life. In the majority of cases, however, the notochord is replaced before maturity by the structure known as the "vertebral column" or "backbone," from which the sub-kingdom *Vertebrata* originally derived its name. This is not the place for an anatomical description of the spinal column, and it is sufficient to state here that it is essentially composed of a series of cartilaginous, or more or less completely ossified, segments or *vertebræ*, arranged so as to form a longitudinal axis, which protects the great masses of the nervous system. It is to be remembered, however, that all Vertebrate animals do not possess a vertebral column. They all possess a *notochord;* but this may be persistent, and in many cases the development of the spinal column is extremely imperfect.

Another embryonic structure which is characteristic of all Vertebrates, is found in the so-called "visceral arches" and "clefts" (fig. 116, D). The "visceral arches" are a series of parallel ridges running transversely to the axis of the body, situated at the sides of, and posterior to, the mouth. As development proceeds, the intervals between these ridges become grooved by depressions which gradually deepen, until they become converted into a series of openings or "clefts," whereby a free communication is established between the upper part of the alimentary canal (pharynx) and the external medium.

The limbs of Vertebrate animals are always articulated to the body, and they are always turned away from the neural aspect of the body. They may be altogether wanting, or they may be partially undeveloped ; but there are never more than two pairs, and they always have an internal skeleton for the attachment of the muscles of the limb.

A specialised blood-vascular or "hæmal" system is present in all the *Vertebrata*, and in all except one—the *Amphioxus*—there is a contractile cavity or *heart*, which never consists of less than two chambers provided with valvular apertures. In all the *Vertebrata* the heart is essentially a *respiratory* heart—that is to say, it is concerned with driving the impure or venous blood to the breathing-organs; and in its simplest form (fishes) it is nothing more than this. In the higher Vertebrates, however, there is superadded to this a pair of cavities which are concerned in driving the pure or arterial blood to the body. In the case of the Mammals, these two circulations are often spoken of as the "lesser" or "pulmonary" circulation, and the "greater" or "systemic" circulation.

In all Vertebrates there is that peculiar modification of the venous system which is known as the "hepatic portal system." That is to say, a portion of the blood which is sent to the alimentary canal, instead of returning to the heart by the ordinary veins, is carried to the liver by a special vessel—the *vena portæ*—which ramifies through this organ after the manner of an artery.

In all Vertebrates, also, is found the peculiar system of vessels known as the "lacteal system." This is to be regarded as an appendage of the venous system of blood-vessels, and consists of a series of vessels which take up the products of digestion from the alimentary canal, elaborate them, and finally empty their contents into the veins.

Lastly, the masticatory organs of Vertebrates are modified portions of the walls of the head, and never "hard productions of the alimentary mucous membrane or modified limbs" (Huxley), as they are amongst the Invertebrata.

The above are the leading characters of the *Vertebrata* as a whole; but before going on to consider the primary divisions of the sub-kingdom, it may be as well to give a very brief and general description of the anatomy of the higher and more typical Vertebrates, commencing with their bony framework or skeleton.

The *skeleton* of the *Vertebrata* may be regarded as consisting essentially of the bones which go to form the head and trunk on the one hand (sometimes called the "axial" skeleton), and of those which form the supports for the limbs ("appendicular" skeleton) on the other hand. The bones of the head and trunk may be looked upon as essentially composed of a series of bony rings or segments, arranged longitudinally, one behind the other. Anteriorly these segments are much expanded, and likewise much modified, to form the bony case which encloses the brain, and which is termed the *cranium* or skull. Behind the head the segments enclose a much smaller cavity, which is called the "neural" or spinal canal, as it encloses the spinal cord; and they are arranged one behind the other, forming the vertebral column. The segments which form the vertebral column are called "vertebræ," and they have the following general structure:—Each vertebra (fig. 117, A) consists of a central piece, which is the fundamental and essential element of the vertebra, and is known as the "body" or "centrum" (*c*). From the upper or posterior surface of the centrum spring two bony arches (*n n*), which are called the "neural arches" or "neurapophyses," because they form with the body a canal—the "neural canal"—which encloses the spinal cord. From the point where the neural arches meet behind, there is usually developed a longer or shorter spine, which is termed the "spinous process" or "neural spine" (*s*). From the neural arches there are also developed in the typical vertebra two processes (*a a*), which are known as the "articular" processes, or "zygapophyses." The vertebræ are united to one another partly by these, but to a greater extent by the bodies or "centra." From the sides of the vertebral body, at the point of junction with the neural arches, there proceed two lateral processes (*d d*), which are known as the "transverse processes." (In the typical vertebra the transverse processes consist each of two pieces, an anterior piece or "parapophysis," and a posterior piece or "diapophysis.") These elements form the *vertebra* of the human anatomist, but the "vertebra" of the transcendental anatomist is completed by a second arch which is placed beneath the body of the vertebra, and which is called the "hæmal" arch, as it includes and protects the main organs of the circulation. This second arch is often only recognisable with great difficulty, as its parts are generally much modified, but a good example may be obtained in the human chest, or in the caudal vertebra of a bony fish.

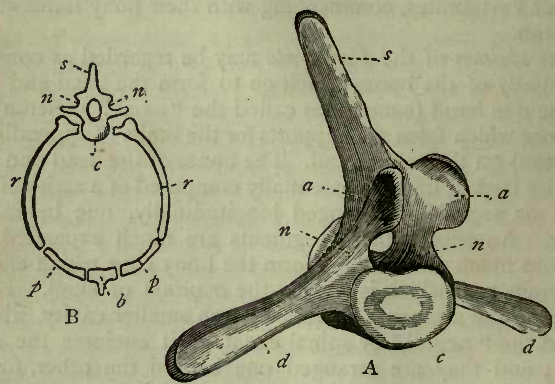


Fig. 117.—A, Lumbar vertebra of a Whale: *c* Body or centrum; *n n* Neural arches; *s* Neural spine; *a a* Articular processes; *d d* Transverse processes. B, Diagram of a thoracic vertebra: *c* Centrum; *n n* Neural arches enclosing the neural canal; *s* Neural spine; *r r* Ribs, assisting in the formation of the hæmal arch; *p p* Costal cartilages; *b* Sternum, with hæmal spine. (After Owen.)

The hæmal arch in the case of the human thorax (fig. 117, B) is formed by the ribs (*r r*) and the costal cartilages (*p p*), and is completed in front by the breast-bone or sternum (*b*), which in some cases—but not in man—develops a spine (the hæmal spine), which corresponds to the neural spine on the opposite aspect of the vertebra.

It follows from the above, that the typical vertebra consists of a central piece or body from which two arches are given off, one of which protects the great masses of the nervous system, and is therefore said to be "neural;" whilst the other protects the main organs of the circulation, and is therefore said to be "hæmal." The correspondence of the typical bony segment or vertebra with the doubly tubular structure of the body in all Vertebrates is thus too obvious to require to be specially pointed out.

As a general rule, the vertebral column is divisible into a number of distinct regions, of which the following are recognisable in man and in the higher *Vertebrata* :—1. A series of vertebræ which compose the neck, and constitute the "cervical region" of the spine (fig. 118, *c*). 2. A number of vertebræ

Fig. 118.—Skeleton of the Beaver (*Castor fiber*), showing the different regions of the vertebral column. *c* Cervical region; *d* Dorsal region; *b* Lumbar region; *s* Sacrum; *t* Caudal region.

which usually carry well-developed ribs, and form the "dorsal region" (*d*). 3. A series of vertebræ which form the region of the loins, or "lumbar region" (*b*). 4. A greater or less number of vertebræ which constitute the "sacral region," and are usually amalgamated or "anchylosed" together to form a single bone, the "sacrum" (*s*). 5. The spinal column is completed by a variable number of vertebræ which constitute the "caudal" region, or tail (*t*).

As regards the *skull* of the *Vertebrata*, it has been thought advisable not to enter into any general details here, partly because the subject is one which can only be properly discussed in a work specially devoted to Human or Comparative Anatomy, and partly because there is still much diversity of opinion as to the exact composition of the skull. There is, however, a very general concurrence of opinion that the skull is composed of a number of separate segments, and this is a point which it is important to remember. By Owen, and by many other competent authorities, these cranial segments are looked upon as being nothing more than so many *vertebræ*, the neural canals of which are greatly expanded to enclose the brain, whilst the hæmal arches are very greatly modified to serve different purposes. This view is not accepted by Huxley, but the general fact that the skull is composed of separate segments appears to be universally admitted. The only portion of the bony framework of the head which it is absolutely essential to understand, is the lower jaw or "mandible." The lower jaw is sometimes wanting, but when present, it consists in all *Vertebrata* of two halves or "rami," which are united to one another in front, and articulate separately with the skull behind. In many cases, each half, or "ramus," of the lower jaw consists of several pieces united to one another by sutures; but in the *Mammalia* each ramus consists of no more than a single piece. The two rami are very variously connected with one another, being sometimes only joined by ligaments and muscles, sometimes united by cartilage or by bony suture, and sometimes fused or anchylosed with one another, so as to leave no evidence of their true composition. The mode by which each ramus of the lower jaw articulates with the skull also varies. In the *Mammalia* the lower jaw articulates with a cavity formed on what is known to human anatomists as the temporal bone; but in Birds and Reptiles, the lower jaw articulates with the skull, not directly, but by the intervention of a special bone, known as the "quadrate bone" or "*os quadratum*."

As regards the *limbs* of Vertebrates, whilst many differences exist, which will be afterwards noticed, there is a general agreement in the parts of which they are composed. As a rule, each pair of limbs is joined to the trunk by means of a series of bones which also correspond to one another in general structure. The fore-limbs, often called the "pectoral" limbs, are united with the trunk by means of a bony arch, which is called the "pectoral" or "scapular" arch; whilst the hind-limbs are similarly connected with the trunk by means of the "pelvic arch." In giving a general description of the parts which compose the limbs and their supporting arches, it will be best to take the case of a Mammal, and the departures from this type will then be readily recognised.

The pectoral or scapular arch consists usually of three bones, the "scapula" or shoulder-blade, the "coracoid," and the "clavicle" or collar-bone; but in the great majority of the Mammals, the coracoid is anchylosed with the scapula, of which it forms a mere process. The scapula or shoulder-blade (fig. 119, *s*) is usually placed outside the ribs, and it forms, either alone or in conjunction with the other bones of the shoulder-girdle, the cavity with which the upper arm is articulated. The coracoid, though rarely existing as a distinct bone in the Mammals, plays a very important part in other Vertebrates, as we shall see hereafter. The clavicles are often wanting, or rudimentary, and they are the least essential elements of the scapular arch. The fore-limb proper consists, firstly, of a single bone which forms the upper arm, and which is known as the *humerus* (*h*). This articulates above with the shoulder-girdle, and is followed below by the fore-arm, which consists of two bones, called the *radius* and *ulna*. Of these the *radius* is chiefly concerned with carrying the hand. The radius and ulna are followed by the bones of the wrist, which are usually composed of several bones, and constitute what is called the *carpus* (*d*). These support the bones of the root of the hand, which vary in number, but are always more or less cylindrical in shape. They constitute what is called the *metacarpus*. The bones of the metacarpus carry the digits,

Fig. 119. — Pectoral limb (arm) of Chimpanzee. (After Owen). *c* Clavicle; *s* Scapula or shoulder-blade; *h* Humerus; *r* Radius; *u* Ulna; *d* Bones of the wrist, or carpus; *m* Metacarpus; *p* Phalanges of the fingers.

which also vary in number, but are composed each of from two to three cylindrical bones, which are known as the *phalanges* (*p*).

Homologous parts are, as a rule, readily recognisable in the hind-limb. The pelvic arch, by which the hind-limb is united with the trunk, consists of three pieces—the *ilium*, *ischium*, and *pubes*—which are usually anchylosed together, and form conjointly what is known as the *innominate bone* (fig. 120, *i*). In most Mammals, the two innominate bones unite in front by a ligamentous or cartilaginous union and they constitute, with the sacrum, what is known as the *pelvis*. The hind-limb proper consists of the following parts:—1. The thigh-bone or *femur*, corresponding with the humerus in the fore-limb. 2. The bones of the shank, corresponding with the radius and ulna of the fore-limb, and known as the *tibia* and *fibula*. Of these, the tibia is mainly or altogether concerned in carrying the foot, and it is thus shown to correspond to the radius, whilst the fibula corresponds to the ulna. 3. The small bones of the ankle, known as the *tarsus*, and varying in number in different cases. 4. A variable number of cylindrical bones (normally five), which are called the *metatarsus*, and which correspond to the metacarpus. 5. Lastly, the metatarsus carries the digits, which consist of from two to three small bones or *phalanges*, as in the fore-limb.

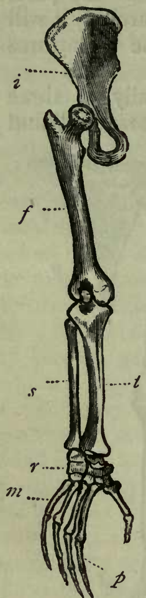


Fig. 120. — Pelvic limb (hind-limb) of Chimpanzee (after Owen). *i* Innominate bone; *f* Femur, or thigh-bone; *t* Tibia; *s* Fibula; *r* Tarsus; *m* Metatarsus; *p* Phalanges of the toes.

The *digestive system* of Vertebrates will be spoken of at greater length hereafter; but a brief sketch may be given here of the general phenomena of digestion. All Vertebrate animals are provided with a mouth for the reception of food, and in the great majority of cases the mouth is furnished with *teeth*, which are used sometimes merely to hold to the prey, but more commonly to cut and bruise the food, and thus render it capable of digestion. The food is also generally subjected in the mouth to the action of "salivary" glands, the secretion of which serves not only to moisten the food, and thus mechanically assist deglutition, but also to render soluble the starchy elements of the food. The food is next swallowed, or, in other words, is transferred from the mouth to the stomach, this being effected by a complicated arrangement of muscles, whereby the food is forced down the gullet (*œsophagus*) to the proper digestive cavity or stomach. In the stomach (fig. 121, *s*) the food is subjected to two sets of actions; it is mechanically triturated and ground down by the constant contractions of the muscular walls of the stomach; and it is subjected to the chemical action of a special fluid secreted by the stomach, and called the "gastric juice." This fluid has the power of reducing albuminoid substances to a soluble form, and by its action the food is ultimately reduced to a thick acid fluid, called the "chyme." Leaving the stomach by its lower aperture (the *pylorus*), the chyme passes into the intestine, the first portion of which is divided into several sections, but is collectively known as the "small intestine." Here the chyme is subjected to the action of three other digestive fluids; the *bile*, secreted by a special organ, the liver; the *pancreatic juice*, secreted by another gland, the pancreas; and the *intestinal juice*, secreted by certain glands situated in the mucous membrane of the intestine itself. The result of the whole process is that the "chyme" is ultimately converted into a white, alkaline, milky fluid, which is called "chyle." The indigestible portions of the food pass from the small intestine into a tube of larger dimensions, called the "large intestine." Such portions of the food as are still soluble, and capable of being employed in nutrition, are here taken up into the blood, the useless remainder being ultimately expelled by an anal aperture. The last portion of the large intestine is usually less convoluted than the rest, and is called the "rectum."

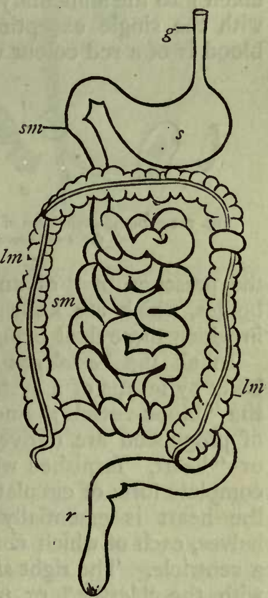


Fig. 121.—Diagram of the digestive system of a Mammal. *g* Gullet; *s* Stomach; *sm* Small intestine; *lm* Large intestine; *r* Rectum, terminating in the aperture of the anus.

The fluid and originally soluble portions of the food, and the chyle which is formed in the process of digestion, are taken into the blood, the losses of which they serve to repair. Part of the nutritive materials of the food is taken up directly by the blood-vessels, and is conveyed by the "vena portæ" to the liver, whence it ultimately reaches the great veins which go to the heart. The greater part, however, of the liquefied food, constituting the chyle, is taken up, not by the blood-vessels, but by a special set of tubes, which form a network in the walls of the intestine, and are known as the "lacteals." In these vessels, and in certain glands which are developed upon them, the chyle undergoes still further elaboration, and is made more similar in composition to the blood itself. All the lacteal vessels ultimately unite into one or more large vessels which open into one of the veins, so that all the chyle is thus finally added to the mass of the circulating blood.

The *blood*, then, or nutrient fluid from which the tissues are built up, is formed in this way out of the materials which are taken into the alimentary canal as food. In all the Vertebrata, with the single exception of the Lancelet (*Amphioxus*), the blood is of a red colour when viewed in mass. This is due to

Fig. 122.—Blood-corpuscles of Vertebrata. *a* Red blood-discs of man ; *b* Blood-discs of Goose ; *c* Crocodile ; *d* Frog ; *e* Skate.

the presence in it of an incredible number of microscopical bodies, which are known as the "blood-corpuscles," the fluid in which these float being itself colourless (fig. 122).

In all the *Vertebrata* the blood is distributed through the body by means of a system of closed tubes, which constitute the "blood-vessels;" and in all except the Lancelet, the means of propulsion are derived from a contractile muscular cavity or "heart," furnished with valvular apertures. In the most complete form of circulation, as seen in Birds and Mammals, the heart is essentially a double organ, composed of two halves, each of which consists of two cavities, an auricle and a ventricle. The right side of the heart is wholly concerned with the "lesser" or pulmonary circulation, whilst the left side is concerned with driving the blood to all parts of the body (systemic circulation). The modifications of the circulatory process will be noticed in speaking of the different classes of Vertebrates, but a brief sketch may be given here of the circulation in its most complete form, as in a Mammal. In such a case, the venous or impure blood, which has circulated through the body and has parted with its oxygen, is returned by the great veins to the right auricle. From the right auricle (fig. 123, *a*) the blood passes by a valvular aperture into the right ventricle (*v*), whence it is driven through the pulmonary artery to the lungs. The right side of the heart is therefore wholly respiratory in its function. Having been submitted to the action of the lungs, and having given off carbonic acid and taken up oxygen, the blood now becomes arterial, and is returned by the pulmonary veins to the left auricle (*a'*). From the left auricle the aerated blood passes through a valvular aperture into the left ventricle (*v'*), whence it is propelled to all parts of the body by means of a great systemic vessel, the "aorta." The left side of the heart is therefore wholly occupied in carrying out the "greater" or systemic circulation.

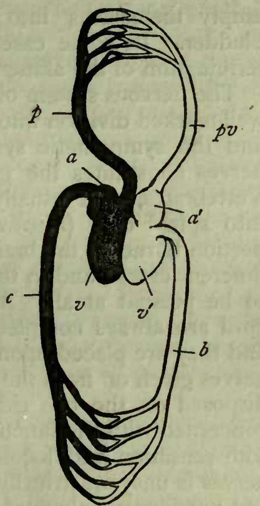


Fig. 123.—Diagram of the circulation of a Mammal. The venous system is marked black; the arterial system is left white. *a* Right auricle; *v* Right ventricle; *p* Pulmonary artery, carrying venous blood to the lungs; *pv* Pulmonary veins carrying arterial blood from the lungs; *a'* Left auricle; *v'* Left ventricle; *b* Aorta, carrying arterial blood to the body; *c* Vena cava carrying venous blood to the heart.

The purification of the blood is carried out in all Vertebrates by means of distinct respiratory organs, assisted to a greater or less extent by the skin. In the Fishes, and in the Amphibians to some extent, the process of respiration is carried on by means of *branchiæ* or gills—that is, by organs adapted for breathing air dissolved in water. These are therefore often spoken of as "Branchiate" Vertebrates; but the Amphibians always develop true lungs in the later stages of their existence. In the Reptiles, Birds, and Mammals, branchiæ are never developed, and the respiration is always carried on by means of true lungs—that is, by organs adapted for breathing air directly. These are therefore often spoken of as the "Abranchiate" Vertebrates.

The waste substances of the body—of which the most important are water, carbonic acid, and urea—are got rid of by the skin, lungs, and kidneys. Under ordinary circumstances, the lungs are mainly occupied with the excretion of carbonic acid and watery vapour. The skin chiefly gets rid of superfluous moisture, but can also in many animals excrete carbonic acid as well. The kidneys are present in almost all Vertebrate animals, and their function is mainly to excrete water, and the nitrogenous substance known as urea. In the majority of cases the fluid excreted by the kidneys is conveyed to the exterior by means of two tubes known as the ureters, which empty themselves into a common receptacle, the urinary bladder. In some cases, however, the ureters open into the termination of the alimentary canal (rectum).

The nervous system of Vertebrate animals usually exhibits a well-marked division into two parts—the cerebro-spinal system, and the sympathetic system. The cerebro-spinal system of nerves constitutes the great mass of the nervous system of Vertebrates, and usually exhibits a well-marked separation into spinal cord (*myelon*) and brain (*encephalon*). The proportion borne by the brain to the spinal cord differs much in different cases; and in the Lancelet a brain can hardly be said to be present at all. As already said, the brain and spinal cord are always completely shut off from the visceral cavity, and they are placed upon the dorsal surface of the body. The nerves given off from the cerebro-spinal axis are symmetrically disposed on the two sides of the body, and they are mainly concerned with the functions of "animal" life—that is to say, with sensation and locomotion. The sympathetic system of nerves is unsymmetrically disposed to a greater or less extent, and presides mainly over the functions of "organic," or "vegetative" life, being mainly concerned with regulating the functions of digestion and respiration, and the circulation of the blood. In its most fully developed form it consists of a double gangliated cord placed in the visceral cavity on the under surface of the spine, and of a series of nervous ganglia, united by nervous cords, and scattered mainly over the great viscera of the thorax and abdomen.

The organs of the senses are well developed in the *Vertebrata*, and those appropriated to the senses of *sight*, *hearing*, *smell*, and *taste* are protected within bony cavities of the head. The perfection of the senses differs much in different cases, but they are probably never wholly wanting in any Vertebrate animal. There are cases in which vision must be of the most rudimentary character; but even in these cases it is probable that there is a perception of light, even if there is no power of distinguishing objects. The only cases in which it would appear that vision is really altogether absent, are those of animals placed under the wholly abnormal condition of spending their existence in darkness (such as the *Proteus anguinus* of the caves of Illyria). Smell, hearing, and taste are probably rarely, if ever, altogether absent in Vertebrates; though in many cases their organs are very rudimentary. Touch, or "tactile sensibility," is usually possessed to a greater or less degree by the entire surface of the body; but the sense of touch is generally localised in certain particular parts, such as the appendages of the mouth, the lips, the tongue, or the digits.

In all *Vertebrata* without exception reproduction is carried on by means of the sexes, and in all the sexes are in different individuals. No Vertebrate animal possesses the power of reproducing itself by fission or gemmation; and in no case are composite organisms or colonies produced. Most of the Vertebrates are *oviparous*, that is to say, the *ova* are expelled from the body of the parent either before or very shortly after impregnation. In other cases, the eggs are retained within the body of the parent until the young are hatched, and in these cases the animals are said to be *ovo-viviparous*. In other cases, again, not only is the egg hatched within the parent, but the embryo is retained within the body of the mother until its development has been carried out to a greater or less extent; and these animals are said to be *viviparous*.

DIVISIONS OF THE VERTEBRATA.—The sub-kingdom *Vertebrata* is divided into the five great classes of the Fishes (*Pisces*), Amphibians (*Amphibia*), Reptiles (*Reptilia*), Birds (*Aves*), and Mammals (*Mammalia*). So far there is perfect unanimity; but when it is inquired into what larger sections the Vertebrata may be divided, there is much difference of opinion. Here, the divisions proposed by Professor Huxley will be adopted, but it is necessary that those employed by other writers should be mentioned and explained.

One of the commonest methods of classifying the *Vertebrata* is to divide them into the two primary sections of the *Branchiata* and *Abranchiata*. Of these, the Branchiate section includes the Fishes and Amphibians, and is characterised by the fact that the animal is always provided at some period of its life with branchiæ or gills. The Abranchiate section includes the Reptiles, Birds, and Mammals, and is characterised by the fact that the animal is never provided at any time of its life with gills. Additional characters of the Branchiate Vertebrates are, that the embryo is not furnished with the structures known as the *amnion* and *allantois*. Hence the Branchiate Vertebrates are often spoken of as the *Anamniota* and as the *Anallantoidea*. In the Abranchiate Vertebrates, on the other hand, the embryo is always provided with an amnion and allantois, and hence this section is spoken of as the *Amniota* or as the *Allantoidea*.*

* The *amnion* (fig. 116, C) is a membranous sac, containing a fluid—the liquor amnii—and completely enveloping the embryo. It consti-

By Professor Owen the *Vertebrata* are divided into the two primary sections of the *Hæmatocrya* and the *Hæmatotherma*, the characters of the blood being taken as the distinctive character. The *Hæmatocrya* or Cold-blooded Vertebrates comprise the Fishes, Amphibia, and Reptiles, and are characterised by their cold blood, and imperfect circulation. The *Hæmatotherma* or Warm-blooded Vertebrates comprise the Birds and the Mammals, and are characterised by their hot blood, four-chambered heart, and complete separation of the pulmonary and systemic circulations. The chief objection to this division lies in the separation which is effected between the Reptiles and the Birds, two classes which are certainly very nearly allied to one another.

By Professor Huxley the *Vertebrata* are divided into the following three primary sections:—

I. ICHTHYOPSIDA.—This section comprises the Fishes and the Amphibians, and is characterised by the presence at some period of life of gills or branchiæ, the absence of an amnion, the absence or rudimentary condition of the allantois, and the possession of nucleated red blood-corpuscles.

II. SAUROPSIDA.—This section comprises the Birds and the Reptiles, and is characterised by the constant absence of gills, the possession of an amnion and allantois, the articulation of the skull with the vertebral column by a single occipital condyle; the composition of each ramus of the lower jaw of several pieces, and the articulation of the lower jaw with the skull by the intervention of an "os quadratum;" and, lastly, the possession of nucleated red blood-corpuscles.

III. MAMMALIA.—This section includes the single class of the Mammals, and agrees with the preceding in never possessing gills, and in having an amnion and allantois. The *Mammalia*, however, differ from the *Sauropsida* in the fact that the skull articulates with the vertebral column by two occipital condyles; each ramus of the lower jaw is simple, composed of

tutes one of the so-called "fœtal membranes," and is thrown off at birth. The *allantois* (fig. 116, C) is an embryonic structure, which is developed out of the middle or "vascular" layer of the germinal membrane. It appears at first as a solid, pear-shaped, cellular mass, arising from the under part of the body of the embryo. In the process of development, the allantois increases largely in size, and becomes converted into a vesicle which envelops the embryo in part or wholly. It is abundantly supplied with blood, and is the organ whereby the blood of the fœtus is aerated. The part of the allantois which is external to the body of the embryo is cast off at birth; but the portion which is within the body is retained and is converted into the urinary bladder.

a single piece, and the lower jaw is united with the temporal (squamosal) element of the skull, and is not articulated to a quadrate bone. There are special glands—the mammary glands—for the nourishment of the young for a longer or shorter period after birth, and the red blood-corpuscles are non-nucleated.

DIVISION I. ICHTHYOPSIDA.

CHAPTER LIV.

CLASS I.—PISCES.

THE first class of the *Vertebrata* is that of the Fishes (*Pisces*), which may be broadly defined as including *Vertebrate animals which are provided with gills throughout the whole of life; the heart, when present, consists (with one exception) of a single auricle and a single ventricle; the blood is cold; the limbs, when present, are in the form of fins, or expansions of the integument; and there is neither an amnion nor allantois in the embryo, unless the latter is represented by the urinary bladder.*

In form, Fishes are adapted for rapid locomotion in water, the shape of the body being such as to give rise to the least possible friction in swimming. To this end also, as well as for purposes of defence, the body is usually enveloped with a coating of scales developed in the inferior or dermal layer of the skin. The more important modifications in the form of these dermal scales are as follows: I. *Cycloid* scales (fig. 124, *a*), consisting of thin, flexible, horny scales, circular or elliptical in shape, and having a more or less completely smooth outline. These are the scales which are characteristic of most of the ordinary bony fishes. II. *Ctenoid* scales (fig. 124, *b*), also consisting of thin horny plates, but having their posterior margins fringed with spines, or cut into comb-like projections. III. *Ganoid* scales, composed of an inferior layer composed of bone, covered by a superficial layer of hard polished enamel (the so-called "ganoine"). These scales (fig.

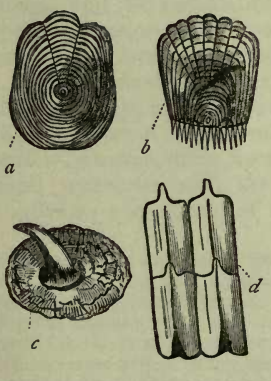


Fig. 124.—Scales of different fishes. *a* Cycloid scale (Pike); *b* Ctenoid scale (Perch); *c* Placoid scale (Thornback); *d* Ganoid scales (*Palæoniscus*).

124, *d*) are usually much larger and thicker than the ordinary scales, and though they are often articulated to one another by special processes, they only rarely overlap. IV. *Placoid* scales, consisting of detached bony grains, tubercles, or plates, of which the latter are not uncommonly armed with spines (fig. 124, *c*).

In most fishes there is also to be observed a line of peculiar scales, forming what is called the "lateral line." Each of the scales in this line is perforated by a tube leading down to a longitudinal canal which runs along the side of the body, and is connected with cavities in the head. The function of this singular system has been ordinarily believed to be that of secreting the mucus with which the surface of the body is covered; but it seems to be more probably sensory in function, and to be connected with the sense of touch.

As regards their true osseous system or endoskeleton, Fishes vary very widely. In the Lancelet there can hardly be said to be any skeleton, the spinal cord being simply supported by the gelatinous notochord, which remains throughout life. In others the skeleton remains permanently cartilaginous; in others it is partially cartilaginous and partially ossified; and, lastly, in most modern fishes it is entirely ossified or converted into bone. Taking a bony fish (fig. 125) as in this respect a typical example of the class, the following are the chief points in the osteology of a fish which require notice :—

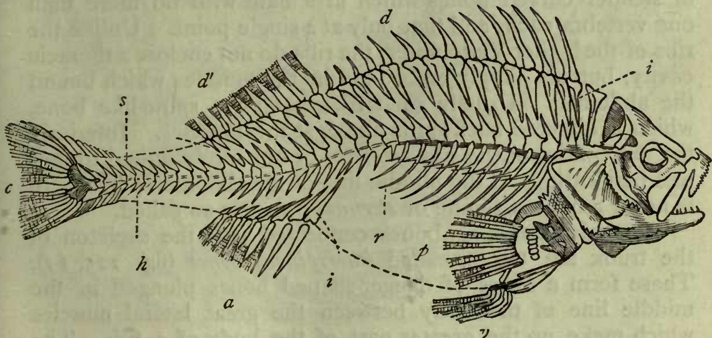


Fig. 125.—Skeleton of the common Perch (*Perca fluviatilis.*) *p* one of the pectora fins; *v* One of the ventral fins; *a* Anal fin, supported upon interspinous bones (*i*); *c* Caudal fin; *d* First dorsal fin; *d'* Second dorsal fin, both supported upon interspinous bones; *i i* Interspinous bones; *r* Ribs; *s* Spinous processes of vertebræ; *h* Hæmal processes of vertebræ.

The *vertebral column* in a bony fish consists of vertebræ, which are hollow at both ends, or biconcave, and are technically said to be "amphicœlous." The cup-like margins of the vertebral bodies are united by ligaments, and the cavities formed between contiguous vertebræ are filled with the gelatinous remains of the notochord. This elastic gelatinous substance acts as a kind of ball-and-socket joint between the bodies of the vertebræ, thus giving the whole spine the extreme mobility which is requisite for animals living in a watery medium. The ossification of the vertebræ is often much more imperfect than the above, but in no case except that of the Bony Pike (*Lepidosteus*) is ossification carried to a greater extent than this. In this fish, however, the vertebral column is composed of "opisthocœlous" vertebræ—that is, of vertebræ the bodies of which are concave behind and convex in front. The entire spinal column is divisible into not more than two distinct regions, an *abdominal* and a *caudal region*. The abdominal vertebræ possess a superior or neural arch (through which passes the spinal cord), a superior spinous process (neural spine), and two transverse processes to which the ribs are usually attached. The caudal vertebræ (fig. 125) have no marked transverse processes; but, in addition to the neural arches and spines, they give off an inferior or *hæmal* arch below the body of the vertebra, and the hæmal arches carry inferior spinous processes (hæmal spines).

The *ribs* of a bony fish are attached to the transverse processes, or to the bodies of the abdominal vertebræ, in the form of slender curved bones which articulate with no more than one vertebra each, and that only at a single point. Unlike the ribs of the higher Vertebrates, the ribs do not enclose a thoracic cavity, but are simply embedded in the muscles which bound the abdomen. Usually each rib gives off a spine-like bone, which is directed backwards amongst the muscles. Inferiorly the extremities of the ribs are free, or are rarely united to dermal ossifications in the middle line of the abdomen; but there is never any breast-bone or *sternum* properly so called.

The only remaining bones connected with the skeleton of the trunk are the so-called *interspinous bones* (fig. 125, *i i*). These form a series of dagger-shaped bones plunged in the middle line of the body between the great lateral muscles which make up the greater part of the body of a fish. The internal ends or points of the interspinous bones are attached by ligament to the spinous processes of the vertebræ; whilst to their outer ends are articulated the "rays" of the so-called "median" fins, which will be hereafter described. As a rule, there is only one interspinous bone to each spinous process, but in the Flat-fishes (Sole, Turbot, &c.) there are two.

Beside the fins which represent the limbs (pectoral and ventral fins), fishes possess other fins placed in the middle line of the body, and all of these alike are supported by bony spines or "rays," which are of two kinds, termed respectively "spinous rays" and "soft rays." The "spinous rays" are simple bony spines, apparently composed of a single piece each, but really consisting of two halves firmly united along the middle line. The "soft rays" are composed of several slender spines proceeding from a common base, and all divided transversely into numerous short pieces. The soft rays occur in many fishes in different fins, but they are invariably found in the caudal fin or tail (fig. 125, *c*). The rays of the median fins, whatever their character may be, always articulate by a hinge-joint with the heads of the interspinous bones.

The *skull* of the bony fishes is an extremely complicated structure, and it is impossible to enter into its composition here. The only portions of the skull which require special mention are the bones which form the gill-cover or operculum,

Fig. 126.—Skull of Cod (*Morrhua vulgaris*)—Cuvier. *a* Urohyal; *b* Basihyal; *c* Ceratohyal; *d* Branchiostegal rays; *p* Præ-operculum; *o* Operculum proper; *s* Sub-operculum; *i* Inter-operculum; *m* Mandible; *n* Inter-maxillary bone.

and the hyoid bone with its appendages. For reasons connected with the respiratory process in fishes, as will be afterwards seen, there generally exists between the head and the scapular arch a great cavity or gap on each side, within which are contained the branchiæ. The cavity thus formed opens externally on each side of the neck by a single vertical fissure or "gill-slit," closed by a broad flap, called the "gill-cover" or "operculum," and by a membrane termed the "branchiostegal membrane."

The gill-cover (fig. 126, *p*, *o*, *s*, *i*) is composed of a chain of broad flat bones, termed the opercular bones. Of these, the innermost articulates with the skull (tympano-mandibular arch), and is called the "præ-operculum;" the next is a large bone called the "operculum" proper; and the remaining two bones, called respectively the "sub-operculum" and "inter-operculum," form, with the operculum proper, the edge of the gill-cover. These various bones are united together by membrane, and they form collectively a kind of movable door, by means of which the branchial chamber can be alternately opened and shut. Besides the gill-cover, however, the branchial chamber is closed by a membrane called the "branchiostegal membrane," which is attached to the os hyoides. The membrane is supported and spread out by a number of slender curved spines, which are attached to the lateral branches of the hyoid bone, act very much as the ribs of an umbrella, and are known as the "branchiostegal rays" (fig. 126, *d*).

The hyoid arch of fishes is attached to the temporal bones of the skull by means of two slender styliform bones, which correspond to the styloid processes of man, and are called the "stylohyal" bones (fig. 127, *f*). The rest of the hyoid arch is composed of a central portion and two lateral branches. Each branch is composed of the following parts:—1. A triangular bone attached above to the stylohyal, and termed the "epihyal bone" (fig. 127, *e*); 2. A much longer bone, known as the "ceratohyal" (*d*). The central portion of the hyoid arch is made up of two small polyhedral bones—the "basihyals" (*b*). From the basihyal there extends *forwards* in many fishes a slender bone, which supports the tongue, and is termed the "glossohyal" or "lingual" bone (*a*). There is also another compressed bone, which extends *backwards* from the basihyals, and which is known as the "urohyal bone" (*c*). This last-mentioned bone is of importance, as it often extends backwards to the point of union of the coracoid bones, and thus forms the isthmus which separates the two branchial apertures.

From the outer margins of the epihyal and ceratohyal bones on each side arise the slender curved "branchiostegal rays," which have been previously mentioned. There are usually seven of these on each side. Above the urohyal, and attached in front to the body of the os hyoides, is a chain of bones, placed one behind the other, and termed by Owen the "basi-

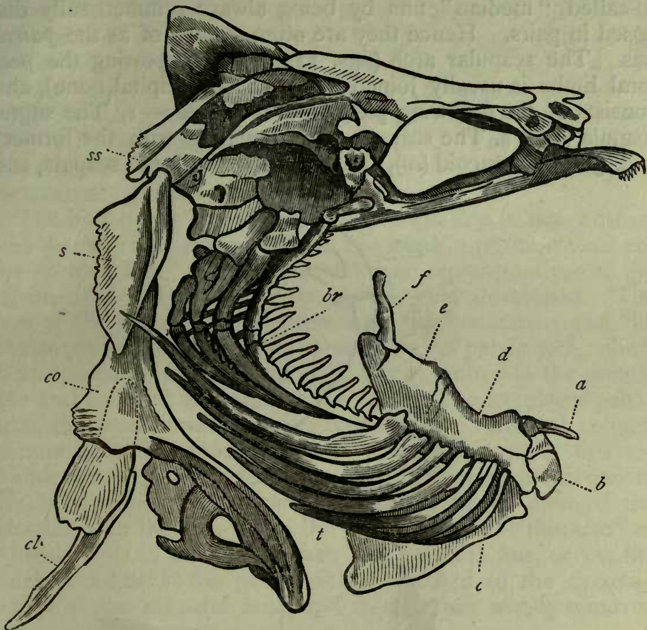


Fig. 127.—Os hyoides, branchiostegal rays, and scapular arch of the Perch (after Cuvier). *ss* Supra-scapula; *s* Scapula; *co* Coracoid; *cl* Supposed representative of the clavicle; *a* Glossohyal bone; *b* Basihyal; *c* Urohyal; *d* Ceratohyal; *e* Epihyal; *f* Stylohyal; *br* Branchial arches; *t* Branchiostegal rays.

branchial bones." Springing from these are four bony arches—the "branchial arches"—which proceed upwards to be connected superiorly by ligament with the under surface of the skull. The branchial arches—as will be subsequently described—carry the branchiæ, and each is composed of two main pieces, termed respectively the "cerato-branchial" and "epi-branchial" bones. The second and third arches are connected with the skull by the intervention of two small bones, often called the "superior pharyngeal bones," but termed by Owen the "pharyngo-branchial" bones.

The *limbs* of fishes depart considerably from the typical form exhibited in the higher Vertebrates. One or both pairs of limbs may be wanting, but when present the limbs are always in the form of *fins*—that is, of expansions of the integument strengthened by bony or cartilaginous fin-rays. The anterior limbs are known as the *pectoral* fins, and the posterior as the *ventral* fins; and they are at once distinguished from the so-called "median" fins by being always symmetrically disposed in pairs. Hence they are often spoken of as the *paired* fins. The scapular arch (figs. 127, 128) supporting the pectoral limbs is usually joined to the skull (occipital bone), and consists of the following pieces on each side:—1. The suprascapula (*ss*); 2. The scapula (*s*), articulating with the former; and, 3. The coracoid (*co*), attached above with the scapula, and

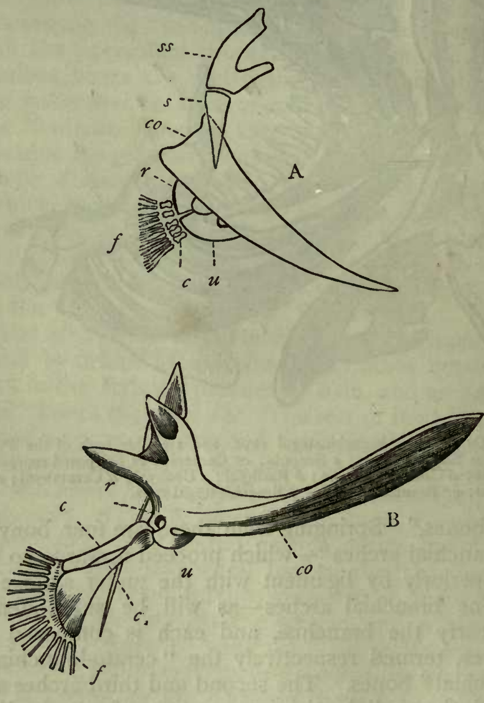


Fig. 128.—Pectoral limbs of Fishes (after Owen). A, Cod (*Morrhua vulgaris*); B, Angler (*Lophius*). *ss* Supra-scapula; *s* Scapula; *co* Coracoid; *r* Radius; *u* Ulna; *cc* Carpal bones; *f* Fin-rays, representing the metacarpus and phalanges of the fingers.

united below, by ligament or suture, with the coracoid of the opposite side, thus completing the pectoral arch. Lastly, there is often another bone, sometimes single, but oftener of two pieces, attached to the upper end of the coracoid, and this is believed to represent the collar-bone or clavicle.*

The fore-limb possesses in a modified form most of the bones which are present in the higher *Vertebrata*. The *humerus*, or bone of the upper arm, is usually wanting, or it is altogether rudimentary. A radius and ulna (fig. 128, *r*, *u*) are usually present, and are followed by a variable number of bones, which represent the carpus, and some of which sometimes articulate directly with the coracoid. The carpus is followed by the "rays" of the fin proper, these representing the metacarpal bones and phalanges.

The hind-limbs or "ventral fins" are wanting in many fishes, and they are less developed and less fixed in position than are the pectoral fins. In the ventral fins no representatives of the tarsus, tibia and fibula, or femur, are ever developed. The rays of the ventral fins—representing the metatarsus and the phalanges of the toes—unite directly with a pelvic arch, which is composed of two sub-triangular bones, united in the middle line and believed to represent the *ischia*. The imperfect pelvic arch, thus constituted, is never united to the vertebral column in any fish. In those fishes in which the ventral fins are "abdominal" in position (*i.e.*, placed near the hinder end of the body) the pelvic arch is suspended freely amongst the muscles. In those in which the ventral fins are "thoracic" or "jugular" (*i.e.*, placed beneath the pectoral fins, or on the sides of the neck) the pelvic arch is attached to the coracoid bones of the scapular arch, and is therefore wholly removed from its proper vertebra.

In addition to the pectoral and ventral fins—the homologues of the limbs—which may be wanting, fishes are furnished with certain other expansions of the integument, which are "median" in position, and must on no account be confounded with the true "paired" fins. These median fins are variable in number, and in some cases there is but a single fringe running round the posterior extremity of the body. In all cases, however, the median fins are "azygous"—that is to say, they occupy the middle line of the body, and are not symmetrically disposed in pairs. Most commonly, the median fins consist of one or two expansions of the dorsal integument, called the "dorsal fins" (fig. 129, *d*, *d'*); one or two on the ventral surface near the anus—the "anal fins" (fig. 129, *a*); and a broad fin at the extremity of the vertebral column, called the

* These are the views entertained by Owen as to the composition and nature of the pectoral arch of fishes, but they are dissented from by Mr Parker, one of the greatest living authorities on this subject.

"caudal fin" or tail (*c*). In all cases, the rays which support the median fins are articulated with the so-called interspinous bones, which have been previously described.

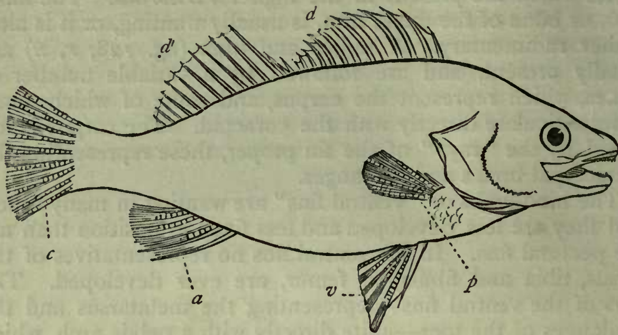


Fig. 129.—Outline of a fish (*Perca granulata*), showing the paired and unpaired fins. *p* One of the pectoral fins; *v* One of the ventral fins; *d* First dorsal fin; *d'* Second dorsal fin; *a* Anal fin; *c* Caudal fin.

The caudal fin or tail of fishes is always set vertically at the extremity of the spine, so as to work from side to side, and it is the chief organ of progression in the fishes. In its vertical position and in the possession of fin-rays, it differs altogether from the horizontal integumentary expansion which constitutes the tail of the Whales, Dolphins, and *Sirenia* (Dugong and Manatee). In the form of the tail fishes exhibit two very distinct types of structure, termed respectively the "homocercal" and "heterocercal" type of tail (fig. 130). The homocercal tail is the one which most commonly occurs in our modern fishes, and it is characterised by the fact that the two lobes of the tail are equal, and the vertebral column, instead of being prolonged into the upper lobe of the tail, stops short at its base. In the heterocercal tail, on the other hand, the vertebral column is prolonged into the upper lobe of the tail, so that the tail becomes unequally lobed, its greater portion being placed

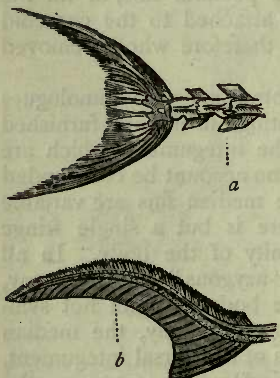


Fig. 130.—Tails of different fishes. *a* Homocercal tail (Sword-fish); *b* Heterocercal tail (Sturgeon).

below the spine. Even where the vertebral column is not prolonged into the upper lobe, the tail may nevertheless become heterocercal, in consequence of a great development of the hæmal spines as compared with the neural spines of the vertebræ.

The process of *respiration* in all fishes is essentially aquatic, and is carried on by means of branchial plates or tufts developed upon the posterior visceral arches, which are persistent, and do not disappear at the close of embryonic life, as they do in other Vertebrates. In the Lancelet alone, respiration is effected partly by branchial filaments placed round the commencement of the pharynx, and partly by the pharynx itself, which is greatly enlarged, and has its walls perforated by a series of transverse ciliated fissures. The arrangement and structure of the branchiæ differs a good deal in the different orders of Fishes, and these modifications will be noticed subsequently. In the meanwhile it will be sufficient to give a brief description of the branchial apparatus in one of the bony fishes. In such a fish, the branchiæ are connected with the hyoid arch, and are situated in two special chambers, situated one on each side of the neck. The branchiæ are carried upon the outer convex sides of what have been already described as the "branchial arches;" that is to say, upon a series of bony arches which are connected with the hyoid arch inferiorly, and are united above with the base of the skull. The internal concave sides of the branchial arches are usually furnished with a series of processes, constituting a kind of fringe, the function of which is to prevent foreign substances finding their way amongst the branchiæ, and thus interfering with the proper action of the respiratory organs. The branchiæ, themselves, usually have the form of a double series of cartilaginous leaflets or laminæ. The branchial laminæ are flat, elongated, and pointed in shape, and they are covered with a highly vascular mucous membrane, in which the branchial capillaries ramify. The blood circulates through the branchial laminæ, and is here subjected to the action of aerated water, whereby it is oxygenated. The water is constantly taken in at the mouth by a movement analogous to swallowing, and it gains admission to the branchial chambers by means of a series of clefts or slits, the "branchial fissures," which are situated on both sides of the pharynx. Having passed over the gills, the deoxygenated water makes its escape posteriorly by an aperture called the "gill-slit" or "opercular aperture," one of which is situated on each side of the neck. As we have seen before, the gill-slit is closed in front by a chain of flat bones, collectively constituting the "gill-cover" or "operculum;" and the gill-covers are finally completed by a variable number of bony spines—the "branchiostegal rays"—which articulate with the hyoid arch, and support a membrane—the "branchiostegal membrane."

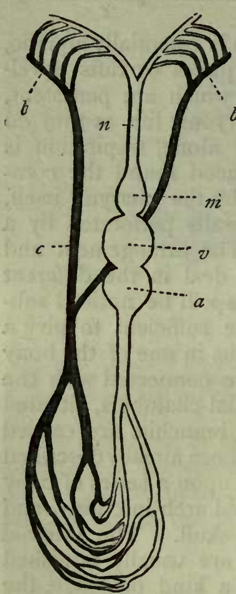


Fig. 131.—Diagram of the circulation in a fish. *a* Auricle, receiving venous blood from the body; *v* Ventricle; *m* Bulbus arteriosus, at the base of the branchial artery; *n* Branchial artery, carrying the venous blood to the gills (*b b*); *c* Aorta, carrying the arterialised blood to all parts of the body.

The *heart* of Fishes is, properly speaking, a branchial or respiratory heart. It consists of two cavities, an auricle and a ventricle (fig. 131, *a*, *v*), and the course of the circulation is as follows:—The venous blood derived from the liver and from the body generally is poured by the vena cava into the auricle (*a*), and from this it is propelled into the ventricle (*v*). From the ventricle arises a single aortic arch (the right), and the base of this is usually dilated into a cavity or sinus, called the "bulbus arteriosus" (*m*). The arterial bulb is sometimes covered with a special coat of striated muscular fibres, and is provided with several transverse rows of valves. In these cases, the bulbus acts as a kind of continuation of the ventricle, being capable of rhythmical contractions. The blood is driven by the ventricle through the branchial artery (*n*) to the gills, through which it is distributed by means of the branchial vessels, the number of which varies (there are *three* on each side in a few fishes, *four* in most of the bony fishes, *five* in the Skates and Sharks, and *six* or *seven* in the Lampreys). The aerated blood which has passed through the gills is not returned to the heart, but is driven from the branchiæ through all parts of the body; the propulsive force necessary for this being derived chiefly from the heart, assisted by the contractions of the voluntary muscles. In some fishes (as in the Eel) the return of the blood to the heart is assisted by a rhythmically contractile dilatation of the caudal vein. The essential peculiarity, then, of the circulation of fishes depends upon this—that the arterialised blood returned from the gills is propelled through the systemic vessels of the body, without being sent back to the heart.

The Lancelet (*Amphioxus*), alone of all Fishes, has no special heart, and the circulation is effected by contractile dilatations developed upon several of the blood-vessels. In the Mud-fish (*Lepidosiren*) the heart consists of *two* auricles and a single ventricle. The blood-corpuscles of Fishes are nucleated (fig. 122, *e*), and the blood is red in all except the *Amphioxus*.

As regards the *digestive system* of Fishes there is not much of peculiar importance. The mouth is usually furnished with a complicated series of teeth, which, in the Bony Fishes, are not only developed upon the jaws proper, but are also situated upon other bones which enter into the composition of the buccal cavity (such as the palate, the pterygoids, vomer, branchial arches, the glossohyal bone, &c.) The œsophagus is usually short and capacious, and generally opens into a large and well-marked stomach. The pyloric aperture of the stomach is usually furnished with a valve, and behind it there is usually a number (from one to sixty) of blind appendages, termed the "pyloric cæca." These are believed to represent the pancreas, but there may be a recognisable pancreas either alone or in addition to the pyloric cæca. The intestinal canal is a longer or shorter, more or less convoluted tube, the absorbing surface of which, in certain fishes, is largely increased by a spiral reduplicature of the mucous membrane, which winds like a screw in close turns from the pylorus to the anus. The liver is usually large, soft, and oily, and a gall-bladder is almost universally present; but in the *Amphioxus* the liver is doubtfully represented by a hollow sac-like organ.

The kidneys of fishes are usually of great size, and form two elongated organs, which are situated beneath the spine, and extend along the whole length of the abdominal cavity. The ureters often dilate, and form a species of bladder, the doubtful representative of the allantois.

Whilst the respiration of all fishes is truly aquatic, most of them are, nevertheless, furnished with an organ which is doubtless the homologue of the lungs of the air-breathing Vertebrates. This—the "air" or "swim bladder"—is a sac containing gas, situated beneath the alimentary tube, and often communicating with the gullet by a duct. In the great majority of fishes the functions of the air-bladder are certainly hydrostatic—that is to say, it serves to maintain the necessary accordance between the specific gravity of the fish and that of the surrounding water. In the singular Mud-fishes, however, it acts as a respiratory organ, and is therefore not only the homologue, but also the analogue, of the lungs of the higher

Vertebrates. In most fishes the air-bladder is an elongated sac with a single cavity, but in many cases it is variously subdivided by septa. In the Mud-fish the air-bladder is composed of two sacs, completely separate from one another, and divided into a number of cellular compartments. The duct leading in many fishes from the air-bladder (*ductus pneumaticus*) opens into the œsophagus, and is the homologue of the wind-pipe (*trachea*). The air contained in the swim-bladder is composed mainly of nitrogen in most fresh-water fishes, but in the sea-fishes it is mainly made up of oxygen.

The *nervous system* of Fishes is of an inferior type of organisation, the brain being of small size, and consisting mainly of ganglia devoted to the special senses. As regards the special senses, there is one peculiarity which deserves special notice, and this is the conformation of the nasal sacs. The cavity of the nose is usually double, and is lined by an olfactory membrane, folded so as to form numerous plicæ. Anteriorly, the water is admitted into the nasal sacs by a single or double nostril, usually by two apertures; but posteriorly the nasal sacs are closed, and do not communicate with the pharynx by any aperture. The only exceptions to this statement are to be found in the Myxinoids and in the Lepidosiren. The essential portion of the organ of hearing (*labyrinth*) is present in almost all fishes, but in none is there any direct communication between the ear and the external medium.

As regards their *reproductive system*, fishes are, for the most part, truly *oviparous*, the ovaries being familiarly known as the "roe." The testes of the male are commonly called the "soft roe" or "milt." The products of the reproductive organs are often set free into the peritoneal cavity, ultimately finding their way to the external medium, either by means of an abdominal pore (or pores), or by being taken up by the open mouths of the "Fallopian tubes." In other cases the generative products are directly conveyed to the exterior by the proper ducts of the reproductive organs.

DIVISIONS OF FISHES.

CHAPTER LV.

PHARYNGOBRANCHII AND MARSIPOBRANCHII.

THE class *Pisces* has been very variously subdivided by different writers; but the classification here adopted is the one proposed by Professor Huxley, who divides the class into the following six orders, in the subdivisions of which Professor Owen has been followed:—

ORDER I. PHARYNGOBRANCHII (= *Cirrostomi*, Owen; and *Leptocardia*, Müller).—This order includes but a single fish, the anomalous *Amphioxus lanceolatus*, or Lancelet, the organisation of which differs in almost all important points from that of all the other members of the class. The order is defined by the following characters, which, as will be seen, are mostly negative:—No skull is present, nor lower jaw (mandible), nor limbs. The notochord is persistent; and there are no vertebral centra nor arches. No distinct brain nor auditory organs are present. In place of a distinct heart, pulsating dilatations are developed upon several of the great blood-vessels. The blood is pale. The mouth is in the form of a longitudinal fissure, surrounded by filaments or cirri. The walls of the pharynx are perforated by numerous clefts or fissures, the sides of which are ciliated, the whole exercising a respiratory function.

The Lancelet is a singular little fish which is found burrowing in sandbanks, in various seas, but especially in the Mediterranean. The body is lanceolate in shape, and is provided with a narrow membranous border, of the nature of a median fin, which runs along the whole of the dorsal and part of the ventral surface, and expands at the tail to form a lancet-shaped caudal fin. No true paired fins, representing the anterior and posterior limbs, are present. The mouth is a longitudinal fissure, situated at the front of the head, and destitute of jaws. It is surrounded by a cartilaginous ring, composed of many pieces, which give off prolongations, so as to form a number of cartilaginous filaments or "cirri" on each side of the mouth. (Hence the name of *Cirrostomi*, proposed by Professor Owen for the order.) The throat is provided on each side with vascular lamellæ, which are believed by Owen

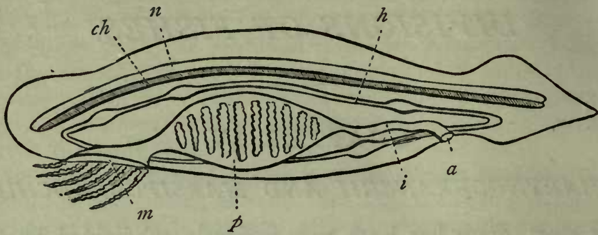


Fig. 132.—Diagram of the Lancelet (*Amphioxus*). *m* Mouth, surrounded by cartilaginous cirri; *p* Greatly dilated pharynx, perforated by ciliated clefts; *i* Intestine, terminating in anus (*a*); *h* Hæmal system, with pulsating dilatations; *ch* Notochord; *n* Spinal cord.

to perform the function of free branchial filaments. The mouth leads into a dilated chamber, which is believed to represent the pharynx, and is termed the "pharyngeal" or "branchial sac." It is an elongated chamber, the walls of which are strengthened by numerous cartilaginous filaments, between which is a series of transverse slits or clefts, the whole covered by a richly ciliated mucous membrane. This branchial dilatation has given rise to the name *Branchiostoma*, often applied to the Lancelet. Posteriorly the branchial sac opens into an alimentary canal, to which is appended a long and capacious sac or cæcum, which is believed to represent the liver. The intestinal tube terminates posteriorly by a distinct anus. Respiration is effected by the admission of water taken in by the mouth into the branchial sac, having previously passed over the free branchial filaments before mentioned. The water passes through the slits in the branchial sac, and thus gains access to the abdominal cavity, from which it escapes by means of an aperture with contractile margins situated a little in front of the anus, and called the "abdominal pore." There is no distinct heart, and the circulation is entirely effected by means of several rhythmically contractile dilatations which are developed upon several of the great blood-vessels. The blood itself is colourless. No kidneys have as yet been discovered, and there is no lymphatic system. There is no skeleton properly so called. In place of the vertebral column, and constituting the whole endoskeleton, is the semi-gelatinous cellular notochord, enclosed in a fibrous sheath, and giving off fibrous arches above and below. The notochord is, further, peculiar in this, that it is prolonged quite to the anterior end of the body, whereas in all other Vertebrates it stops short at the pituitary fossa. There is no cranium, and the spinal cord does not expand anteriorly to form a distinct cerebral mass. The brain, however, may be said to be represented, since the anterior portion of the nervous axis gives off nerves to a pair of rudimentary eyes, and another branch to a ciliated pit, believed to represent an olfactory organ. The generative organs (ovaria and testes) are not furnished with any efferent ducts (oviduct or vas deferens). The generative products, therefore, must be admitted into the abdominal cavity, and gain the external medium by the "abdominal pore."

ORDER II. MARSIPOBRANCHII (= *Cyclostomi*, Owen; and *Cyclostomata*, Müller). — This order includes the Lampreys (*Petromyzonidæ*) and the Hag-fishes (*Myxinidæ*), and is defined by the following characters:—The body is cylindrical, worm-like, and destitute of limbs. The skull is cartilaginous, without cranial bones, and having no lower jaw (mandible). The notochord is persistent, and there are either no vertebral centra, or but the most rudimentary traces of them. The heart consists of one auricle and one ventricle, but the branchial artery is not furnished with a bulbus arteriosus. The gills are sac-like, and are not ciliated.

The type of piscine organisation displayed in the *Marsipobranchii* is of a very low grade, as indicated chiefly by the persistent notochord without vertebral centra, the absence of any traces of limbs, the absence of a mandible, and the structure of the gills.

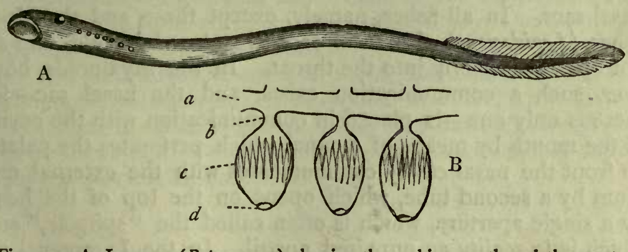


Fig. 133.—A, Lamprey (*Petromyzon*), showing the sucking-mouth and the apertures of the gill-sacs. B, Diagram to illustrate the structure of the gills in the Lamprey: *a* Pharynx; *b* Tube leading from the pharynx into one of the gill-sacs; *c* One of the gill-sacs, showing the lining membrane thrown into folds; *d* External opening of the gill-sac. (In reality the gill-sacs do not open directly into the pharynx, but into a common respiratory tube, which is omitted for the sake of clearness.)

Both the Lampreys (fig. 133, A) and the Hag-fishes are vermiform, eel-like fishes, which agree in possessing no paired fins, to represent the limbs, but in having a median fin running round the hinder extremity of the body. The skeleton remains throughout life in a cartilaginous condition, the chorda dorsalis is persistent, and the only traces of bodies of vertebræ are found in hardly perceptible rings of osseous matter developed in the sheath of the notochord. The neural arches of the vertebræ, enclosing the spinal cord, are only represented by cartilaginous prolongations. The mouth in the Hag-fish (*Myxine*) is of a very remarkable character, and enables it to lead a very peculiar mode of life. It is usually found, namely, embedded in the interior of some other larger fish, into which it has succeeded in penetrating by means of its singular dental apparatus. The mouth is sucker-like, destitute of jaws, but provided with tactile filaments or cirri. In the centre of the palate is fixed a single, large, recurved fang, which is firmly attached to the under surface of the cranium. The sides of this fang are strongly serrated, and it is by means of this that the Hag-fish bores its way into its victim, having previously attached itself by its sucker-like mouth. In the Lampreys the mouth has also the form of a circular cup or sucker, and is also destitute of jaws; but in addition to the palatine fang of the *Myxine*, the margins of the lips bear a number of horny processes, which are not really true teeth, but are hard structures developed in the labial mucous membrane. The tongue, also, is armed with serrated teeth, and acts as a kind of piston; so that the Lampreys are in this manner enabled to attach themselves firmly to solid objects.

A very remarkable peculiarity in the Hag-fishes, and one very necessary to remember, is found in the structure of the nasal sacs. In all fishes, namely, except these and the Mudfishes (*Lepidosiren*), the nasal sacs are closed behind, and do not open posteriorly into the throat. In the Myxinoids, however, such a communication exists, and the nasal sac—for there is only one—is placed in communication with the cavity of the mouth by means of a canal which perforates the palate. In front the nasal cavity communicates with the external medium by a second tube, which opens on the top of the head by a single aperture, which is often called the "spiracle," and which is in reality an unpaired nostril. In the Lampreys, on the other hand, the single nasal sac has the same structure as in the typical fishes—that is to say, it is closed behind, and does not communicate in any way with the cavity of the mouth.

Another very remarkable point in the Hag-fishes and Lampreys is to be found in the structure of the gills, from which the name of the order is derived. In the Lampreys, in place of the single gill-slit, covered by a gill-cover, as seen in the ordinary bony fishes, the side of the neck, when viewed externally, exhibits six or seven round holes placed far back in a line on each side (fig. 133, A). In the Hag-fishes the external apertures of the gills are reduced to one on each side, placed below the head; but the internal structure of the gills is the same in both cases. In both the Lampreys and the Hag-fishes, namely, the gills are in the form of sacs or pouches (fig. 133, B), the mucous membrane of which is thrown into folds or plaits like the leaves of a book, over which the branchial vessels ramify. Internally the sacs communicate with the cavity of the pharynx, either directly or by the intervention of a common respiratory tube. It follows from this, that the gill-pouches on the two sides, with their included fixed branchial laminæ, communicate freely with one another through the pharynx. The object of this arrangement appears to be mainly that of obviating the necessity of admitting water to the gills through the mouth, as is the case with the ordinary bony fishes. These fishes are in the habit of fixing themselves to foreign objects by means of the suctorial mouth; and when in this position it is, of course, impossible that they can obtain the necessary water of respiration through the mouth. As the branchial pouches, however, on the two sides of the neck communicate freely with one another through the pharynx, water can readily pass in and out. This, in the Lampreys, is further assisted by a kind of elastic cartilaginous framework upon which the respiratory apparatus is supported, and which acts somewhat like the ribs of the higher *Vertebrata*. Water can also be admitted to the pharynx, and thence to the branchial sacs, by means of a tube which leads from the pharynx to an aperture placed on the top of the head.

The Lampreys are, some of them, inhabitants of rivers; but the great Sea-lamprey (*Petromyzon marinus*) only quits the salt water in order to spawn. The Hag-fish (*Myxine glutinosa*) is an inhabitant of the North Sea, and is commonly captured on the Norwegian coast.

CHAPTER LVI.

TELEOSTEI.

ORDER III. TELEOSTEI.—This order includes the great majority of fishes in which there is a well-ossified endoskeleton, and it corresponds very nearly with Cuvier's division of the "osseous" fishes. The *Teleostei* are defined as follows:—The skeleton is usually well ossified; the cranium is provided with cranial bones; and a mandible is present; whilst the vertebral column almost always consists of more or less completely ossified vertebræ. The pectoral arch has a clavicle; and the two pairs of limbs, when present, are in the form of fins supported by rays. The gills are *free*, pectinated or tufted in shape; a bony gill-cover and branchiostegal rays being always developed. The branchial artery has its base developed into a bulbus arteriosus; but this is never rhythmically contractile, and is separated from the ventricle by no more than a single row of valves.

The order *Teleostei* comprises almost all the common fishes; and it will be unnecessary to dilate upon their structure, as they were taken as the types of the class in giving a general description of the Fishes. It may be as well, however, to recapitulate very briefly some of the leading characters of the order.

I. The *skeleton*, instead of remaining throughout life more or less completely cartilaginous, is now always more or less thoroughly ossified. The notochord is not persistent, and the vertebral column, though sometimes cartilaginous, consists of a number of vertebræ. The bodies of the vertebræ are what is called "amphicœlous"—that is to say, they are concave at both ends. It follows from this, that between each pair of vertebræ there is formed a doubly-conical cavity, and this is filled with the cartilaginous or semi-gelatinous remains of the notochord. By this means an extraordinary amount of flexibility is given to the entire vertebral column. In no fish except the Bony Pike (which belongs to the order *Ganoidei*) is the ossification of the vertebral centra carried further than this. The skull is of an extremely complicated nature, being composed of a number of distinct cranial bones; and a mandible or lower jaw is invariably present.

II. The anterior and posterior pairs of limbs are usually, but not always, present, and when developed they are always in the form of fins. The fins may be supported by "spinous" or "soft" rays, of which the former are simple undivided spines of bone, whilst the latter are divided transversely into a number of short transverse pieces, and also are broken up into a number of longitudinal rays proceeding from a common root. (The Fishes with soft rays in their paired fins are termed "*Malacopterygii*"—those with spinous rays, "*Acanthopterygii.*")

III. Besides the paired fins, representing the limbs, there is a variable number of unpaired or azygous integumentary expansions, which are known as the "median fins." When fully developed (fig. 129), they consist of one or two fins on the back—the "dorsal" fins; one or two on the ventral surface—the "anal" fins; and one clothing the posterior extremity of the body—the "caudal" fin. The caudal fin is set vertically, and not horizontally, as in the Whales and Dolphins; and in all the bony fishes its form is "homocercal"—that is, it consists of two equal lobes, and the vertebral column is not prolonged into the superior lobe. In all the median fins the fin-rays are supported upon a series of dagger-shaped bones, which are plunged in the flesh of the middle line of the body, and are attached to the spinous processes of the vertebræ. These are the so-called "interspinous" bones.

IV. The *heart* consists of two chambers—an auricle and a ventricle, and the branchial artery is furnished with a bulbus arteriosus. The arterial bulb, however, is not furnished with a special coat of striated muscular fibres, is not rhythmically contractile, and is separated from the ventricle by no more than a single row of valves (fig. 134, A).

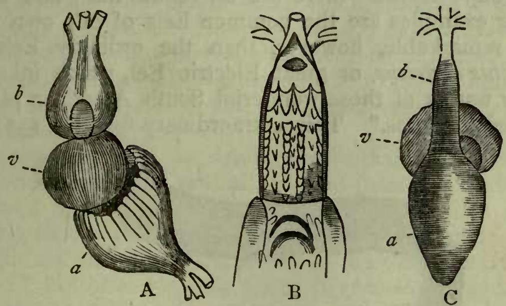


Fig. 134.—A, Heart of the Angler (*Lophius piscatorius*). B, Arterial bulb of Bony Pike (*Lepidosteus*) cut open. C, Heart of the same, viewed externally: *a* Auricle; *v* Ventricle; *b* Arterial bulb.

V. The *respiratory organs* consist of free, pectinated, or tufted branchiæ, situated in two branchial chambers, each of which communicates internally with the pharynx by a series of clefts, and opens externally on the side of the neck by a single aperture (or "gill-slit"), which is protected in front by a bony gill-cover, and is also closed by a "branchiostegal membrane," supported upon "branchiostegal rays." The branchiæ are attached to a series of bony branchial arches, which are connected inferiorly with the hyoid bone and superiorly with the skull; and the water required in respiration is taken in at the mouth by a process analogous to swallowing.

VI. The nasal sacs never communicate posteriorly with the cavity of the pharynx.

The subdivisions of the osseous fishes are so numerous, and they contain so many families, that it will be sufficient to run over the more important sub-orders, and to mention the more familiar examples of each.

SUB-ORDER A. MALACOPTERI, Owen (= *Physostomata*, Müller).—This sub-order is defined by usually possessing a complete set of fins, supported by rays, all of which are "*soft*" or many-jointed, with the occasional exception of the first rays in the dorsal and pectoral fins. A swim-bladder is always present, and always communicates with the œsophagus by means of a duct, which is the homologue of the windpipe. The skin is rarely naked, and is mostly furnished with cycloid scales; but in some cases ganoid plates are present.

This sub-order is one of great importance, as comprising many well-known and useful fishes. It is divided into two groups, according as ventral fins are present or not. In the first group—*Apoda*—there are no ventral fins; and the most familiar examples are the common Eels of our own country. More remarkable, however, than the ordinary Eels is the *Gymnotus electricus*, or great Electric Eel, which inhabits the marshy waters of those wonderful South American plains, the so-called "Llanos." This extraordinary fish (fig. 135) is from

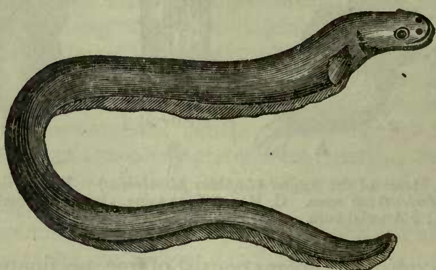


Fig. 135.— Electric Eel (*Gymnotus electricus*).

five to six feet in length, and the discharge of its electrical organs is sufficiently powerful to kill even large animals. The following striking account is given by Humboldt of the manner in which the *Gymnoti* are captured by the Indians:—"A number of horses and mules are driven into a swamp which is closely surrounded by Indians, until the unusual disturbance excites the daring fish to venture an attack. Serpent-like, they are seen swimming along the surface of the water, striving cunningly to glide under the bellies of the horses. By the force of their invisible blows numbers of the poor animals are suddenly prostrated; others, snorting and panting, their manes erect, their eyes wildly flashing terror, rush madly from the raging storm; but the Indians, armed with long bamboo staves, drive them back into the midst of the pool.

"By degrees the fury of this unequal contest begins to slacken. Like clouds which have discharged their electricity, the wearied eels disperse. They require long rest and nourishing food, to repair the galvanic force which they have so lavishly expended. Their shocks gradually become weaker and weaker. Terrified by the noise of the trampling horses, they timidly approach the banks of the morass, where they are wounded by harpoons, and drawn on shore by non-conducting pieces of dry wood.

"Such is the remarkable contest between horses and fish. That which constitutes the invisible but living weapon of these inhabitants of the waters—that which, awakened by the contact of moist and dissimilar particles, circulates through all the organs of animals and plants—that which, flashing amid the roar of thunder, illuminates the wide canopy of heaven—which binds iron to iron, and directs the silent recurring course of the magnetic needle—all, like the refracted rays of light, flow from one common source, and all blend together into one eternal all-pervading power."

The second group of the *Malacopteri* is that of the *Abdominalia*, in which there are ventral fins, and these are abdominal in position. Space will not permit of more here than merely mentioning that in this section are contained amongst others the well-known and important groups of the *Clupeidæ* (Herring tribe), the Pikes (*Esocidæ*), the Carps (*Cyprinidæ*), the *Sternoptixinæ*, and the *Salmonidæ*, comprising the various species of Salmon and Trout. Also belonging to this group are the Sheat-fishes (*Siluridæ*), which are chiefly noticeable because they are amongst the small number of living fishes possessed of structures of the same nature as the fossil spines known as "ichthyodorulites." The structure in question consists of the first ray of the pectoral fins, which is largely developed and constitutes a formidable spine, which the animal can erect and depress at pleasure. Unlike the old "ichthyodorulites," however, the spines of the *Siluridæ* have their bases modified for articulation with another bone, and they are not simply hollow and implanted in the flesh. The "Siluroids" are also remarkable for their resemblance to certain of the extinct Ganoid fishes (*e. g.*, *Pterichthys*, *Coccosteus*, &c.), caused by the fact that the head is protected with an exoskeleton of dermal bones.

SUB-ORDER B. ANACANTHINI.—This sub-order is distinguished by the fact that the fins are entirely supported by "soft" rays, and never possess "spiny" rays; whilst the ventral fins are either wanting, or, if present, are placed under the throat, beneath or in advance of the pectorals, and supported by the pectoral arch. The swim-bladder may be wanting, but when present it does not communicate with the œsophagus by a duct.

As in the preceding order, the *Anacanthini* are divided into two groups, distinguished by the presence or absence of the ventral fins. In the first of these groups (*Apoda*) are only a few fishes, of which one of the most familiar examples is the little Sand-eel (*Ammodytes lancea*), which occurs on all our coasts. In the second group (*Sub-brachiata*) in which ventral fins exist, are the two important families of the *Gadidæ* and *Pleuronectidæ*. The *Gadidæ* or Cod family, comprising the Haddock, Whiting, Ling, and Cod itself, is of great value to man, most of its members being largely consumed as food. In the *Pleuronectidæ* or Flat-fishes are comprised the Sole, Plaice, Turbot, Halibut, Brill and others, in all of which there is a very curious modification in the form of the body. The body, namely, in all the Flat-fishes (fig. 136) is very much compressed

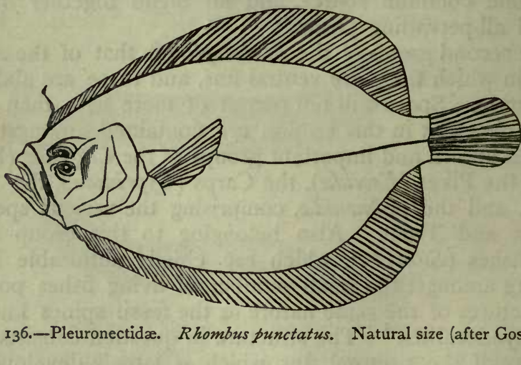


Fig. 136.—Pleuronectidæ. *Rhombus punctatus.* Natural size (after Gosse).

from side to side, and is bordered by long dorsal and anal fins. The bones of the head are twisted in such a manner that the two eyes are both brought to one side of the body. The fish usually keeps this side uppermost and is dark-coloured on this aspect, whilst the opposite side, on which it rests, is white. From this habit of the Flat-fishes of resting upon one flat surface, the sides are often looked upon as the dorsal and ventral surfaces of the body. This, however, is erroneous, as they are shown by the position of the paired fins to be truly the *lateral* surfaces of the body.

SUB-ORDER C. ACANTHOPTERI.—This sub-order is characterised by the fact that one or more of the first rays in the fins are in the form of true, unjointed, inflexible, "spiny" rays. The exoskeleton consists, as a rule, of ctenoid scales. The ventral fins are generally beneath or in advance of the pectorals, and the duct of the swim-bladder is invariably obliterated.

This sub-order comprises two families :—

a. The *Pharyngognathi*, in which the inferior pharyngeal bones are anchylosed so as to form a single bone, which is usually armed with teeth. The family is not of much importance, the only familiar fishes belonging to it being the "Wrasses" (*Cyclolabridæ*).

b. The *Acanthopteri veri*, characterised by having always spiny rays in the first dorsal fin, and usually in the first rays of the other fins, whilst the inferior pharyngeal bones are never anchylosed into a single mass. This family includes many subordinate groups, and may be regarded as, on the whole, the most typical division of the Teleostean Fishes. It will not be necessary, however, to do more than mention as amongst the more important fishes contained in it, the Perch family (*Percidæ*), the Mullets (*Mugilidæ*), the Mackerel family (*Scomberidæ*), the Gurnards (*Sclerogenidæ*), the Gobies (*Gobiidæ*), the Blennies (*Blenniidæ*), and the Anglers (*Lophiidæ*).

SUB-ORDER D. PLECTOGNATHI.—This sub-order is characterised by the fact that the maxillary and premaxillary bones are immovably connected on each side of the jaw. The endoskeleton is only partially ossified, and the vertebral column often remains permanently cartilaginous. The exoskeleton is in the form of ganoid plates, scales, or spines. The ventral fins are generally wanting, and the air-bladder is destitute of a duct.

The most remarkable fishes of this section are the Trunkfishes (*Ostraciontidæ*, fig. 137), in which the body is entirely enclosed, with the exception of the tail, in an immovable case, composed of large ganoid plates, firmly united to one another at their edges.

Besides the Trunk-fishes, this section also includes the Filefishes (*Balistidæ*) and the Globe-fishes (*Gymnodontidæ*).

SUB-ORDER E. LOPHOBRANCHII. — This is a small and unimportant group, mainly characterised by the peculiar structure of the gills, which are arranged in little tufts upon the branchial arches, instead of the comb-like plates of the typical bony fishes. The endoskeleton is only partially converted into bone, and the exoskeleton, by way of compensation, consists of ganoid plates. The swim-bladder is destitute of an air-duct.

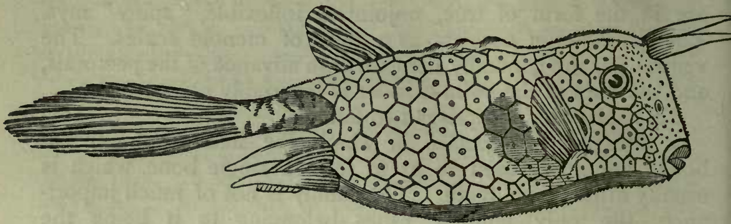


Fig. 137.—Ostraciontidæ. Horned Trunk-fish (*Ostracion cornutus*).

The singular Sea-horses (*Hippocampidæ*), now kept in most of our large aquaria, belong to this sub-order, but the only point about them which requires notice is the curious fact that the males in this family are provided with a sort of marsupial pouch, into which the eggs are placed by the female, and to which the young, when hatched, can retire if threatened by any danger. This singular cavity is only found in the males, and is situated at the base of the tail. More familiar than the Sea-horses are the Pipe-fishes (*Syngnathidæ*), of which one species occurs commonly on our shores.

CHAPTER LVII.

GANOIDEI.

ORDER IV. GANOIDEI. — The fourth order of fishes is the large and important one of the *Ganoid* fishes, represented, it is true, by few living forms, but having an enormous development in past geological epochs. For this reason the study of the Ganoid fishes is one which claims considerable attention.

The order *Ganoidei* may be defined by the following characters:—The endoskeleton is only partially ossified, the vertebral column mostly remaining cartilaginous throughout life, especially amongst the extinct forms of the Palæozoic period, in which the notochord is persistent. The skull is furnished with distinct cranial bones, and the lower jaw is present. The exoskeleton is in the form of ganoid scales, plates, or spines. There are usually two pairs of limbs, in the form of fins, each supported by fin-rays. The first rays of the fins are mostly in the form of strong spines. The pectoral arch has a clavicle, and the posterior limbs (ventral fins) are placed close to the anus. The caudal fin is mostly unsymmetrical or "heterocercal." The swim-bladder is always present, is often cellular, and is provided with an air-duct. The intestine is often furnished with a spiral valve. The gills and opercular apparatus are essentially the same as in the Bony fishes. The heart has one auricle and a ventricle, and the base of the branchial artery is dilated into a bulbus arteriosus, which is rhythmically contractile, is furnished with a distinct coat of striated muscular fibres, and is provided with several transverse rows of valves.

Of these characters, the ones which it is most important to remember are the following :—

I. The *endoskeleton* is rarely thoroughly ossified, but varies a good deal as to the extent to which ossification is carried. In some forms, including most of the older members of the order, the chorda dorsalis is persistent, no vertebral centra are developed, and the skull is cartilaginous, and is protected by ganoid plates. Even in these forms, however, the peripheral elements of the vertebræ are ossified. In others, the bodies of the vertebræ are marked out by osseous or semi-cartilaginous rings, enclosing the primitive matter of the notochord. In others, the vertebræ are like those of the Bony fishes—that is to say, deeply biconcave or "amphicœlous." In one Ganoid, however—the Bony Pike (*Lepidosteus*)—the vertebral column consists of a series of "opisthocœlous" vertebræ—that is to say, vertebræ which are convex in front and concave behind. This is the highest point of development reached in the spinal column of any fish, and its structure is more Reptilian than Piscine.

II. The *exoskeleton* consists in all Ganoid fishes of scales, plates, or spines, which are said to possess *ganoid* characters. The peculiarities of these scales are that they are composed of two distinct layers—an inferior layer of bone and a superficial covering of a kind of enamel, somewhat similar to the enamel of the teeth, called "ganoine." In form the ganoid scales most generally exhibit themselves as rhomboidal plates, placed edge to edge, without overlapping, in oblique rows, the plates of each row being often articulated to those of the next by distinct processes (fig. 124, *d*). In other cases the ganoid structures are simply in the form of detached plates, tubercles, or spines; and in some cases their *shape* is even undistinguishable from the horny scales of the typical Teleostean fishes. In all cases, however, whatever their form may be, they have the distinctive ganoid structure, being composed of an inferior layer of true bone and a superior layer of enamel. It is to be remembered, however, that these *ganoid* plates and scales are not confined to the fishes of the order *Ganoidei*, but that they occur in two sub-orders of the Bony fishes—namely, the *Plectognathi* and *Lophobranchii*—and in some others of the *Teleostei* as well.

III. As to the *fins*, both pectorals and ventrals are usually present, and the ventrals are always placed far back in the neighbourhood of the anus, and are never situated in the immediate vicinity of the pectorals. In some living and many extinct forms the fin-rays of the paired fins are arranged so as to form a fringe round a central lobe (fig. 138). This structure characterises a division of Ganoids called by Huxley, for this reason, *Crossopterygidæ*, or "fringe-finned." The form of the caudal fin varies, the Ganoids being in this respect intermediate between the Bony fishes, in which the tail is "homocercal," and the Sharks and Rays, in which there is a "heterocercal" caudal fin. In the majority of Ganoids, then, the tail is unsymmetrical or "heterocercal," but it is sometimes equi-lobed or "homocercal."

IV. As to the structure of the *respiratory organs*, the Ganoid fishes agree essentially with the Bony fishes. They all possess *free* pectinated gills attached to branchial arches, and enclosed in a branchial chamber, which is protected by an operculum, and is closed by a branchiostegal membrane, usually supported by branchiostegal rays. Besides the ordinary branchiæ there is frequently an additional gill, called the "opercular branchia," attached to the interior of each operculum, and below this a false gill or "pseudo-branchia," which receives arterialised blood only.

V. There is always a swim-bladder, which is often divided by partitions into several cells, and is always connected with the gullet by an air-duct, as in the Malacopterous division of the Teleostean fishes.

VI. As to the structure of the *heart*, the Ganoids differ from the Bony fishes, and agree with the Sharks and Rays in having a rhythmically contractile bulbus arteriosus, which is furnished with a special coat of striated muscular fibres, and is separated from the ventricle by several rows of valves (fig. 134, B, C). This is a decided advance in structure, as in this way the arterial bulb is enabled to act as a continuation of the ventricle.

VII. The intestine is often furnished with a spiral reduplication of its mucous membrane, forming a spiral valve, such as we shall afterwards see in the Sharks and Rays.

The order of the Ganoid fishes is divided by Owen into the two divisions of the *Lepidoganoidei* and the *Placoganoidei*. The best-known living fishes belonging to the Lepidoganoids are the Bony Pike and the *Polypterus*. The Bony Pike (*Lepidosteus*) inhabits the rivers and lakes of North America, and attains a length of several feet. The body is entirely clothed with an armour of ganoid scales, arranged in obliquely transverse rows. The vertebral column is exceedingly well ossified, and is reptilian in its characters, the bodies of the vertebræ being "opisthocœlous." The jaws form a long narrow snout, armed with a double series of teeth; and the tail is heterocercal.

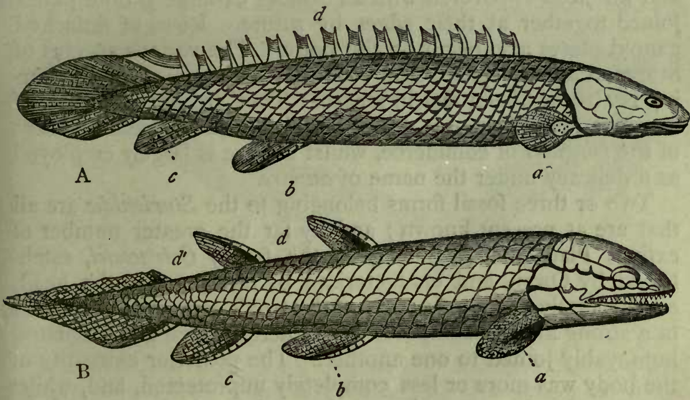


Fig. 138.—Ganoid Fishes. A, *Polypterus;* B, *Osteolepis* (extinct). *a* One of the pectoral fins, showing the fin-rays arranged round a central lobe; *b* One of the ventral fins; *c* Anal fin; *d* Dorsal fin; *d'* Second dorsal fin.

The *Polypteri*, of which several species are known, inhabit the Nile, Senegal, and other African rivers, and are remarkable for the peculiar structure of the dorsal fin (fig. 138, A), which is broken up into a number of separate portions, each composed of a single spine in front, with a soft fin attached to it behind. Two species of *Polypterus* have recently been stated to possess *external* branchiæ when young, losing them when fully grown. This observation, if confirmed, will bring the Ganoids into a nearer relationship with the Mud-fishes (*Lepidosiren*).

The section *Placoganoidei* includes the largest and best known of all the living Ganoid fishes—namely, the Sturgeons—and it also contains some highly singular fossil forms. The sub-order is defined by the fact that the skeleton is always imperfectly ossified, and often retains the notochord, whilst the head and more or less of the body are protected by large ganoid plates, which in many cases are united together at their edges by sutures. The tail is heterocercal.

The family *Sturionidæ* comprises the various species of Sturgeon, which are found in the North, Black, and Caspian seas, whence they ascend the great rivers for the purpose of spawning. Other allied forms are peculiar to the North American continent (*e. g.*, the Paddle-fish, *Spatularia*). The vertebral column in the Sturgeon remains permanently in an embryonic condition. The notochord is persistent, and the vertebral centra are wanting, but the neural arches of the vertebræ reach the condition of cartilage. The mouth is destitute of teeth, and the head is covered with an armour of large ganoid plates joined together at their edges by suture. Rows of detached ganoid plates also occur on the body. The various species of Sturgeon attain a great size, one—the Beluga—often measuring twelve or fifteen feet in length. They are commercially of considerable importance, the swimming-bladder yielding most of the *isinglass* of commerce, whilst the roe is largely employed as a delicacy under the name of *caviare.*

Two or three fossil forms belonging to the *Sturionidæ* are all that are at present known; and by far the greater number of extinct Placoganoids belong to the family *Ostracostei*, established by Owen, and characterised by the fact that the head, and generally the anterior part of the trunk as well, was encased in a strong armour composed of numerous large ganoid plates, immovably joined to one another. The posterior extremity of the body was more or less completely unprotected, and, whilst the notochord was persistent, the peripheral elements of the vertebræ—namely, the neural and hæmal spines—were ossified. The following are the more remarkable forms belonging to this section:—

a. Pterichthys.—This is one of the most singular of fossil fishes, and was first discovered in the Old Red Sandstone by the late Hugh Miller. The whole of the head and the anterior part of the trunk were defended by a buckler of large ganoid plates, those covering the trunk forming a back-plate and a breast-plate, articulated together at the sides.

The rest of the body was covered with small ganoid scales (fig. 140). A small dorsal fin, a pair of ventrals, a pair of pectorals, and a heterocercal tail-fin were present. The form of the pectoral fins is the peculiar characteristic of the *Pterichthys.* These were in the form of two long curved spines, something like wings, covered by finely tuberculated ganoid plates. From their form, they cannot have been of much use in swimming; but they probably, as suggested by Owen, enabled the fish to shuffle along the sandy bottom of the sea, if left dry at low water.

b. Pteraspis.—In most respects this genus was not unlike *Pterichthys*, but it did not possess the peculiar pectoral fins of the latter. One species of Pteraspis has been found in the Upper Silurian Rocks (Ludlow), and is as yet one of the earliest known indications of the appearance of the great sub-kingdom *Vertebrata* upon the globe.

c. Cephalaspis (fig. 139). This, again, is not unlike *Pterichthys* in many respects. The cephalic buckler, however, has its posterior angles produced backwards, so as to give it the shape of a "saddler's knife," whilst the pectoral limbs had not the form of spines.

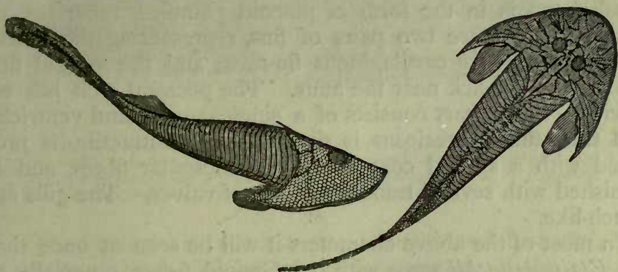


Fig. 139.—*Cephalaspis Lyellii.*

d. Coccosteus (fig. 140). — This is another characteristic genus of the Old Red Sandstone. In this genus, as in the preceding, there is a cephalic buckler, the plates of which are

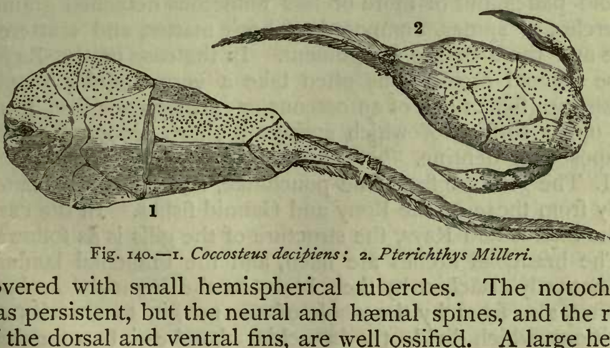


Fig. 140.—1. *Coccosteus decipiens;* 2. *Pterichthys Milleri.*

covered with small hemispherical tubercles. The notochord was persistent, but the neural and hæmal spines, and the rays of the dorsal and ventral fins, are well ossified. A large heterocercal tail-fin was doubtless present as well.

CHAPTER LVIII.

ELASMOBRANCHII AND DIPNOI.

ORDER V. ELASMOBRANCHII (= *Selachia*, Müller; *Placoidei*, Agassiz; *Holocephali* and *Plagiostomi*, Owen).—This order includes the Sharks, Rays, and Chimæræ, and corresponds with the greater and most typical portion of the *Chondropterygidæ* or Cartilaginous Fishes of Cuvier. The order is distinguished by the following characters:—The skull and lower jaw are well developed, but there are no cranial bones, and the skull consists of a single cartilaginous box, without any indication of sutures. The vertebral column is sometimes composed of distinct vertebræ, sometimes cartilaginous or sub-notochordal. The exoskeleton is in the form of placoid granules, tubercles, or spines. There are two pairs of fins, representing the limbs, and supported by cartilaginous fin-rays; and the ventral fins are placed far back near the anus. The pectoral arch has no clavicle. The heart consists of a single auricle and ventricle, and the bulbus arteriosus is rhythmically contractile, is provided with a special coat of striated muscular fibres, and is furnished with several transverse rows of valves. The gills are pouch-like.

In most of the above characters it will be seen at once that the *Elasmobranchii* agree with the Ganoid fishes, especially as regards the structure of the heart. The following points of difference, however, require more special notice:—

I. The *exoskeleton* is what is called by Agassiz "placoid." It consists, namely, of no continuous covering of scales or ganoid plates, but of more or less numerous detached grains, tubercles, or spines, composed of bony matter, and scattered here and there in the integument. In the case of the Rays, these placoid ossifications often take a very singular shape, consisting (fig. 124, *c*) of an osseous or cartilaginous disc, from the upper surface of which springs a sharp recurved spine, composed of dentine.

II. The *gills* are fixed and pouch-like, and differ very materially from those of the Bony and Ganoid fishes. In the case of the Sharks and Rays, the structure of the gills is as follows:—The branchial arches are fixed, and the branchial laminæ are not only attached by their bases to the branchial arches, but are also fixed by the whole of one margin to a series of partitions, which divide the branchial chamber into a number of distinct pouches (fig. 141). Each partition, therefore, carries a series of branchial laminæ attached to each side like the leaves of a book. By means of these septa a series of branchial sacs or pouches are formed, each of which opens internally into the pharynx by a separate slit, and communicates externally with the water by a separate aperture placed on the side of the neck (fig. 141, B). The arrangement of the gills being such, there is, of course, no gill-cover, and no branchiostegal membrane or rays. In one section of the order, however—viz., the *Holocephali*—though the *internal* structure of the gills is the same as the above, there is only a single branchial aperture or gill-slit *externally*, and this is protected by a rudimentary operculum and branchiostegal rays.

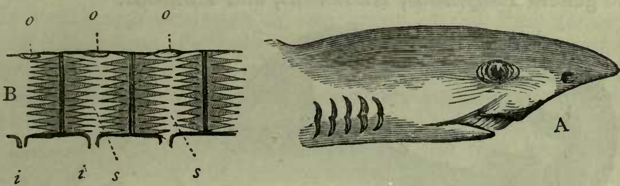


Fig. 141.—A, Head of Piked Dog-fish (*Spinax*), showing the transverse mouth on the under surface of the head, and the apertures of the gill-pouches. B, Diagram of the structure of the gill-pouches: *o o* External apertures; *i i* Apertures leading into the pharynx; *s s* Gill-sacs, containing the fixed gills.

III. Another character in the *Elasmobranchii*, shared, however, by many of the Ganoids, is the structure of the intestinal canal. The intestine is extremely short; but, to compensate for this, there is a peculiar folding of the mucous membrane, constituting what is known as the "spiral valve." The mucous membrane, namely, from the pylorus to the anal aperture, is folded into a spiral reduplication, which winds in close coils round the intestine, like the turns of a screw. By this means the absorptive surface of the intestine is enormously increased, and its shortness is thus compensated for.

The order *Elasmobranchii* is divided into two sub-orders—the *Holocephali*, characterised by the mouth being terminal in position, and there being only a single gill-slit; and the *Plagiostomi*, in which the mouth is transverse, and placed on the under surface of the head (fig. 141, A), and there are several branchial apertures on each side of the neck.

Sub-order A. Holocephali.—This sub-order includes certain curious fishes, of which the only living forms are the *Chimæridæ*. The notochord is persistent; but the neural arches and transverse processes are cartilaginous. The jaws are bony, and are covered by broad plates representing the teeth. The exoskeleton consists of placoid granules. The first ray of the anterior dorsal fin is in the form of a powerful defensive spine, like the "ichthyodorulites" of many fossil fishes. The ventral fins are abdominal, and the tail is heterocercal. There is only a single external gill-aperture, covered with a gill-cover and branchiostegal membrane ; but only a small portion of the borders of the branchial laminæ is free. The mouth is placed at the extremity of the head.

The best-known living representative of the sub-order is the *Chimæra monstrosa* (fig. 142, B), commonly known as the "king of the Herrings." In the Secondary and Tertiary Rocks, however, are found several fossil forms, constituting the genera *Edaphodus*, *Elasmodus*, and *Ischiodus*.

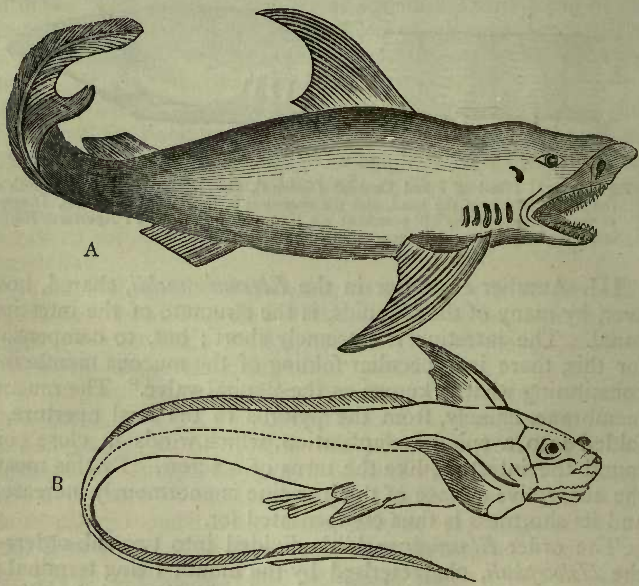


Fig. 142.—Plagiostomi and Holocephali. A, White Shark (*Carcharias*); B, *Chimæra monstrosa*. (After Gosse).

SUB-ORDER B. PLAGIOSTOMI.—This sub-order is of considerably greater importance, as it includes the well-known Sharks and Rays. The vertebral centra are usually more or less ossified, and even when quite cartilaginous, the centra are marked out by distinct rings. The skull is in the form of a cartilaginous capsule, without distinct cranial bones. The mouth is transverse, and is placed on the under surface of the head (fig. 141, A). The exoskeleton consists of placoid granules, tubercles, or spines. The branchial sacs open externally by as many distinct apertures as there are sacs, and there is no operculum. A pair of tubes proceed from the pharynx to open on the upper surface of the head by two apertures, which are termed "spiracles." By means of these water can be admitted to the pharynx, and thence to the gills.

By Professor Owen the Plagiostomi are divided into three sections, termed respectively the *Cestraphori*, the *Selachii*, and the *Batides*.

a. Cestraphori.—In this division there is a strong spine in front of each dorsal fin, and the back teeth are obtuse. The only living representative of this group is the Port Jackson Shark (*Cestracion Philippi*), characterised by its pavement of plate-like crushing teeth, adapted for comminuting small Molluscs and Crustaceans. It is exclusively an inhabitant of the Australian seas, and is remarkable for its close resemblance to a large group of extinct forms, of which the best known are the genera *Hybodus* and *Acrodus* from the Secondary Rocks.

b. Selachii.—This group comprises the formidable Sharks and Dog-fishes, and is characterised by the lateral position of the branchiæ on the side of the neck, and by the fact that the pectoral fins have their ordinary form and position. The Dog-fishes are of common occurrence in British seas, but are of little value. Their egg-cases are frequently cast up on our shores, and are familiarly known as "Mermaid's purses." The true Sharks are not infrequently found in various European seas, but they are mostly inhabitants of warmer waters. One of the largest is the "White Shark" (*Carcharias vulgaris*), which attains a length of over thirty feet (fig. 142, A).

c. Batides.—This group includes the Rays and Skates, and is distinguished by the fact that the branchial apertures are placed on the under surface of the body, forming two rows of openings a little behind the mouth. In the typical members of the group, the body is flattened out so as to form a kind of disc (fig. 143), the greater part of which is made up of the enormously developed pectoral fins. Upon the upper surface of the disc are the eyes and spiracles; upon the lower surface are the nostrils, mouth, and branchial apertures. The flattened bodies of the Rays, however, must be carefully distinguished from those of the Flat-fishes (*Pleuronectidæ*). In the former, the flat surfaces of the body are truly the dorsal and ventral surfaces. In the latter, as before remarked, the body is flattened, not from above downwards, but from side to side, and the head is so twisted that both eyes are brought to one side of the body.

The typical members of the *Batides* are the Skates and Rays, of which the common Thornback (*Raia clavata*) may be taken as a familiar example. More remarkable than the common Rays is the Electric Ray or *Torpedo*, which has the power of discharging electrical shocks, if irritated. The identity of the force produced in this way with the electricity of the machine has been demonstrated by many careful experiments. The Torpedo owes its remarkable powers to two special organs—the "electrical organs," which consist of two masses placed on each side of the head, and consisting each of numerous vertical gelatinous columns, separated by membranous septa, and richly furnished with nerves; the whole arrangement presenting a singular resemblance to the cells of a voltaic battery. There is no doubt, however, but that the force which is expended in the production of the electricity is only nerve-force. For every equivalent of electricity which is generated, the fish loses an equivalent of nervous energy; and for this reason, the production of the electric force is strictly limited by the amount of nerve-force possessed by the animal.

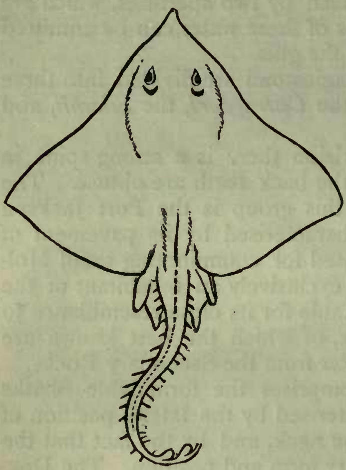


Fig. 143.—Batides. *Raia marginata*, one of the Skates. Reduced one-sixth. (After Gosse.)

In the Saw-fish (*Pristis antiquorum*) the body has not the typical flattened form of the Rays, and the snout is elongated so as to form a long sword-like organ, the sides of which are furnished with strong tooth-like spines. This constitutes a powerful weapon, with which the Saw-fish attacks the largest marine animals.

Before leaving the *Elasmobranchii*, a few words may be said as to their position in the class of Fishes. From the cartilaginous nature of the endoskeleton, and the similarity between the form of their gills and those of the Lampreys and Myxinoids, the *Elasmobranchii* were long placed low down in the scale of fishes, to which also the permanently heterocercal tail conduced. When we come, however, to take into consideration the sum of all their characters, there can be little hesitation in placing the order nearly at the summit of the entire class. The nervous system, and especially the cerebral mass, is very much more highly developed proportionately than is the case with any other division of the fishes. The organs of sense are, comparatively speaking, of a very high grade of organisation, the auditory organs being more than ordinarily elaborate, the eyes being sometimes furnished with a third eyelid (*membrana nictitans*), and the nasal sacs having a very complex structure. The structure of the heart agrees with that of the Ganoids, and is a decided advance upon the heart of the more typical bony fishes. Finally, the embryo, before its exclusion from the egg, is furnished with external filamentous branchiæ, this being a decided approximation to the *Amphibia*.

ORDER VI. DIPNOI (=*Protopteri*, Owen).—This order is a very small one, and includes only the singular Mud-fishes (*Lepidosiren*); but it is nevertheless of great importance as exhibiting a distinct transition between the fishes and the *Amphibia*. So many, in fact, and so striking, are the points of resemblance between the two, that until recently the *Lepidosiren* (fig. 144) was always made to constitute the lowest class of the *Amphibia*. The highest authorities, however, now concur in placing it amongst the fishes, of which it constitutes the highest order. The order *Dipnoi* is defined by the following characters:—The body is fish-like in shape. There is a skull with distinct cranial bones and a lower jaw, but the notochord is persistent, and there are no vertebral centra, nor an occipital condyle. The exoskeleton consists of small, horny, overlapping scales, having the "cycloid" character. The pectoral and ventral limbs are both present, but have the form of awl-shaped, filiform, many-jointed organs, of which the former only have a membranous fringe inferiorly. The ventral limbs are attached close to the anus, and the pectoral arch has a clavicle; but the scapular arch is attached to the occiput. The hinder extremity of the body is fringed by a vertical median fin. The heart has two auricles and one ventricle. The respiratory organs are twofold, consisting on the one hand of free filamentous gills contained in a branchial chamber, which opens externally by a single vertical gill-slit; and on the other hand of true lungs in the form of a double cellular air-bladder, communicating with the œsophagus by means of an air-duct or trachea. The branchiæ are supported upon branchial arches, but these are not connected with the hyoid bone; and in some cases, at any rate, rudimentary *external* branchiæ exist as well. The nasal sacs open posteriorly into the throat.

If these characters are examined a little more minutely, it is easy to point to those in which the *Lepidosiren* approaches the Fishes, and to those in which it resembles the Amphibians. It resembles the Fishes in the shape of the body, and in the possession of a covering of horny overlapping scales of the true cycloid character; whilst the limbs are more like those of fishes than of reptiles. The fin, also, which clothes the posterior extremity of the body, is a decided fish-like character. The most marked piscine feature, however, is the presence of free branchiæ, attached to branchial arches, and placed in a branchial cavity, which opens internally into the pharynx by a number of slits, and communicates externally with the outer world by means of a single vertical gill-slit.

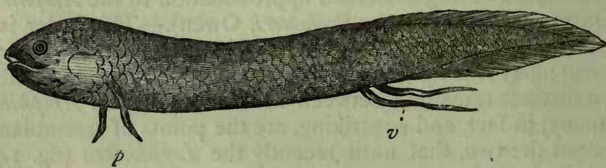


Fig. 144.—Dipnoi. *Lepidosiren annectens.*

On the other hand, the *Lepidosiren* approximates to the Amphibians in the following important points:—The heart consists of *three* cavities, two auricles and a single ventricle. True lungs are present with a trachea and glottis, returning their blood to the heart by a distinct pulmonary vein, and in every respect discharging the functions of the lungs of the higher Vertebrates. It is true that the lungs of the *Lepidosiren* are merely a modification of the swim-bladder of the other fishes, but the significance of the change of function is not affected by this. Lastly, sometimes, at any rate, there are rudimentary external branchiæ placed on the side of the neck. This feature, as will be seen shortly, is characteristic of all the Amphibians, either permanently or in their immature state.

Upon the whole, then, whilst for the purposes of systematic classification the *Lepidosiren* must be placed amongst the Fishes, it is not to be forgotten that many of its characters are those of a higher class, and that it may justly be looked upon as a connecting link, or transitional form, between the two great divisions of the Fishes and the Amphibians.

As regards their distribution and mode of life, two species at least of *Lepidosiren* are known—the *L. paradoxa* from the Amazon, and the *L. annectens* from the Gambia. They both inhabit the waters of marshy tracts, and appear to be able in the dry season to bury themselves in the mud, forming a kind of chamber in which they remain dormant till the return of the rains. Recently there has been discovered in the rivers of Queensland (Australia) a fish which has been described under the name of *Ceratodus* (?) *Fosteri*, and which would appear to be very closely related to the *Lepidosiren*.

CHAPTER LIX.

DISTRIBUTION OF FISHES IN TIME.

THE geological history of fishes presents some points of peculiar interest. Of all the classes of the great sub-kingdom *Vertebrata*, the fishes are the lowest in point of organisation. It might therefore have been reasonably expected that they would present us with the first indications of vertebrate life upon the globe; and such is indeed the case. After passing through the enormous group of deposits known as the Laurentian, Huronian, Cambrian, and Lower Silurian formations—representing an immense lapse of time during which, so far as we yet know, no vertebrate animal had been created, we find in the Upper Silurian Rocks the first traces of fish. The earliest of these, in Britain, is found in the base of the Ludlow Rocks (Lower Ludlow Shale), and belongs to the Placoganoid genus *Pteraspis*. Also in the Ludlow Rocks, but at the summit of their upper division, are found fin-spines and shagreen, probably belonging to Cestraciont fishes—that is to say, to fishes of as high a grade of organisation as the *Elasmobranchii*. So abundant are the remains of fishes in the next great geological epoch—namely, the Devonian or Old Red Sandstone—that this period has frequently been designated the "Age of Fishes." Most of the fishes of the Old Red Sandstone belong to the order *Ganoidei*. In the Carboniferous and Permian Rocks which close the Palæozoic period, most of the fishes are still Ganoid, but the former contain the remains of many Plagiostomous fishes. At the close of the Palæozoic and the commencement of the Mesozoic epoch, the Ganoid fishes begin to lose that predominant position which they before occupied, though they continue to be represented through the whole of the Mesozoic and Kainozoic periods up to the present day. The Ganoids, therefore, are an instance of a family which has endured through the greater part of geological time, but which early attained its maximum, and has been slowly dying out ever since. Towards the close of the Mesozoic period (in the Cretaceous period), the great family of the Teleostean or Bony fishes is for the first time known certainly to have made its appearance. The families of the *Marsipobranchii*, *Pharyngobranchii*, and *Dipnoi*, have not left, so far as is known, any traces of their existence in past time. Judging from analogy, however, it is highly probable that the two former of these must have had a vast antiquity, and it is not impossible that the so-called "Conodonts" from the Lower Silurian Rocks of Russia may yet be shown to be the horny teeth of fishes allied to the Lampreys. At present, however, the weight of evidence is in favour of looking upon these problematical little bodies as probably referable to some of the *Invertebrata*.

Leaving these unrepresented orders out of consideration, the following are the chief facts as to the geological distribution of the other great groups:—

I. *Ganoidei.*—As far as is yet known with certainty, the oldest representatives of the fishes belong to this order. The order is represented, namely, in the Upper Silurian Rocks by the remains of at least four genera. In the Devonian Rocks, or Old Red Sandstone, the Ganoids attain their maximum both in point of numbers and development. The Placoganoid division of the order is represented by the singular genera *Pterichthys* (fig. 140), *Cephalaspis* (fig. 139), *Pteraspis*, and *Coccosteus* (fig. 140). The Lepidoganoid division of the order is now also abundantly represented for the first time, the genera *Dipterus*, *Osteolepis* (fig. 138), *Glyptolepis*, *Holoptychius*, *Diplacanthus*, and many others belonging to this section. As regards the further distribution of the Placoganoids, the section of the *Ostracostei*, characterised by the great development of the cephalic buckler, appears to have died out at the close of the Devonian period. The other section, however, namely, that of the *Sturionidæ*, is represented in the Liassic period (*Mesozoic*) by the genus *Chondrosteus*, and in the Eocene (*Kainozoic*) by a true Sturgeon, the *Acipenser toliapicus*.

The Lepidoganoids continue from the period of the Old Red in great profusion, and they are represented by very many genera in the Carboniferous and Permian Rocks. In the earlier portion of the Mesozoic period—*i.e.*, in the Lias and Trias—they are still represented, but all the forms are as yet heterocercal. In the Oolitic Rocks, for the first time, Lepidoganoids with homocercal tails appear, and they continue to be represented up to the present day.

II. *Elasmobranchii.*—Like the *Ganoidei*, the great order of the Sharks and Rays is one of vast antiquity. At the top of the Upper Ludlow Rocks, or at the close of the Upper Silurian epoch, there have been discovered the remains of undoubted Plagiostomous fishes, most nearly allied to the existing Port Jackson Shark (*Cestracion Philippi*). These remains consist chiefly of defensive spines, which formed the first rays in the dorsal fins, and upon these the genus *Onchus* has been founded. Besides these there have been found portions of skin or "shagreen," with little placoid tubercles, like the skin of a living shark. These have been referred to the genus *Sphagodus*. They are the earliest known remains of Plagiostomous fishes, and with the exception of the few remains from the Lower Ludlow Rocks, they are the earliest known remains of fishes in the stratified series. The discovery of these remains, at that time the earliest known traces of Vertebrate life, is due to the genius of Sir Roderick Murchison, the author of 'Siluria.'

Most of the fossil *Elasmobranchii* belong to the division

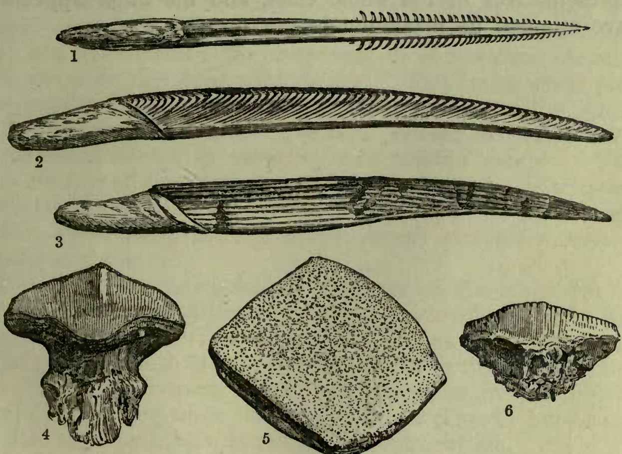


Fig. 145.—1. Fin-spine of *Pleuracanthus* (one of the Rays); 2. *Gyracanthus*; 3. *Ctenacanthus*; 4. Tooth of *Petalodus*; 5. *Psammodus*; 6. *Ctenoptychius*. All from the Carboniferous Rocks.

Cestraphori of Owen, so called because they are provided with the large fin-spines, which are known to geologists as "ichthyodorulites." The two families of this division—the Cestracionts and Hybodonts—are largely represented in past time, the former chiefly in the Palæozoic period, the latter chiefly in the Mesozoic Rocks. Subjoined is an illustration of the "ichthyodorulites" and teeth of some of the Palæozoic *Cestraphori.*

The true Sharks are represented in the later Mesozoic deposits (*e.g.*, by teeth of *Notidanus* in the Oolites); but they are chiefly Tertiary. The teeth of *Odontaspis*, *Galeocerdo*, and *Carcharodon*, are good examples from the Eocene of the Isle of Sheppey. The true Rays are older than the true Sharks, the Carboniferous fossil, *Pleuracanthus*, being probably the spine of a Ray (fig. 145). Numerous remains of Rays, chiefly in the form of the pavement-like teeth, are known, both from the Secondary and Tertiary Rocks. The last division of the *Elasmobranchii*—viz., that of the *Holocephali*, is poorly represented in past time by the Mesozoic and Kainozoic *Ischiodus*, *Elasmodus*, *Ganodus*, and *Edaphodus.*

III. The *Bony* or *Teleostean* Fishes do not make their appearance sooner than the Cretaceous period—that is, towards the close of the Mesozoic epoch. From this time on, however, Bony fishes with cycloid or ctenoid scales are the chief representatives of the whole class, and the order appears to have attained its maximum in our present seas.

DIVISION I. ICHTHYOPSIDA.

CHAPTER LX.

CLASS II.—AMPHIBIA.

THE class *Amphibia* comprises the Frogs and Toads, the Salamandroids, the *Cæciliæ*, and the extinct *Labyrinthodonts*, and may be briefly defined as follows :—As is the case with the Fishes, the embryo is not furnished with an amnion, and the urinary bladder is the only representative of the allantois. As in Fishes, also, *branchiæ or filaments adapted for breathing air dissolved in water are always developed upon the visceral arches for a longer or shorter time.* On the other hand, the Amphibians differ from the Fishes in the fact that *true lungs are always present in the adult; the limbs are never converted into fins; and when median fins are present, as is sometimes the case, these are never furnished with fin-rays.* The limbs, when present, exhibit in their skeleton the same parts as do the limbs of the higher Vertebrates. *The skull always articulates with the vertebral column by means of two occipital condyles. The heart consists of two auricles and a single ventricle. The nasal sacs communicate posteriorly with the pharynx; and the rectum, ureters, and ducts of the reproductive organs open into a common chamber or "cloaca."*

The great and distinguishing character of the *Amphibia* is the fact that they undergo a *metamorphosis* after their exclusion from the egg. They commence life as water-breathing larvæ, provided with gills or branchiæ; but in their adult state they invariably possess lungs; the branchiæ in the higher forms disappearing when the lungs are developed; but being in other cases permanently retained throughout life.

In the earliest embryonic condition the branchiæ are *external*, placed on the side of the neck, and not situated in an internal chamber as in Fishes. In some cases, the external branchiæ only are present, and they are, in any case, the gills which are retained in those forms in which the branchiæ are permanent (*Perennibranchiata*). In the tailed Amphibians

(*Urodela*) and in the Frogs and Toads (*Anoura*) two sets of gills are developed—an external set, which is very soon lost, and an internal set, which is retained for a longer or shorter

Fig. 146.—*Anoura*. *Hyla leucotænia*, one of the Tree-frogs (after Günther).

period. As maturity is approached, true lungs adapted for breathing air are developed. The development, however, of the lungs varies with the completeness with which aerial respiration has to be accomplished; being highest in those forms which lose their gills when grown up (*Caducibranchiata*), and lowest in those in which the branchiæ are retained throughout life (*Perennibranchiata*).

In accordance with the change from an aquatic or branchial to a more or less completely aerial or pulmonary mode of respiration, considerable changes are effected in the course and distribution of the blood-vessels. In the larval condition, when the respiration is entirely effected by means of the gills, the circulation is carried on very much as it is in Fishes. The heart is composed of a single auricle and ventricle, and the blood is propelled through a bulbus arteriosus and branchial artery to the gills. The aerated blood is then collected in the branchial veins, and instead of being returned to the heart, is forthwith propelled to all parts of the body, the descending aorta being formed out of the branchial veins. At this stage, therefore, the heart is a branchial one, and the single contraction of the heart is sufficient to drive the blood through both the branchial and systemic circulations, just as we saw was permanently the case with all the Fishes except the *Lepidosiren*. The pulmonary arteries are at first very small, and take their origin from the last pair of branchial arteries. When the lungs, however, are developed, and the respiration commences to be aerial, the pulmonary arteries increase proportionately in size, and more and more blood is gradually diverted from the gills and carried to the lungs, so that the branchiæ suffer a proportionate diminution in size. In those Amphibians in which branchiæ are permanently retained (*Perennibranchiata*), this state of affairs remains throughout life—that is to say, a portion of the venous blood is sent by the pulmonary artery to the lungs, and a portion goes to the gills. In those Amphibians, however, in which the adult breathes by lungs alone (*Caducibranchiata*), further changes ensue. In these the pulmonary arteries increase so much in size that they ultimately divert all the blood from the branchiæ, and these organs, having fulfilled their temporary function, become atrophied and disappear. The vessels which return the aerated blood from the lungs (the pulmonary veins) increase in size proportionately with their increased work, and ultimately come to open into a second auricle formed at their point of union. The heart, therefore, of the *Amphibia* in their adult state consists of *two* auricles and a common ventricle. The right auricle receives the venous blood from the body, and the left receives the arterial blood from their lungs, and both empty their contents into the single ventricle. As in Reptiles, therefore, the ventricular cavity of the heart in adult Amphibians contains a mixed fluid, partly venous and partly arterial, and from this both the body and the lungs are supplied with blood.

As regards the digestive system of the *Amphibia* there is little to say, except that the rectum opens, as it does in Reptiles, into a common chamber or "cloaca," into which are also discharged the secretions of the kidneys and generative organs. A liver, gall-bladder, spleen, and pancreas are always present. Singular pulsating cavities, belonging to the lymphatic system, and known as "lymph-hearts," are also present in the higher Amphibians.

CHAPTER LXI.

ORDERS OF AMPHIBIA.

THE *Amphibia* are usually divided by modern writers into four orders, the old order *Lepidota*, comprising the *Lepidosiren*, being now placed at the head of the Fishes, under the name of *Dipnoi*. Whilst there is a general agreement as to the number and characters of the Amphibian orders, the names employed to designate them are very various, and it really matters little which are adopted.

ORDER I. OPHIOMORPHA, Owen (= *Gymnophiona*, Huxley; *Apoda* of older writers; *Ophidobatrachia*).—This is a small order, including only certain snake-like, vermiform animals, which are found in various tropical countries, burrowing in marshy ground, something like gigantic earthworms. They form the family *Cæciliadæ*, and are characterised by their snake-like form, and by having the anus placed almost at the extremity of the body. The skin is quite soft, but differs from that of the typical Amphibians in having small horny scales embedded in it. Another fish-like character is that the vertebræ are amphicœlous or biconcave, and the cavities formed by their apposition are filled with the cartilaginous or gelatinous remains of the notochord. The skin is transversely wrinkled, but there are no limbs. The eyes are rudimentary, and are concealed beneath the skin.

The position of the *Cæciliæ* was long doubtful; but their Amphibian character was ultimately proved by the discovery that whilst the adult breathes by lungs, the young possess internal branchiæ, communicating with the external world by a branchial aperture on each side of the neck. Only a few species of *Cæcilia* are known, and they are all inhabitants of hot climates, such as South America, Java, Ceylon, and the Guinea coast. They sometimes attain a length of several feet.

ORDER II. URODELA (= *Ichthyomorpha*, Owen; *Saurobatrachia*).—This order is commonly spoken of collectively as that of the "Tailed" Amphibians, from the fact that the larval tail is always retained in the adult. The *Urodela* are characterised by having the skin naked, and destitute of any exoskeleton. The body is elongated posteriorly to form a compressed or cylindrical tail, which is permanently retained throughout life. The dorsal vertebræ are biconcave (*amphicœlous*), or concave behind and convex in front (*opisthocœlous*), and they have short ribs attached to the transverse processes. The bones of the fore-arm (*radius* and *ulna*) on the one hand, and those of the shank (*tibia* and *fibula*) on the other, are not anchylosed to form single bones.

In one section of the order—formerly called *Amphipneusta*—the gills are retained throughout life, and the animal is therefore "perennibranchiate." In this section are the *Proteus*, *Siren*, and *Menobranchus*. In the remaining members of the order the gills disappear at maturity, and the animal is therefore "caducibranchiate." In this section are the land and water salamanders. One form, however — the Axolotl of Mexico—appears to be sometimes caducibranchiate, though generally perennibranchiate. The genera *Amphiuma* and *Menopoma*, also, exhibit a partially intermediate state of parts, for though they lose their branchiæ when adult, they nevertheless retain the branchial apertures behind the head.

Fig. 147.—Head and fore-part of the body of *Proteus anguinus*, showing the external branchiæ and tridactylous fore-limb.

Of the perennibranchiate *Urodela*, one of the best known is the singular *Proteus* (*Hypochthon*) *anguinus* (fig. 147), which is only found inhabiting pools in certain caves in Illyria and Dalmatia. It is of a pale flesh-colour, or nearly white, with three pairs of scarlet branchiæ on each side of the neck. It attains a length of nearly a foot, and has two pairs of weak limbs, of which the anterior have three toes, and the posterior only two. From its habitat, the power of vision must be quite unnecessary, and, as a matter of fact, the eyes are altogether rudimentary. Several varieties of *Proteus* are known, and the one figured above has been described as a distinct species (*P. zanthostictus*).

Of the *Sirenidæ*, the most familiar are the Siren itself and the Axolotl. The Siren, or Mud-eel, is found abundantly in the rice-swamps of South Carolina, and attains a length of three feet. The branchiæ are persistent, and the hinder pair of legs wholly wanting. Two other species are known, but they are likewise confined to North America.

The Axolotl (*Siredon pisciforme*, fig. 148) is a native of the

Mexican lakes, and attains a length of about a foot or fourteen inches. It possesses both pairs of limbs, the anterior pair having four toes and the hinder pair five toes. As ordinarily known in its native country, the Axolotl is certainly perennibranchiate, and they breed in this condition freely. There is no doubt, however, that individual specimens may lose their gills, without thereby suffering any apparent change, except it be one of colour. The Axolotl, therefore, is in the singular position of being sometimes "caducibranchiate," whilst it is ordinarily "perennibranchiate." Nearly allied to the Axolotl is the *Menobranchus* of North America, in which the branchiæ are persistent. *Amphiuma* and *Menopoma*, as already remarked, differ from the forms just mentioned in losing the gills when adult, but in retaining the external branchial apertures on the side of the neck. The former is exclusively North American, whilst the latter is represented by different but nearly-related species in both North America and Java. Both possess the normal two pairs of limbs.

Fig. 148. — The Axolotl (*Siredon pisciforme*)—after Tegetmeier. The ordinary form, with persistent branchiæ.

In the second section of the *Urodela*, comprising those forms in which the gills are caducous, and both pairs of limbs are always present, are the Water-salamanders or Tritons, and the Land-salamanders. The Tritons are the only examples of the aquatic Salamanders which occur in Britain, and every one, probably, is acquainted with the common Newt.

The Water-salamanders or Newts (fig. 149) are distinguished from the terrestrial forms by being furnished with a compressed fish-like tail, and by being strictly oviparous. The larvæ are tadpole-like, with external branchiæ, which they retain till about the third month. The adult is destitute of gills, and

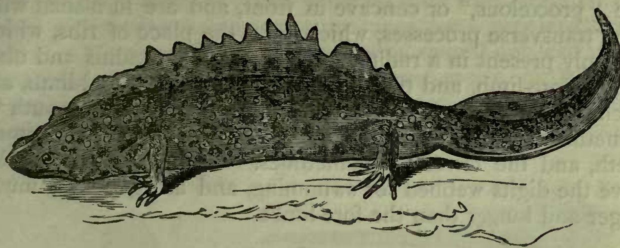


Fig. 149.—Great Water-newt (*Triton cristatus*)—after Bell.

breathes by lungs alone, but the larval tail is retained throughout the life of the animal.

The development of the Newts is so like that of the Frogs that it is unnecessary to dilate further upon it here; but there are these two points of difference to be noticed:—1*stly*, That the embryonic tail is not cast off in the adult; and, 2*dly*, That the fore-limbs are developed sooner than the hind-limbs—the reverse of this being the case amongst the *Anoura*.

The Land-salamanders form the genus *Salamandra*, and are distinguished from their aquatic brethren by having a cylindrical instead of a compressed tail, and by bringing forth their young alive, or by being ovo-viviparous, in which case the larvæ have sometimes shed their external branchiæ prior to birth. The chief thing to remember about the Land-salamanders, and, indeed, about all the *Urodela*, is their complete distinctness from the true Lizards (*Lacertilia*). They are often completely lizard-like in form when adult, but they always possess gills in the earlier stages of their existence, and this distinguishes them from all the Lacertilians.

ORDER III. ANOURA (= *Batrachia*, Huxley; *Theriomorpha*, Owen; *Chelonobatrachia*, &c.).—This order includes the Frogs and Toads, and is perhaps best designated by the name of *Anoura*, or "Tail-less" Amphibians. The name *Batrachia*, employed by Huxley, is inexpedient, partly because it is used by Owen to designate the entire class *Amphibia*, and partly because, in common language, it is usual to understand by a "Batrachian" any of the higher Amphibians, such, for instance, as a Labyrinthodont.

The *Anoura*, or Tail-less Amphibians, are characterised by the following points:—The adult is destitute of both gills and tail, both of which structures exist in the larva, whilst the two pairs of limbs are always present. The skin is soft, and there are rarely any traces of an exoskeleton. The dorsal vertebræ are "procœlous," or concave in front, and are furnished with long transverse processes, which take the place of ribs, which are only present in a rudimentary form. The radius and ulna in the fore-limb, and the tibia and fibula in the hind-limb, are anchylosed to form single bones (fig. 150). The mouth is sometimes edentulous, but the upper jaw has usually small teeth, and the lower jaw sometimes. The hind-limbs usually have the digits webbed for swimming, and are generally much larger and longer than the fore-limbs.

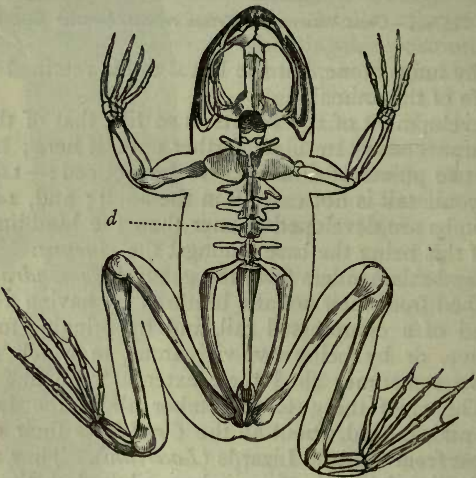


Fig. 150.—Skeleton of the common Frog (*Rana temporaria*). *d* Dorsal vertebræ, with long transverse processes.

In the adult *Anoura*, respiration is purely aerial, and is carried on by means of lungs, which are, comparatively speaking, well developed. As there are no movable ribs by which the thoracic cavity can be expanded, the process of respiration is somewhat peculiar. The animal first closes its mouth, and fills the whole buccal cavity with air taken in through the nostrils. The posterior nares are then closed, and by the contraction of the muscles of the cheeks and pharynx the inspired air is forcibly driven into the windpipe through the open glottis. The process, in fact, is one of swallowing; and it is possible to suffocate a frog simply by holding its mouth open, and thereby preventing the performance of the above-mentioned actions. There can be no doubt, also, that the skin in these animals plays a very important part in the aeration of the blood, and that the frogs especially can carry on their respiration cutaneously, without the assistance of the lungs, for a very lengthened period. This undoubted fact, however, should not lead to any credence being given to the often-repeated stories of the occurrence of frogs and toads in cavities in solid rock, no authenticated instance of such a phenomenon being as yet known to science.

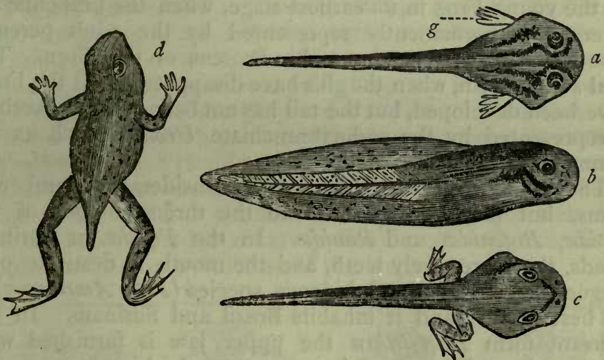


Fig. 151.—Development of the common Frog (*Rana temporaria*). *a* Tadpole, viewed from above, showing the external branchiæ (*g*); *b* Side view of a somewhat older specimen, showing the fish-like tail; *c* Older specimen, in which the hind-legs have appeared; *d* Specimen in which all the limbs are present, but the tail has not been wholly absorbed. (After Bell.)

The young or larvæ of the Frogs and Toads are familiarly known as "Tadpoles." The ova of the Frog are deposited in masses in water, and the young form, upon exclusion from the egg, presents itself as a "tailed" Amphibian, completely fish-like in form, with a broad rounded head, a sac-like abdomen, and a compressed swimming-tail (fig. 151, *a*). There are at first two sets of gills, one external and the other internal. The external branchiæ (fig. 151, *a*) have the form of filaments attached to the side of the neck, and they disappear very shortly after birth. The internal branchiæ are attached to cartilaginous arches, which are connected with the hyoid bone, and they are contained in a gill-cavity, protected by a flap of integument, which differs from the gill-cover of fishes in never developing any opercular bones or branchiostegal rays. Within the branchial chamber thus formed the fore-limbs are budded forth, but the hind-limbs are the first to appear, instead of the fore-limbs, as is the case with the *Urodela*. Even after the first appearance of the limbs the tail is still retained as an instrument of progression; but as the limbs become fully developed, the tail gradually is absorbed (fig. 151, *d*), until in the adult it has wholly disappeared.

The development of the Frog is thus a good illustration of the general zoological law that the transient embryonic stages of the higher members of any division of the animal kingdom are often represented by the permanent condition of the lower members of the same division. Thus the transitory condition of the young Frog in its earliest stage, when the branchiæ are external, is permanently represented by the adult perennibranchiate *Urodela*, such as the Proteus or the Siren. The final stage, again, when the gills have disappeared and the limbs have been developed, but the tail has not been wholly absorbed, is represented by the caducibranchiate *Urodela*, such as the common Newt.

The order *Anoura* comprises a considerable number of forms, but may be divided into the three sections of the *Pipidæ*, *Bufonidæ*, and *Ranidæ*. In the *Pipidæ*, or Surinam Toads, there are rarely teeth, and the mouth is destitute of a tongue. A singular and hideous species (*Pipa Americana*) is the best known, and it inhabits Brazil and Surinam. In the aberrant form *Dactylethra* the upper jaw is furnished with small teeth, and the three inner toes of the hind-feet are furnished with nails, as is the case with no other Amphibian, except *Salamandra unguiculata* amongst the *Urodela*. This curious form is found at the Cape of Good Hope and in Mozambique.

In the Toads, or *Bufonidæ*, a tongue is present, but the jaws are not armed with teeth. The tongue agrees with that of the Frogs in being fixed to the *front* of the mouth, whilst it is *free behind*, so that it can be protruded for some distance from the mouth. The hind-limbs are not disproportionately developed, whilst the toes are only imperfectly webbed, and the toes of the fore-limb are free. The common Toad (*Bufo vulgaris*) is an excellent example of this family.

In the *Ranidæ* the tongue has the same form as in the Toads, but the upper jaw always carries teeth. The hind-limbs are much larger than the fore-limbs, and are fitted for leaping, whilst the toes are webbed. The toes of the fore-limbs are free. The common Frog (*Rana temporaria*) is a good example of the typical *Ranidæ;* but the Tree-frogs (*Hyla*) are adapted for a wholly different mode of life, having the toes of all the feet furnished with terminal suckers, by the help of which they climb with ease. They are mostly found in warm countries, especially in America, but one species is European (fig. 146).

ORDER IV. LABYRINTHODONTIA.—The members of this, the last order of the Amphibia, are entirely extinct. They were Batrachians, probably most nearly allied to the *Urodela*, but all of large size, and some of gigantic dimensions, the skull of one species (*Labyrinthodon Jagaeri*) being upwards of three feet in length and two feet in breadth. The Labyrinthodonts were first known to science simply by their footprints, which were found in certain sandstones of the age of the Trias. These footprints consisted of a series of alternate pairs of hand-shaped impressions, the hinder print of each pair being much larger than the one in front (fig. 152). So like were these impressions to the shape of the human hand that the unknown animal which produced them was at once christened *Cheirotherium*, or "Hand-beast." Further discoveries, however, soon showed that the footprints of *Cheirotherium* had been produced by different species of Batrachians, to which the name of Labyrinthodonts was applied, in consequence of the complex microscopic structure of the teeth.

Fig. 152.—Footprints of a Labyrinthodont (*Cheirotherium*).

The Labyrinthodonts were "salamandriform, with relatively weak limbs and a long tail."—(Huxley.) The vertebral centra and arches were ossified, and the bodies of the dorsal vertebræ are biconcave (amphicœlous). "In the thoracic region three superficially-sculptured exoskeletal plates, one median and two lateral, occupy the place of the interclavicle and clavicles. Between these and the pelvis is a peculiar armour, formed of rows of oval dermal plates, which lie on each side of the middle line of the abdomen, and are directed obliquely forwards and inwards to meet in that line."—(Huxley.)

The head was defended by an external covering or helmet of hard and polished osseous plates, sculptured on their external surface, and often exhibiting peculiar smooth symmetrical grooves—the so-called "mucous canals." The skull was articulated to the vertebral column by two occipital condyles. The teeth are rendered complex by numerous foldings of their parietes, giving rise to the "labyrinthine" pattern, from which the name of the order is derived.

The Labyrinthodonts are known to occur from the Carboniferous to the Triassic or Liassic period inclusively; but they are most characteristically and distinctively Triassic.

DISTRIBUTION OF AMPHIBIA IN TIME.—From a geological point of view by far the most important of the *Amphibia* are the *Labyrinthodontia*, the distribution of which has just been spoken of. The living orders of *Amphibia* are of much more modern date, being, as far as known, wholly Tertiary and Post-tertiary. The *Anoura* are represented by both Toads and Frogs in Miocene times, and they have survived to the present day. The "Tailed" Amphibians are best known to geologists by a singular fossil, which was described by its original discoverer as human, under the name of *Homo diluvii testis.* The fossil in question is of Miocene age, and it is now known to belong to a Salamander, nearly allied to the giant-salamander of Java (*Menopoma*). It is termed the *Andrias Sheuchzeri.*

DIVISION II. SAUROPSIDA.

CHAPTER LXII.

CLASS III.—REPTILIA.

THE second great division of the Vertebrate Sub-kingdom, according to Huxley, is that of the *Sauropsida*, comprising the true Reptiles and the Birds. It is, no doubt, at first sight an almost incredible thing that there should be any near bond of relationship between the Birds and the Reptiles, no two classes of animals being more unlike one another in habits and external appearance. It is, nevertheless, the fact that the Birds are more nearly related to the Reptiles than to any other class of the *Vertebrata*, and it will shortly be seen that many affinities and even transitional forms are known to exist between these great sections. The Reptiles and Birds, then, may be naturally included in a single primary section of Vertebrates, which may be called *Sauropsida* after Huxley, and which is defined by the possession of the following characters:—At no period of existence are branchiæ, or water-breathing respiratory organs, developed upon the visceral arches; the embryo is furnished with a well-developed amnion and allantois; the red corpuscles of the blood are nucleated (fig. 122, *b*, *c*); the skull articulates with the vertebral column by means of a single articulating surface or condyle; and each half or "ramus" of the lower jaw is composed of several pieces, and articulates with the skull, not directly, but by the intervention of a peculiar bone, called the "quadrate bone," or "os quadratum" (fig. 153).

These being the common characters of Reptiles and Birds by which they are collectively distinguished from other Vertebrates, it remains to inquire what are the characters by which they are distinguished from one another. The following, then, are the characters which separate the Reptiles from the Birds:—The blood in Reptiles is cold—that is to say, slightly warmer than the external medium—owing mainly to the fact that the pulmonary and systemic circulations are always directly connected together, either within the heart or in its immediate neighbourhood, so that the body is supplied with a mixture of venous and arterial blood, in place of pure arterial blood alone. The terminations of the bronchi at the surface of the lung are closed, and do not communicate with air-sacs, placed in different parts of the body. When the epidermis develops horny structures, these are in the form of horny plates or scales, and never in the form of feathers. The fore-limbs are formed for various purposes, including in some cases even flight, but they are never constructed upon the type of the "wings" of Birds. Lastly, with one or two doubtful exceptions, whilst the ankle-joint is placed between the distal and proximal portions of the tarsus, the tarsal and metatarsal bones of the hind-limb are never anchylosed into a single bone.

These are the leading characters by which Reptiles are distinguished from Birds, but we must not forget the other distinctive peculiarities in which Reptiles agree with Birds, and differ from other Vertebrates—namely, the presence of an amnion and allantois in the embryo, the absence of branchiæ at all times of life, the possession of only one occipital condyle, and the articulation of the complex lower jaw with the skull by means of a quadrate bone.

It is now necessary to consider these characteristics of the *Reptilia* a little more minutely. The class includes the Tortoises and Turtles, the Snakes, the Lizards, the Crocodiles, and a number of extinct forms; and with the exception of the Tortoises and Turtles they are mostly of an elongated cylindrical shape, provided posteriorly with a long tail. The limbs may be altogether absent, as in the Snakes, or quite rudimentary, as in some of the Lizards, but as a general rule both pairs of limbs are present, sometimes in the form of ambulatory legs, sometimes as swimming-paddles, and in some extinct forms modified to subserve an aerial life. The endoskeleton is always well ossified, and is never cartilaginous or semi-cartilaginous, as in many fishes and some Amphibians. The skull articulates with the atlas by a single condyle. The lower jaw is complex, each half or ramus being composed of from four to six pieces, united to one another by sutures (fig. 153). In the Tortoises, however, these are anchylosed into a single piece, and the two rami are also anchylosed. In most Reptiles, however, the two rami of the lower jaw are only loosely united—in the Snakes by ligaments and muscles only, in the Lizards by fibro-cartilage, and in the *Crocodilia* by a regular suture. In all, the lower jaw articulates with the skull by a quadrate bone (fig. 153, *a*); and as this often projects backwards, the opening of the mouth is often very extensive, and may even extend beyond the base of the skull. Teeth are usually present, but are not sunk in separate sockets or alveoli, except in

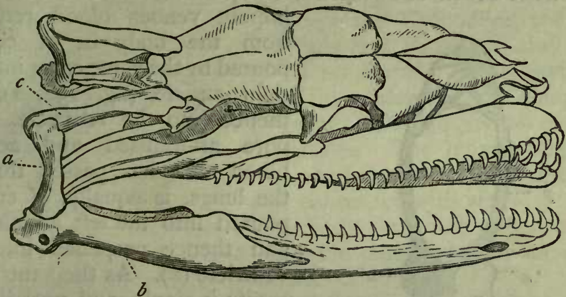


Fig. 153.—Skull of a Serpent (*Python*). *b* Articular portion of the lower jaw; *a* Quadrate bone; *c* Squamosal portion of the temporal bone.

the Crocodiles. In the Tortoises and Turtles alone there are no teeth, and the jaws are simply sheathed in horn, constituting a kind of beak like that of a bird.

Ribs are always present and always well developed, but they differ much in form. It is not correct, however, to regard the presence of ribs as separating the true Reptiles from the *Amphibia*, as is sometimes stated. Some of the most Lizard-like of the Amphibians, such as the Siren, possess short but well-developed ribs, and rudiments of ribs are traceable in other orders; whilst in the *Cæciliæ* they are large and well developed.

As regards the exoskeleton, all Reptiles have horny epidermic scales, and they are divided into two great sections—called respectively *Squamata* and *Loricata*—according as the integumentary skeleton consists simply of these scales, or there are osseous plates developed in the derma as well. In the Tortoises, the epidermic plates unite with the bony exoskeleton and with the true endoskeleton to form the case or box in which the body of these animals is enclosed.

The digestive system of the *Reptilia* possesses few characters of any special importance, except that the rectum opens, as in *Amphibia*, into a common cavity or "cloaca," which not only receives the fæces, but also serves for the discharge of the products of the urinary and generative organs.

The *heart* in the Reptiles consists of two completely separate auricles, and a ventricular cavity, which is divided into two by an incomplete partition. In the *Crocodilia* alone is the septum between the ventricles a perfect one, and even in these, as in all other Reptiles, the heart consists *functionally* of no more than three chambers. The ordinary course of the circulation, where the ventricular septum is imperfect, is as follows:—The impure venous blood returned from the body is, of course, poured by the venæ cavæ into the right auricle (fig. 154, *a*), and thence into the ventricle. The pure arterialised and aerated blood that has passed through the lungs, is equally, of course, poured into the left auricle (*a'*), and thence propelled into the ventricle (*v*). As the ventricular cavity is single, and not divided by a complete partition, it follows of necessity that there is a mixture in the ventricle, resulting in the production of a mixed fluid, consisting partly of venous and partly of arterial blood. This mixed fluid, then, occupies the common ventricular cavity, and by this it is driven both to the lungs (through the pulmonary artery), and to the body (through the systemic aorta). Consequently, in Reptiles, both the lungs and the various tissues and organs of the body are supplied with a mixture of arterial and venous blood, and not with unmixed blood—the lungs with purely venous, and the body with purely arterial blood—as is the case with the higher *Vertebrata*. In the *Crocodilia*, as before said, the partition between the ventricles is a complete one, and consequently this mixture of the arterial and venous blood cannot take place within the heart itself. In these Reptiles, however, a direct communication exists between the pulmonary artery and aorta (the right and left aortæ) by the so-called "foramen Panizzæ," close to the point where these vessels spring respectively from the right and left ventricle. In these Reptiles, therefore, the same mixture of arterial blood with

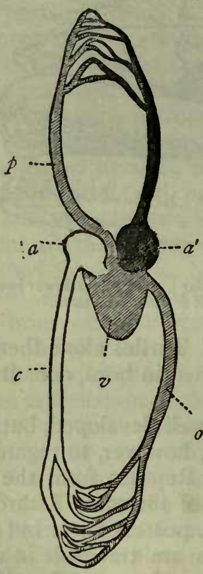


Fig. 154.—Diagram of the circulation in Reptiles. (The venous system is left light, the arterial system is black, and the vessels containing mixed blood are cross-shaded.) *a* Right auricle, receiving venous blood from the body; *a'* Left auricle, receiving arterial blood from the lungs; *v* Arterio-venous ventricle, containing mixed blood, which is driven by (*p*) the pulmonary artery to the lungs, and by (*o*) the aorta to the body.

venous takes place as in the lower *Reptilia*, though probably not to so complete an extent. It is this peculiarity of the circulation in all Reptiles which conditions their low temperature, slow respiration, and generally sluggish vital actions.

The *lungs* in all Reptiles, except the Crocodiles, are less completely cellular than in the Birds and Mammals, and they often attain a very great size. In no Reptile is the cavity of the thorax shut off from that of the abdomen by a complete muscular partition or "diaphragm;" though traces of this structure are found in the Crocodiles. The lungs, therefore, often extend along the whole length of the thoracico-abdominal cavity. In no case are the lungs connected with air-receptacles situated in different parts of the body; and not uncommonly there is only a single active lung, the other being rudimentary or completely atrophied (*Ophidia*).

Lastly, all Reptiles are essentially oviparous, but in some cases the eggs are retained within the body till the young are ready to be excluded, and the animals are then ovo-viviparous. The egg-shell is usually parchment-like, but sometimes contains more or less calcareous matter.

CHAPTER LXIII.

DIVISIONS OF REPTILES.

Chelonia and Ophidia.

The class *Reptilia* is divided into the following nine orders, of which the first four are represented by living forms, whilst the remaining five are extinct:—

1. *Chelonia* (Tortoises and Turtles). 2. *Ophidia* (Snakes). 3. *Lacertilia* (Lizards). 4. *Crocodilia* (Crocodiles and Alligators).	Recent.
5. *Ichthyopterygia*. 6. *Sauropterygia*. 7. *Anomodontia*. 8. *Pterosauria*. 9. *Deinosauria*.	Extinct.

Order I. Chelonia.—The first order of living Reptiles is that of the *Chelonia*, comprising the Tortoises and Turtles, and distinguished by the following characters :—There is an osseous exoskeleton which is combined with the endoskeleton to form a kind of bony case or box in which the body of the animal is enclosed, and which is covered by a leathery skin, or, more usually, by horny epidermic plates. The dorsal vertebræ are immovably connected together, and are devoid of transverse processes. The ribs are greatly expanded (fig. 155, *r*), and are united to one another by sutures, so that the walls of the thoracic cavity are immovable. All the bones of the skull except the lower jaw and the hyoid bone are immovably united together. There are no teeth, and the jaws are encased in horn so as to form a kind of beak. The heart is three-chambered, the ventricular septum being imperfect. There is a large urinary bladder, and the anal aperture is longitudinal or circular.

Of these characters of the *Chelonia*, the most important and distinctive are the nature of the jaws, and the structure of the exoskeleton and skeleton. As regards the first of these points, the lower jaw in the adult appears to consist of a single piece, its complex character being masked by anchylosis. The separate pieces which really compose each ramus of the jaw are immovably anchylosed together, and the two rami are also united in front by a true bony union. There are also no teeth, and the edges of the jaws are simply sheathed in horn, constituting a sharp beak. As regards the second of these points, the bony case in which the body of a Chelonian is enclosed consists essentially of two pieces, a superior or dorsal piece, generally convex, called the "carapace," and an inferior or ventral piece, generally flat or concave, called the "plastron." The carapace and plastron are firmly united along their edges, but are so excavated in front and behind as to leave apertures for the head, tail, and fore and hind limbs. The limbs and tail can almost always be withdrawn at will under the shelter of the thoracico-abdominal case formed in this way by the carapace and plastron, and the head is also generally retractile.

The carapace or dorsal shield is composed of the following elements :—

1. *The spinous processes of the dorsal vertebræ*, which are much flattened out laterally and form a series of broad plates. 2. The *ribs*, which are also much flattened and expanded, and constitute what are known as the "costal plates" (fig. 155, *r*). They are generally eight in number on each side, and are commonly united throughout the whole of their lateral margins by sutures. In some cases, however, they leave marginal apertures towards their extremities, and these openings are

simply covered by a leathery skin or by horny plates. 3. The margin of the carapace is completed by a series of bony plates, which are called the "marginal plates." These are variously

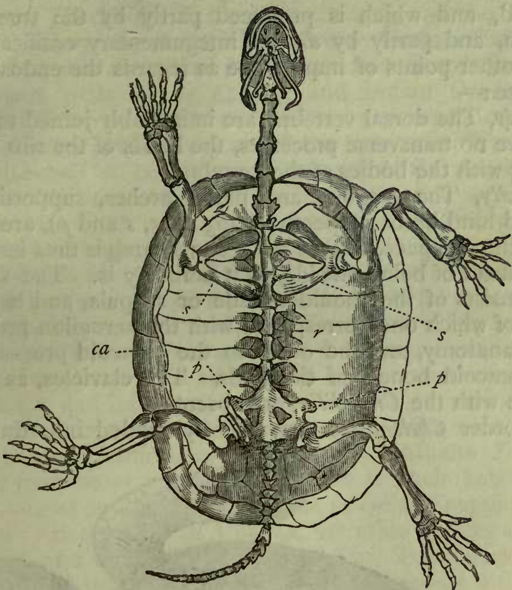


Fig. 155.—Skeleton of Tortoise (*Emys Europea*), the plastron being removed. *ca* Carapace; *r* Ribs, greatly expanded, and united by their edges; *s* Scapular arch, placed within the carapace, and carrying the fore-limbs; *p* Pelvic arch, also placed within the carapace, and carrying the hind-limbs.

regarded as being dermal bones belonging to the exoskeleton, or as being endoskeletal, and as representing the ossified cartilages of the ribs (in this last case the marginal plates would correspond with what are known as the "sternal ribs" of Birds).

The "plastron" or ventral shield is composed of a number of bony plates (nine in number), the nature of which is doubtful. By Professor Owen, the plastron is still regarded as a greatly-developed breast-bone or sternum. By Huxley and Rolleston, on the other hand, the *Chelonia* are regarded as being wholly without a sternum, and the bones of the plastron are looked upon as exclusively integumentary ossifications. Both the carapace and the plastron are covered by a leathery skin, or more generally by a series of horny plates (fig. 156), which roughly correspond with the bony plates below, and which constitute in some species the "tortoise-shell" of commerce. These *epidermic* plates, however, must on no account be confounded with the true bony box in which the animal is enclosed, and which is produced partly by the true endoskeleton, and partly by *dermal* integumentary ossifications.

The other points of importance as regards the endoskeleton are these :—

Firstly, The dorsal vertebræ are immovably joined together, and have no transverse processes, the heads of the ribs uniting directly with the bodies of the vertebræ.

Secondly, The scapular and pelvic arches, supporting the fore and hind limbs respectively (fig. 155, *s* and *p*), are placed *within* the carapace, so that the scapular arch is thus inside the ribs, instead of being outside, as it normally is. The scapular arch consists of the shoulder-blade or scapula, and two other bones, of which one corresponds with the acromion process of human anatomy, and the other to the coracoid process, or to the "coracoid bone" of the Birds. The clavicles, as is also the case with the *Crocodilia*, are absent.

The order *Chelonia* is conveniently divided into three sec-

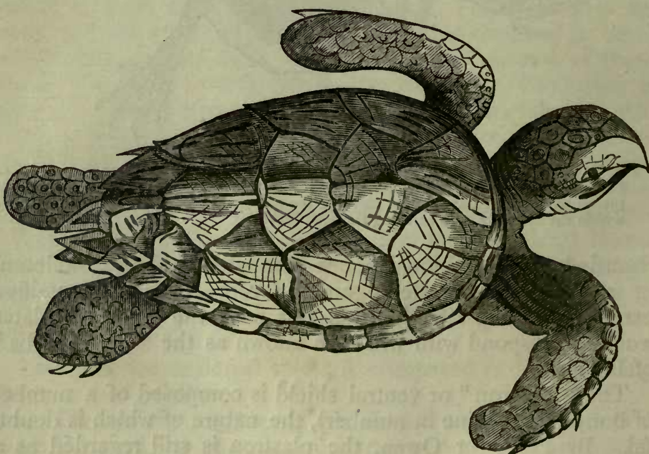


Fig. 156.—Hawk's-bill Turtle (*Chelonia imbricata*)—after Bell.

tions, according as the limbs are natatory, amphibious, or terrestrial. In the first of these, the limbs are converted into most efficient swimming-paddles, all the toes being united by a common covering of integument. In this section are the well-known Turtles (*Cheloniidæ*), all of which swim with great ease and power, but are comparatively helpless upon the land (fig. 156). The best-known species are the "edible" or Green Turtle (*Chelonia mydas*), the Loggerhead Turtle (*Chelonia caouanna*), the Hawk's-bill Turtle (*C. imbricata*), and the Leathery Turtle (*Sphargis coriacea*). The Green Turtle is largely imported into this country as a delicacy, and occurs abundantly in various parts of the Atlantic and Indian Oceans. The Hawk's-bill Turtle is of even greater commercial importance, as the horny epidermic plates of the carapace constitute the "tortoise-shell" so largely used for ornamental purposes. The Leathery Turtle is remarkable in having the carapace covered with a leathery skin in place of the horny plates which are found in other species.

In the second section of the *Chelonia*, in which the limbs are adapted for an amphibious life, are the Mud-turtles or Soft Tortoises (*Trionycidæ*), and the Terrapenes (*Emydidæ*). In the *Trionycidæ* the development of the carapace is imperfect, the ribs being expanded and united to one another only near their bases, and leaving apertures near their extremities. The entire carapace is covered by a smooth leathery skin, and the horny jaws are furnished with fleshy lips. All the *Trionycidæ* inhabit fresh water and are carnivorous in their habits. One of the largest and best known is the so-called Snapping Turtle (*Trionyx ferox*) of North America, but other species are found in Egypt and in the East Indies. The Terrapenes (*Emys*) have a horny beak, and have the shield covered with epidermic plates. They are inhabitants of fresh water, and are most of them natives of America.

The third section of the *Chelonia* comprises only the Land Tortoises (*Testudinidæ*), in which the limbs are adapted for terrestrial progression, and the feet are furnished with short nails. The carapace is strongly convex, and is covered by horny epidermic plates; the head, limbs, and tail can be completely retracted within the carapace. Though capable of swimming, the Tortoises are really terrestrial animals, and are strictly vegetable-feeders. The most familiar species is the *Testudo Græca*, which is indigenous in Spain, Italy, and Greece, but is commonly kept in this country as a domestic pet.

Distribution of Chelonia in Time.—The earliest known traces of Chelonians occur in the Permian Rocks, in the lower portion, that is, of the New Red Sandstone of older geologists. These traces, however, are not wholly satisfactory, since they consist solely of the footprints of the animal upon the ripple-marked surfaces of the sandstone. Of this nature is the *Chelichnus*

Duncani, described by Sir William Jardine in his classical work on the "Ichnology" of Annandale in Dumfriesshire. The earliest unequivocal remains of Chelonians are in the Oolitic Rocks (the *Chelonia planiceps* of the Portland Stone). Fossil *Cheloniidæ*, *Emydidæ*, and *Trionycidæ* occur, also, from the Upper Oolites to the present day, the Eocene period being peculiarly rich in their remains. In the Tertiary deposits of India (Sivalik Hills) there occurs a gigantic fossil Tortoise—the *Colossochelys Atlas*—which is believed to have been eighteen to twenty feet in length, and to have possibly survived to within the human period.

ORDER II. OPHIDIA.—The second order of Reptiles is that of the *Ophidia*, comprising the Snakes and Serpents, and distinguished by the following characters:—

The body is always more or less elongated, cylindrical, and worm-like, and whilst possessing a covering of horny scales, is always unprovided with a bony exoskeleton. The dorsal vertebræ are concave in front (procœlous), with rudimentary transverse processes. There is never any sternum, nor pectoral arch, nor fore-limbs, nor sacrum, and as a rule there are no traces of hind-limbs. Rudimentary hind-limbs, however, are occasionally present (*e.g.*, in *Python* and *Tortrix*). There are always numerous ribs. The two halves or rami of the lower jaw are composed of several pieces, and the rami are united anteriorly by ligaments and muscles only, and not by cartilage or suture. The lower jaw further articulates with the skull by means of a quadrate bone (fig. 153, *a*), which is always more or less movable, and is in turn united with the squamous portion of the temporal bone, which is also movable, and is not firmly united with the skull. Hooked conical teeth are always present, but they are never lodged in distinct sockets or alveoli. Functionally, they are capable of performing nothing more than merely holding the prey fast, and the Snakes are provided with no genuine masticatory apparatus. The heart has three chambers, two auricles and a ventricle, the latter imperfectly divided into two cavities by an incomplete septum. The lungs and other paired organs are mostly not bilaterally symmetrical, one of each pair being either rudimentary or absent. There is no urinary bladder, and the cloacal aperture is transverse.

Of these characters of the Snakes, the most obvious and striking are to be found in the nature of the organs of locomotion. The front limbs, with the scapular arch and sternum, are invariably altogether absent; and the hind-limbs, if not wholly wanting, are never represented by more than a pair of rudimentary pelvic bones concealed within the muscles on each side of the anal aperture, and never exhibiting any outward evidence of their existence beyond the occasional presence of short horny claws or spurs ("calcaria"). In the entire absence, then, or rudimentary condition of the limbs, the Snakes progress by means of the ribs. These bones are always extremely numerous (sometimes amounting to more than three hundred pairs), and in the absence of a sternum they are, of course, extremely movable. Their free extremities, in fact, are simply terminated by tapering cartilages, which are attached by muscular connections to the abdominal scales or "scuta" of the integument. By means of this arrangement the Serpents are enabled to progress rapidly, walking, so to speak, upon the ends of their ribs; their movements being much facilitated by the extreme mobility of the whole vertebral column, conditioned by the cup-and-ball articulation of the bodies of the vertebræ with one another.

The body in the Snakes is covered with numerous scales, developed apparently in the lower layer of the epidermis, and covered by a thin, translucent, superficial pellicle, which is periodically cast off and renewed. On the head and along the abdomen these scales are larger than over the rest of the body, and they constitute what are known as the "scuta" or shields.

The only other points in the anatomy of the *Ophidia* which demand special attention are the structure of the tongue, teeth, and eye.

The tongue in the Snakes is probably an organ more of

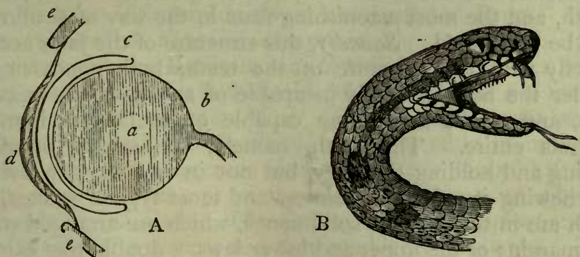


Fig. 157.—A, Diagram of the eye of a Serpent (after Cloquet): *a* Ball of the eye covered by a conjunctival sac, into which the lachrymal secretion is discharged; *b* Optic nerve; *d* Antocular membrane, formed by the epidermis; *e e* Ring of scales surrounding the eye. B, Head of the common Viper (*Pelias berus*)—after Bell—showing the bifid tongue, and the poison-fangs in the upper jaw.

touch than of taste. It consists of two muscular cylinders, united towards their bases, but free towards their extremities. The bifid organ, thus constituted, can be protruded and retracted at will, being in constant vibration when protruded, and being in great part concealed by a sheath when retracted.

As regards the eye of Serpents (fig. 157, A), the chief peculiarity lies in the manner in which it is protected externally. There are no eyelids, and hence the stony unwinking stare of all snakes. In place of eyelids, the eye is surrounded by a circle of scales (*e e*), to the circumference of which is attached a layer of transparent epidermis, which covers the whole eye (*d*), and is termed the antocular membrane. This is covered internally by a thin layer of the conjunctiva, which is reflected forwards from the conjunctiva covering the ball of the eye itself. In this way a cavity or chamber is formed between the two layers of conjunctiva, and the lachrymal secretion by which the eye is moistened is received into this. The outer epidermic layer (antocular membrane) covering the ball of the eye in front, is periodically shed with the rest of the epidermis, the animal being rendered thereby blind for a few days. The pupil of the eye is round in most Snakes, but forms a vertical slit in the venomous Serpents and in the Boas.

As regards the dental and maxillary apparatus of the Serpents, the following points require notice. *Firstly*, in consequence of the articulation of the lower jaw with a movable quadrate bone, which is often directed backwards, in consequence of the quadrate bone being connected with a movable squamosal bone, and in consequence of the rami of the jaw being united in front by ligaments and muscles only, the mouth in the Snakes is capable of opening to an enormous width, and the most astonishing feats in the way of swallowing can be performed. *Secondly*, this structure of the jaws accords exactly with the structure of the teeth, both concurring to render the Snakes wholly incapable of anything like mastication, and at the same time capable of swallowing immense morsels entire. The teeth, namely, are simply fitted for seizing and holding the prey, but not in any way for dividing or chewing it. In the harmless and most typical snakes, the teeth are in the form of solid cones, which are arranged round the margins of the upper and lower jaws, a double row existing in the palate as well. *Thirdly*, in the venomous snakes, however, the ordinary teeth are usually wanting upon the superior maxillæ, and these bones are themselves very much reduced in size. In place of the ordinary teeth, they carry the so-called poison-fangs (fig. 157, B). These are a pair of long, conical, curved fangs, one on each maxilla, which can be raised and depressed at will. Each tooth is perforated by a tube, opening by a distinct aperture at the apex of the tooth, and conveying the duct of the so-called poison-gland. This is a gland, probably produced by a modification of one of the buccal salivary glands, situated behind and under the eye on each side, and secreting the fluid which renders the bite of these snakes dangerous or fatal. When the animal strikes its prey, the poison-fangs are erected, and the poison is forced through the tube which perforates each, partly by the contractions of the muscular walls of the gland, and partly by the muscles of the jaws. In most poisonous snakes the superior maxillæ carry no other teeth except the poison-fangs and their rudimentary successors, but in some cases there are a few teeth behind the fangs; whilst the palatine teeth are always present, as in the harmless species. Some of the most deadly snakes, too, carry upon the upper maxillæ long grooved or canaliculated fangs, which cannot be raised or depressed at will, and which have smaller solid teeth behind them. Others, again, not certainly known to be poisonous, have canaliculated fangs placed far back upon the superior maxillæ, with small solid teeth in front of them.

Fourthly, in all the Serpents the teeth are anchylosed to the jaw, and are never sunk into distinct sockets or alveoli.

A good classification of the *Ophidia* is still a desideratum, and probably, in the meanwhile, the one proposed by Dr Gray is the best. This eminent naturalist divides the snakes into the two sub-orders of the *Viperina* and *Colubrina*, the former having only two perforated poison-fangs on the superior maxillæ, whilst these bones in the latter carry solid teeth, either with or without additional canaliculated fangs.

The sub-order *Viperina* comprises the common Vipers (*Viperidæ*), and the Rattlesnakes (*Crotalidæ*), the former being wholly confined to the Old World, whilst the latter are mostly American. The common Viper (*Pelias berus*) occurs abundantly in England and Scotland, and is capable of inflicting a severe and even dangerous bite, though it is doubtful if fatal effects ever follow except in the case of children or subjects previously debilitated. The Rattlesnakes are almost exclusively natives of America, and they are highly poisonous. The extremity of the tail in the true Rattlesnake (*Crotalus horridus*) is furnished with a series of horny epidermic rings, constituting an appendage which is known as the "rattle." This produces a kind of rattling noise when the animal moves, but the exact object of this appendage is a doubtful one. The head of the Viperine Snakes (figs. 157, 158) is broad, somewhat triangular in shape, broadest at its middle, and showing a very distinct line of demarcation between the head and neck. The head also, is usually covered with small scales, rarely interspersed with larger plates or "scuta" (fig. 158). The *Colubrina* include for the most part harmless snakes, but together with these are some of the most deadly of all the venomous snakes. In accordance with this they are often divided into the three sections of the *Innocua*, *Suspecta*, and *Venenosa*. In the first of these sections (*Innocua*), the superior maxillæ are provided with solid teeth only, and there are no fangs. In this section are the common Ringed Snake of our own country and the Boas and Pythons of warm climates. The common Ringed Snake (*Coluber natrix*) of Britain is a perfectly harmless animal which is commonly found in damp situations, and which lives mainly upon frogs. Closely allied to this is the Black Snake (*Coluber constrictor*) of North America, also perfectly harmless. The *Boidæ* or Boas and Pythons are the largest of all living snakes, attaining a length of certainly over twenty feet. Their bite is perfectly harmless, but they are nevertheless highly dangerous and destructive animals, owing to their great size and enormous muscular power. They seize their prey and coil themselves round it in numerous folds, by tightening which they gradually reduce their victim to the condition of a shapeless bolus, fit to be swallowed. In this way a good-sized Python or Boa will certainly dispose of an animal as large as a sheep or goat, and it is asserted that even human beings may be devoured in this way by large individuals of the family. The Boas and Pythons occur in both the Old and New World, the Pythons, however, all belonging to the Old World; and they are amongst the most formidable of all living Ophidians.

In the section *Suspecta*, in which there are canaliculated fangs placed far back on the superior maxillæ, with smaller solid teeth in front of them, are certain unimportant snakes, partly aquatic and partly terrestrial in their habits, and all belonging to the Old World.

In the group *Venenosa*, in which there are canaliculated fangs placed in front of the superior maxillæ with smaller solid teeth behind them, are some of the most deadly of all living serpents. One of the best known of these is the Hooded Snake, or *Cobra di Capello* (*Naja tripudians*), which is commonly found in Hindostan, and is the snake usually carried about by the Indian snake-charmers. Also in this section are the venomous Water-snakes (*Hydrophidæ*), which have a compressed tail, and are adapted for an aquatic life. They mostly frequent the mouths of rivers in droves, and they swim with great grace and rapidity.

A very good general character by which the Colubrine snakes may be distinguished from the Viperine snakes, is in the shape and armature of the head. In the *Viperina*, as before said, the head (figs. 157, 158) is triangular, broadest behind, and separated from the neck by a more or less marked diminution in the diameter of this latter part. The scales, too, which cover the head are of small size. In the Colubrine snakes, on the

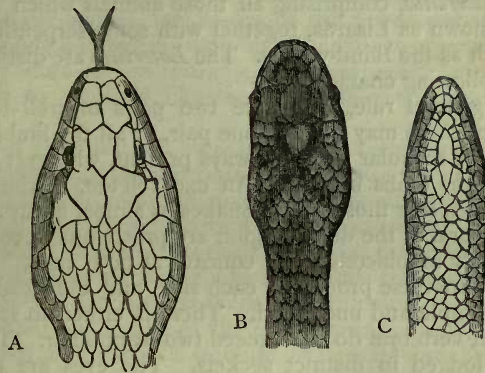


Fig. 158.—A, Head of Colubrine Snake (*Coluber natrix*); B, Head of Viperine Snake (*Pelias berus*); C, Head of Blind-worm (*Anguis fragilis*), one of the serpentiform Lizards. (After Bell.)

other hand, the head is not markedly triangular, and gradually tapers off into the neck, whilst the upper surface of the head is usually covered with large shield-like plates or "scuta" (fig. 158, A).

Distribution of Ophidia in Time.—The *Ophidia* are not known to occur in any Palæozoic or Mesozoic deposit. The earliest known traces of any serpent are in the Lower Kainozoic Rocks, the oldest being the *Palæophis toliapicus* of the London Clay of Sheppey. The nearly-allied *Palæophis typhæus* of the Eocene beds of Bracklesham appears to have been a Boa-constrictor-like snake of about twenty feet in length. In some of the later deposits have been found the poison-fangs of a venomous snake. Upon the whole, however, the snakes must be looked upon as a comparatively modern group, and not as one of any great geological antiquity.

CHAPTER LXIV.

LACERTILIA AND CROCODILIA.

Order III. Lacertilia.—The third order of Reptiles is that of the *Lacertilia*, comprising all those animals which are commonly known as Lizards, together with some serpentiform animals such as the Blind-worms. The *Lacertilia* are distinguished by the following characters :—

As a general rule, there are two pairs of well-developed limbs, but there may be only one pair, or all the limbs may be absent. A scapular arch is always present, whatever the condition of the limbs may be. An exoskeleton, in the form of horny scales like those of the Snakes, is almost always present. The vertebræ of the dorsal region are procœlous or concave in front, rarely amphicœlous or concave at both ends. There is a single transverse process at each side, and the heads of the ribs are simple and undivided. There is either no sacrum, or the sacral vertebræ do not exceed two in number. The teeth are not lodged in distinct sockets. The eyes are generally furnished with movable eyelids, and are always so in the completely snake-like forms. The heart consists of two auricles and a ventricle, the latter partially divided by an incomplete partition. There is a urinary bladder, and the aperture of the cloaca is transverse.

As a general rule, the animals included under this order have four well-developed legs (fig. 159), and would therefore be popularly called "Lizards." Some of the *Lacertilia*, how-

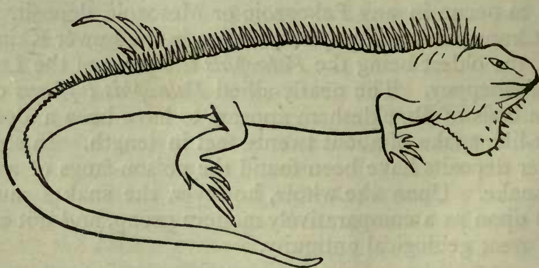


Fig. 159.—Iguana.

ever, have only a single developed pair of limbs, and some have none at all; thus coming in external appearance closely to resemble the true Snakes or Ophidians. These serpentiform

Lizards, however, can be distinguished from the true Snakes, amongst other characters, by the structure of the jaws. In the Snakes, as before said, the two rami of the lower jaw are loosely united in front by ligaments and muscles, and are attached behind to a movable quadrate bone, which is in turn connected with a movable squamosal, this giving an enormous width of gape to these animals. In the Lizards, however, even in those most like the Snakes, the halves of the lower jaw are firmly united to one another in front, and though the quadrate bone is usually more or less movable, the jaws can in no case be separated to anything like the extent that characterises the *Ophidia*.

Another good and still more obvious character is to be found in the structure of the protective coverings of the eye. In the Snakes eyelids are wanting, and the eye is simply covered by a layer of epidermis, constituting the so-called "antocular membrane." In almost all the Lizards, on the other hand, including all the completely snake-like forms, there are movable eyelids, and in few cases is there any structure comparable to the antocular membrane of the true Snakes. Lastly, the typical Lizards all possess a sternum or breast-bone, but this is wanting in some of the snake-like forms, so that it cannot be appealed to as a character by which the *Lacertilia* can be separated from the *Ophidia*.

The whole order of the *Lacertilia* is very often united with the next group of the Crocodilia, under the name of *Sauria*. The term "Saurian," however, is an exceedingly convenient one to designate all the reptiles which approach the typical Lizards in external configuration, whatever their exact nature may be; and from this point of view it is often very useful as applied to many fossil forms, the structure of which is only imperfectly known. It is therefore perhaps best to employ this term merely in a loose general sense.

The *Lacertilia* are often divided into the two great groups of the *Fissilinguia* and *Brevilinguia*, according as the tongue is bifid and protrusible like that of the Ophidians, or is thick and fleshy, and only protrusible when the mouth is open. These distinctions, however, are not of any very great value, and no good general arrangement of the order has hitherto been proposed. Here, therefore, it will be sufficient to treat very shortly of the more important families of the Lacertilians.

The first family of any importance is that of the *Amphisbænidæ*, comprising a number of snake-like animals which have long occupied a debatable position. In their serpentiform cylindrical form these animals closely resemble the true *Ophidia*, and this likeness is still further increased by the absence or rudimentary condition of the limbs. The scapular arch and sternum, however, are present in a rudimentary form, and in one genus (*Chirotes*) there is a pair of short fore-limbs, placed near the head, and furnished with five fingers. Another character separating the *Amphisbænidæ* from the true Snakes is the structure of the lower jaw, the rami of which are united in front by a symphysis so as greatly to restrict the gape. The *Amphisbænidæ* are all small animals, found chiefly in South America, but also in Africa and Spain.

The next great family is that of the *Scincidæ*, including a number of small Lacertilians, some of which are completely snake-like, whilst others possess two limbs, and others again have the normal two pairs of limbs in a well-developed condition. All possess movable eyelids, and in all the conformation of the lower jaw is Lacertilian, and not Ophidian. Of the snake-like forms of this group, none is more familiarly known than the Blind-worm or Slow-worm (*Anguis fragilis*, fig. 160),

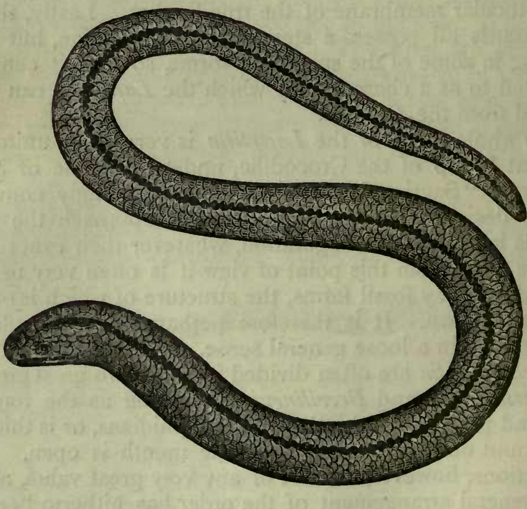


Fig. 160.—The Blind-worm (*Anguis fragilis*)—after Bell.

which is found over almost the whole of Europe, in western Asia, and northern Africa, and which is one of the most abundant of the British Reptiles. The Blind-worm possesses no external appearance of limbs, though the scapular and pelvic arches are present in a rudimentary condition. Its appearance is completely serpentiform, and it is vulgarly regarded as a dangerous and venomous animal, but quite erroneously, as it is even unable to pierce the human skin. It is a perfectly harmless animal, living upon worms, insects, and snails, and hybernating during the winter. It derives its specific name of *fragilis* from the fact that when alarmed it stiffens its muscles to such an extent that the tail can be readily broken off, as if it were brittle.

Numerous other small Lizards are referable to the *Scincidæ*, but it is only necessary to mention the Skinks themselves (*Scincus*), in which both pairs of limbs are present in a well-developed state. The Skinks are found in almost all the warmer parts of the Old World, and closely-allied forms (such as the West Indian "Galliwasp") are found in the New World.

The next family is that of the *Lacertidæ*, comprising the typical Lizards, in which there are always four well-developed limbs, each terminated by five free toes of unequal lengths. The body is covered with scales, which assume the form of shields or "scuta" over the abdomen and on the head. The tongue is slender, bifid, and protrusible. The only truly British Lizards are the Sand-Lizard (*Lacerta agilis*), and the Viviparous Lizard (*Zootoca vivipara*); and the commonest form upon the Continent is the graceful little Green Lizard (*Lacerta viridis*), which also occurs in Jersey. The Lizards of the Old World are represented in America by the *Ameivæ*, some of which attain a length of several feet.

Very closely allied to the true Lizards are the *Varanidæ* or Monitors, which indeed are only separated by the comparatively trivial fact that the abdomen and head are covered with ordinary scales, and not with large "scuta." The Monitors are exclusively found in the Old World, and are the largest of all the recent *Lacertilia;* the *Varanus Niloticus* of Egypt attaining a length of six feet, and the *Varanus bivittatus* of Java attaining to as much as eight feet.

The *Geckotidæ* form a large family of Lizards, comprising a great number of species, occurring in almost all parts of the world. One of their leading characters is to be found in the fact that the eyes are not furnished with movable eyelids, but are covered by a transparent fixed eyelid, resembling the "antocular membrane" of the Snakes, behind which the eye moves freely. The tongue, too, is short, fleshy, and only protrusible to a very limited extent. They feed on insects, and are found in abundance in the warmer parts of both the Old and New Worlds.

The *Iguanidæ* constitute another large family of Lizards, also belonging partly to the Old and partly to the New World. They are often divided into "ground-iguanas," in which the

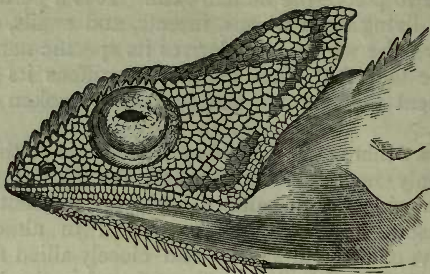


Fig. 161.—Head of a Chameleon (*C. Petersii*)—after Gray.

body is flat and depressed, and "tree-iguanas," in which the body is compressed. The members of the genus *Iguana* itself (fig. 159) are confined to the New World, and are distinguished by having the throat furnished with a pendulous dewlap or fold of skin, the edge of which is toothed. The back and tail, too, are furnished with an erect crest of pointed scales. The Iguana attains a length of from four to five feet, and though not of a very inviting appearance, is highly esteemed as food. More remarkable than the true Iguanas is the little Flying Dragon (*Draco volans*) of the East Indies and Indian Archipelago. In this singular little Lizard there is a broad membranous expansion on each side, formed by a fold of the integument, supported upon the anterior false ribs, which run straight out from the spinal column. By means of these lateral expansions of the skin, the *Draco volans* can take long flying leaps from tree to tree, and can pursue the insects on which it feeds; but the lateral membranes simply act as parachutes, and there is no power of true flight, properly so called.

The last family of the living Lizards which requires notice is that of the *Chamæleontidæ*, containing the familiar little *Chamæleo Africanus*, which occurs abundantly in the north of Africa and in Egypt, and is so well known for its power of changing its colour under irritation or excitement. In this genus the eye (fig. 161) is of large size, and is covered by a single circular lid, formed by a coalescence of the two lids, and perforated centrally by a small aperture, by which the rays of light reach the pupil. The Chameleon is naturally a sluggish animal, but it catches its food, consisting of insects, by darting out its long, fleshy, and glutinous tongue —an operation which it effects with the most extraordinary rapidity.

Distribution of Lacertilia in Time.—The geological range of the true *Lacertilia* is not by any means very great, nor, with a single exception, are their remains of much importance. The earliest traces of Lizards in the stratified series are found in the fresh-water strata of the Purbeck Beds at the summit of the Jurassic Series. Several small Lizards occur here, and have been described under the names of *Nathetes*, *Macellodon*, *Saurillus*, and *Echinodon*. The most remarkable fossil Lizard, however, is the *Mosasaurus* of the Chalk. This gigantic reptile occurs at the very summit of the Cretaceous Series, in what is known as the Maestricht Chalk. The skull is no less than five feet long; and as the tail and limbs were formed for swimming, there can be little doubt but that *Mosasaurus*—like the living *Amblyrhynchus*—was aquatic in its habits, and frequented the sea-shore.

Order IV. Crocodilia.—The last and highest order of the living *Reptilia* is that of the *Crocodilia*, including the living Crocodiles, Alligators, and Gavials, and characterised by the following peculiarities:—

The body is covered with an outer epidermic exoskeleton composed of horny scales, and an inner dermal exoskeleton consisting of bony plates or scutes, which may be confined to the dorsal surface alone, or may exist on the ventral surface as well. The bones of the skull and face are firmly united together, and the two halves or rami of the lower jaw are united in front by a suture. There is a single row of teeth, which are implanted in distinct sockets. The centra of the dorsal vertebræ in all living *Crocodilia* are procœlous, or concave in front, but in the extinct forms they may be either amphicœlous (concave at both ends) or opisthocœlous (concave behind). The vertebral ends of the anterior trunk-ribs are bifurcate. There are two sacral vertebræ. False ribs are usually developed in the wall of the abdomen. There are no clavicles. The heart consists of four completely distinct and separate cavities, two auricles, and two ventricles, the ventricular septum—as in no other Reptiles—being complete. The right and left aortæ, however, or, in other words, the pulmonary artery and systemic aorta are connected together close to their origin by a small aperture (*foramen Panizzæ*), so that the two sides of the heart communicate with one another. The aperture of the cloaca is longitudinal, and not transverse, as in the Lizards. All the four limbs are present, the anterior ones being pentadactylous, the posterior tetradactylous. All are oviparous.

The chief points by which the Crocodiles are distinguished from their near allies, the Lacertilians, are the possession of a partial bony dermal exoskeleton in addition to the ordinary epidermic covering of scales, the lodgment of the teeth in distinct sockets, and the fact that the mixture of venous and arterial blood, which is so characteristic of Reptiles, takes place, not in the heart itself, but in its immediate neighbourhood, by a communication between the pulmonary artery and aorta directly after their origin.

The only other points about the Crocodiles which require special notice are that the eyes are protected by movable eyelids; the ear is covered by a movable ear-lid; the nasal cavities open in front by a single nostril, and are shut off from the cavity of the mouth, but open far back into the cavity of the pharynx; and lastly, the tongue is large and fleshy, and is immovably attached to the bottom of the mouth. (Hence the belief of the ancients that the Crocodile had no tongue.)

The *Crocodilia* abound in the fresh waters of hot countries, and are the largest of all living Reptiles, not uncommonly attaining a length of twenty feet or upwards. They are divided by Owen into three sub-orders, according to the shape of the dorsal vertebræ, termed the *Procœlia*, *Amphicœlia*, and *Opisthocœlia*.

Sub-order 1. *Procœlia.*—In this sub-order are all the living members of the *Crocodilia*, distinguished by having the bodies of the dorsal vertebræ concave in front (procœlous). The best-known species of the living *Crocodilia* are the Gavial (*Gavialis Gangetica*), the Nilotic Crocodile (*Crocodilus Niloticus*), and the Alligator (*Alligator Mississipensis*). These three forms have at the present day a very restricted geographical

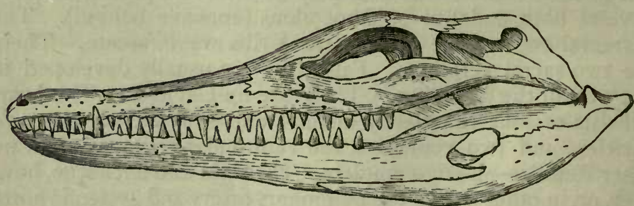


Fig. 162.—Skull of young *Crocodilus biporcatus* (after Van der Höven).

range, the Gavial being exclusively confined to the rivers of Hindostan, the *Crocodilus Niloticus* being African, and the Alligators being American. The Gavial is distinguished by its elongated snout, at the extremity of which the nostril is placed, and by the fact that the teeth are pretty nearly equal in size and similar in form in the two jaws. In the true Crocodiles (fig. 162) the fourth tooth in the lower jaw is larger than the others, and forms a canine tooth, which is received into a notch excavated in the side of the alveolar border of the upper jaw, so that it is visible externally when the mouth is closed. In the Caimans or Alligators the same tooth in the lower jaw forms a canine, but it is received into a pit in the palatal surface of the upper jaw, where it is entirely concealed when the mouth is shut.

True procœlian Crocodiles occur for the first time in the Greensand (Cretaceous Series) of North America. In Europe, however, the earliest remains of procœlian Crocodiles are from the Lower Tertiary Rocks (Eocene). It is a curious fact that in the Eocene Rocks of the south-west of England, there occur fossil remains of all the three living types of the *Crocodilia*—namely, the Gavials, true Crocodiles, and Alligators; though at the present day these forms are all geographically restricted in their range, and are never associated together.

Sub-order 2. *Amphicœlia.*—The Amphicœlian Crocodiles, with biconcave vertebræ, are entirely extinct. They have but a limited geological range, extending only from the Lias to the Chalk, inclusive, and being therefore strictly Mesozoic.* The biconcave vertebræ show a decided approach to the structure of the backbone in fishes; and as the rocks in which they occur are marine, there can be little doubt but that these Crocodiles were, in the majority of cases at any rate, marine. The most important genera belonging to this order are *Teleosaurus*, *Steneosaurus*, *Dakosaurus*, *Makrospondylus*, and *Suchosaurus*, the last being from the fresh-water deposits of the Wealden (Cretaceous).

Sub-order 3. *Opisthocœlia.*—This sub-order, like the last, is entirely extinct, and is exclusively Mesozoic, all the known examples occurring in the Liassic, Oolitic, and Cretaceous Rocks. The most important genera are *Streptospondylus* and *Cetiosaurus*. The *Cetiosaurus longus* of the Upper Oolites (Portland Stone) must have been the largest of all known *Crocodilia*, the vertebræ of the tail measuring as much as seven inches in length, and more than seven inches across.

* If the so-called "Thecodont" Reptiles, such as *Thecodontosaurus* and *Belodon*, belong to this sub-order, then the Amphicœlian *Crocodilia* date from the age of the Triassic Rocks.

CHAPTER LXV.

EXTINCT ORDERS OF REPTILES.

It remains now to consider briefly the leading characters of five wholly extinct orders of Reptiles, the peculiarities of which are very extraordinary, and are such as are exhibited by no living forms.

Order V. Ichthyopterygia, Owen (= *Ichthyosauria*, Huxley).—The gigantic Saurians forming this order were distinguished by the following characters:—

The body was fish-like, without any distinct neck, and probably covered with a smooth or wrinkled skin, no horny or bony exoskeleton having been ever discovered. The vertebræ were numerous, deeply biconcave or amphicœlous, and having the neural arches united to the centra by a distinct suture. The anterior trunk-ribs possess bifurcate heads. There is no sacrum, and no sternal ribs or sternum, but clavicles were present as well as an interclavicle (episternum); and false ribs were developed in the walls of the abdomen. The skull had enormous orbits separated by a septum, and an elongated snout. The eyeball was protected by a ring of bony plates in the sclerotic. The teeth were not lodged in distinct sockets, but in a common alveolar groove. The fore and hind limbs were converted into swimming-paddles, the ordinary number of digits (five) remaining recognisable, but the phalanges being greatly increased in number, and marginal ossicles being added as well. A vertical caudal fin was in all probability present.

The order *Ichthyopterygia* includes only the gigantic and fish-like *Ichthyosauri* (fig. 163), all exclusively Mesozoic, and abounding in the Lias, Oolites, and Chalk, but especially characteristic of the Lias. There is no doubt whatever but that the *Ichthyosauri* were essentially marine animals, and they have been often included with the next order (*Sauropterygia*) in a common group, under the name of *Enaliosauria* or Sea-lizards.

In the biconcave vertebræ and probable presence of a vertical tail-fin, the *Ichthyosaurus* approaches the true Fishes. There is, however, no doubt as to the fact that the animal was strictly an air-breather, and its reptilian characters cannot be questioned, at the same time that the conformation of the limbs is decidedly Cetacean in many respects. Much has been gathered from various sources as to the habits of the *Ichthyosaurus*, and its history is one of great interest. From the researches of Buckland, Conybeare, and Owen, the following facts appear to be pretty well established :—That the *Ichthyosauri* kept chiefly to open waters may be inferred from their

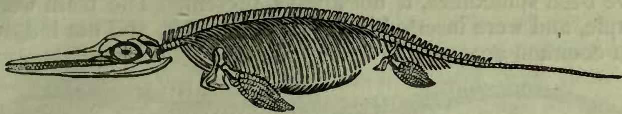


Fig. 163.—*Ichthyosaurus communis.*

strong and well-developed swimming-apparatus. That they occasionally had recourse to the shore, and crawled upon the beach, may be safely inferred from the presence of a strong and well-developed bony arch, supporting the fore-limbs, and closely resembling in structure the scapular arch of the *Ornithorhynchus* or Duck-mole of Australia. That they lived in stormy seas, or were in the habit of diving to considerable depths, is shown by the presence of a ring of bony plates in the sclerotic, protecting the eye from injury or pressure. That they possessed extraordinary powers of vision, especially in the dusk, is certain from the size of the pupil, and from the enormous width of the orbits. That they were carnivorous and predatory in the highest degree is shown by the wide mouth, the long jaws, and the numerous, powerful, and pointed teeth. This is proved, also, by an examination of their petrified droppings, which are known to geologists as "coprolites," and which contain numerous fragments of the scales and bones of the Ganoid fishes which inhabited the same seas.

ORDER VI. SAUROPTERYGIA, Owen (=*Plesiosauria*, Huxley).—This order of extinct reptiles, of which the well-known *Plesiosaurus* may be taken as the type, is characterised by the following peculiarities :—

The body, as far as is known, was naked, and not furnished with any horny or bony exoskeleton. The bodies of the vertebræ were either flat or only slightly cupped at each end, and the neural arches were anchylosed with the centra, and did not remain distinct during life. The transverse processes of the vertebræ were long, and the anterior trunk-ribs had simple, not bifurcate, heads. No sternum or sternal ribs are known to have existed, but there were false abdominal ribs. The neck in most was greatly elongated, and composed of numerous vertebræ. The sacrum was composed of two vertebræ. The orbits were of large size, and there was a long snout, as in the *Ichthyosauri*, but there was no circle of bony plates in the sclerotic.

The limbs agree with those of the *Ichthyosauri* in being in the form of swimming-paddles (fig. 164), but differ in not possessing any supernumerary marginal ossicles. A pectoral arch, formed of two clavicles and an interclavicle (episternum) appears to have been sometimes, if not always, present. The teeth were simple, and were inserted into distinct sockets, and not lodged in a common groove.

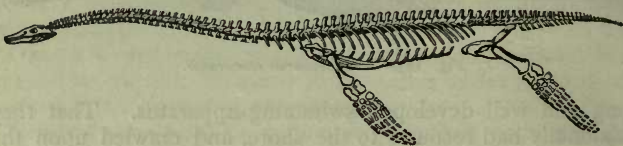


Fig. 164.—*Plesiosaurus dolichodeirus.*

The most familiar and typical member of the *Sauropterygia* is the *Plesiosaurus* (fig. 164), a gigantic marine reptile, chiefly characteristic of the Lias and Oolites. As regards the habits of the *Plesiosaurus*, Dr Conybeare arrives at the following conclusions :—"That it was aquatic is evident from the form of its paddles; that it was marine is almost equally so from the remains with which it is universally associated; that it may have occasionally visited the shore, the resemblance of its extremities to those of the Turtles may lead us to conjecture; its movements, however, must have been very awkward on land; and its long neck must have impeded its progress through the water, presenting a striking contrast to the organisation which so admirably fits the *Ichthyosaurus* to cut through the waves." As its respiratory organs were such that it must of necessity have required to obtain air frequently, we may conclude "that it swam upon or near the surface, arching back its long neck like a swan, and occasionally darting it down at the fish which happened to float within its reach. It may, perhaps, have lurked in shoal water along the coast, concealed amongst the sea-weed; and raising its nostrils to a level with the surface from a considerable depth, may have found a secure retreat from the assaults of powerful enemies; while the length and flexibility of its neck may have compensated for the want of strength in its jaws, and its incapacity for swift motion through the water."

The geological range of the *Plesiosaurus* is from the Lias to the Chalk inclusive, and specimens have been found indicating a length of from eighteen to twenty feet.

Of the other genera of the *Sauropterygia*, *Simosaurus* and *Nothosaurus* are from the Trias, and are chiefly characteristic of its middle division, the Muschelkalk. *Placodus* is another genus, also from the Muschelkalk, and is characterised by the extraordinary form of the teeth, which resembled those of many fishes in forming broad crushing plates, constituting a kind of pavement.

ORDER VII. ANOMODONTIA, Owen (= *Dicynodontia*, Huxley).—The leading characters of this order are to be found in the structure of the jaws, which appear to have been sheathed in horn, so as to constitute a kind of beak, very like that of the Chelonians. In the genera *Rhynchosaurus* and *Oudenodon* both jaws seem to have been altogether destitute of teeth, but in *Dicynodon* there were two long tusks, growing from persistent pulps, placed one on each side in the upper jaw. The pectoral and pelvic arches were very strong, and the limbs were well developed and fitted for walking, and not for swimming.

Dicynodon and *Oudenodon* are known only from strata of supposed Triassic age in South Africa and India, but *Rhynchosaurus* occurs in the Trias of Europe.

ORDER VIII. PTEROSAURIA.—This order includes a group of extraordinary flying Reptiles, all belonging to the Mesozoic epoch, and exhibiting in many respects a very extraordinary combination of characters. The most familiar members of the order are the so-called "Pterodactyles," and the following are the characters of the order :—

No exoskeleton is known to have existed. The dorsal vertebræ are procœlous, and the anterior trunk-ribs are double-headed. There is a broad sternum with a median ridge or keel, and ossified sternal ribs. The jaws were always

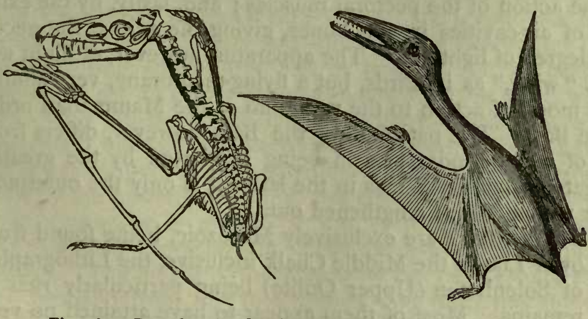


Fig. 165.—*Pterodactylus brevirostris.* Skeleton and restoration.

armed with teeth, and these were implanted in distinct sockets. In some forms (*Ramphorhynchus*) there appear to have been no teeth in the anterior portion of the jaws, and these parts seem to have been sheathed in horn, so as to constitute a kind of beak. A ring of bony plates occurs in the sclerotic coat of the eye. The pectoral arch consists of a scapula and distinct coracoid bone, articulating with the sternum as in Birds, but no clavicles have hitherto been discovered. The fore-limb (fig. 165) consists of a humerus, ulna and radius, carpus, and hand of four fingers, of which the inner three are short and unguiculate, whilst the outermost is clawless and is enormously elongated. Between this immensely-lengthened finger, the side of the body, and the comparatively small hind-limb, there must have been supported an expanded flying-membrane or "patagium," which the animal must have been able to employ as a wing, much as the Bats of the present day. Lastly, most of the bones were "pneumatic"—that is to say, were hollow and filled with air.

By the presence of teeth in distinct sockets, and, as will be seen hereafter, especially in the structure of the limbs, the Pterodactyles differed from all known Birds, and there can be little question as to their being genuine Reptiles. The only Reptile, however, now existing, which possesses any power of sustaining itself in the air, is the little *Draco volans*, but this can only take extended leaps from tree to tree, and cannot be said to have any power of flight properly so called. That the Pterodactyles, on the other hand, possessed the power of genuine flight is shown by the presence of a median keel upon the sternum, proving the existence of unusually-developed pectoral muscles; by the articulation of the coracoid bones with the top of the sternum, providing a fixed point or fulcrum for the action of the pectoral muscles; and, lastly, by the existence of air-cavities in the bones, giving the animal the necessary degree of lightness. The apparatus, however, of flight was not a "wing," as in Birds, but a flying-membrane, very similar in its mode of action to the patagium of the Mammalian order of the Bats. The patagium of the Bats, however, differs from that of the Pterodactyles in being supported by the greatly-elongated fingers, whereas in the latter it is only the outermost finger which is thus lengthened out.

The *Pterosauria* are exclusively Mesozoic, being found from the Lower Lias to the Middle Chalk inclusive, the Lithographic Slate of Solenhofen (Upper Oolite) being particularly rich in their remains. Most of them appear to have attained no very great size, but the remains of a species from the Cretaceous Rocks have been considered to indicate an animal with more than twenty feet expanse of wing, counting from tip to tip.

In the genus *Pterodactylus* proper, the jaws are provided with teeth to their extremities, all the teeth being long and slender.

In *Dimorphodon*, the anterior teeth are large and pointed, the posterior teeth small and lancet-shaped.

In *Ramphorhynchus*, the anterior portion of both jaws is edentulous, and may have formed a horny beak, but teeth are present in the hinder portion of the jaws.

ORDER IX. DINOSAURIA.—The last order of extinct Reptiles is that of the *Dinosauria*, comprising a group of very remarkable Reptiles, which show many points of decided affinity to the Birds on the one hand, and to the so-called Pachydermatous Mammals on the other. Most of the *Dinosauria* were of gigantic size, and the order is defined by the following characters:—

The skin was sometimes naked, sometimes furnished with a well-developed exoskeleton, consisting of bony shields, much resembling those of the Crocodiles. A few of the anterior vertebræ were opisthocœlous, the remainder having flat or slightly biconcave bodies. The anterior trunk-ribs were double-headed. The teeth were confined to the jaws and implanted in distinct sockets. There were always two pairs of limbs, and these were strong, furnished with claws, and adapted for terrestrial progression. In some cases the fore-limbs were very small in proportion to the size of the hind-limbs. No clavicles have been discovered.

The most familiar examples of the *Dinosauria* are *Megalosaurus* and *Iguanodon.*

Megalosaurus is a gigantic Oolitic Reptile, which occurs also in the Cretaceous series (Weald Clay). Its length has been estimated at between forty and fifty feet, the femur and tibia each measuring about three feet in length. As the head of the femur is set on nearly at right angles with the shaft, whilst all the long bones contain large medullary cavities, there can be no doubt but that *Megalosaurus* was terrestrial in its habits. That it was carnivorous and destructive in the highest degree is shown by the powerful, pointed, and trenchant teeth.

The *Iguanodon* is mainly, if not exclusively, Cretaceous, being especially characteristic of the great delta-deposit of the Wealden. The length of the *Iguanodon* has been estimated as being probably from fifty to sixty feet, and from the close resemblance of its teeth to those of the living Iguanas, there is little doubt that it was herbivorous and not carnivorous. The femur of a large *Iguanodon* measures from four to five feet in length, with a circumference of twenty-two inches in its smallest part. From the disproportionately small size of the fore-limbs, and from the occurrence of *pairs* of gigantic three-toed footsteps in the same beds, it has been concluded, with much probability, that *Iguanodon*, in spite of its enormous bulk, must have walked temporarily or permanently upon its hind-legs, thus coming to present a most marked and striking affinity to the Birds.

The most remarkable, however, of the *Dinosauria* is the little *Compsognathus longipes* from the Lithographic Slate of Solenhofen, referred to this order by Professor Huxley. This Reptile is not remarkable for its size, which does not seem to have been much more than two feet, but for the remarkable affinities which it exhibits to the true Birds. The head of *Compsognathus* was furnished with *toothed* jaws, and supported upon a long and slender neck. The fore-limbs were very short, but the hind-limbs were long and like those of Birds. The *proximal* portion of the tarsus resembled that of Birds in being anchylosed to the lower end of the tibia; but the *distal* portion of the tarsus—unlike that of Birds—was free, and was not anchylosed with the metatarsus. Huxley concludes that "it is impossible to look at the conformation of this strange Reptile, and to doubt that it hopped or walked in an erect or semi-erect position, after the manner of a bird, to which its long neck, slight head, and small anterior limbs must have given it an extraordinary resemblance."

DIVISION II. SAUROPSIDA.

CHAPTER LXVI.

CLASS IV.—AVES.

The fourth class of the *Vertebrata* is that of *Aves*, or Birds. The Birds may be shortly defined as being "oviparous Vertebrates with warm blood, a double circulation, and a covering of feathers" (Owen). More minutely, however, the Birds are defined by the possession of the following characters :—

The embryo possesses an amnion and allantois, and branchiæ or gills are never developed at any time of life upon the visceral arches. The skull articulates with the vertebral column by a single occipital condyle. Each half or ramus of the lower jaw consists of a number of pieces, which are separate from one another in the embryo; and the jaw is united with the skull, not directly, but by the intervention of a quadrate bone (as in the Reptiles). The fore-limb in no existing birds possesses more than three fingers or digits, and the metacarpal bones are anchylosed together. In all living Birds the fore-limbs are useless as regards prehension, and in most they are organs of flight. The hind-limbs in all Birds have the ankle-joint placed in the middle of the tarsus, the proximal portion of the tarsus coalescing with the tibia, and the distal portion of the tarsus being anchylosed with the metatarsus to constitute a single bone known as the "tarso-metatarsus."

The heart consists of four chambers, two auricles, and two ventricles; and not only are the right and left sides of the heart completely separated from one another, but there is no communication between the pulmonary and systemic circulations, as there is in Reptiles. There is only one aortic arch, the right. The blood is hot, having an average temperature of as much as 103° to 104°. The blood-corpuscles are oval and nucleated.

The respiratory organs are in the form of spongy cellular lungs, which are not freely suspended in pleural sacs; and the bronchi open on their surface into a number of air-sacs, placed in different parts of the body.

All birds are oviparous, none bringing forth their young alive, or being even ovo-viviparous. All birds are, lastly, provided with an epidermic covering, so modified as to constitute what are known as *feathers*.

Professor Huxley's account of the method in which feathers are produced is so remarkably clear, that no apology is necessary for quoting it in its entirety. Feathers "are evolved within sacs from the surface of conical papillæ of the dermis. The external surface of the dermal papilla, whence a feather is to be developed, is provided upon its dorsal surface with a median groove, which becomes shallower towards the apex of the papilla. From this median groove lateral furrows proceed at an open angle, and passing round upon the under surface of the papilla, become shallower, until, in the middle line, opposite the dorsal median groove, they become obsolete. Minor grooves run at right angles to the lateral furrows. Hence the surface of the papilla has the character of a kind of mould, and if it were repeatedly dipped in such a substance as a solution of gelatine, and withdrawn to cool until its whole surface was covered with an even coat of that substance, it is clear that the gelatinous coat would be thickest at the basal or anterior end of the median groove, at the median ends of the lateral furrows, and at those ends of the minor grooves which open into them; whilst it would be very thin at the apices of the median and lateral grooves, and between the ends of the minor grooves. If, therefore, the hollow cone of gelatine, removed from its mould, were stretched from within, or if its thinnest parts became weak by drying, it would tend to give way, along the inferior median line, opposite the rod-like cast of the median groove, and between the ends of the casts of the lateral furrows, as well as between each of the minor grooves, and the hollow cone would expand into a flat feather-like structure, with a median shaft, as a 'vane' formed of 'barbs' and 'barbules.' In point of fact, in the development of a feather, such a cast of the dermal papilla is formed, though not in gelatine, but in the horny epidermic layer developed upon the mould, and, as this is thrust outwards, it opens out in the manner just described. After a certain period of growth the papilla of the feather ceases to be grooved, and a continuous horny cylinder is formed, which constitutes the 'quill.'"

A typical feather (fig. 166) consists of the following parts:—1. The "quill" or "barrel" (*a*), which forms the basal portion of the feather, by which it is inserted in the skin on its own dermal papilla. It is the latest-formed portion of the feather, and consists of a hollow horny cylinder. 2. The "shaft," (*b*) which is simply a continuation of the quill, and which forms the central axis of the feather. The inferior surface of the shaft always exhibits a strong longitudinal groove, and it is composed of a horny external sheath, containing a white spongy substance, very like the pith of a plant. 3. The shaft carries the lateral expansions or "webs" of the feather, collectively constituting the "vane." Each web is composed of a number of small branches, which form an open angle with the shaft, and which are known as the "barbs" (*c*). The margins of each barb are, in turn, furnished with a series of still smaller branches, which are known as the "barbules." As a general rule, the extremities of the barbules are hooked, so that those springing from the one side of each barb interlock with those springing from the opposite side of the next barb. In this way the barbs are kept in apposition with one another over a greater or less portion of the entire web. More or less of the barbs in the lower portion of the feather are, however, disunited, and not connected by their barbules; and these constitute what is known as the "down." In the Ostriches, Emeus, and some others, all the barbs of the feathers are disconnected, giving to the plumage of these birds its peculiarly soft character. At the point where the shaft joins the quill there is very generally found a small feather, known as the "accessory plume," or "plumule." This is usually much the same in structure as the main feather, but considerably smaller. It

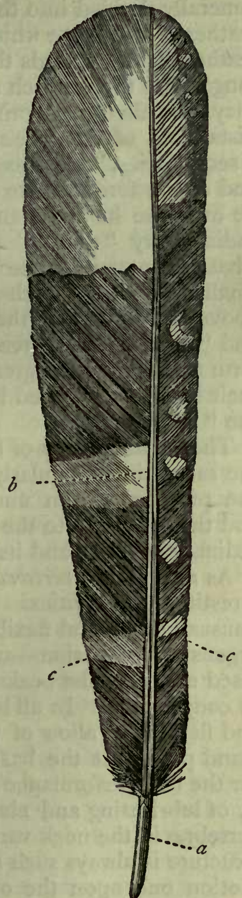


Fig. 166.—Quill-feather (*Stenopsis*). *a* Quill or barrel; *b* Shaft; *c c* Webs, composed of the barbs, and together forming the "vane."

may, however, be as large as the original feather, or it may be reduced to nothing more than a tuft of down.

The feathers vary in different parts of the bird, and are generally divided into those which cover the body—"clothing feathers," and those which occur in the wings and tail—"quill-feathers." As regards the great quill-feathers of the wings, the longest are those which arise from the bones of the hand, and they are called the "primaries." Those which arise from the distal end of the fore-arm (radius and ulna) are termed the "secondaries," and those which are attached to the proximal end of the fore-arm are the "tertiaries." The feathers which lie over the humerus and scapula are the "scapulars." The rudimentary "thumb" also carries some quills, which form what is known as the "alula," or "bastard-wing." The smaller feathers, which cover the bases of the quill-feathers above and below, are the "wing-coverts"—"greater," "lesser," and "under." The great quill-feathers of the tail ("rectrices") form a kind of fan of great use in steering the bird in flight, and their bases are covered by a series of feathers which constitute the "tail-coverts."

The entire *skeleton* of the Birds is singularly compact, and at the same time singularly light. The compactness is due to the presence of an unusual amount of phosphate of lime; and the lightness, to the absence in many of the bones of the ordinary marrow, and its replacement by air.

As regards the *vertebral column*, birds exhibit some very interesting peculiarities. The cervical region of the spine is unusually long and flexible, since the fore-limbs are useless as organs of prehension—and all acts of prehension must be exercised either by the beak or by the hind-feet, or by both acting in conjunction. In all birds alike, the neck is sufficiently long and flexible to allow of the application of the beak to an oil-gland placed at the base of the tail, this act being necessary for the due performance of the operation of "preening"—that is, of lubricating and cleaning the plumage. The number of vertebræ in the neck varies from nine to twenty-four, and their structure is always such as to allow of considerable freedom of motion one upon the other. The dorsal vertebræ vary from six to ten in number, and of these the anterior four or five are generally anchylosed with one another, so as to give a base of resistance to the wings. In the Cursorial birds, however (such as the Ostrich and Emeu), and in some others (such as the Penguin), in which the power of flight is wanting, the dorsal vertebræ are all more or less freely movable one upon another. There are no lumbar vertebræ, but all the vertebræ between the last dorsal and the first caudal (varying from nine to twenty) are anchylosed together to form a bone which is ordinarily known as the "sacrum." To this, in turn, the iliac bones are anchylosed along its whole length, giving perfect immobility to this region of the spine and to the pelvis.

The coccygeal or caudal vertebræ vary in number from eight to ten, and are movable upon one another. The most noticeable feature about this part of the spinal column is what is known as the "ploughshare-bone." This is the last joint of the tail, and is a long, slender, ploughshare-shaped bone, destitute of lateral processes, and without any medullary canal (fig. 170, B). In reality it consists of two or more of the caudal vertebræ, completely anchylosed, and fused into a single mass. It is usually set on to the extremity of the spine at an angle more or less nearly perpendicular to the axis of the body; and it affords a firm basis for the support of the great quill-feathers of the tail ("rectrices"). It also supports the coccygeal oil-glands, and can be raised at pleasure, so as to meet the bill, when the operation of preening is in progress. In the Cursorial Birds, which do not fly, the terminal joint of the tail is not ploughshare-shaped. In the extraordinary Mesozoic bird, the *Archæopteryx macrura*, there is no ploughshare-bone, and the tail consists of twenty separate vertebræ, all distinct from one another, and each carrying a pair of quill-feathers, one on each side (fig. 183). As the vertebræ of the ploughshare-bone are distinct from one another in the embryos of existing birds, the tail of the *Archæopteryx* is to be regarded as a case of the permanent retention in the adult of an embryonic character. In the increased number of caudal vertebræ, however, and in some other characters, the tail of the *Archæopteryx* makes a decided approach to the true Reptiles.

The various bones which compose the *skull* of Birds are amalgamated in the adult so as to form a single piece, and the sutures even are obliterated, the lower jaw alone remaining movable. The occipital bone carries a single occipital condyle only, and this is hemispherical or nearly globular in shape. The "beak" (fig. 167), which forms such a conspicuous feature in all birds, consists of an upper and lower half, or a "superior" and "inferior mandible." The upper mandible is composed almost entirely of the greatly elongated intermaxillary bones, flanked by the comparatively small superior maxillæ. The inferior mandible is primitively composed of twelve pieces, six on each side; but in the adult these are all indistinguishably amalgamated with one another, and the lower jaw forms a single piece. As in the Reptiles, the lower jaw articulates with the skull, not directly, but through the intervention of a distinct bone—the quadrate bone or tympanic bone—which always re-

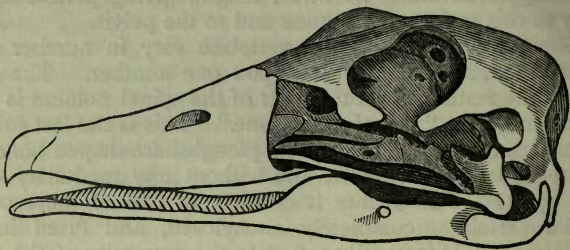


Fig. 167.—Skull of Spur-winged Goose (*Plectropterus Gambensis*).

mains permanently movable, and is never anchylosed with the skull. In no bird are teeth ever developed in either jaw, but both mandibles are encased in horn, forming the beak, and the margins of the bill are sometimes serrated.

The thoracic cavity is bounded by the dorsal vertebræ, which are usually, as before said, anchylosed to one another to a greater or less extent. Laterally, the thorax is bounded by the ribs, which vary in number from six to ten pairs. In most birds each rib carries a peculiar process—the "uncinate process"—which arises from its posterior margin, is directed upwards and backwards, and passes over the rib next in succession behind, where it is bound down by ligament. The first and last dorsal ribs carry no uncinate processes, and in some cases the processes continue throughout life as separate pieces (fig. 168, B). Anteriorly, the ribs articulate with a series of straight bones, which are called the "sternal ribs," but which in reality are to be looked upon as the ossified "costal cartilages." These sternal ribs (fig. 168, B) are in turn movably articulated to the sternum in front, and "they are the centres upon which the respiratory movements hinge" (Owen). In front the thoracic cavity is completed by an enormously-expanded sternum or breast-bone, which in some birds of great powers of flight extends over the abdominal cavity as well, in some cases even reaching the pelvis. The sternum of all birds which fly, is characterised by the presence of a greatly-developed median ridge or keel (fig. 168, A), to which are attached the great pectoral muscles which move the wings. As a general rule, the size of this sternal crest allows a very tolerable estimate to be formed of the flying powers of the bird to which it may have belonged; and in the Ostriches and other birds which do not fly, there is no sternal keel. At its anterior angles the sternum exhibits two pits for the attachment of the coracoid bones.

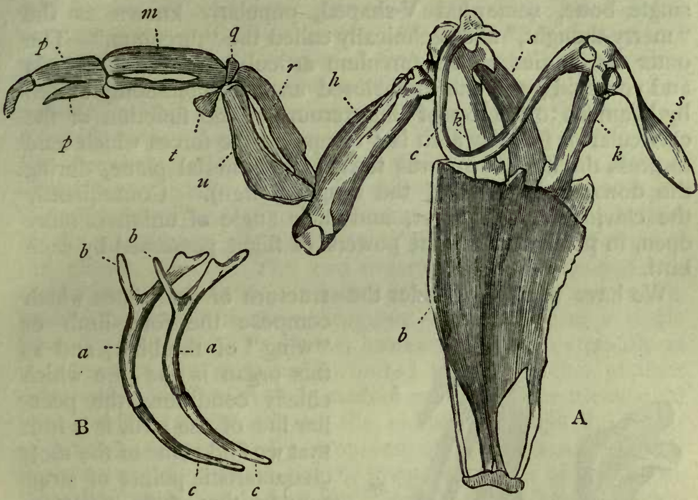


Fig. 168.—A, Breast-bone, shoulder-girdle, and fore-limb of Penguin (after Owen): *b* Sternum, with the sternal keel; *s s* Scapulæ; *k k* Coracoid bones; *c* Furculum or merry-thought, composed of the united clavicles; *h* Humerus; *u* Ulna; *r* Radius; *t* Thumb; *m* Metacarpus; *p* Phalanges of the fingers. B, Ribs of the Golden Eagle: *a a* Ribs giving off (*b b*) uncinate processes; *c c* Sternal ribs.

The scapular or pectoral arch consists of the shoulder-blade or scapula, the collar-bone or clavicle, and the coracoid bone, on each side. The scapula, as a rule (fig. 168, A, *s s*), is a simple elongated bone, not flattened out into a broad plate, and carrying no transverse ridge, or spinous process. Only a portion of the glenoid cavity for the articulation with the head of the humerus is formed by the scapula, the remainder being formed by the coracoid. The coracoid bones (fig. 168, A, *k k*) correspond with the coracoid processes of man, but in birds they are distinct bones and are not anchylosed with the scapula. The coracoid bone on each side is always the strongest of the bones forming the scapular arch. Superiorly it articulates with the clavicle and scapula, and forms part of the glenoid cavity for the humerus. Inferiorly each coracoid bone articulates with the upper angle of the sternum. The position of the coracoids is more or less nearly vertical, so that they form fixed points for the action of the wings in their downward stroke. The clavicles (fig. 168, A, *c*) are rarely rudimentary or absent, and are in some few cases separate bones. In the great majority, however, of birds, the clavicles are anchylosed together at their anterior extremities, so as to form a single bone, somewhat V-shaped, popularly known as the "merry-thought," and technically called the "furculum." The outer extremities of the furculum articulate with the scapula and coracoid; and the anchylosed angle is commonly united by ligament to the top of the sternum. The function of the clavicular or furcular arch is "to oppose the forces which tend to press the humeri inwards towards the mesial plane, during the downward stroke of the wing" (Owen). Consequently the clavicles are stronger, and their angle of union is more open, in proportion to the powers of flight possessed by each bird.

We have next to consider the structure of the bones which compose the fore-limb or "wing" of the bird; and as this organ is the one which chiefly conditions the peculiar life of the bird, it is in it that we find some of the most characteristic points of structure in the whole skeleton. Though considerably modified to suit its function as an organ of aerial progression, the wing of the bird is readily seen to be homologous with the arm of a man or the fore-limb of a Mammal (fig. 168, A, and fig. 169). The upper arm (*brachium*) is supported by a single bone, the humerus, which is short and strong, and articulates above with the articular cavity formed partly by the scapula and partly by the coracoid (fig. 169, *h*). The humerus is succeeded distally by the fore-arm (*antibrachium*) constituted by the normal two bones, the radius and ulna (fig. 169, *r*, *u*), of which the radius is much the smaller and more slender, and the ulna much

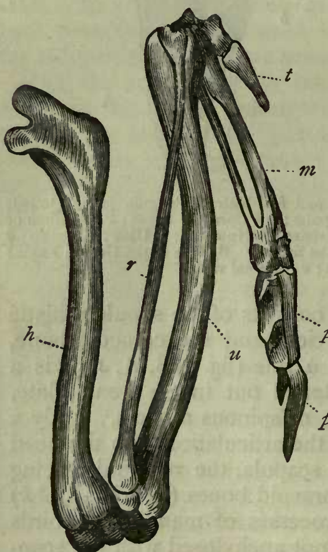


Fig. 169. — Fore-limb of the Jer-falcon. *h* Humerus; *r* Radius; *u* Ulna; *t* "Thumb;" *m* Metacarpals, anchylosed at their extremities; *p p* Phalanges of fingers.

the larger and stronger. The ulna and radius are followed inferiorly by the bones of the wrist or carpus; but these are reduced in number to *two* small bones, "so wedged in between the antibrachium and metacarpus as to limit the motions of the hand to those of abduction and adduction necessary for the folding up and expansion of the wing; the hand is thus fixed in a state of pronation; all power of flexion, extension, or of rotation, is removed from the wrist-joint, so that the wing strikes firmly, and with the full force of the contraction of the depressor muscles, upon the resisting air" (Owen). One other bone of the normal carpus (namely, the "os magnum") is present, but this is anchylosed with one of the metacarpals. There are thus really *three* carpal bones, though only two appear to be present. The carpus is followed by the metacarpus, the condition of which agrees with that of the carpal bones. The two outermost of the normal five metacarpals are absent, and the remaining three are anchylosed—together with the os magnum—so as to form a single bone (fig. 169, *m*). This bone, however, appears externally as if formed of *two* metacarpals united to one another at their extremities, but free in their median portion. The metacarpal bone which corresponds to the radius is always the larger of the two (as being really composed of two metacarpals), and it carries the digit which has the greatest number of phalanges. This digit corresponds with the "index" finger, and it is composed of two, or sometimes three, phalanges (fig. 169, *p*). At the proximal end of this metacarpal, at its outer side, there is generally attached a single phalanx, constituting the so-called "thumb" (fig. 169, *t*), which carries the "bastard-wing." The digit which is attached to the ulnar metacarpal corresponds to the "ring finger," and never consists of more than a single phalanx (fig. 169).

As regards the structure of the posterior extremity or hind-limb, the pieces which compose the innominate bones (namely, the ilium, ischium, and pubes) are always anchylosed to one another; and the two innominate bones are also always anchylosed, by the medium of the greatly-elongated ilia, to the sacral region of the spine. In no living bird, however, with the single exception of the Ostrich, are the innominate bones united in the middle line in front by a symphysis pubis. The stability of the pelvic arch, necessary in animals which support the weight of the body on the hind-limbs alone, is amply secured in all ordinary cases by the anchylosis of the ilia with the sacrum.

As in the higher Vertebrates, the lower limb (fig. 170, A) consists of a femur, a tibia and fibula, a tarsus, metatarsus, and phalanges; but some of these parts are considerably obscured by anchylosis. The femur or thigh-bone (fig. 170, A, *f*) is generally very short, comparatively speaking. The chief

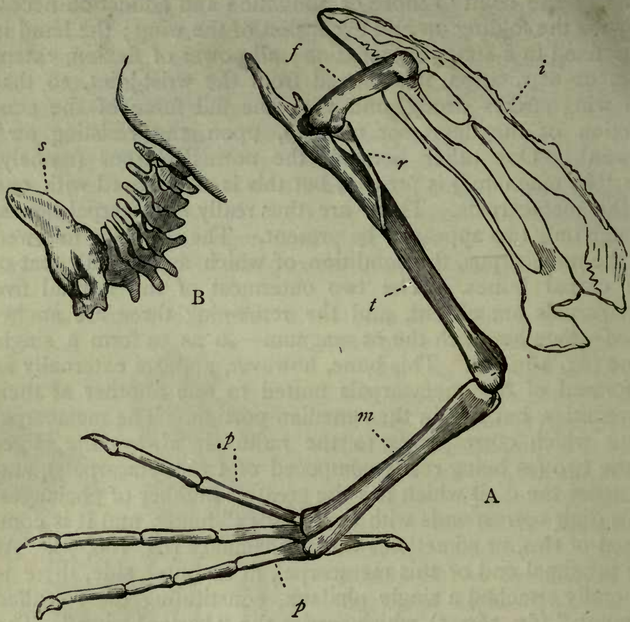


Fig. 170.—A, Hind-limb of the Loon (*Colymbus glacialis*)—after Owen: *i* Innominate bone; *f* Thigh-bone or femur; *t* Tibia, with the proximal portion of the tarsus anchylosed to its lower end; *r* Fibula; *m* Tarso-metatarsus, consisting of the distal portion of the tarsus anchylosed with the metatarsus; *p p* Phalanges of the toes. B, Tail of the Golden Eagle: *s* Ploughshare-bone, carrying the great tail-feathers.

bone of the leg is the tibia (*t*), to which a thin and tapering fibula (*r*) is anchylosed. The upper end of the fibula, however, articulates with the external condyle of the femur. The ankle-joint is placed, as in Reptiles, between the proximal and distal portions of the tarsus. The proximal portion of the tarsus is undistinguishably amalgamated with the lower end of the tibia. The distal portion of the tarsus is anchylosed with the whole of the metatarsus to constitute the most characteristic bone in the leg of the Bird—the "tarso-metatarsus" (*m*). In most of the long-legged birds, such as the waders, the disproportionate length of the leg is given by an extraordinary elongation of the tarso-metatarsus.

The tarso-metatarsus is followed inferiorly by the digits of the foot. In most birds the foot consists of three toes directed forwards and one backwards—four toes in all. In no wild bird are there *more* than four toes, but often there are only three, and in the Ostrich the number is reduced to two. In all birds which have three anterior and one posterior toe, it is the posterior thumb or *hallux* (that is to say, the innermost digit of the hind-limb) which is directed backwards; and it invariably consists of *two* phalanges only. The most internal of the three toes which are directed forwards, consists of *three* phalanges; the next has *four* phalanges; and the outermost or "little" toe is made up of *five* phalanges (fig. 170, A). This increase in an arithmetical ratio of the phalanges of the toes, in proceeding from the inner to the outer side of the foot, obtains in almost all birds, and enables us readily to detect which digit is suppressed, when the normal four are not all present. Variations of different kinds exist, however, in the number and disposition of the toes. In many birds—such as the Parrots—the outermost toe is turned backwards, so that there are two toes in front and two behind. In others, again, the outer toe is normally directed forwards, but can be turned backwards at the will of the animal. In the Swifts, on the other hand, all four toes are present, but they are all turned forwards. In many cases—especially amongst the Natatorial birds—the hallux is wholly wanting, or is rudimentary. In the Emeu, Cassowary, Bustards, and other genera, the hallux is invariably absent, and the foot is three-toed. In the Ostrich both the hallux and the next toe ("index") are wanting, and the foot consists simply of two toes, these being the outer toe and the one next to it.

The *digestive system* of birds comprises the beak, tongue, gullet, stomach, intestines, and cloaca. Teeth are invariably wanting in birds, and the jaws are encased in horn, constituting the bill. The form of the bill varies enormously in different birds, and it is employed for holding and tearing the prey, for prehensile purposes, for climbing, and in some birds as an organ of touch. In these last-mentioned cases the bill is more or less soft, and is supplied with filaments of the fifth nerve. In many birds, too, in which the bill is not soft, the base of the upper mandible is surrounded by a circle of naked skin, constituting what is called the "cere," and this, no doubt, serves also as a tactile organ.

The tongue of birds can hardly be looked upon as an organ of taste, since it is generally cased in horn like the mandibles. It is, in fact, principally employed as an organ of prehension;

but in some cases—as in the Parrots—it is soft and fleshy, and then, doubtless, is to some extent connected with the sense of taste. It is essentially composed of a prolongation of the hyoid bone (the glosso-hyal), which is sheathed in horn, and is variously serrated or fringed.

Salivary glands are invariably present, but they are rarely of large size, and they have often a very simple structure.

In accordance with the structure of the neck, the gullet in birds is usually of great length, and it is generally very dilatable. In the carnivorous, or Raptorial, and in the granivorous birds, the gullet (fig. 171, *o*) is dilated into a pouch, which is situated

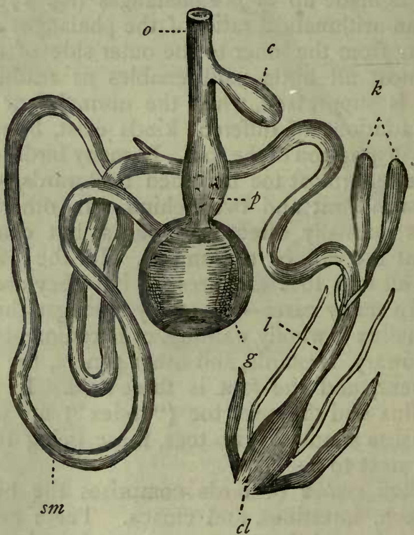


Fig. 171.—Digestive System of the Common Fowl (after Owen). *o* Gullet; *c* Crop; *p* Proventriculus; *g* Gizzard; *sm* Small intestine; *k* Intestinal cæca; *l* Large intestine; *cl* Cloaca.

at the lower part of the neck, just in front of the merry-thought. This is what is known as the "crop" or "ingluvies" (*c*), and it may be either a mere dilatation of the tube of the gullet, or it may be a single or double pouch. The food is detained in the crop for a longer or shorter time, according to its nature, before it is subjected to the action of the proper digestive organs. The œsophagus, after leaving the crop, shortly opens into a second cavity, which is known as the "proventriculus" or "ventriculus succenturiatus" (*p*). This is the true digestive cavity, and its mucous membrane is richly supplied with gastric follicles which secrete the gastric juice. The proventriculus, however, corresponds, not with the whole stomach of the Mammals, but only with its cardiac portion; and it opens into a second, muscular cavity, which corresponds to the pyloric division of the Mammalian stomach. The gizzard (*g*) is situated below the liver, and forms in all birds an elongated sac, having two apertures above, of which one conducts into the duodenum or commencement of the small intestine, whilst the other communicates with the proventriculus. The two chief forms of gizzard are exhibited respectively by the Raptorial birds, which feed on easily-digested animal food, and the *Rasores* and some of the *Natatores*, which feed on hardly-digested grains. In the birds of Rapine the gizzard scarcely deserves the name, being nothing more than a wide membranous cavity with thin walls. In the granivorous birds, whose hard food requires crushing, the gizzard is enormously developed; its lining coat is formed of a thick, horny epithelium, and its walls are extremely thick and muscular. This constitutes a grinding apparatus, like the stones of a mill; whilst the "crop" or œsophageal dilatation may be compared to the "hopper" of a mill, since it supplies to the gizzard "small successive quantities of food as it is wanted" (Owen). Supplementing the action of the muscular walls of the gizzard, and acting in the place of teeth, are the small stones or pebbles, which, as is so well known, so many of the granivorous birds are in the habit of swallowing with their food, or at other times. In fact there can be no doubt but that the gravel and pebbles swallowed by these birds is absolutely essential to existence, since the gizzard, without this assistance, is unable properly to triturate the food.

The intestinal canal extends from the gizzard to the cloaca, and is comparatively speaking short. The secretions of the liver and pancreas are poured into the small intestine, as in Mammals. The commencement of the large intestine is almost always furnished with two long "cæca" or blind tubes, the length of which varies a good deal in different birds (fig. 171, *k*). They are sometimes wanting; and their exact function is uncertain; though they are most probably connected partly with digestion and partly with excretion. The large intestine is always very short—seldom more than a tenth part of the length of the body—and it terminates in the "cloaca" (fig. 171, *cl*). This is a cavity which in all birds receives the termination of the rectum, the ducts of the generative organs and the ureters; and serves, therefore, for the expulsion of the fæces, the generative products, and the urinary secretion.

Respiration is effected in Birds more completely and actively than in any other class of the *Vertebrata*, and as the result of this, their average temperature is also higher. This extensive development of the respiratory process is conditioned by the fact that, in addition to true lungs, air is admitted into a greater or less number of the bones, and into a number of cavities—the so-called air-receptacles—which are distributed through various parts of the body. By this extensive penetration of air into various parts of the body, the aeration of the blood is effected, not only in the lungs, but also over a greater or less extent of the systemic circulation as well; and hence in Birds this process attains its highest perfection. The cavities of the thorax and abdomen are not separated from one another by a complete partition, the diaphragm being only present in a rudimentary form. The lungs are two in number, of a bright-red colour, and spongy texture. They are confined to the back of the thorax, extending along each side of the spine, from the second dorsal vertebra to the kidney. They differ from the lungs of the Mammals in not being freely suspended in a pleural membrane. The pleura, on the other hand, is reflected only over the anterior surface of the lungs. The bronchi, or primary divisions of the windpipe (fig. 172), diminish in size as they pass through the lung, by giving off branches, which, in turn, give off the true air-vesicles of the lung. When the bronchial tubes reach the surface of the lung, they open, by a series of distinct apertures, into a series of "air-sacs." These are a series of membranous sacs formed by the continuation of the lining membrane of the bronchi, and supported by reflections of the serous membrane of the thoracico-abdominal cavity. In those aquatic birds which, like the Penguin, do not enjoy the power of flight, the air-cells are

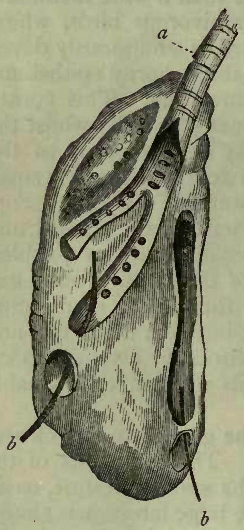


Fig. 172.—Lung of Goose (after Owen). *a* Main bronchus dividing into secondary branches as it enters the lung, these giving off smaller branches, the openings of which are seen on the back of the bronchial tubes; *b b* Bristles passed from the bronchi through the apertures on the surface of the lung by which the bronchi communicate with the air-receptacles.

restricted to the abdomen; but in most birds they are continued along the sides of the neck and limbs. In some cases—as the Pelican and Gannet—air-receptacles are situated beneath almost the whole of the integument. The air-cells not only greatly reduce the specific gravity of the bird, and thus fit them for an aerial life, but also assist in the mechanical work of respiration, and must also greatly promote the aeration of the blood.

In connection with the air-receptacles, and as an extension of them, is a series of cavities occupying the interior of a greater or less number of the bones, and also containing air. In young birds these air-cavities do not exist, and the bones are filled with marrow as in the Mammals. The extent also to which the bones are "pneumatic" varies greatly in different birds. In the Penguin—which does not fly—all the bones contain marrow, and there are no air-cavities. In the large Running Birds (*Cursores*), such as the Ostrich, the bones of the leg, pelvis, spine, ribs, skull, and sternum are pneumatic; but the bones of the wings, with the exception of the scapular arch, are without air-cavities, and permanently retain their marrow. All birds which fly, with the singular exception of the Woodcock, have air admitted to the humerus. In the Pelican and Gannet, all the bones of the skeleton, except the phalanges of the toes, are penetrated by air; and in the Hornbill even these are pneumatic. The functions discharged by the air-cavities of the bones appear to be much the same as those of the air-receptacles—namely, that of diminishing the specific gravity of the body and subserving the aeration of the blood.

The *heart* in all Birds consists of four chambers, two auricles and two ventricles. The right auricle and ventricle, constituting the right side of the heart, are wholly concerned with the pulmonary circulation; the left auricle and ventricle, forming the left side of the heart, are altogether occupied with the systemic circulation; and no communication normally exists in adult life between the two sides of the heart. In all essential details, both as regards the structure of the heart itself and the course taken by the circulating fluid, Birds agree with Mammals. The venous blood—namely, that which has circulated through the body—is returned by the venæ cavæ to the right auricle, whence it is poured into the right ventricle. The right ventricle propels it through the pulmonary artery to the lungs, where it is aerated, and becomes arterial. It is then sent back by the pulmonary veins to the left auricle, whence it is driven into the left ventricle. Finally, the left ventricle propels the aerated blood to all parts of the body through the great systemic aorta.

The chief difference between Birds and Reptiles as regards the course of the circulation is, that in the Birds the two sides of the heart are completely separated from one another, the blood sent to the lungs being exclusively venous, whereas that which is sent to the body is exclusively arterial. In Reptiles, on the other hand, the pulmonary and systemic circulations are connected together either in, or in the immediate neighbourhood of, the heart; so that mixed venous and arterial blood is propelled both through the lungs and through every part of the body.

In accordance with their extended respiration and high muscular activity, the complete separation of the greater and lesser circulations, and the perfect structure of the heart, Birds maintain a higher average temperature than is the case with any other class of the *Vertebrata*. This result is also to a considerable extent conditioned by the non-conducting nature of the combined down and feathers which form the integumentary covering of Birds.

The *urinary organs* of Birds consist of two elongated kidneys and two ureters, but there is no urinary bladder. The ureters open into the cloaca, or into a small urogenital sac which communicates with the cloaca.

As regards the *reproductive organs*, the males have two testes placed above the upper extremities of the kidneys, and their efferent ducts (*vasa deferentia*) open into the cloaca alongside of the ureters. A male organ (*penis*) may or may not be present, but there is no perfect urethra. The female bird, as a general rule, is provided with only one ovary and oviduct—that of the left side—the corresponding organs of the right side being rudimentary or absent. The oviduct is very long and tortuous, and the egg, during its passage through it, receives the albuminous covering which serves for the nutrition of the embryo, and which is known as the "white" of the egg. The lower portion of the oviduct is dilated, and the egg receives here the calcareous covering which constitutes the "shell." Finally, the oviduct debouches into the cloaca, into which the egg, when ready, is expelled. The further development of the chick is secured by the process of "incubation" or brooding, for which birds are peculiarly adapted, in consequence of the high temperature of their bodies.

The development of the ovum belongs to physiology, and does not concern us here. It is sufficient to notice the means by which in many cases the chick is ultimately enabled to escape from the egg. When development has reached a stage at which external life is possible, it is of course necessary for the chick to be liberated from the egg, the shell of which is often extremely hard and resistant. To this end, in very many instances, the young bird is provided with a little calcareous knob on the point of the upper mandible, and by means of this it chips out an aperture through the shell. Having effected its purpose, this temporary appendage then disappears, without leaving a trace behind.

The state of the young upon exclusion from the egg is very different in different cases, and in accordance with this, Birds have been divided into the two sections of the *Autophagi* or *Aves præcoces*, and the *Heterophagi* or *Aves altrices*. In the *Autophagi* the young bird is able to run about and help itself from the moment of liberation from the egg. In the *Heterophagi* the young are born in a blind and naked state, unable to feed themselves, or even to maintain unassisted the necessary vital heat. In these birds, therefore, the young require to be brooded over and fed by the parents for a longer or shorter period after exclusion from the egg.

As regards their *nervous system*, the brain of birds is relatively larger, especially as regards the size of the cerebrum proper, than the brain of Reptiles. The cerebellum, though always present, consists simply of the central lobe (the "vermiform process"), and is not provided with the lateral lobes which occur in the Mammals, or they are only present in a rudimentary form. The corpus callosum is absent, and the surface of the cerebral hemispheres is devoid of convolutions.

As regards the *organs of the senses*, the eyes are always well developed, and in no bird are they ever rudimentary or absent. The chief peculiarity of the eye is that the cornea forms a segment of a much smaller sphere than does the eyeball proper, so that the anterior part of the eye is obtusely conical, whilst the posterior portion is spheroidal. Another peculiarity is that the form of the eye is maintained by a ring of from thirteen to twenty bony plates, which are placed in the anterior portion of the sclerotic coat. Eyelashes are almost universally absent; but in addition to the ordinary upper and lower eyelids, Birds possess a third membranous eyelid—the "membrana nictitans"—which is sometimes pearly-white, sometimes more or less transparent. This third eyelid is placed on the inner side of the eye, and possesses a special muscular apparatus, by which it can be drawn over the anterior surface of the eye like a curtain, moderating the intensity of the light. As to the organ of hearing, Birds possess no external ear or concha, by which sounds can be collected and transmitted to the internal ear. In some birds, however, as in the Ostrich and Bustard, the external meatus auditorius is surrounded by a circle of feathers, which can be raised and depressed at will. The external nostrils in Birds are usually placed on the sides of the upper mandible, near its base, in the form of simple perforations, which sometimes communicate from side to side by the deficiency of the septum narium. In the singular *Apteryx* of New Zealand the nostrils are placed at the extreme end or tip of the elongated upper mandible. Sometimes the nostrils are defended by bristles, and sometimes by a scale (*Rasores*). Taste must be absent, or almost absent, in the great majority of birds, the tongue being nothing more than a horny sheath surrounding a process of the hyoid bone, and serving for deglutition or to seize the prey. In the Parrots, however, the tongue is thick and fleshy, and some perception of taste may be present. Touch or tactile sensibility, too, as already remarked, is very poorly developed in Birds. The body is entirely, or almost entirely, covered with feathers; the anterior limbs are converted into wings, and rendered thereby useless as organs of touch; and the posterior limbs are covered with horny scales or feathers. The bill certainly officiates as an organ of touch, but it cannot possess any acute sensibility, as in most birds it is encased in a rigid horny sheath. In some birds, however, such as the common Duck, the texture of the bill is moderately soft, and it is richly supplied with filaments of the fifth nerve; so that in these cases the bill doubtless constitutes a tolerably efficient tactile organ. The "cere," too, or the fleshy scale found at the base of the bill in some birds, is in all probability also used as a tactile organ.

The last anatomical peculiarity of Birds which requires notice is the peculiar apparatus known as the "inferior larynx," by which the song of the singing birds is conditioned. "The air-passages of birds commence by a simple *superior larynx*, from which a long *trachea* extends to the anterior aperture of the thorax, where it divides into the two *bronchi*, one for each lung. At the place of its division there exists in most birds a complicated mechanism of bones and cartilages, moved by appropriate muscles, and constituting the true organ of voice; this part is termed the *inferior larynx*."—(Owen.) The structure of the vocal apparatus is extremely complicated, and there is no necessity for entering upon it here. It is to be remembered, however, that those modifications of the voice which constitute the song of birds, are produced in a special and complex cavity placed at the point where the trachea divides into the two bronchi, and *not* in a true larynx situated at the summit of the windpipe. Lastly, the trachea of birds is always of considerable proportionate length, and it is often twisted or dilated at intervals, this structure, doubtless, having something to do with the production of vocal sounds.*

Before passing on to the consideration of the divisions of Birds, a few words may be said as to the *migration* of birds. In temperate and cold climates comparatively few birds remain constantly in the same region in which they were hatched. Those which do so remain, are called "permanent birds" (*aves manentes*). Other birds, such as the Woodpeckers, wander about from place to place, without having any fixed direction. These are called "wandering birds" (*aves erraticæ*), and their irregular movements are chiefly conditioned by the scarcity or abundance of food in any particular locality. Other birds, however, at certain seasons of the year, undertake long journeys, usually uniting for this purpose into large flocks. These birds—such as the swallows, for instance—are properly called "migratory birds" (*aves migratoriæ*). The movements of these birds are conditioned by the necessity of having a certain mean temperature, and consequently they leave the cold regions at the approach of winter, and return again for the warmer season.

CHAPTER LXVII.

DIVISIONS OF BIRDS.

1. General Divisions of Aves. 2. Natatores. 3. Grallatores.

Owing to the extreme compactness and homogeneity of the entire class *Aves*, conditioned mainly by their adaptation to an aerial mode of life, the subject of their classification has been one of the greatest difficulties of the systematic Zoologist.

By Professor Huxley the Birds are divided into the following three orders:—

1. Saururæ.—In this order the caudal vertebræ are numerous, and there is no ploughshare-bone. The tail is

* The student desirous of fuller information as to the anatomy of Birds should consult the masterly article by Owen on "Aves" in the 'Cyclopædia of Anatomy and Physiology,' or the second volume of the 'Vertebrata' of the same author, from which the preceding summary has been chiefly derived.

longer than the body, and the metacarpal bones are not anchylosed together. This order includes only the single extinct bird the *Archæopteryx macrura*, in which the long lizard-like tail is only the most striking of several abnormalities.

2. RATITÆ.—This order comprises the Running birds, which cannot fly, such as the Ostriches, Emeus, and Cassowaries. It is characterised by the fact that the sternum has no median ridge or keel for the attachment of the great pectoral muscles. The sternum is therefore raft-like (from the Lat. *rates*, a raft), hence the name of the order.

3. CARINATÆ.—This comprises all the living Flying birds, and is characterised by the fact that the sternum is furnished with a prominent median ridge or keel (*carina*); hence the name of the order.

This is probably the nearest approach to a strictly natural classification of Birds which has yet been proposed; but the order *Carinatæ* is so disproportionately large as compared with the other two, that it would lead to considerable inconvenience if it were to be adopted here.

For the purposes of the present work it will be better to adhere, with some modifications, to the classification of the Birds originally proposed by Kirby, and since sanctioned by the adoption of other distinguished naturalists. In this more generally current, but certainly artificial, arrangement, the Birds are divided into the following seven orders, founded chiefly on the habits and mode of life, and on the resulting anatomical or structural peculiarities. To these an eighth order must be added for the reception of the Mesozoic bird, the *Archæopteryx*, the discovery of which dates from a recent period. Before entering upon a consideration of the individual orders, it will be as well to present to the student, synoptically and in an easily-remembered form, the leading differences between these eight orders :—

1. *Natatores or Swimmers.*—These are characterised by the fact that the toes are united by a membrane or web; the legs are short and are placed behind the point of equilibrium of the body. The body is closely covered with feathers, and with a thick coating of down next the skin. (*Ex.* Ducks, Geese, Pelicans, Gulls.)

2. *Grallatores or Waders.*—The Wading birds are characterised by the possession of long legs, which are naked or are not covered with feathers from the distal end of the tibia downwards. The toes are long, straight, and not united to one another by a membrane or web. (*Ex.* Curlews, Herons, Storks.)

3. *Cursores or Runners.*—The Cursorial birds have very short wings which are not used in flight, and the sternum is without a ridge or keel. The legs are exceedingly robust, and there are only two or at most three developed toes, the hind-toe or hallux being always absent or quite rudimentary. The order agrees with the *Ratitæ* of Huxley. (*Ex.* Ostrich, Emeu, Apteryx.)

4. *Rasores or Scratchers.*—The Rasorial birds have usually strong feet with powerful blunt claws adapted for scratching, but sometimes for perching. All the four toes are present. The upper mandible is vaulted, and the nostrils are pierced in a membranous space at its base, and are covered by a cartilaginous scale. (*Ex.* Fowls, Game-birds, Pigeons.)

5. *Scansores or Climbers.*—The Climbing birds are characterised by the structure of the foot, in which two toes are turned backwards and two forwards, so as to give the bird unusual facilities in climbing trees. (*Ex.* Parrots, Toucans, Woodpeckers.)

6. *Insessores or Perchers.*—The Insessorial or Passerine birds are characterised by having slender and short legs, with three toes before and one behind, the two external toes generally united by a very short membrane, and the whole foot being adapted for perching. This is by far the largest order of birds, and includes all our ordinary songsters, such as the Thrushes, Linnets, Larks, &c., together with the Swallows, Humming-birds, and many others.

7. *Raptores or Birds of Prey.*—The Birds of Rapine are characterised by their strong, curved, sharp-edged and sharp-pointed beak, adapted for tearing animal food; and by their robust legs armed with four toes, three in front and one behind, all furnished with long, strong, crooked claws or talons. (*Ex.* Eagles, Hawks, Owls.)

8. *Saururæ.*—The metacarpal bones are not anchylosed together, and the tail is longer than the body, and consists of numerous free vertebræ, without a terminal ploughshare-bone. The only member of this order is the extinct *Archæopteryx.*

ORDER I. NATATORES.—The order of the *Natatores* or Swimmers comprises a number of birds which are as much or even more at home in the water than upon the land. In accordance with their aquatic habit of life, the *Natatores* have a boat-shaped body, usually with a long neck. The legs are short, and placed behind the centre of gravity of the body, this position enabling them to act admirably as paddles, at the same time that it renders the gait upon dry land more or less awkward and shuffling. In all cases the toes are "webbed" or united by membrane to a greater or less extent (fig. 173, A). In many instances the membrane or web is stretched completely from toe to toe, but in others the web is divided or split up between the toes, so that the toes are fringed with membranous borders, but the feet are only imperfectly webbed. As their aquatic mode of life exposes them to great reductions of temperature, the body of the Natatorial birds is closely covered with feathers and with a thick coating of down next the skin. They are, further, prevented from becoming wet in the water by the great development of the coccygeal oil-gland, by means of which the plumage is kept constantly lubricated and waterproof. They are usually polygamous, each male consorting with several females; and the young are hatched in a condition not requiring any special assistance from the parents, being able to swim and procure food for themselves from the moment they are liberated from the egg.

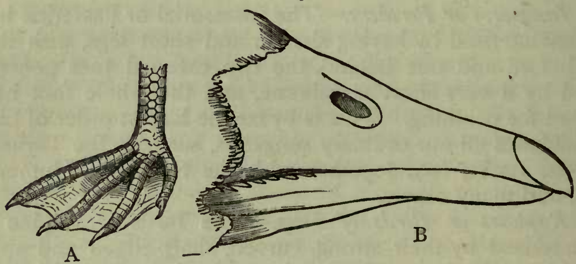


Fig. 173.—Natatores. A, Foot of Cormorant (*Phalacrocorax*); B, Beak of the Bean-goose (*Anser segetum*).

The *Natatores* are divided by Owen into the following four families:—

Fam. 1. *Brevipennatæ.*—In this family of the swimming birds the wings are always short, and are sometimes useless as organs of flight, the tail is very short, and the legs are placed very far back, so as to render terrestrial progression very difficult or awkward. The family includes the Penguins, Auks, Guillemots, Divers, and Grebes. In the Penguins (*Spheniscidæ*) the wings are completely rudimentary, without quills, and covered with a scaly skin. They are useless, as far as flight is concerned, but they are employed by the bird as fins, enabling it to swim under water with great facility. The feet are webbed, and the hinder toe is rudimentary or wanting. The Penguins live in the seas of the southern hemisphere, on the coasts of South Africa and South America, especially at Terra del Fuego, and in the solitary islands of the South Pacific. When on land the Penguins stand bolt upright, and as they usually stand on the shore in long lines, they are said to present a most singular appearance. In the Auks (*Alcidæ*) the wings are better developed than in the Penguins, and they contain true quill-feathers; but they are still short as compared with the size of the body, and are of more use as fins than for flight. The great Auk or Gare-fowl (*Alca impennis*) is remarkable for being one of the birds which appear to have become entirely extinct within the human period, having been, in fact, destroyed by man himself. It used to abound in the arctic regions, and occasionally visited our own shores in the winter. The little Auk (*Mergulus alba*) occurs still in abundance in the seas of the arctic regions. Other well-known members of this group are the Razor-bill, the Puffins (*Fratercula arctica*), and the Guillemots (*Uria*).

In the Divers (*Colymbidæ*), comprising the true Divers and the Grebes, the power of flight is pretty well developed, but the bird still is much more active in the water, swimming or diving, than on land. The Grebes are not uncommon in our own country, and are largely killed for making muffs, collars, and other articles of winter dress. They have the membrane between the toes deeply incised. In the Divers proper the front toes are completely united by a membrane. The Northern Diver or Loon (*Colymbus glacialis*) is a familiar example, and is found on the coasts of high northern latitudes.

Fam. 2. *Longipennatæ.*—This family of *Natatores* is characterised by the well-developed wings, the pointed, sometimes knife-like, sometimes hooked bill, and by never having the hallux united with the anterior toes by a membrane. The following are the more important groups coming under this head :—

a. Laridæ, or Gulls and Terns, having powerful wings, a free hinder toe, and the three anterior toes united by a membrane. The Gulls form an exceedingly large and widely distributed group of birds; and the Terns or Sea-swallows are equally beautiful, if not quite so common.

b. Procellaridæ, or Petrels, closely resembling the true Gulls, but having no hinder toe, and having the upper mandible strongly hooked. The smaller species of Petrel are well known to all sailors under the name of Storm-birds and Mother Carey's Chickens. The largest member of the group is the gigantic Albatross (*Diomedea exulans*), not uncommonly found far from land in both the northern and southern oceans. The

Albatross sometimes measures as much as fifteen feet from the tip of one wing to that of the other, and their flight is powerful in proportion.

Fam. 3. *Totipalmatæ,* characterised by having the hinder toe or hallux more or less directed inwards, and united to the innermost of the anterior toes by a membrane (fig. 173, A). In this family are the Pelicans, Cormorants, Gannets, Frigate-birds, Darters, and others.

The Pelicans (*Pelicanidæ*) are large birds, which subsist on fish, and are found in Europe, Asia, Africa, and the New World. They sometimes measure as much as from ten to fifteen feet between the tips of the wings, and most of the bones are pneumatic, so that the skeleton is extremely light. The lower mandible is composed of two flexible branches which serve for the support of a large "gular" pouch, formed by the loose unfeathered skin of the neck. The fish captured by the bird are temporarily deposited in this pouch, and the parent birds feed their young out of it.

In the Cormorants (*Phalacrocorax*) there is no pouch beneath the lower mandible, but the skin of the throat is very lax and distensible. They are widely distributed over the world, one species being very abundant in many parts of Europe. The Gannets (*Sula*) have a compressed bill, the margins of which are finely crenate or toothed. They occur abundantly on many parts of the coasts of northern Europe, one of the most noted of their stations being the Bass Rock at the mouth of the Firth of Forth. Another species (*Sula variegata*) is of greater importance to man, as being one of the birds from the accumulated droppings of which guano is derived. The Frigate-birds (*Tachypetes*) are chiefly remarkable for their extraordinary powers of flight, conditioned by their enormously long and powerful wings and long forked tail. They occur on the coasts of tropical America, and are often found at immense distances from any land.

The Darters (*Plotus*) are somewhat aberrant members of this group, characterised by their elongated necks and long pointed bills. They occur in America, Africa, and Australia, and catch fish by suddenly darting upon them from above.

Fam. 4. *Lamellirostres.*—The last family of the *Natatores* is that of the *Lamellirostres*, including the Ducks, Geese, Swans, and Flamingos; and characterised by the form of the beak (figs. 167, 173), which is flattened in form and covered with a soft skin. The edges of the bill are further furnished with a series of transverse plates or lamellæ, which form a kind of fringe or "strainer," by means of which these birds sift the mud in which they habitually seek their food. The bill is richly supplied with filaments of the fifth nerve, and doubtless serves as an efficient organ of touch. The feet are furnished with four toes, of which three are turned forwards, and are webbed, whilst the fourth is turned backwards, and is free. The trachea in the males is generally enlarged or twisted in its lower part, and co-operates in the production of the peculiar clanging note of most of these birds. The body is heavy, and the wings only moderately developed.

The groups of the Ducks (*Anatidæ*), Geese (*Anserinæ*), and Swans (*Cygnidæ*), are too familiar to require any special notice.

The Flamingos, however, forming the group of the *Phœnicopteridæ*, require some notice; if only for the fact that the legs are so long and slender that they have often been placed in the order *Grallatores* on this account. The three anterior toes, however, are webbed or completely united by membrane, and the bill is lamellate, so that there can be little hesitation in leaving the Flamingo in its present position amongst the *Natatores*. The common Flamingo (*Phœnicopterus ruber*) occurs abundantly in various parts of southern Europe. It stands between three and four feet in height, the general plumage being rose-coloured, the wing-coverts red, and the quill-feathers of the wings black. The tongue is fleshy, and one of the extravagances of the Romans during the later period of the Empire was to have dishes composed solely of Flamingos' tongues. Other species occur in South America and Africa.

ORDER II. GRALLATORES.—The birds comprising the order of the *Grallatores*, or Waders, for the most part frequent the banks of rivers and lakes, the shores of estuaries, marshes, lagoons, and shallow pools, though some of them keep almost exclusively to dry land, preferring, however, moist and damp situations. In accordance with their semi-aquatic amphibious habits, the Waders are distinguished by the great length of their legs; the increase in length being mainly due to the great elongation of the tarso-metatarsus. The legs are also unfeathered from the lower end of the tibia downwards. The toes are elongated and straight (fig. 174, A), and are never completely palmate, though sometimes semi-palmate. There are three anterior toes, and usually a short hallux, but the latter may be wanting. The wings are long, and the power of flight usually considerable; but the tail is short, and the long legs are stretched out behind in flight to compensate for the brevity of the tail. The body is generally slender, and the neck and beak usually of considerable length (fig. 174, B). They are sometimes polygamous, sometimes monogamous, and the young of the former are able to run about as soon as they are hatched.

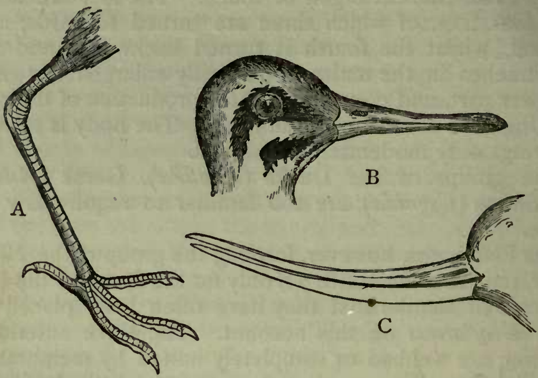


Fig. 174.—Grallatores. A, Leg and foot of the Curlew; B, Head of Snipe; C, Beak of the Avocet.

The most typical Waders—those, namely, which are semi-aquatic in their habits—spend most of their time wading about in shallow waters or marshes, feeding upon small fishes, worms, shell-fish, or insects. Others, such as the Storks, live mostly upon the land, and are more or less exclusively vegetable-feeders.

The *Grallatores* are divided by Owen into the four families of the *Macrodactyli*, the *Cultirostres*, the *Longirostres*, and the *Pressirostres*.

Fam. 1. *Macrodactyli.*—In this family the feet are furnished with four elongated, sometimes lobate, toes, and the wings are of moderate or less than average size. In many of their characters a considerable number of the birds of this family approach the Rasorial birds, and differ from the true Waders. The beak is mostly short, rarely longer than the head, and is compressed from side to side, or wedge-shaped. The legs are strong and not particularly lengthy; but the toes are often of great length, and are furnished with long claws. The neck is not very long, and the tail is very short. Some of them are strictly aquatic in their habits, and, like the Coots, approach in many respects to the *Natatores;* others, again, are exclusively terrestrial. The most familiar members of this family are the Rails (*Rallidæ*), Water-hens (*Gallinulæ*), the Coots (*Fulica*), and the Jacana (*Parra jacana*). The Water-hens and Coots are aquatic or semi-aquatic, swimming and diving with great ease. In the Coots the toes are semi-palmate, being bordered by membranous lobes, like the toes of the Grebes. Amongst the Coots should probably be placed the *Notornis* (Owen), long supposed to be extinct, but recently proved to be still living in the Middle Island of New Zealand. The *Notornis* is much larger than the ordinary Coots, and is remarkable in the fact that, like many extinct and some living New Zealand birds, the wings are so rudimentary as to be useless for flight. The true Rails, comprising the common Land-rail (*Rallus aquaticus*), and the Corn-crake (*Crex pratensis*) of our own country, live almost exclusively on land, though the former usually frequents damp or marshy places. In the Jacanas, lastly, the feet are furnished with excessively long and slender toes, which enable the bird to run about upon the leaves of aquatic plants.

Fam. 2. *Cultirostres.*—In this family of the *Grallatores* are some of the most typical and familiar forms contained in the entire order. The bill in this family is long—usually longer than the head—and is compressed from side to side; the legs are long and slender, having a considerable portion of the tibiæ unfeathered; and the feet have four toes, which are usually connected to a greater or less extent at their bases by membrane. In this family are the Cranes, Herons, Stork, Ibis, Spoonbill, and others of less importance.

The Cranes (*Gruidæ*) are large and elegant birds, and are chiefly remarkable for their long migrations, which were noticed by many classical authors. In these journeys the Cranes usually fly in large flocks, led by a single leader, so that the whole assemblage assumes a wedge-like form; or they fly in long lines. The common Crane (*Grus cinerea*) breeds in the north of Europe and Siberia, and migrates southwards at the approach of winter. The Herons (*Ardeidæ*) are familiarly known to every one in the person of the common Gray or Crested Heron (*Ardea cinerea*). It was one of the birds most generally pursued in the now almost extinct sport of falconry. Various species of Heron are found over the whole world, both in temperate and hot climates.

The Ibises (*Tantalinæ*) form a group of beautiful birds, species of which occur in all the warm countries of the world. One, the *Ibis religiosa*, was regarded by the ancient Egyptians as a deity, and was treated with divine honours, being often embalmed along with their mummies, or figured on their monuments.

The Storks (*Ciconinæ*) are large birds, of which one, the common Stork (*Ciconia alba*), is rarely found in Britain, but occurs commonly on the Continent, where it is often semi-domesticated.

The Spoonbills (*Plataleadæ*) are also large birds, very like the Storks, but the bill is flattened out so as to form a broad spoon-like plate. The common White Spoonbill (*Platalea leucorodia*) is found commonly on the Continent, but is of very rare occurrence in Britain.

Fam. 3. *Longirostres.*—The third family of Waders is that of the *Longirostres*, characterised by the possession of long, slender, soft bills, grooved for the perforations of the nostrils (fig. 174, B). The legs are sometimes rather short, sometimes of great length; the toes are of moderate length, and the hallux is usually short, and is sometimes absent. The bill in these birds serves as an organ of touch, being used as a kind of probe to feel for food in mud or marshy soil. To fulfil this purpose, the tip of the bill is furnished with numerous filaments of the fifth nerve. They feed mostly upon insects and worms, and are not strictly aquatic in their habits, mostly frequenting marshy districts, moors, fens, the banks of rivers or lakes, or the shores of the sea.

In this family of the Long-billed Waders are the Snipes (*Scolopacidæ*), the Sandpipers (*Tringidæ*), the Curlews (*Numenius*), the Ruffs, Godwits, Turnstones, Avocet, and many others which need no particular notice.

Fam. 4. *Pressirostres.*—The members of this family are characterised by the moderate length of the bill, which is seldom longer than the head, and has a compressed tip. The legs are long, but the toes are short, and are almost always partially connected together at their bases by membrane. The hallux is short, and is often wanting. In this section are two very distinct sub-families, the *Charadriidæ* or Plovers and the *Otidæ* or Bustards. In the former of these the legs are long and slender, the toes are united at their bases by a small membrane, and the hind-toe is very small and raised above the ground, or is entirely wanting. In this group are the true Plovers and Lapwings, the Oyster-catcher (*Hæmatopus*), and the Thick-knee (*Œdicnemus*). In the *Otidæ*, or Bustards, the legs are long and the toes are short and furnished with stout claws. The hinder toe or hallux is entirely wanting; and these birds are chiefly interesting from the affinities which they exhibit to the *Rasores* on the one hand, and to the *Cursores* (Ostrich, &c.) on the other. The wings, however, are of ample size, and the tail is long, the reverse being the case in the *Cursores*. The Bustards are entirely confined to the Old World, and two species were formerly not uncommon in Britain.

CHAPTER LXVIII.

CURSORES AND RASORES.

Order III. Cursores.—The third order of Birds is that ot the *Cursores*, or Runners, comprising the Ostriches, Rheas, Cassowaries, Emeus, and the singular *Apteryx* of New Zealand. In many respects the *Cursores* are to be looked upon as an artificial assemblage; but in the meanwhile it will be most convenient to consider them as forming a distinct division. The *Cursores* are characterised by the rudimentary condition of the wings, which are so short as to be useless for flight, and by the compensating length and strength of the legs. In accordance with this condition of the limbs, many of the bones retain their marrow, and the sternum (fig. 175, B) is destitute of the prominent ridge or keel, to which the great pectoral muscles are attached (hence the name of *Ratitæ*, applied by Huxley to the order). In the Ostrich the pubic bones of the pelvis unite to form a symphysis pubis, as they do in no other bird, and in all the pelvic arch possesses unusual strength and stability. The legs are extremely robust and powerful, and the hind-toe is entirely wanting, except in the *Apteryx*, in which it is rudimentary. The anterior toes are two or three in number, and are provided with strong blunt claws or nails. The plumage presents the remarkable peculiarity that the barbs of the feathers, instead of being connected to one another by hooked barbules, as is usually the case, are remote and disconnected from one another, presenting some resemblance to hairs.

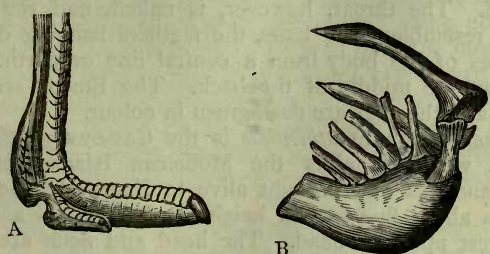


Fig. 175.—Cursores. A, Foot of the Ostrich (*Struthio camelus*); B, Sternum of the Emeu (*Dromaius Novæ-Hollandiæ*).

The order *Cursores* may be divided into the two families of the *Struthionidæ* and the *Apterygidæ*—the former characterised by the absence of the hallux, and comprising the Ostrich, Rhea, Emeu, and Cassowary, with several extinct forms; the latter comprising only the *Apteryx* of New Zealand, and characterised by the possession of a rudimentary hallux.

The African Ostrich (*Struthio camelus*) occurs in the desert plains of Africa and Arabia, and is the largest of all living birds, attaining a height of from six to eight feet. The head and neck are nearly naked, and the quill-feathers of the wings and tail have their barbs wholly disconnected, constituting the ostrich-plumes of commerce. The legs are extremely strong, and are terminated by two toes only (fig. 175, A), these consisting respectively of four and five phalanges, showing that it is the hallux and the innermost toe which are wanting. The Ostriches run with extraordinary speed, and can outstrip the fastest horse. They are polygamous, each male consorting with several females, and they generally keep together in larger or smaller flocks. The eggs are of great size, averaging three pounds each in weight, and the hens lay their eggs in the same nest, this being nothing more than a hole scratched in the sand. The eggs appear to be hatched mainly by the exertions of both parents, relieving each other in the task of incubation, but also partly by the heat of the sun.

The American Ostriches or *Rheas* are much smaller than the African Ostrich, and have the head feathered, whilst the feet are furnished with three toes each. They inhabit the great plains of South America, and are polygamous.

The Emeu (*Dromaius Novæ-Hollandiæ*) is exclusively found in the Australian continent, and nearly equals the African Ostrich in size, attaining a height of from five to seven feet. The feet are furnished with three toes each, and the head is feathered. The throat, however, is naked, and the general plumage resembles long hairs, the feathers hanging down on both sides of the body from a central line or parting which runs down the middle of the back. The Emeus are monogamous, and the eggs are dark green in colour.

The last of the *Struthionidæ* is the Cassowary (*Casuarius galeatus*), which inhabits the Moluccan Islands and New Guinea, and was first brought alive to Europe by the Dutch. It stands about five feet in height, and possesses a singular horny crest upon its head. The head and neck are naked, and the feet have three toes each. The general plumage is black, and the feathers more or less closely resemble hairs.

The second family of the Cursorial birds is that of the *Apterygidæ*, comprising only the singular *Apteryx* of New Zealand. The beak in the *Apteryx* is long, slender, and slightly curved, the tip being obtuse, and the nostrils placed at the extremity of the upper mandible. The legs are comparatively short, and there is a rudimentary hind-toe or hallux, forming a kind of spur, furnished with a claw. The wings are entirely rudimentary, and are quite concealed by the feathers, each terminating in a sharp claw. The feathers are long and narrow, and the tail is short and inconspicuous. The *Apteryx* is wholly confined to New Zealand, and is nocturnal in its habits, living upon insects and worms.

Besides the above-mentioned living forms, the order *Cursores* comprises several gigantic extinct forms, which will be treated of when describing the geological distribution of Birds as a class.

ORDER IV. RASORES.—The fourth order of Birds is that of the *Rasores*, or Scratchers, often spoken of collectively as the "Gallinaceous" birds, from the old name of "Gallinæ," given to the order by Linnæus. The *Rasores* are characterised by the convex, vaulted upper mandible, having the nostrils pierced in a membranous space at its base. The nostrils are covered by a cartilaginous scale. The legs are strong and robust, mostly covered with feathers as far as the joint between the tibia and tarso-metatarsus. There are four toes, three in front and one behind, the latter being short, and placed at a higher level than the other toes. All the toes terminate in strong blunt claws suitable for scratching (fig. 176, A). The food of the Scratchers or Gallinaceous birds consists chiefly of hard grains and seeds, and in accordance with this they have a capacious crop and an extremely strong and muscular gizzard. They mostly nidificate, or build their nests, upon the ground, and the more typical members of the order are polygamous. The males take no part in either nidification or incubation, and the young are generally "precocious," being able to run about and provide themselves with food from the moment they quit the egg. The young of the Pigeons and Doves, however, are brought forth in a comparatively helpless condition. The wings in the majority of the *Rasores* are more or less weak, and the flight is feeble and accompanied with a whirring sound. Many of the Pigeons, however, are capable of very powerful and sustained flight.

The order *Rasores* is divided into two sub-orders, called respectively the *Gallinacei* and the *Columbacei*, or sometimes, from the characters of the sounds which they utter, the *Clamatores* and the *Gemitores*.

Sub-order 1. *Gallinacei* or *Clamatores*. — This sub-order comprises the typical members of the order *Rasores*, such as the common Fowls, Turkeys, Partridge, Grouse, Pea-fowl, and a number of allied forms. Its characters are therefore those of the order itself, but it is especially distinguished from the *Columbacei* by being less fully adapted for flight. The body is

Fig. 176.—Rasores. A, Foot of Fowl (*Gallus Bankiva*); B, Head of Guinea-fowl.

much heavier comparatively speaking, the legs and feet are stronger, and the wings shorter and less powerful. On the whole, therefore, these birds are worse fliers than the *Columbacei*, and are better adapted for living upon the ground. The back of the tarsus, too, is usually furnished in the males with a spur (*calcar*), which is used as an offensive weapon, and has sometimes been looked upon as a rudimentary toe. Lastly, the *Gallinacei* are all polygamous, and the males are usually much more brilliantly coloured than the females, this being an adaptive modification of the plumage to meet this peculiarity in their mode of life.

The two most important families of the *Gallinacei* are the *Tetraonidæ* and the *Phasianidæ*.

The *Tetraonidæ*, or Grouse family, comprises the Capercailzie (*Tetrao urogallus*), the Blackcock (*Tetrao tetrix*), the common or Red Grouse (*Lagopus Scoticus*), the Ptarmigan (*Lagopus vulgaris*), the Partridges (*Perdix*), the Quails (*Coturnix*), and many other allied forms.

The *Phasianidæ* or Pheasant family, comprises the Turkeys and Guinea-fowl (*Meleagrinæ*), the common Pheasant (*Phasianus Colchicus*), the Golden and Silver Pheasants, the common Fowl (*Gallus domesticus*), and the Pea-fowl (*Pavoninæ*). None of these birds—all of which can be domesticated, and most of which are of great value to man—are natives of this country, though they will all breed readily, and thrive even in confinement. The domestic Turkey (*Meleagris gallopavo*) is originally a native of North America, where it still occurs in a wild condition, having been brought to Europe about the beginning of the sixteenth century. The Guinea-fowl (*Numida Meleagris*) is originally an African bird. The common Pheasant (*Phasianus Colchicus*), though now regarded as an indigenous bird, truly belongs to Asia, and it is asserted that it was really brought to Europe from Colchis by the Greeks; hence its specific name. The common Fowl is certainly not a native of Europe, and it is almost as certainly a native of Asia or of some of the Asiatic islands; but its exact original habitat is uncertain, as is the species from which the domestic breeds are descended (commonly said to be the *Gallus Bankiva* of Java). The introduction of the Fowl into Europe is lost in the mists of antiquity, and it is wholly unknown whence the original stock may have been brought. The Pea-fowl (*Pavo*) are really natives of Thibet and Hindostan, and were originally brought to Greece by Alexander the Great. They were formerly much esteemed as food, but are now regarded merely from an ornamental point of view. There are many other forms belonging to the Gallinaceous section of the *Rasores*, but these are in every way the most important.

The second sub-order of the *Rasores* is that of the *Columbacei* or *Gemitores*, comprising the Doves and Pigeons, and often raised to the rank of a distinct order under the name of *Columbæ.* The *Columbacei* are separated from the more typical members of the *Rasores* by being furnished with strong wings, so as to endow them with considerable powers of flight. In place, therefore, of being chiefly ground-birds, they are to a great extent arboreal in their habits, and in accordance with this the feet are slender, and are well adapted for perching. There are four toes, three in front and one behind, and the former are never united towards their bases by a membrane, though the base of the outer toe is sometimes united to that of the middle toe. Lastly, they are all monogamous, and pair for life, in consequence of which fact, and of their being readily susceptible of domestication, they present an enormous number of varieties, often so different from one another that they would certainly be described as distinct species if found in a wild state. It seems certain, however, that all the common domestic breeds of Pigeons, however unlike one another, are really descended from the Rock-pigeon (*Columba livia*), which occurs wild in many parts of Europe, and has retained its distinguishing peculiarities unaltered for many centuries up to the present day. Finally, the young of the *Columbacei* are born in a naked and helpless state, whilst those of the *Gallinacei* are "precocious," and can take care of themselves from the moment of their liberation from the egg.

Of the various living birds included in this section, the true Pigeons (*Columbidæ*) are too well known to require any description; but the Ground-pigeons (*Gouridæ*) depart to some extent from this type, being ground-loving birds, more closely allied to the ordinary *Gallinacei.* The only other member of the sub-order which requires special notice, is the remarkable extinct bird, the Dodo (*Didus ineptus*), which seems certainly to belong here, though its size was gigantic, and some of its characters very anomalous. The Dodo may, properly speaking, be said to be extinct, since it no longer occurs in a living state, but it is not extinct in the sense that geologists speak of "fossils" as extinct; since it has been extirpated by man himself within quite a recent period—in fact not more than three centuries ago. The Dodo was an inhabitant of the Island ot the Mauritius up to the commencement of the seventeenth century, and was a large bird, considerably over the size of a swan. All that remains nowadays to prove the existence of the Dodo are two or three old, but apparently faithful, oil-paintings, two heads, a foot, and some feathers, to which a few bones have recently been added. The Dodo owed its extermination to the fact that it was unable to fly. The body must have been extremely weighty, and the wings were rudimentary and completely useless as organs of flight. The legs were short and stout, the feet had four toes each, and the tail was extremely short, carrying, as well as the wings, a tuft of soft plumes. The beak (unlike that of any of the *Columbacei* except the little *Didunculus strigirostris*) was strongly arched towards the end, and the upper mandible had a strongly hooked apex, not at all unlike that of a bird of prey. The nearest living ally of the Dodo appears to be the little *Didunculus* just alluded to, which inhabits the Navigator Islands, and is little bigger than a partridge.

It is worthy of notice that in the little island of Rodriguez, lying to the east of Mauritius, there existed one large wingless bird, the Solitaire or *Pezophaps*, which has likewise become extinct during the human period. Other cases in which wingless birds have been, or are being, exterminated by man, lead us to the belief that the absence of wings is not compatible with the coexistence of birds and human beings. In other words, the sole protection possessed by birds against the destructive propensities of man is to be found in their power of flight.

CHAPTER LXIX.

SCANSORES AND INSESSORES.

ORDER V. SCANSORES.—The order of the Scansorial or Climbing birds is easily and very shortly defined, having no other distinctive and exclusive peculiarity except the fact that the feet are provided with four toes, of which two are turned backwards and two forwards. Of the two toes which are directed backwards, one, of course, is the hallux or proper hind-toe, and the other is the outermost of the normal three anterior toes. This arrangement of the toes (fig. 177, A) enables the *Scansores* to climb with unusual facility. Their powers of flight, on the other hand, are generally only moderate and below the average. Their food consists of insects or fruit. Their nests are usually made in the hollows of old trees, but some of them have the remarkable peculiarity that they build no nests of their own, but deposit their eggs in the nests of other birds. They are all monogamous.

The most important families of the *Scansores* are the Cuckoos (*Cuculidæ*), the Woodpeckers and Wry-necks (*Picidæ*), the Parrots (*Psittacidæ*), and the Toucans (*Rhamphastidæ*).

The *Cuculidæ*, or Cuckoos, are chiefly remarkable for the extraordinary fact that many of them, instead of nidificating and incubating for themselves, lay their eggs in the nests of other birds. As a rule, only one egg is deposited in each nest, and the young Cuckoo which is hatched from it, is brought up by the foster-parent, generally at the expense of the legitimate offspring. The large Channel-bill (*Scythrops Novæ-Hollandiæ*) is said to possess the same curious habit, but many species of this group build nests for themselves in the ordinary manner.

The second family of the *Scansores* is that of the *Picidæ*, and comprises the Woodpeckers and Wry-necks. These birds feed chiefly upon insects, and the tongue is extensible and covered with a viscid secretion, so as to enable them to catch their prey by suddenly darting it out.

The next family is that of the Parrots (*Psittacidæ*), the largest group of the *Scansores*, comprising over three hundred species. The bill in the Parrots is large and strong, and the upper mandible is considerably longer than the lower and is hooked at its extremity (fig. 177, B). The bill is used as a kind of third foot in climbing. At the base of the upper mandible is a "cere," in which the nostrils are pierced. The tongue is soft and fleshy. The feet are especially adapted for climbing, some, however, of the Parrots moving about actively on the ground. The colours of the plumage are generally extremely bright and gaudy; and they live for the most part upon

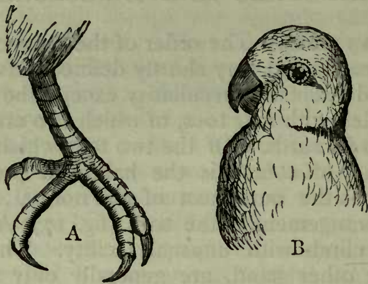


Fig. 177.—A, Foot of Woodpecker (*Picus*); B, Head of Love-bird (*Agapornis*).

fruits. The Parrots are divided into numerous sub-families, such as the Cockatoos, the true Parrots and the Parrakeets. They are all natives of hot climates, abounding especially in tropical America and in the forests of Australia. The true Macaws (*Arainæ*) are exclusively American; and the true Parrakeets, *Pezoporinæ*, are exclusively confined to the eastern hemisphere, being especially characteristic of Australia.

In the last family of the *Scansores* are the Toucans (*Rhamphastidæ*), characterised by having a bill which is always very large, longer than the head, and sometimes of comparatively gigantic size. The mandibles are, however, to a very great extent hollowed out into air-cells, so that the weight of the bill is much less than would be anticipated from its size. The Toucans live chiefly upon fruits, and are all confined to the hotter regions of South America, frequenting the forests in considerable flocks.

ORDER VI. INSESSORES.—The sixth order of Birds is that of the *Insessores*, or Perchers—often spoken of as the *Passeres*, or "Passerine" Birds. They are defined by Owen as follows:—

"Legs slender, short, with three toes before and one behind, the two external toes united by a very short membrane" (fig. 178, A, B).

"The *Perchers* form the largest and by far the most numerous order of birds, but are the least easily recognisable by distinctive characters common to the whole group. Their feet, being more especially adapted to the delicate labours of nidification, have neither the webbed structure of those of the *Swimmers*, nor the robust strength and destructive talons which characterise the feet of the *Birds of Rapine*, nor yet the extended toes which enable the *Wader* to walk safely over marshy soils and tread lightly on the floating leaves of aquatic plants; but the toes are slender, flexible, and moderately elongated, with long, pointed and slightly-curved claws.

"The Perchers in general have the females smaller and less brilliantly coloured than the males; they always live in pairs, build in trees, and display the greatest art in the construction of their nests. The young are excluded in a blind and naked state, and wholly dependent for subsistence during a certain period on parental care. The brain arrives in this order at its greatest proportionate size; the organ of voice here attains its greatest complexity, and all the characteristics of the bird, as power of flight, melody of voice, and beauty of plumage, are enjoyed in the highest perfection by one or other of the groups of this extensive and varied order."

The structure of the feet, then, gives the definition of the order, but the minor subdivisions are founded on the nature

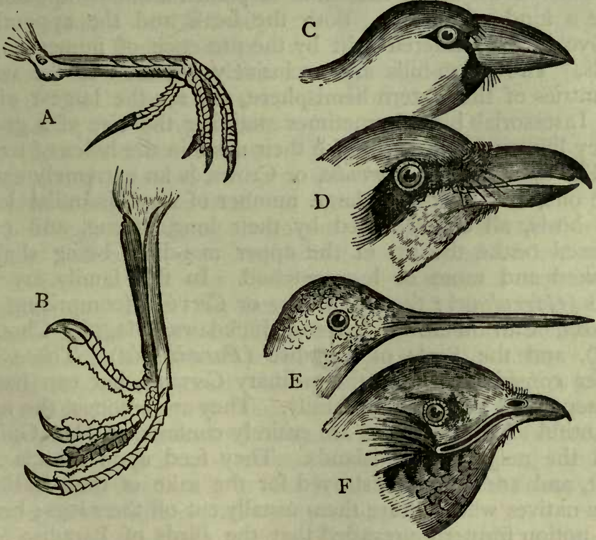


Fig. 178.—Insessores. A, Foot of Yellow Wagtail; B, Foot of Water-ousel; C, Conirostral beak (Hawfinch); D, Dentirostral beak (Shrike); E, Tenuirostral beak (Humming-bird); F, Fissirostral beak (Swift).

of the beak; this organ varying in form according to the nature of the food, "which may be small or young birds, carrion, insects, fruit, seeds, vegetable juices, or of a mixed kind" (Owen).

In accordance with the form of the beak, the *Insessores* have been divided into four great sections or sub-orders, known as the *Conirostres*, *Dentirostres*, *Tenuirostres*, and *Fissirostres*.

Sub-order 1. *Conirostres.*—In this section of the *Insessores* the beak is strong and on the whole conical, broad at the base and tapering with considerable rapidity to the apex (fig. 178, C). The upper mandible is not markedly toothed at its lower margin. Good examples of the Conirostral type of beak are to be found in the common Sparrow, Hawfinch, or Bullfinch. The greater number of the *Conirostres* are omnivorous; the remainder are granivorous, or feed on seeds and grains. The sub-order includes the families of the Horn-bills (*Buceridæ*), the Starlings (*Sturnidæ*), the Crows (*Corvidæ*), the Cross-bills (*Loxiadæ*), and the Finches and Larks (*Fringillidæ*).

In the Horn-bills the conirostral shape of the beak is masked, partly by its being of very great size, and partly by the fact that above the upper mandible is placed a hollow appendage like a kind of helmet. Both the beak and the appendage above it are rendered light by the presence of numerous air-cells. The Horn-bills are exclusively confined to the warm countries of the eastern hemisphere, and are the largest of all the Insessorial birds, sometimes attaining the size of a goose. They live on fruits, and make their nests in the holes of trees.

The family of the *Corvidæ*, or Crows, is an extremely extensive one, and includes a large number of very dissimilar looking birds, all characterised by their long, strong, and compressed beaks, the tip of the upper mandible being slightly hooked and more or less notched. In this family are the Jays (*Garrulinæ*); the true Crows or *Corvinæ* (comprising the Rooks, Carrion-crows, Ravens, Jackdaws, Magpie, Chough, &c.), and the Birds of Paradise (*Paradiseidæ*). These last differ considerably from the ordinary *Corvidæ*, but can hardly be separated as a distinct family. They are amongst the most beautiful of all birds, and are entirely confined to New Guinea and the neighbouring islands. They feed upon insects and fruit, and are largely destroyed for the sake of their feathers. The natives who capture them usually cut off their legs; hence the notion formerly prevailed that the Birds of Paradise were destitute of these limbs. It is only the males which possess the brilliant plumage, the females being soberly dressed; and in accordance with this fact, it is stated that the Birds of Paradise are polygamous, being in this respect an exception to the entire order of the *Insessores*.

The family of the Starlings (*Sturnidæ*) is not separated from that of the Crows by any important characters. Besides our common Starlings, it includes a number of other more or less singular birds, of which the Bower-birds of Australia are perhaps the most peculiar. These curious birds have the habit of building very elaborate bowers, often very beautifully constructed and of considerable size, in which they amuse themselves and apparently make love to one another. These bowers are wholly independent of their nests, which they construct elsewhere.

The last family of the *Conirostres* is that of the *Fringillidæ*, comprising the Finches, Linnets, and Larks. In these birds the bill is stout and conical, with a sharp apex, but not having the upper mandible toothed. The toes are adapted for perching, and are provided with long and curved claws, that of the hinder toe being usually longer than the rest. They are all monogamous, and they build more or less elaborate nests. In this family are the true Finches (*Fringillina*), the Buntings, the Larks, the Tanagers, the Grosbeaks, and many others, but their numbers are so great that any further notice of them is impossible here.

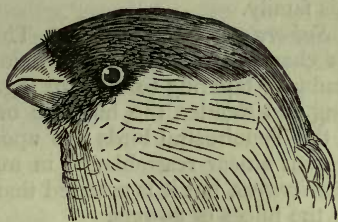


Fig. 179.—Head of the common Bullfinch (*Pyrrhula vulgaris*), showing the Conirostral beak.

The only remaining members of the *Conirostres* which require notice are the Cross-bills (*Loxiadæ*), which are sometimes placed with the Finches, and sometimes considered as a separate order. In these birds the structure of the beak is so peculiar that its Conirostral character is completely masked, and it has been looked upon as a deformity. Both mandibles, namely, cross one another towards the tip, giving the entire bill a most remarkable appearance. In point of fact, however, instead of being a deformity, the bill of the Cross-bills is a beautiful natural adaptation, enabling the bird with the greatest facility to tear in pieces the hard fir-cones, on the seeds of which it feeds.

Sub-order 2. *Dentirostres.*—The birds in this section are characterised by the fact that the upper mandible is provided with a distinct notch in its lower margin near the tip (fig. 178, D). They all feed upon insects. This sub-order includes the Shrikes (*Laniidæ*), the Fly-catchers (*Muscicapidæ*), the Thrushes (*Merulidæ*), the Tits (*Parinæ*), and the Warblers (*Sylviadæ*).

The Shrikes are highly predacious birds, which in many respects make a close approach to the true Birds of Prey. They feed, however, mostly upon worms and insects, and only occasionally destroy small birds or mice.

The great family of the Thrushes (*Merulidæ*) comprises not only the true Thrushes, Field-fares, and Blackbirds, but a number of exotic forms, of which the most familiar are the Orioles, so well known for their brilliant plumage and their beautifully-constructed nests.

In the *Sylviadæ*, amongst other forms, are the Wag-tails (*Motacillinæ*) and the Pipits (*Anthus*), the Titmice, Robins, Hedge-sparrow, Stone-chat, Redstarts, and other well-known British birds. The Titmice (*Parinæ*) are often placed in the sub-order of the *Conirostres*. The Nightingale also belongs to this family.

Sub-order 3. *Tenuirostres.*—The members of this sub-order are characterised by the possession of a long and slender beak, gradually tapering to a point (fig. 178, E). The toes are very long and slender, the hind-toe or hallux especially so. Most of the Tenuirostral birds live upon insects, and some of these present a near resemblance in many of their characters to the *Dentirostres*, but it is asserted that some live partially or wholly on the juices of flowers.

The chief families of the *Tenuirostres* are the Creepers (*Certhidæ*), the Honey-eaters (*Meliphagidæ*), the Humming-birds (*Trochilidæ*), the Sun-birds (*Promeropidæ*), and the Hoopoes (*Upupidæ*), of which only the Creepers and Humming-birds need any further notice.

The family *Certhidæ* includes several familiar British birds, such as the little brown Creeper (*Certhia familiaris*), the Nuthatch (*Sitta Europæa*), and the Wrens (*Troglodytes*). With these are a number of exotic forms, of which the singular Lyre-birds of Australia are the most remarkable.

The family of the *Trochilidæ*, or Humming-birds, includes the most fragile and brightly coloured of all the birds, some not weighing more than twenty grains when alive, and many exhibiting the most brilliant play of metallic colours. The Humming-birds are pre-eminently South American, but extend northwards as far even as the southern portions of Canada. The bill (fig. 178, E) is always very long and slender, as are the toes also. The tongue is bifid, and appears to be used either to catch insects within the corollas of flowers, or to suck up the juices of the flowers themselves.

Sub-order 4. *Fissirostres.*—In this sub-order of the *Insessores* the beak is short but remarkably wide in its gape (fig. 178, F), and the opening of the bill is fenced in by a number of bristles (*vibrissæ*). This arrangement is in accordance with the habits of the *Fissirostres*, the typical members of which live upon insects and take their prey upon the wing. The most typical Fissirostral birds, in fact, such as the Swallows and Goat-suckers, fly about with their mouths widely opened; and the insects which they catch in this way are prevented from escaping partly by the bristles which border the gape, and partly by a viscid saliva which covers the tongue and inside of the mouth.

The typical *Fissirostres*, characterised by this structure of the beak, comprise three families—the Swallows and Martens (*Hirundinidæ*), the Swifts (*Cypselidæ*), and the Goat-suckers (*Caprimulgidæ*). These three families differ in many important respects from one another, but it would be inconvenient to separate them here. The Swifts, especially, are remarkable for the peculiarity that whilst the hallux is present, it is turned forwards along with the three anterior toes. The Goat-suckers, again, hunt their prey by night, and they are provided with the large eyes and thick soft plumage of all nocturnal birds. Besides the above, there remain the two families of the King-fishers and Bee-eaters, which are generally placed amongst the *Fissirostres*, though in very many respects the arrangement appears to be an unnatural one. These families are characterised by their stronger and longer bills, and by having the external toe nearly as long as the middle one, to which it is united nearly as far as the penultimate joint. In consequence of this peculiar conformation of the toes, these families were united by Cuvier into a single group under the name of *Syndactyli*.

The Bee-eaters (*Meropidæ*) live upon insects, chiefly upon various species of bees and wasps; but the King-fishers live upon small fish, which they capture by dashing into the water. The common King-fisher (*Alcedo ispida*) is a somewhat rare native of Britain, and is perhaps the most beautiful of all our truly indigenous species. Some exotic King-fishers are of large size, and one of the most remarkable of them is the Laughing Jackass (*Dacelo gigas*) of Australia, so called from its extraordinary song, resembling a prolonged hysterical laugh.

CHAPTER LXX.

RAPTORES AND SAURURÆ.

ORDER VII. RAPTORES.—All the members of this order are characterised by the shape of the bill, which is "strong, curved, sharp-edged, and sharp-pointed, often armed with a lateral tooth" (Owen.) The upper mandible is the longest (fig. 180, B), and is strongly hooked at the tip. The body is very muscular; the legs are robust, short, with three toes in front and one behind, all armed with long, curved, crooked claws or talons (fig. 180, A); the wings are commonly pointed, and of considerable size, and the flight is usually rapid and powerful. The Birds of Rapine are monogamous, and the female is larger than the male. They build their nests generally in lofty and inaccessible situations, and rarely lay more than four eggs, from which the young are liberated in a naked and helpless condition.

The order *Raptores* is divided into two great sections—the *Nocturnal* Birds of Prey, which hunt by night, and have the eyes directed forwards; and the *Diurnal* Raptores, which catch their prey by day, and have the eyes directed laterally.

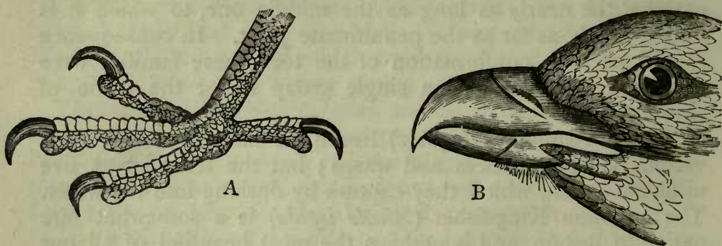
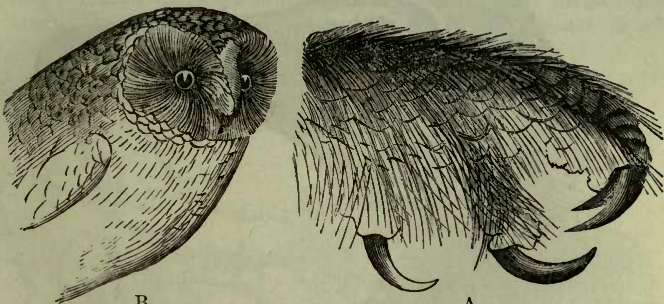


Fig. 180.—A, Foot of the Peregrine Falcon; B, Head of Buzzard.

The section of the *Nocturnal Raptores* includes the single family of the *Strigidæ*, or Owls. In these birds the eyes are large, and are directed forwards. The plumage is exceedingly loose and soft, so that their flight (even when they are of large size) is almost noiseless. The beak is short, strongly hooked, furnished with bristles at its base, and having the nostrils pierced in a membranous "cere" at the base of the upper mandible. The cranial bones are highly pneumatic, and the head is therefore of large size. The feathers of the face usually form an incomplete or complete "disc" or circle round each eye (fig. 181, B), and a circle of plumes is likewise placed round each external meatus auditorius. The legs are short and strong, and are furnished with four toes, all armed with strong crooked talons. The outer toe can be turned backwards, so that the foot has some resemblance to that of the *Scansores*. The tarso-metatarsus is densely feathered (fig. 181, A), and the plumes sometimes extend to the extremities of the toes. The œsophagus is not dilated into a crop; and the indigestible portions of the food are rejected by regurgitation from the stomach in the form of small pellets. The Owls hunt their prey in the twilight or on moonlight nights, and they live mostly upon field-mice and small birds, though they will also eat insects or frogs.



B A

Fig. 181.—A, Foot of tawny Owl (*Ulula stridula*); B, Head of white Owl (*Strix flammea*).

The section of the *Diurnal Raptores* includes the two groups of the *Accipitrinæ* (Falcons, Hawks, and Eagles), and the *Vulturidæ*, or Vultures. The eyes in this section are much smaller than in the preceding, and are placed laterally; and the plumage is not soft. As regards their power of flight, they show a decided advance upon the Nocturnal Birds of Prey. The wings are long and pointed; the sternal keel and pectoral muscles are greatly developed; and many of the members of this section exhibit a more rapid power of locomotion than is seen in any other division of the animal kingdom. The bill is long and strong, with a large "cere" at the base of the upper mandible, in which the nostrils are pierced. The tarso-metatarsus and toes are usually covered by scales, and are rarely feathered. Lastly, the œsophagus is dilated into a capacious crop.

In the *Accipitrinæ* or *Falconidæ* (fig. 180, B) the head and neck are always clothed with feathers, and the eyes are more or less sunk in the head, and provided with a superciliary ridge or eyebrow. It is to a great extent to the presence of this ridge that many of these birds owe their fearless and bold expression. In this family are the Falcons, Hawks, Buzzards, Kites, Harriers, and Eagles, most of which are so well known that any description is unnecessary.

In the *Vulturidæ* (fig. 182) the eyes are destitute of an eyebrow, and the head and neck are frequently naked, or covered only by a short down. In this family are the Bearded Vultures, the true Vultures, and the Condor.

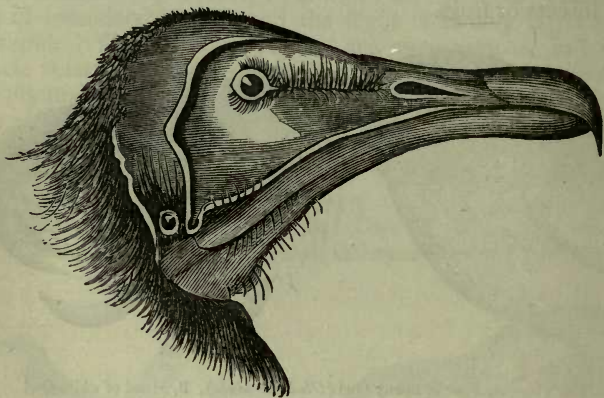


Fig. 182.—Head of Vulture (*Neophron percnopterus*).

The Bearded Vulture, or Lammergeyer (*Gypsaetus barbatus*), is the largest of European birds, measuring from nine to ten feet from the tip of one wing to that of the other. This powerful and rapacious bird inhabits the mountain-ranges of the south of Europe and the west of Asia, and feeds chiefly on goats, lambs, and deer, which it kills by precipitating down steep declivities. It is distinguished from the true Vultures by the fact that the head and neck are feathered.

The true Vultures have the head, and generally the neck also, naked, or covered with down. They are filthy and disgusting birds, which live almost entirely upon carrion, a peculiarity which renders them of great service in hot climates.

The last member of this section is the gigantic Condor (*Sarcorhampus gryphus*). This enormous bird has a stretch of wing of over fourteen feet, and is usually seen soaring at great heights in the air, rising, it is said, to a height of over twenty thousand feet. It inhabits the lofty mountain-ranges of the Andes, and builds its nest at a height of from ten to fifteen thousand feet.

ORDER VIII. SAURURÆ.—This order includes only the extinct bird, the *Archæopteryx macrura*, a single specimen of which—and that but a fragmentary one—has been discovered in the Lithographic Slates of Solenhofen (Upper Oolites). This extraordinary bird appears to have been about as big as a Rook; but it differs from all known birds in having two free claws belonging to the wing, and in having a long lizard-like tail, longer than the body, and composed of separate vertebræ. The tail was destitute of any ploughshare-bone, and each vertebra carried a single pair of quills. The metacarpal bones, also, were not anchylosed together as they are in all other known Birds, living or extinct.

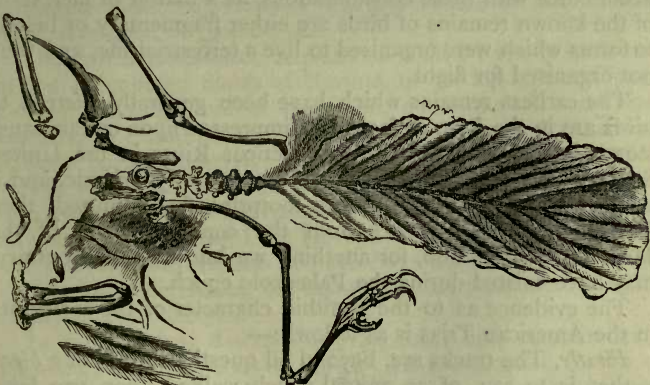


Fig. 183.—*Archæopteryx macrura*, showing tail and tail-feathers, with detached bones.

CHAPTER LXXI.

DISTRIBUTION OF AVES IN TIME.

As regards the geological distribution of Birds, there are many reasons why we should be cautious in reasoning upon merely negative evidence, and more than ordinarily careful not to infer the non-existence of birds during any particular geological epoch, simply because we can find no positive evidence for their presence. As Sir Charles Lyell has well remarked, "the powers of flight possessed by most birds would insure them against perishing by numerous casualties to which quadrupeds are exposed during floods;" and, "if they chance to be drowned, or to die when swimming on water, it will scarcely ever happen that they will be submerged so as to become preserved in sedimentary deposits," since, from the lightness of the bones, the carcase would remain long afloat, and would be liable to be devoured by predacious animals. As, with a few utterly trivial exceptions, all the deposits in which fossils are found have been laid down in water, and more especially as they are for the most part marine, these considerations put forward by Sir Charles Lyell afford obvious ground against the anticipation that the remains of birds should be either of frequent occurrence or of a perfect character in any of the fossiliferous rocks. In accordance with these considerations, as a matter of fact, most of the known remains of birds are either fragmentary or belong to forms which were organised to live a terrestrial life, and were not organised for flight.

The earliest remains which have been generally referred to birds are in the form of footprints impressed upon certain sandstones in the valley of the Connecticut River in the United States. These sandstones are almost certainly Triassic, and if the ornithic character of these footprints be admitted, then Birds date their existence from the commencement of the Mesozoic period, and, for anything we know to the contrary, may have existed during the Palæozoic epoch.

The evidence as to the ornithic character of the footprints in the American Trias is as follows:—

Firstly, The tracks are, beyond all question, those of a *biped* —that is to say, of an animal which walked upon two legs. No living animals walk habitually upon two legs except Man and Birds, and therefore there is a *primâ facie* presumption that the authors of these prints were birds.

Secondly, The impressions are mostly tridactylous—that is to say, formed by an animal with three toes on each foot, as is the case in many Waders and most Cursorial birds.

Thirdly, The impressions of the toes show the same numerical progression in the number of phalanges as exists in living birds—that is to say, the innermost of the anterior toes has three phalanges, the middle one has four, and the outermost toe has five phalanges.

Taking this evidence collectively, it would have seemed, till lately, tolerably certain that these impressions were formed by Birds. We must not, however, lose sight of the possibility that these impressions may have been formed by Reptiles more bird-like in their characters than any of the living forms with which we are acquainted. The recent researches of Huxley, Cope, and others, go to show that the *Dinosaurian* Reptiles possessed the power of walking temporarily or permanently on the hind-legs, and many curious affinities to the true Birds have been pointed out. It is therefore by no means impossible that these footprints of the Connecticut valley are truly Reptilian.

The size and other characters of the above-mentioned im pressions vary much, and they have certainly been produced by several different animals. In the largest hitherto discovered, each footprint is twenty-two inches long, and twelve inches wide, showing that the feet were four times as large as those of the African Ostrich. The animal, therefore, which produced these impressions—whether Avian or Reptilian—must have been of gigantic size.

The first unmistakable remains of a bird have been found in the Solenhofen Slates of Bavaria, of the age of the Upper Oolites. A single unique specimen, consisting of bones and feathers, but unfortunately without the skull, is all that has hitherto been discovered; and it has been named the *Archæopteryx macrura*. The characters of this singular and aberrant bird, which alone constitutes the order *Saururæ*, have been already given, and need not be repeated here.

Other doubtful remains of birds have been alleged to occur in the Mesozoic series, but many of these certainly belong in reality to Pterodactyles.

In the Tertiary Rocks, however, there are, comparatively speaking, many remains of birds. In the Eocene Rocks of France has been found a large bird, as big as an Ostrich, the so-called *Gastornis Parisiensis*; and in England, in the same formation, we have a small Vulture (*Lithornis vulturinus*), and a King-fisher (*Halcyornis toliapicus*). In the Eocene of Glaris in Switzerland occurs, also, the oldest known Insessorial or Passerine bird, the *Protornis Glarisiensis*, which was about as big as a lark.

Numerous remains of birds have likewise been found in the Miocene and Pliocene deposits. With the exception, however, of the Mesozoic *Archæopteryx*, by far the most remarkable remains of birds have been found in the Post-tertiary or Pleistocene deposits. All the remains now alluded to are those of gigantic wingless birds; and it is worthy of notice that they are exclusively found in regions now tenanted by smaller wingless birds, whilst there is reason to believe that some of them have been in existence during the human period. Most of the remains in question have been found in New Zealand, where there have been obtained the bones of several species of large wingless birds, referred by Owen to the genera *Dinornis*, *Palapteryx*, and *Aptornis*. The *Dinornis giganteus* must have been one of the most gigantic of the whole class of birds, the tibia measuring upwards of a yard in length, and the skeleton indicating a bird which stood at least ten feet in height. In another species, the *Dinornis elephantopus*, the "framework of the skeleton is the most massive of any in the whole class of birds," and "the toe-bones almost rival those of the Elephant" (Owen). The feet were furnished with three anterior toes, and are of interest as presenting us with an undoubted bird big enough to produce the largest of the footprints of the Triassic Sandstones of Connecticut. There is reason to believe from the traditions of the Maories that the *Dinornis* was living at no very remote period, and that it has been exterminated by man.

In Madagascar bones have been discovered of a bird as large or larger than the *Dinornis giganteus*, which has been described under the name of the *Æpiornis maximus*. With the bones have been found eggs measuring from thirteen to fourteen inches in diameter, and computed to be as big as three ostrich-eggs, or one hundred and forty-eight hens' eggs. Unlike New Zealand, where there is the *Apteryx*, Madagascar itself has no living wingless birds; but in the neighbouring island of Mauritius the Dodo has been exterminated less than three hundred years ago; and the little island of Rodriguez, in the same geographical province, has in a similar period lost the wingless Solitaire (*Pezophaps*).

DIVISION III. MAMMALIA.

CHAPTER LXXII.

General Characters of the Mammalia.

The last and highest class of the *Vertebrata*, that of the *Mammalia*, may be shortly defined as including *Vertebrate animals in which some part or other of the integument is always provided with hairs at some time of life; and the young are nourished, for a longer or shorter time, by means of a special fluid—the milk—secreted by special glands—the mammary glands.* These two characters are of themselves sufficient broadly to separate the Mammals from all other classes of the Vertebrate sub-kingdom. In addition, however, to these two leading peculiarities, the Mammals exhibit the following other characters of scarcely less importance:—

1. The skull articulates with the vertebral column by means of a double articulation, the occipital bone carrying two condyles, in place of the single condyle of the Reptiles and Birds.

2. The lower jaw or mandible consists of two halves or rami, united anteriorly by a symphysis, but not necessarily anchylosed; but these are each composed of a single piece, instead of being complex and consisting of several pieces, as in the Reptiles and Birds. Further, the lower jaw always articulates directly with the squamosal element of the skull, and is never united to an os quadratum, as in the *Sauropsida*.

3. The two hemispheres of the cerebral mass, or brain proper, are united together by a more or less extensively developed "corpus callosum" or commissure.

4. The heart consists—as in Birds—of four cavities or chambers, two auricles and two ventricles. The right and left sides of the heart are completely separated from one another, and there is no communication between the pulmonary and systemic circulations. The red blood-corpuscles are non-nucleated, and, with the exception of the *Camelidæ*, they are circular biconcave discs. There is only one aorta—the left—which turns over the left bronchus, and not over the right, as it does in Birds.

5. The cavities of the thorax and abdomen are completely separated from one another by a muscular partition—the diaphragm or midriff.

6. The respiratory organs are in the form of two lungs placed in the thorax, but none of the bronchi end in air-receptacles, distributed through the body, as in Birds.

7. The embryo mammal is invariably enveloped in an amnion, and an allantois is never wanting. The allantois, however, either disappears at an early period of life, or it develops the structure known as the "placenta." The placenta is a vascular organ which serves as a means of communication between the parent and the fœtus, but it will be noticed more particularly hereafter.

8. In no Mammal do the visceral arches and clefts of the embryo ever carry branchiæ, as they do in the Fishes and Amphibians.

These are the essential characters which distinguish the *Mammalia* as a class, but it will be necessary to consider these, and some other points, in a more detailed manner.

In the first place, with regard to the osteology of the Mammals, the following points should be noticed:—

With the exception of the Whales and Dolphins (*Cetacea*), and the Dugongs and Manatees (*Sirenia*), the vertebral column is divisible into the same regions as in man—namely, into a cervical, dorsal, lumbar, sacral, and caudal or coccygeal region (see fig. 118). In the *Cetacea* and *Sirenia* the dorsal region of the spine is followed by a number of vertebræ which compose the hinder extremity of the body, but which cannot be separated into lumbar, sacral, and caudal vertebræ.

In spite of the great difference which is observable in the length of the neck in different Mammals, the number of vertebræ in the cervical region is extraordinarily constant, being almost invariably seven, as in man. In this respect there is no difference between the Whale and the Giraffe. The only exceptions to this law are the *Manatus australis*, one of the Sea-cows, which has usually six cervical vertebræ, and the three-toed Sloth (*Bradypus tridactylus*), which is commonly regarded as possessing nine, though competent anatomists would refer the posterior two of these to the dorsal region.

The dorsal vertebræ are mostly thirteen in number, but they vary from ten to twenty-four. In Man there are twelve, in one of the Armadillos only ten, and in the three-fingered Sloth the maximum is attained. The lumbar vertebræ are usually six or seven in number, rarely fewer than four. In Man they are five in number, and they are reduced to two in the two-toed Sloth, one of the Ant-eaters, and the Duck-mole.

The first vertebra, or atlas, always bears two articular cavities for the reception of the two condyles of the occipital bone, and the second vertebra, or axis, usually has an "odontoid" process on which the head rotates. In the true Whales, however, in which the cervical vertebræ are anchylosed together to a greater or less extent, and the neck is immovable, the odontoid process is also wanting.

In almost all Mammals the spinous processes of the dorsal vertebræ are very largely developed for the attachment of the structure which is known as the *ligamentum nuchæ*. This is a great band of elastic fibrous tissue, which is attached in front to the occipital bone and spinous processes of the cervical vertebræ, and which relieves the muscles of the task of supporting the head, in those Mammals which progress with the body in a horizontal position. The development of the *ligamentum nuchæ* is consequently, as a rule, proportionate to the size of the head and the length of the neck. In Whales no such apparatus is necessary, owing to the fixation of the cervical vertebræ by anchylosis; and in Man, who walks erect, the *ligamentum nuchæ* can hardly be said to exist as a distinct structure, being merely represented by a band of fascia.

The number of lumbar and sacral vertebræ, as we have seen, varies in different mammals; but ordinarily some of the vertebræ are anchylosed into a single bone, and have the iliac bones abutting against them, thus constituting the "sacrum" of human anatomists. In the *Cetacea* and *Sirenia*, in which the hind-limbs are wanting, and the pelvis rudimentary, there is no "sacrum."

The thoracic cavity or chest in Mammals is always enclosed by a series of ribs, the number of which varies with that of the dorsal vertebræ. In most cases each rib articulates by its head with the bodies of *two* vertebræ, and by its tubercle with the transverse process of one of these vertebræ (the lower one). In the *Monotremata* (*e. g.*, the Duck-mole), the ribs articulate with the body of the vertebra only, and in the Whales the hindermost of the ribs, or all of them, articulate with the transverse processes only, and not with the centra at all.

There are usually no bony pieces uniting the ribs with the sternum or breast-bone in front, as in Birds; but the so-called "sternal ribs" of *Aves* are represented by the "costal cartilages" of the Mammals. In some cases, however, the cartilages of the ribs do become ossified and constitute sternal ribs. Sometimes, as in the Armadillos, there is a joint between the vertebral rib and costal cartilage. More rarely, as in the *Monotremes*, an intermediate piece is found between the vertebral and costal portions of the rib. Only the anterior ribs reach the sternum, and these are called the "true" ribs; the posterior ribs, which fall short of the breast-bone, being known as the "false" ribs.

The sternum or breast-bone is formed of several pieces placed one behind the other, but usually anchylosed together to form a single bone. It is placed upon the ventral surface of the body, and is united with the vertebral column by the ribs and their cartilages. It is generally a long and narrow bone, but in the *Cetacea* it is broad. It is only in some burrowing animals (such as the Moles) and in the true flying Mammals (the Bats), that the sternum is provided with any ridge or keel for the attachment of the pectoral muscles, as it is in Birds. The sternum is primitively composed of three pieces, an anterior piece or *præsternum*, a middle piece or *mesosternum*, and a posterior piece or *xiphisternum*. The præsternum is the "manubrium sterni" of human anatomy, and is the portion of the sternum which lies in front of the attachment of the second pair of ribs. All the other ribs are connected with the mesosternum. The *xiphisternum* is the "xiphoid cartilage" of human anatomy, and it commonly remains throughout life more or less unossified. In the Monotremes there is a T-shaped bone above or in front of the præsternum, but this is probably to be regarded as belonging to the shoulder-girdle, and as representing the "episternum" or "interclavicle" of the Reptiles.

The normal number of limbs in the *Mammalia* is four, two anterior and two posterior; and hence they are often spoken of as "quadrupeds," though all the limbs are not universally present, and other animals have four limbs as well. The anterior limbs are not known to be wanting in any Mammal, but the posterior limbs are absent in the *Cetacea* and *Sirenia*.

As regards the structure of the anterior limb, the chief points to be noticed concern the means by which it is connected with the trunk. The scapula or shoulder-blade is never absent, and it is in the form of a broad flat bone, applied to the outer aspect of the ribs, and much more developed than in the Birds. The coracoid bone, which forms such a marked feature in the scapular arch of *Aves*, is fused with the scapula, and only articulates with the sternum in the Duck-mole and Echidna (*Monotremata*). In all other Mammals the coracoid forms merely a process of the scapula, and does not reach the top of the breast-bone. The collar-bones or clavicles never unite in any Mammal to form a "furculum," as in Birds; but in the Monotremes they unite with an "inter-clavicle" placed in front of the sternum. The clavicles, in point of fact, are not present in a well-developed form in any Mammals except in those which use the anterior limbs in flight, in digging, or in prehension. The *Cetacea*, the Hoofed Quadrupeds (*Ungulata*), and some of the *Edentata*, have no clavicles. Most of the *Carnivora* and some Rodents possess a clavicle, but this is imperfect, and does not articulate with the top of the sternum. The Insectivorous Mammals, many of the Rodents, the Bats, and all the *Quadrumana*, have (with man) a perfect clavicle articulating with the anterior end of the sternum.

The humerus, or long bone of the upper arm (*brachium*), is never wanting, but is extremely short in the Whales, in which the anterior limbs are converted into swimming-paddles. In many Mammals, as in the Monkeys, and *Felidæ* (constituting the most typical group of the *Carnivora*), the median nerve and brachial or ulnar artery are protected on their way down the arm by a canal placed a little above the elbow, and formed by a process—the "supra-condyloid" process—which is sometimes present in man as an abnormality.

In the fore-arm of all Mammals the ulna and radius are recognisable, but they are not necessarily distinct; and the radius, as being the bone which mainly supports the hand, is the only one which is always well developed, the ulna being often rudimentary. In the *Cetacea* the ulna and radius are anchylosed together; and in most of the Hoofed Quadrupeds they are anchylosed towards their distal extremities. In the flying Mammals or Bats alone is the ulna ever altogether absent. The fore-arm attains its greatest perfection in man, in whom the radius can rotate upon the ulna, so as to allow the back of the hand to be placed upwards or downwards, these movements being known respectively as "pronation" and "supination." In the Monkeys only is there any approach to this power of rotation.

The fore-arm is succeeded by the small bones which compose the wrist or "carpus." These are eight in number in man, but vary in different Mammals from five to eleven.

The metacarpus in man and in most Mammals consists of five cylindrical bones, articulating proximally with the carpus, and distally with the phalanges of the fingers. The most remarkable modification of this normal state of things occurs in the Ruminants and in the Horse. In the Ruminants, in which the foot is cleft, and consists of two toes only, there are two metacarpal bones in the embryo; but these are anchylosed together in the adult, and form a single mass which is known as the "canon-bone" (fig. 184, *ca*). In the Horse, in which the foot consists of no more than a single digit, there is only a single metacarpal bone, on each side of which are two little bony spines — the so-called "splint-bones" — which are attached superiorly to the carpus. These are to be regarded as rudimentary metacarpals; but by Cuvier they were looked upon as imperfect fingers. In most of the other Ungulates there are at least three metacarpals, and in the Elephants there are five.

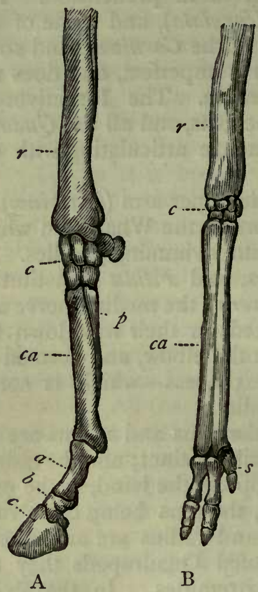


Fig. 184.—A, Fore-leg of the Horse: *r* Radius; *c* Carpus; *ca* Canon-bone; *p* Splint-bone; *a* First phalanx or "great pastern;" *b* Second phalanx or "small pastern;" *c* Ungual phalanx or "coffin-bone." B, Fore-limb of a Deer: *r* Radius; *c* Carpus; *ca* Canon-bone; *s* Supplementary toe.

The normal number of digits is five, but they vary from one to five. The middle finger is the longest and most persistent of the digits of the fore-limb; and in the Horse it is the only one which is left (fig. 184, A). The thumb is very frequently absent. In the Ruminants there are only two fingers which are functionally useful, these carrying the hoofs. In all Ruminants, however, there are two rudimentary and functionally useless digits in addition.

Normally each digit has three phalanges, except the thumb, which has only two. In the Whales and Dolphins (*Cetacea*), in which the anterior limbs form swimming-paddles, very like those of the *Ichthyosaurus* and *Plesiosaurus*, the phalanges are considerably increased in number as they are in those Reptiles. In all the Mammalia, too, except the *Cetacea*, it is the rule that the terminal phalanx in each digit should carry a nail, claw, or hoof.

The power of opposing the thumb to the other digits of the hand is found only in Man, and in a considerable number of the *Quadrumana*, but never so perfectly developed as in Man. In Man only does this power attain its full perfection, and it constitutes one of the most striking of the merely *anatomical* peculiarities by which Man is separated from the Monkeys.

As, however, this feature is purely adaptive, and is really to be regarded as of extremely small physiological value, we ought to learn from this that the difference between man and the *Quadrumana* is to be sought in the mental powers of each, and not in any merely structural character.

Whilst the anterior limbs are never absent in any Mammal, the posterior limbs are occasionally wholly wanting, as in the *Cetacea* and *Sirenia*. Generally speaking, however, the posterior limbs are present, and the pelvic arch has much the same structure as in man. The two halves of the pelvis—the ossa innominata—consist each of three pieces in the embryo—viz., the ilium, ischium, and pubes, which meet to form the cup-shaped cavity known as the "acetabulum," with which the head of the thigh-bone articulates. In the adult Mammal these three bones are anchylosed together, and the two ossa innominata unite in front by means of a symphysis pubis, constituted either by a cartilaginous union (synchondrosis), or by merely ligamentous attachment. In some Mammals, however, such as the Mole, and many of the Bats, the pubic bones remain disunited during life. As a rule, also, the ossa innominata are firmly united with the vertebral column. In the Cetaceans, in which the hind-limbs are wanting, and there is no sacrum, the innominate bones are rudimentary, and are not attached in any way to the spine.

The only other bones which are ever connected with the pelvis are two small bones which are directed upwards from the brim of the pelvic cavity in Marsupials and Monotremes. These are the so-called "Marsupial bones" regarded generally as not forming parts of the skeleton properly so called, but as being ossifications of the internal tendons of the "external oblique" muscles of the abdomen (fig. 187).

In those Mammals which possess hind-limbs, the normal composition of the member is of the following parts :—1. A thigh-bone or femur; 2. Two bones forming the shank, and known as the tibia and fibula; 3. A number of small bones constituting the ankle or tarsus; 4. The "root" of the foot, made up of the "metatarsus;" 5. The phalanges of the toes (see fig. 120).

The thigh-bone or femur articulates with the pelvis, usually at a very open angle. In Man it is distinguished by being the longest bone of the body, and by having the axis of its shaft nearly parallel to that of the vertebral column. In most Mammals the femur is relatively shorter, and the axis of its shaft deviates considerably from that of the spine, being sometimes at right angles, or even at an acute angle.

Of the bones of the leg proper the tibia corresponds to the radius in the fore-limb, as shown by its carrying the tarsus; and the fibula is the representative of the ulna. The articulation between the tibia and fibula on the one hand, and the femur on the other, constitutes the "knee-joint," which is usually defended in front by the "knee-pan" or patella, a large sesamoid bone developed in the tendons of the great extensor muscles of the thigh. The patella is of small size in the *Carnivora*, but does not appear to be wanting in any except the Marsupials. In many cases the tibia and fibula are anchylosed towards their distal extremities. In the Horse the fibula has much the same character as in Birds, being a long splint-like bone which only extends about half-way down the tibia. In the Ruminants the reverse of this obtains, the upper half of the fibula being absent, and only the lower half present.

The tibia articulates with the tarsus, consisting in man of seven bones, but varying in different Mammals from four to nine.

The foot consists normally of five toes connected with the tarsus by means of five metatarsal bones, which closely resemble the metacarpals. In the Ruminants there are only two metatarsals, and these are anchylosed in the adult, and carry two toes. In the Horse there is only one metatarsal supporting a single toe. As a rule, the number of digits in the hind-limb or foot is the same as that in the fore-limb or hand; but this is not always the case. In the Lions, Tigers, Cats, and Dogs, the posterior limb carries only four toes, the innermost toe or hallux being wanting. In the *Quadrumana*, again, all the five toes are generally present, but the four outer toes are much longer than in Man, and the hallux is shorter than the other toes, and often opposable to them, so that the foot forms a kind of posterior hand. The hallux is also not uncommonly opposable in other cases.

The cranial bones are invariably connected with one another by sutures, and in no other examples than the Monotremes are these sutures obliterated in the adult. The differences of opinion which are entertained as to the fundamental structure of the skull are so enormous that it will be best not to attempt here any detailed description of the skull of the Mammalia, more especially as there is as yet no universal agreement even as to the nomenclature to be employed. It is sufficient to remember that the skull is composed of a series of bony segments, which are usually regarded as modified vertebræ. The occipital bone carries two condyles for articulation with the first cervical vertebra. The lower jaw is composed of two halves or rami, which are distinct from another in the embryo, and may or may not be anchylosed together in the adult. However this may be, in no Mammal is the ramus of the lower jaw composed of several pieces, as it is in Birds and Reptiles, nor does it articulate with the skull by the intervention of an os quadratum. On the other hand, each ramus of the lower jaw in the Mammals is composed of only a single piece, and articulates with the squamosal element of the skull, or, in other words, with the squamous portion of the temporal bone.

Teeth are present in the great majority of Mammals; but they are only present in the embryo of the Whalebone Whales, and are entirely absent in the genera *Echidna*, *Manis*, and *Myrmecophaga*. In the Duck-mole (*Ornithorhynchus*) the teeth are horny, and the same was the case in the extinct *Rhytina* amongst the *Sirenia*. In all other Mammals the teeth have their ordinary structure of dentine, enamel, and crusta petrosa, these elements being variously disposed in different cases. In no Mammals are the teeth ever anchylosed with the jaw, and in all the teeth are implanted into distinct sockets or alveoli, which, however, are very imperfect in some of the Cetacea.

Many Mammals have only a single set of teeth throughout life, and these are termed by Owen "monophyodont." In most cases, however, the first set of teeth—called the "milk" or "deciduous" teeth—is replaced in the course of growth by a second set of "permanent" teeth. The deciduous and permanent sets of teeth do not necessarily correspond to one another; but no Mammal has ever *more* than these two sets. The Mammals with two sets of teeth are called by Owen "diphyodont."

In Man and in many other Mammals the teeth are divisible into four distinct groups, which differ from one another in position, appearance, and function; and which are known respectively as the *incisors*, *canines*, *præmolars*, and *molars* (fig. 185). "Those teeth which are implanted in the præmaxillary bones, and in the corresponding part of the lower jaw, are called 'incisors,' whatever be their shape or size. The tooth in the maxillary bone which is situated at or near to the suture with the præmaxillary, is the 'canine,' as is also that tooth in the lower jaw which, in opposing it, passes in front of its crown when the mouth is closed. The other teeth of the first set are the 'deciduous molars;' the teeth which displace and succeed them vertically are the 'præmolars;' the more posterior teeth, which are not displaced by vertical successors, are the 'molars' properly so called."—(Owen.) The deciduous dentition, therefore, of a diphyodont Mammal consists of only three kinds of teeth—incisors, canines, and molars. The incisor and canine teeth of the deciduous set are replaced by the teeth which bear the same names in the permanent set. The deciduous "molars," however, are replaced by the permanent "præmolars," and the "molars" of the permanent set of teeth are not represented in the deciduous series, only existing once, and not being replaced by successors.

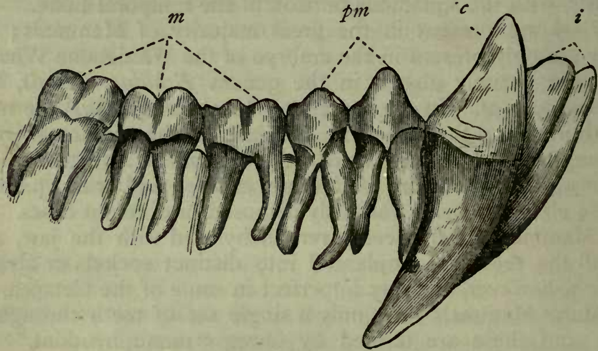


Fig. 185.—Teeth of the right side of the lower jaw of the Chimpanzee (after Owen). *i* Incisors; *c* Canine teeth: *pm* Præmolars; *m* Molars.

All these four kinds of teeth are not necessarily present in all Mammals, and, as will be afterwards seen, the characters of the teeth are amongst the most important of the distinctions by which the Mammalian orders are separated from one another. The variations which exist in the number of teeth in different Mammals are usually expressed by a "dental formula," which presents the "dentition" of both jaws in a condensed and easily-recognised form.

According to Owen, the typical permanent dentition of a diphyodont Mammal would be expressed by the following formula:—

$$i\,\frac{3-3}{3-3};\ c\,\frac{1-1}{1-1};\ pm\,\frac{4-4}{4-4};\ m\,\frac{3-3}{3-3} = 44$$

The four kinds of teeth are indicated in such a formula by the letters—incisors *i*, canines *c*, præmolars *pm*, molars *m*. The numbers in the upper line indicate the teeth in the upper jaw, those in the lower line stand for those in the lower jaw; and the number of teeth on each side of the jaw is indicated by the short dashes between the figures.

As regards the digestive system of the *Mammalia*, salivary glands are present in all except the true *Cetacea*. The alimentary canal has in most cases essentially the same structure as in man; and the same accessory glands are present—namely, the liver and pancreas. Some very remarkable modifications occur in the structure of the stomach and in the termination of the intestine; but these will be noticed in speaking of the orders in which they occur. The cavity of the abdomen is always separated from that of the thorax by a complete muscular partition—the diaphragm—as is the case in no other Vertebrate animals. The abdomen contains the greater portion of the alimentary canal, the liver, spleen, pancreas, kidneys, and other organs. The thorax mainly holds the heart and lungs.

The heart is contained in a serous bag, the pericardium, and consists (as in Birds) of two auricles and two ventricles. The effete and deoxygenated blood is returned from the tissues by the veins, and is conducted by the two venæ cavæ to the right side of the heart into the right auricle. From the right auricle it passes into the right ventricle, whence it is propelled through the pulmonary artery to the lungs. Having been submitted to the action of the air, the blood, now arterialised, is carried by the pulmonary veins to the left auricle, and thence into the left ventricle. From the left ventricle the aerated blood is driven through the aorta and systemic vessels to all parts of the body. In Mammals, therefore, as in Birds, the pulmonary and systemic circulations are altogether distinct and separate from one another. The two sides of the heart—except in the fœtus and as an abnormality in adults—have no communication with one another except by means of the capillaries.

The red blood-corpuscles are never nucleated, and in all except the *Camelidæ* (in which they are oval) they are circular and discoid.

The lungs of Mammals differ from those of Birds in being freely suspended in the thoracic cavity, the greater part of which they fill, and in being enclosed freely in a serous sac (*pleura*) which envelops each lung. The lungs are minutely cellular throughout, and the bronchi never open on the surface of the lung into a series of air-receptacles communicating with one another, and placed in different parts of the body, as is the case in Birds.

There is no "inferior larynx" in any Mammal, and the upper aperture of the true larynx is always protected by an epiglottis.

The kidneys in Mammals are situated in the lumbar region, and exhibit a division of their substance into cortical and medullary portions.

There are two ovaries in all Mammals, and the oviducts are known as the "Fallopian tubes." Each oviduct dilates on its way to the surface into a uterine cavity, which opens into the vagina. In the Monotremes and Marsupials this primitive condition is retained throughout life, the uterus remaining double, and opening by two apertures into the cloaca or vagina. In most cases this condition is so far modified in the adult, that the two uteri have coalesced inferiorly, so as to have only a single opening into the vagina, whilst they separate into two horns or "cornua" superiorly. Only in the Monkeys and in Man have the two uteri completely coalesced to form a completely single cavity, into the "fundus" of which the Fallopian tubes open. In male Mammals there are always two testes present. In many Mammals the testes are permanently retained in the abdominal cavity and there is no scrotum. This is the case in the Monotremes, the Elephants, all the *Cetacea*, and many of the *Edentata*. Mostly, however, the testes at an early period of life are transferred from the abdomen to a pouch of integument called the "scrotum." Usually the scrotum is placed beneath the pubic arch and behind the penis, but this position is reversed in the Marsupials.

Mammary glands are present in all Mammals, and they are regarded by Huxley as an extreme modification of the cutaneous sebaceous glands. In the male Mammals the mammary glands are present, but, under all ordinary circumstances, they remain functionally useless and undeveloped. Considerable differences obtain as to the number and position of the mammary glands in different cases; but they are always placed on the inferior surface of the body, and their ducts in the great majority of cases open collectively upon a common elevation —the "teat" or "nipple." In the *Monotremata*, however, there are no nipples, the ducts of the mammary glands opening either into a pouch of the integument (*Echidna*) or upon a flat surface (*Ornithorhynchus*).

The young Mammal is nourished for a longer or shorter time by the milk secreted by the mammary glands of the mother. In ordinary cases the milk is obtained by voluntary suction on the part of the young animal; but in the Marsupials the young are at first unable to suck for themselves, and the milk is forced out of the gland by the contractions of a special muscle.

The nervous system of Mammals is chiefly remarkable for the great proportionate development of the cerebral mass as compared with the size of the spinal cord. In the higher Mammals, again, the hemispheres of the cerebrum are much more largely developed proportionately than the remaining parts of the brain. The brain of the Mammals is chiefly distinguished from that of the lower *Vertebrata* by the fact that the two hemispheres of the cerebellum are united by a transverse commissure—the *pons Varolii*—and the hemispheres of the brain are connected by a great commissure—the *corpus callosum*—which is, however, of small size in the lower *Mammalia*.

The senses, as a rule, attain great perfection in the Mammals; and the only sense which appears to be ever entirely wanting is that of vision. In one of the most familiar instances of this last-mentioned fact—namely, in the Mole—it has recently been shown that it is only in the adult that vision is lost, but that the organs of sight are well developed in the young. The sclerotic coat of the eye is never supported by a ring of bony plates as in Birds and many Reptiles. As a rule, in addition to the upper and lower eyelids there is a third perpendicular lid—the *membrana nictitans*—but this is wanting or quite rudimentary in Man and in the Monkeys.

An external ear or *concha* for collecting the vibrations of sound is usually present, but is wanting in the *Cetacea*, many of the Seals, and in some other cases.

The integument is furnished over a greater or less portion of its surface with the epidermic appendages known as "hairs." These are developed, much as feathers are, upon little eminences or papillæ of the derma, but they do not split up in the process of development as feathers do. In the *Manis* or Scaly Ant-eater the epidermic appendages are in the form of horny scales, and not uncommonly they are developed into long spines, as in the *Echidna*, Porcupine, and Hedgehog. In the Armadillos, again, the integument has the power of developing plates of bone over a greater or less extent of its surface. The only apparent exception to the universal presence of hairs in some part or other of the skin of all Mammals is constituted by the *Cetacea*, some of which are without hairs in the adult state. Some, however, of these (such as the Whales) possess a few bristles in the neighbourhood of the mouth even when fully grown. And the Dolphins, which are totally hairless when adult, exhibit tufts of hair on the muzzle in the fœtal state.

CHAPTER LXXIII.

CLASSIFICATION OF THE MAMMALIA.

NUMEROUS classifications of the *Mammalia* have been proposed, and it is a matter of regret that no one has been universally accepted by Zoologists. Here, it will be sufficient to describe briefly the three leading systems upon which the *Mammalia* have been divided into sub-classes; whilst the first will be adopted as sufficient for all practical purposes.

I. By many writers the class *Mammalia* is divided into two great primary divisions, the *Placentalia* or Placental Mammals, and the *Implacentalia* or Non-placental Mammals, according as the structure known as the "placenta" is present or absent. The placenta, as before said, is a vascular organ developed in the greater number of Mammals, by means of which the blood of the fœtus is brought into relation with the blood of the mother. The sub-class *Placentalia*, in which such a vascular connection between the mother and fœtus exists, comprises by far the largest number of the Mammals. The sub-class *Implacentalia*, in which no such vascular connection exists, comprises only the two orders of the *Monotremata* and the *Marsupialia*.

II. By Professor Owen the *Mammalia* are divided into four sub-classes, characterised by the structure of the brain, as follows:—

a. Lyencephala, characterised by the fact that the cerebral hemispheres are without folds, and leave the cerebellum, the olfactory lobes, and part of the optic lobes uncovered. The hemispheres are not connected together by a corpus callosum. (*Monotremata* and *Marsupialia.*)

b. Lissencephala, characterised by the fact that the cerebral hemispheres are smooth or are provided with few folds, and leave the cerebellum and part of the olfactory lobes exposed. A corpus callosum is present. (*Cheiroptera, Insectivora, Rodentia, Edentata.*)

c. Gyrencephala, characterised by the fact that the hemispheres of the cerebrum cover the greater part of the cerebellum and the olfactory lobes. A corpus callosum is present, and the surface of the cerebral hemispheres is thrown into numerous convolutions. (*Cetacea, Carnivora, Sirenia, Proboscidea, Ungulata, Quadrumana.*)

d. Archencephala, characterised by the fact that the cerebral hemispheres now completely overlap the cerebellum and olfactory lobes; the number of convolutions attains its maximum; and there is a corpus callosum. (Man.)

This is the primary classification of the *Mammalia* put forth by Owen, and there can be no question but that in many respects it expresses substantial and important differences. It will not be adopted here, partly because it is somewhat difficult to follow or to apply in practice, and partly because some of the characters upon which it is founded are denied by other eminent naturalists. Thus, in the definition of the sub-class *Lyencephala* it is stated as one of the essential characters that there is no corpus callosum or commissure between the hemispheres of the cerebrum. On the other hand, it is asserted by Flower and Huxley that a corpus callosum does exist in these animals, though it never attains to any high degree of development.

III. It was proposed by De Blainville, and the arrangement has been accepted by Huxley and Rolleston, to divide the *Mammalia* into the following three sub-classes, founded upon the nature of the reproductive organs:—

a. *Ornithodelphia*, characterised by the fact that the uterine enlargements of the oviducts do not coalesce even in their inferior portion to form a common uterine cavity, but open separately as in the Birds and Reptiles. Furthermore, the two uteri open, not into a distinct vagina, but into a cloacal cavity, into which the rectum and ureters also discharge themselves; so that the condition of parts is very much the same as it is in Birds.

This division includes only the Duck-mole (*Ornithorhynchus*) and the Porcupine Ant-eater (*Echidna*), forming collectively the single order of the *Monotremata*.

b. *Didelphia*, characterised by the fact that the uterine dilatations of the oviducts continue distinct throughout life, opening into two distinct vaginæ, which in turn open into a urogenital canal, which is distinct from the rectum, though embraced by the same sphincter muscle.

This sub-class contains the *Marsupialia*, such as the Kangaroos, Opossums, Wombats, &c., most of which are almost entirely confined to Australia. They have many other characters in common, which will be spoken of hereafter.

III. *Monodelphia*, characterised by the fact that the uterine enlargements of the oviducts coalesce to a greater or less extent to form a single uterine cavity, which, however, generally shows its true composition by being divided superiorly into two cornua. The uterus opens again into a single vagina, which is always distinct from the rectum. This sub-class corresponds with the division of the "Placental" Mammals, and includes all the *Mammalia* except the Monotremes and Marsupials.

Before going on to consider the different orders of the *Mammalia* in detail, it may be as well very briefly to run over the leading characters by which the various orders are distinguished:

Order I. Monotremata, characterised by the fact that the ureters and ducts of the reproductive organs open into a common urogenital canal, which in turn opens, along with the rectum, into a "cloaca." The testes are abdominal, and are not lodged in a scrotum. The mammary glands have no nipples. The young is devoid of a placenta, but the female possesses no marsupial pouch, though the pelvis is furnished with "marsupial bones." In this order are only the Duck-mole and the Echidna.

Order II. Marsupialia, characterised by the fact that the uterine dilatations of the oviducts open with the ureters into a urogenital canal, which is distinct from the rectum, though embraced by the same sphincter muscle. The testes are not abdominal, but are lodged in a scrotum which is suspended by a narrow neck in front of the penis. The females are mostly furnished with a marsupial pouch, in which the young are carried for some period after birth. The young are not provided with a placenta, and are born in a very imperfect state of development. Marsupial bones are present. In this order are the Kangaroos, Opossums, Wombats, &c.

Order III. Edentata or *Bruta*, characterised by the universal absence of the median incisors, and the general absence of all the incisors. The canines are usually wanting as well, and sometimes there are no molars either. There is only one set of teeth, and the teeth have neither complete roots nor are furnished with a covering of enamel. The toes are always furnished with claws. Placenta sometimes deciduate, sometimes non-deciduate. As examples of this order may be taken the Sloths, Armadillos, and the great Ant-eater.

Order IV. Sirenia, comprising the Dugongs and Manatee, characterised by being adapted to an aquatic life. Body fish-like, with a strong horizontal tail-fin. There is no sacrum, and the hind-limbs are invariably wanting, whilst the fore-limbs are converted into swimming-paddles. There are, in the living forms at any rate, two sets of teeth, and the molars have flattened crowns adapted for a vegetable diet. There are two nostrils, and these are placed at the upper part of the snout. There are two mammæ, and these are placed on the chest, and not on the abdomen.

Order V. Cetacea, comprising the true Whales and Dolphins, characterised by being aquatic Mammals, with a horizontal tail-fin, no sacrum nor hind-limbs, and fore-limbs in the form of swimming-paddles. The nostrils are single or double, and are placed on the top of the head. The mammary glands are two in number, and are placed in the region of the groin. There is never more than one set of teeth, and in many cases the adult is destitute of teeth altogether. Placenta non-deciduate.

Order VI. Ungulata or *Hoofed Quadrupeds*, comprising the whole of the Ruminants, the Horses, and most of the old group of the Pachydermatous Mammals. This order is split up into many important sections, and, as a whole, it is simply characterised by the fact that there are never more than four full-sized toes to each limb, and that the extremities of the toes are furnished with expanded nails, constituting hoofs. There are no clavicles. Placenta non-deciduate.

Order VII. Hyracoidea, comprising only the single genus *Hyrax*, characterised by having no canines, but by having long curved incisors, which grow from permanent pulps, as in the Rodents. There are no clavicles. The front-feet have four toes, and the hind-feet three. The placenta is deciduate and zonary.

Order VIII. Proboscidea, comprising no other living Mammal except the Elephant, characterised by having no canines, but only molars and incisors, of which the latter grow from permanent pulps, and constitute defensive tusks. There are no clavicles. The feet are five-toed. The nose is prolonged into a proboscis. The mammæ are two in number. The placenta is deciduate and zonary.

Order IX. Carnivora, comprising all the well-known beasts of prey, such as Lions, Tigers, Dogs, Cats, &c., together with the aquatic Seals and Walruses. They are all characterised by always possessing the three different kinds of teeth—incisors-canines, and molars—the canines being usually of great length, and a greater or less number of the molars having sharp cutting edges. The clavicles are always rudimentary, the teats are abdominal, and the placenta is deciduate and zonary.

Order X. Rodentia, comprising the Beavers, Rats, Mice, Hares, Rabbits, Squirrels, and others, characterised by the absence of canines and the possession of no more than two incisors in the lower jaw, and usually no more than two in the upper jaw. The incisors are greatly developed, growing from permanent pulps, and continuing to grow during the life of the animal. Placenta deciduate and discoidal.

Order XI. Cheiroptera, comprising only the various Bats, and characterised by the fact that the four outer or ulnar fingers are greatly developed and elongated, and are united together by a leathery flying-membrane or "patagium," which is continued from the hand and arm to the side of the body and hind-limb. By means of this patagium the Bats possess the power of flight. Clavicles are always present. The teeth vary a good deal, but there are always canines. The placenta is deciduate and discoidal.

Order XII. Insectivora, comprising the Moles, Shrew-mice, and Hedgehogs, characterised by having the crowns of the molar teeth furnished with sharp and pointed cusps. Well-developed clavicles are present in almost all cases. The placenta is deciduate and discoidal.

Order XIII. Quadrumana, comprising the Lemurs, Apes, and Monkeys. Dentition usually the same as in man, or with an additional præmolar on each side of each jaw, or varying a good deal in the lower forms. The series of teeth is uneven and interrupted. The innermost digit of the fore-limb (*pollex*) is opposable to the other fingers when present, but it may be wanting. The hallux is also opposable to the other toes of the hind-limb, so that the hind-feet constitute prehensile hands. Clavicles are always present. The placenta is deciduate and discoidal.

Order XIV. Bimana.—This order includes Man alone. The dental formula is—

$$i\,\frac{2-2}{2-2};\ c\,\frac{1-1}{1-1};\ pm\,\frac{2-2}{2-2};\ m\,\frac{3-3}{3-3} = 32.$$

The teeth are nearly even, and are not interrupted by any interval (*diastema*). The pollex or thumb on the fore-limb is opposable to the other digits, but this is not the case with the hallux or great-toe. The attitude of the body in progression is habitually erect. The placenta is deciduate and discoidal.

NON-PLACENTAL MAMMALS.

CHAPTER LXXIV.

MONOTREMATA AND MARSUPIALIA.

ORDER I. MONOTREMATA.—The first and lowest order of the *Mammalia* is that of the *Monotremata*, constituting by itself the division *Ornithodelphia*, and containing only two genera, both belonging to Australia—namely, the Duck-mole (*Ornithorhynchus*) and the Porcupine Ant-eater (*Echidna*).

The order is distinguished by the following characters:—The intestine opens into a "cloaca," which receives also the products of the urinary and generative organs, which discharge themselves into a urogenital canal, the condition of parts being very much the same as in Birds. The jaws are either wholly destitute of teeth (*Echidna*), or are furnished with horny plates which act as teeth. The pectoral arch has some highly bird-like characters, the most important of these being the extension of the coracoid bones to the anterior end of the sternum. The females possess no marsupial pouch, but the pelvis is furnished with the so-called "marsupial bones," believed to be ossifications of the internal tendon of the external oblique muscle of the abdomen. The testes of the male are abdominal throughout life, and there is therefore no scrotum, whilst the vasa deferentia open into the cloaca. The corpus callosum is very small, and has been asserted to be altogether wanting. There are no external ears. The mammary glands have no nipples, and their ducts open either into a kind of integumentary pouch (*Echidna*) or simply on a flat surface (*Ornithorhynchus*). The young are said to be destitute of a placenta, or, in other words, no vascular connection is established between the fœtus and the mother. The feet have five toes each, armed with claws, and the males carry perforated spurs on the back of the tarsus (attached to a supplementary tarsal-bone).

The order *Monotremata* includes only the two genera *Orni-*

thorhynchus and *Echidna*—the one represented by a single species (*O. paradoxus*), and the other by two species (*E. hystrix* and *E. setosa*). All are exclusively confined to Australia and Tasmania.

The *Ornithorhynchus* or Duck-mole is one of the most extraordinary of Mammals. The body (fig. 186) resembles that of a mole or small otter, and is covered with a close, short, brown fur. The tail is broad and flattened. The jaws are produced to form a beak just like that of a duck in appearance; hence the name of "Duck-billed animal," often applied to it. The margins of the jaw are sheathed with horn, and furnished with transverse horny plates; but there are no teeth. The nostrils are placed at the apex of the upper mandible. The legs are short, and the feet have five toes each, furnished with

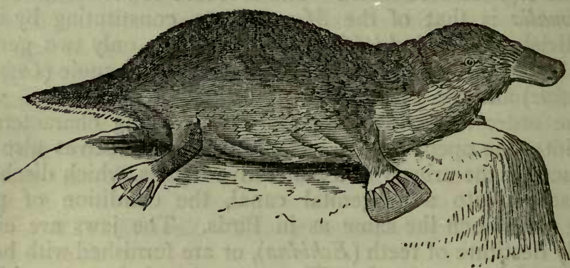


Fig. 186.—*Ornithorhynchus paradoxus.*

strong claws, which enable the animal to burrow with facility. The toes are also united by a membrane or web, so that the animal swims with great ease. The *Ornithorhynchus* is exclusively found in Australia and Tasmania, and inhabits streams and ponds. Its food consists chiefly, if not exclusively, of insects, and the animal makes very extensive burrows on the banks of the rivers which it frequents. The young are born quite blind, and nearly naked, and the method in which they obtain milk from the mother is somewhat obscure, as there are no nipples, nor is there any marsupial pouch. It is certain, however, that the beak of the young animal is extremely different from what it is in the adult condition.

The genus *Echidna* is represented by two species, *E. hystrix* and *E. setosa*, both belonging to the Australian province. The *Echidna hystrix* is the best-known species, and in some external respects is not unlike a large hedgehog, having the back covered with strong spines, interspersed with a general coating of bristly hairs. The snout has not the form of a duck's bill, as in the *Ornithorhynchus*, but the two mandibles are greatly elongated, and are enclosed in a continuous skin till close upon their extremities, where there is a small aperture for the protrusion of a very long and flexible tongue. The jaws are wholly devoid of teeth or anything in the place of teeth; and the nostrils are placed at the extremity of the cylindrical snout. The feet have five toes each, furnished with strong curved digging-claws, but the toes are not webbed. The *Echidna* measures from fifteen to eighteen inches in length, and is a nocturnal animal. It lives in burrows, and feeds upon insects, which it catches by protruding its long and sticky tongue.

ORDER II. MARSUPIALIA.—The order *Marsupialia* constitutes by itself the sub-class *Didelphia*, and forms with the *Monotremata* the division of the Non-placental Mammals. With the single exception of the genus *Didelphys*, which is American, all the *Marsupialia* belong to the Melanesian province; that is to say, they all belong to Australia, Van Diemen's Land, New Guinea, and some of the neighbouring islands.

The following are the characters which distinguish the order:—

The skull is composed of distinct cranial bones united by sutures, and they all possess true teeth; whilst the angle of the lower jaw is almost always inflected. The pectoral arch has the same form as in the higher Mammals, and the coracoid no longer reaches the anterior end of the sternum. All possess the so-called "marsupial bones," attached to the brim of the pelvis. The corpus callosum is very small, and has been asserted to be absent. The young Marsupials are born in a very imperfect condition, of very small size, and at a stage when their development has proceeded to a very limited degree only. It is believed that there is no placenta or vascular communication between the mother and fœtus, parturition taking place before any necessity arises for such an arrangement. As the young are born in such an imperfect state of development, special arrangements are required to secure their existence. When born, they are therefore, in the great majority of cases, transferred by the mother to a peculiar pouch formed by a folding of the integument of the abdomen. This pouch is known as the "marsupium," and gives the name to the order. Within the marsupium are contained the nipples, which are of great length. Being for some time after their birth extremely feeble, and unable to perform the act of suction, the young within the pouch are nourished involuntarily, the mammary glands being provided with special muscles which force the milk into the mouths of the young. At a later stage the young can suckle by their own exertions, and they leave the pouch and return to it at will. In a few forms there is no complete marsupium as above described; but the structure of the nipples is the same, and the young are carried about by the mother, adhering to the lengthy teats.

The so-called "marsupial bones" (fig. 187) doubtless serve to support the marsupial pouch and its contained young, but this cannot be their sole function, since they occur in the Monotremes, in which there is no pouch.

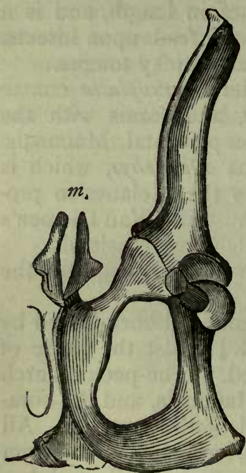


Fig. 187.—One side of the pelvis of a Kangaroo, showing the "marsupial bones" (*m*)—after Owen.

The oviducts open into vaginal tubes which open into a urogenital canal; but this does not open into a "cloaca," though embraced by a sphincter muscle common to it and to the rectum. The testes are not abdominal throughout life as in the Monotremes, but are lodged in a scrotum. This, however, is placed in front of the penis, and not beneath the pubic arch as in most Mammals. From this unusual position of the scrotum, it is regarded by Owen as being the same structure as the marsupial pouch of the female, turned inside out. Though they form an extremely natural order, sharply separated from all the rest of the Mammals, the Marsupials form a large and varied group. In fact this order, from being the almost exclusive possessor of a continent as large as Australia, has to discharge in the economy of nature functions which are elsewhere discharged by several orders.

The *Marsupialia* are divided by Owen into the following sections:—

a. Rhizophaga.—In this section is the well-known Australian animal, the Wombat (*Phascolomys fossor*), often called by the colonists the "badger." The Wombat is a stout, heavy animal, which attains a length of from two to three feet. The legs are very short and stout, and the animal burrows with ease by means of strong curved digging-claws, with which the fore-feet are furnished. The tail in the Wombat is quite rudimentary, and the whole body is clothed with a brown woolly hair. In its dentition the Wombat presents a curious resemblance to the herbivorous Rodents. There are two incisors in each jaw, and these are long and rootless, growing from permanent pulps. There are no canines, so that the incisors and præmolars are separated by a considerable space. The dental formula is—

$$i\,\frac{1-1}{1-1};\; c\,\frac{0-0}{0-0};\; pm\,\frac{1-1}{1-1};\; m\,\frac{4-4}{4-4} = 24.$$

The præmolars and molars agree with the incisors in growing from permanent pulps, in which respect the Wombat differs from all the other Marsupials, and agrees with the herbivorous Rodents, with those *Edentata* which have teeth, and with the extinct *Toxodon*.—(Owen.)

The Wombat is a nocturnal animal, and feeds chiefly upon roots and grass.

b. Poephaga.—In this section are the Kangaroos (*Macropodidæ*) and the Kangaroo-rats or Potoroos (*Hypsiprymnus*), all strictly phytophagous. The Kangaroos are distinguished by the disproportionate length of the hind-limbs and disproportionate development of the posterior portion of the body as compared with the fore-limbs and fore part of the body. The hind-legs are exceedingly long and strong, and the feet are much elongated—the whole sole being applied to the ground. The hind-feet have four toes each, of which the central one is by far the largest, and the two inner toes are very small, and are united by a common integument. The tail is also extremely long and strong, and by the assistance of this organ and the powerful hind-limbs the Kangaroos are enabled to effect extraordinarily long and continuous leaps. In fact, leaping is the ordinary mode of progression in the typical Kangaroos; and when walking upon all fours their locomotion is slow and ungraceful. The anterior extremity of the body is very diminutive as compared with the posterior, and the fore-limbs are quite small, but have five well-developed toes armed with strong nails. The head is small, with large ears, and the dental formula is—

$$i\,\frac{3-3}{1-1};\; c\,\frac{0-0}{0-0};\; pm\,\frac{1-1}{1-1};\; m\,\frac{4-4}{4-4} = 28.$$

There are therefore six upper incisors, two lower incisors, and no functional canines (though rudimentary upper canines are present in the young of some of the Kangaroos, at any rate). The stomach is complex, and sacculated. The Kangaroos are all herbivorous, and mostly live, either scattered or gregariously, on the great grassy plains of Australia. The "Tree-kangaroos," however (constituting the genus *Dendro-*

lagus) live mostly in trees, and in adaptation to this mode of life the fore-legs are nearly as long and strong as the hind-legs. They are natives of New Guinea.

The Kangaroo-rats (*Hypsiprymnus*) differ from the true Kangaroos chiefly in their smaller size, and in the presence of well-developed upper canines (fig. 188, B). They are diminutive nocturnal animals, and they live mostly upon roots.

c. Carpophaga.—Intermediate between the Kangaroos and the typical members of the present section (the Phalangers) is the *Phascolarctos*—the "native sloth" or "bear" of the Australian colonists and the "koala" of the natives. This curious animal is about two feet in length, having a stout body, covered with a dense bluish-grey fur. The tail is wanting; and the feet are furnished with strong curved claws, which enable the animal to pass the greater part of its existence in trees. In

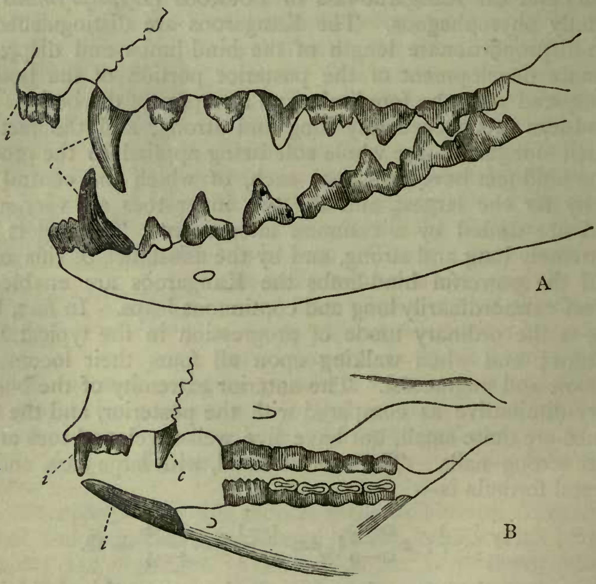


Fig. 188.—A, Dentition of a Carnivorous Marsupial (*Thylacinus*), showing the long and pointed canines and the trenchant molars and præmolars. B, Dentition of a herbivorous Marsupial (*Hypsiprymnus*), showing the flat-crowned molars. (After Owen.) *c* Canine teeth; *i i* Incisors.

this it is greatly assisted by the fact that all the feet are prehensile, the hallux being opposable, and the digits of the fore-limb divided into two sets, the thumb and index-finger being opposable to the other fingers. The koala is a slow animal which feeds on the foliage of the trees in which it spends its existence.

The typical group of the Carpophagous Marsupials is that of the *Phalangistidæ* or Phalangers, so called because the second and third digits of the hind-feet are joined together almost to their extremities. The family includes a number of small Marsupials, fitted for an arboreal existence, to which end the hallux is opposable and nail-less, whilst the four remaining toes of the hind-feet have long curved claws. The tail, too, is generally very long, and its tip is usually prehensile. The Phalangers are all small nocturnal animals which live upon fruits and other vegetable food. The best known of them is the Australian Opossum (*Phalangista vulpina*), which must not be confounded with the true or American Opossums, which belong to another section of the *Marsupialia*. The Phalangers, namely, are distinguished from the Opossums properly so called, amongst other characters, by their dentition, the canine teeth being always very small and functionally useless in the lower jaw, and sometimes in the upper jaw as well. The *Phalangista vulpina* is nocturnal and arboreal in its habits, and its flesh is esteemed a great delicacy by the native Australians, with whom opossum-hunting is a favourite pursuit.

The flying Phalangers or *Petauri* are closely allied to the true Phalangers, but differ in not having a prehensile tail, and in having a fold of skin extending on each side between the sides of the body and the fore and hind limbs. By the help of these lateral membranes the *Petauri* can take extensive leaps from tree to tree; but though called "flying" Phalangers, they have no power of flight properly so called. They are beautiful little animals, nocturnal in their habits, and having the body clothed with a soft and delicate fur.

d. Entomophaga. — In this section the jaws are always furnished with canine teeth, but these are not of very large size, and the animals composing the section are therefore not highly predacious, but "prey, for the most part, on the smaller and weaker classes of invertebrate animals." In this section are the Bandicoots (*Peramelidæ*), the American Opossums (*Didelphidæ*), and the Banded Ant-eater (*Myrmecobius*).

The Bandicoots (*Peramelidæ*) are small Australian animals, which appear to fill the place of the Hedgehogs, Shrew-mice, and other small *Insectivora* of the Old World. The hind-limbs in the Bandicoots are considerably longer than the fore-limbs, and their progression is therefore by a series of bounds.

The fore-limbs have really five toes each, but only the central three of these are well developed, the outermost and innermost digits being rudimentary. The three functional toes are armed with long strong claws, with which the Bandicoots burrow with great ease. The marsupial pouch—and this is a singular point—opens, in some species at any rate, backwards instead of forwards. In the nearly-allied genus *Chæropus*, also from Australia, it appears that the two outer toes of the fore-feet are entirely absent.

The second family of this section—namely, the true Opossums or *Didelphidæ*—is remarkable in being the only group of the whole order which occurs out of the Australian province. The *Didelphidæ*, namely, are exclusively found in North and South America, where they are known as "Opossums." A considerable number of species are known, but they are mostly of small size, the largest measuring not more than from two to three feet, inclusive of the tail. The Virginian Opossum (*Didelphys Virginiana*) is the only member of the family which is found in North America, and it was the earliest Marsupial known to science. Most of the Opossums are carnivorous, feeding upon small quadrupeds and birds, but they also eat insects, and sometimes even fruit. One species (*Didelphys cancrivora*) lives chiefly upon Crabs; and the Yapock (*Cheironectes*) has webbed feet, and appears to lead a semi-aquatic life. All the *Didelphidæ* have the hallux nail-less and opposable to the other toes, so as to convert the hind-feet into prehensile hands, and all have a more or less perfectly prehensile tail, these being adaptations to an arboreal life. The marsupial pouch is sometimes not present in a complete form, but is merely represented by cutaneous folds of the abdomen concealing the nipples. In the *Didelphys dorsigera*, in which this peculiarity obtains, the young soon leave the nipples, and are then carried about on the back of the mother, to whom they cling by twining their prehensile tails round hers. The dentition of the Opossums is remarkable for the great number of the incisor teeth, the dental formula being—

$$i\ \frac{5-5}{4-4};\ c\ \frac{1-1}{1-1};\ pm\ \frac{3-3}{3-3};\ m\ \frac{4-4}{4-4} = 50.$$

The Banded Ant-eater (*Myrmecobius fasciatus*) is a small but extremely elegant little animal, which inhabits Western and Southern Australia, and lives upon insects (fig. 189). The tail is bushy, and differs from that of the *Didelphidæ* in not being prehensile. The fore-feet have five toes armed with claws; the hind-feet have only four toes. The *Myrmecobius* is remarkable for the extraordinary number of molar teeth, in which it exceeds any existing Marsupial, and is only surpassed by some of the Armadillos. The dental formula is—

$$i\ \frac{4-4}{3-3};\ c\ \frac{1-1}{1-1};\ pm\ \frac{3-3}{3-3};\ m\ \frac{6-6}{6-6} = 54.$$

e. Sarcophaga.—This is the last section of the existing Marsupials, and includes a number of predacious and rapacious

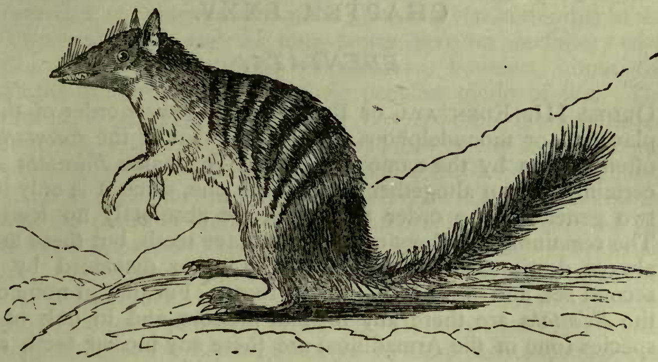


Fig. 189.—*Myrmecobius fasciatus.*

forms, which fill the place held elsewhere by the true *Carnivora.* They are distinguished by the fact that the intestine is destitute of a cæcum, and by their strictly carnivorous dentition, the canines being strong, long, and pointed, whilst the molars and præmolars have cutting edges furnished with three cusps (fig. 188, A). The best-known species of this section are the *Thylacinus cynocephalus* and the *Dasyurus ursinus.* The former of these is the largest of the rapacious Marsupials, being about as big as a shepherd's dog. It is a native of Van Diemen's Land, and is known to the colonists as the "hyæna." Its head is very large, and the back exhibits several transverse black bands. It lives in caverns and amongst the rocks in the wildest parts of the colony, and its numbers have been very much reduced by the constant war waged upon it by the settlers. The *Dasyurus ursinus* is also a native of Van Diemen's Land, where it is known as the "native devil." Though smaller than the Thylacine, the *Dasyurus* is extremely ferocious, and is capable of committing great havoc amongst animals even as large as sheep.

PLACENTAL MAMMALS.

CHAPTER LXXV.

EDENTATA.

ORDER III. EDENTATA, or BRUTA.—The lowest order of the placental or monodelphous Mammals is that of the *Edentata*, often known by the name of *Bruta*. The name *Edentata* is certainly not an altogether appropriate one, since it is only in two genera in the order that there are absolutely no teeth. The remaining members of the order have teeth, but these are always destitute of true enamel, are never displaced by a second set, and have no complete roots. Further, in none of the *Edentata* are there any median incisors, and in only one species (one of the Armadillos) are there any incisor teeth at all. Canine teeth, too, are almost invariably wanting. Clavicles are usually present, but are absent in the Scaly Ant-eater or *Manis*. All the toes are furnished with long and powerful claws. The mammary glands are usually pectoral, but are sometimes abdominal in position. The testes are abdominal in position. The skin is often covered with bony plates or horny scales.

The order *Edentata* is conveniently divided into two great sections, in accordance with the nature of the food, the one section being phytophagous, the other insectivorous. In the former section is the single group of the Sloths (*Bradypodidæ*). In the latter are the two groups of the Armadillos (*Dasypodidæ*), and the various species of Ant-eaters (the latter constituting Owen's group of the *Edentula*).

The order *Edentata* is but sparingly represented in modern times, and its geographical distribution is peculiar. The true Ant-eaters, the Armadillos and the Sloths, are entirely confined to South America, in which country a group of gigantic extinct Edentates existed in Post-tertiary times. The Scaly Ant-eater or *Manis* is common to Asia and Africa, and the genus *Orycteropus* is peculiar to South Africa.

The family *Bradypodidæ* comprises some exceedingly curious animals which are exclusively confined to South America, inhabiting the vast primæval forests of that continent. The Sloths have a remarkably short and rounded face, and the body is covered with hair. The incisor teeth are altogether wanting, but there are always simple molars, and in the Two-toed Sloth or Unau the first tooth in each jaw on each side is so much larger than the others, and so much more pointed, that it has been regarded as a canine. The stomach is complex, somewhat resembling that of the Ruminants. The cervical vertebræ are generally regarded as being more than the normal seven in number in the Two-toed Sloth, and the long bones have no medullary cavities. The most striking peculiarities, however, about the Sloths are connected with their peculiar mode of life. The Sloths, in fact, are constructed to pass their life suspended from the under surface of the branches of the trees amongst which they live ; and for this end their organisation is singularly adapted. The fore-limbs are much longer than the hind-limbs, and the bones of the fore-arm are unusually movable. All the feet, but especially the fore-feet, are furnished with enormously long curved claws (fig. 190), by the aid of which the animal is enabled to move about freely suspended back-downwards from the branches. Not only is this the ordinary mode of progression amongst the Sloths, but even in sleep the animal appears to retain this apparently unnatural position.

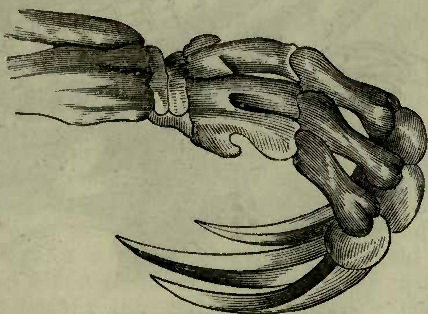


Fig. 190.—Hand of Three-toed Sloth (*Bradypus tridactylus*)—after Owen.

Owing to the disproportionate size of the fore-limbs as compared with the hind-limbs, and owing to the fact that the hind-feet are so curved as to render it impossible to apply the sole to the ground, the Sloth is an extremely awkward animal upon the ground, and it has therefore recourse to terrestrial progression only when absolutely compelled to do so. Whilst the name of "Sloth" may thus appear to be a merited one from the point of view of a terrestrial Mammal, it is wholly undeserved when the animal is looked upon as especially adapted for an arboreal existence.

The second family of the *Edentata* is that of the *Dasypodidæ* or Armadillos. These are found exclusively in South America, as are the Sloths, but they are very different in their habits. The Armadillos are burrowing animals, furnished with strong digging-claws and well-developed collar-bones. The jaws are provided with numerous simple molars, which attain the enormous number of nearly one hundred in the great Armadillo (*Dasypus gigas*). The upper surface of the body is covered with a coat of mail, formed of hard bony plates or shields, united at their edges. A portion of this armour covers the head and shoulders, and another portion protects the hind-quarters; whilst between these is a variable number of movable bands which run transversely across the body, and give the necessary flexibility to this singular dermoskeleton. In some species this flexibility is so great that the animal can roll itself up like a hedgehog. The tail is likewise covered with bony scutes.

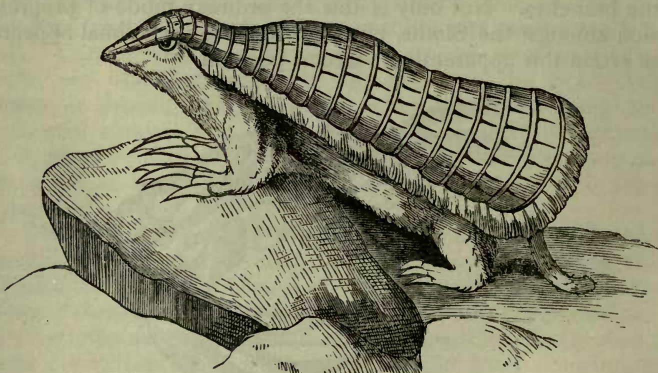


Fig. 191.—*Chlamyphorus truncatus.*

The Armadillos are confined entirely to South America, ranging from Mexico to Patagonia. In this country, also, have been found the remains of a gigantic armour-plated animal allied to the Armadillos, which will be subsequently described under the name of the *Glyptodon.*

The remaining members of the *Edentata* are the various Ant-eaters, but these are so different from one another in their characters that they form three distinct families, also distinguished by their geographical distribution.

a. Myrmecophagidæ.—This family is exclusively confined to South America, as are the two preceding, and it contains only the Hairy or true Ant-eaters. These curious animals feed chiefly upon Ants and Termites, which they catch with their long sticky tongues. The jaws are wholly destitute of teeth; the body is covered with hair; there is a long tail; and the feet are armed with long and strong curved digging-claws.

The best-known species of this family is the "Tamandua" or Great Ant-eater (*Myrmecophaga jubata*). This singular animal attains a length of over four feet, and has an extremely long and bushy tail. The jaws are produced to form a long and slender snout, which is entirely enclosed in the skin, till just at its extremity, where there is an aperture for the protrusion of the thread-like tongue. The anterior feet have four, and the posterior feet five toes, all armed with strong curved claws, which, when not used in digging, are bent inwards, so that the animal walks on the sides of the feet. The animal is perfectly harmless and gentle when unmolested, and leads a solitary life. It lives mainly upon Termites, into the nests of which it forces its way by means of the powerful claws. When the Termites rush out to see what is the matter, the Ant-eater thrusts out its glutinous tongue, an action which can be repeated with marvellous rapidity.

b. Manidæ.—This family includes only the Scaly Ant-eaters or Pangolins, all exclusively confined to the Old World, and found in both Africa and Asia. The whole of the body in the *Manidæ* is covered with an armour of horny imbricated plates, overlapping like the tiles of a house, and apparently consisting of agglutinated hairs. The legs are short, and furnished with five toes each, ending in long and strong digging-claws; but there are no clavicles. The tongue resembles that of the Hairy Ant-eaters in being long and contractile, and capable of being exserted for a considerable distance beyond the mouth. It is covered with a glutinous saliva, and is the agent by which the animal catches ants and other insects. The jaws are wholly destitute of teeth. When threatened by danger, the Pangolins roll themselves up into a ball, like the hedgehogs. The tail is comparatively long, and is covered with scales. Though very strong for their size, none of the species attain a length of more than three or four feet, inclusive of the tail.

c. Orycteropidæ.—The last family of the living Edentata is that of the *Orycteropidæ*, comprising only the single genus *Orycteropus*. This genus comprises only a single species, the

O. Capensis, which is peculiar to South Africa, and is known by the Dutch colonists as the "Aardvark" or Ground-hog. The animal is nocturnal in its habits, and lives upon insects. The body is elongated, and the tail is long, the species attaining a total length of four feet or more. The legs are short, the anterior pair having four unguiculate toes, the posterior five. The claws are strong and curved, and enable the animal to construct extensive burrows. The skin is very thick, and is thinly covered with bristly hairs; and the tail is hairy. The head is elongated, and the mouth small—devoid of incisor and canine teeth, but furnished with a number of cylindrical molars $(\frac{7-7}{6-6})$. The crowns of the molars are flat, and they are composed of dentine traversed by numerous dichotomising pulp-cavities. The tongue is long, and is covered by a sticky saliva, by the aid of which the animal catches insects.

CHAPTER LXXVI.

SIRENIA AND CETACEA.

ORDER IV. SIRENIA.—This order comprises no other living animals except the Dugongs and Manatees, which are often placed with the true *Cetaceans* (Whales and Dolphins) in a common order. There is no doubt, in fact, but that the *Sirenia* are very closely allied to the *Cetacea*, and though they are to be regarded as separate orders, yet they may be advantageously considered as belonging to a single section, which has been called *Mutilata*, from the constant absence of the hind-limbs.

The *Sirenia* agree with the Whales and Dolphins in their complete adaptation to an aquatic mode of life (fig. 192); especially in the presence of a powerful caudal fin, which differs from that of Fishes in being placed horizontally and in being a mere expansion of the integuments, not supported by bony rays. The hind-limbs are wholly wanting, and there is no sacrum. The anterior limbs are converted into swimming-paddles or "flippers." The snout is fleshy and well developed, and the nostrils are placed on its upper surface, and not on the top of the head, as in the Whales. Fleshy lips are present, and the upper one usually carries a moustache. The skin is covered with fleshy bristles. The head is not disproportionately large, as in the true Whales, and is not so gradually prolonged into the body as it is in the latter. There may be only six cervical vertebræ. The teats are two in number and are "thoracic," —*i. e.*, are placed on the chest. There are no clavicles, and the digits have no more than three phalanges each. The testes are retained throughout life within the abdomen, but vesiculæ seminales are present. The animal is diphyodont, the permanent teeth consisting of molars with flattened crowns adapted for bruising vegetable food, and incisors which are present in the young animal, at any rate. In the extinct *Rhytina* it does not appear that there were any incisor teeth.

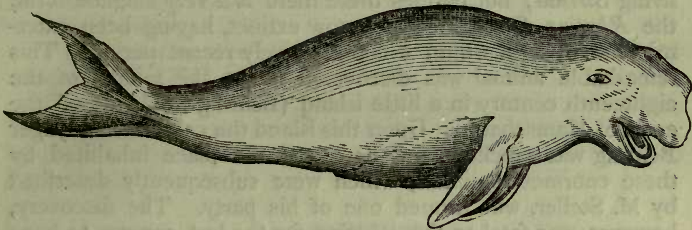


Fig. 192.—Sirenia. Dugong (*Halicore*).

The only existing *Sirenia* are the Manatees (*Manatus*) and the Dugongs (*Halicore*), often spoken of collectively as "sea-cows," and forming the family of the *Manatidæ*.

The Manatees are characterised by the possession of numerous molar teeth ($\frac{8-8}{8-8}$), and of two small upper incisors, which are wanting in the adult. The tail-fin is oblong or oval in shape, and the anterior limbs are furnished with nails to the four outer digits. They occur on the east coast of North America, especially in the Gulf of Mexico, and another species is found on the west coast of Africa. They are generally found in considerable numbers about the mouths of rivers and estuaries, and they appear to live entirely upon sea-weeds, aquatic plants, or the littoral vegetation. They are large awkward animals, attaining a length of from eight to ten feet as a rule, but sometimes growing to a length of nearly twenty feet.

The Dugongs (*Halicore*, fig. 192) have $\frac{5-5}{5-5}$ molar teeth in the young condition, but only $\frac{2-2}{2-2}$ when old. Inferior incisors are present in the young animal, but are wanting in the adult. The upper jaw carries two permanent incisors, which are entirely concealed in the jaw in the females, but which increase in size in the males with the age of the animal, till they become pointed tusks. The anterior extremities are nail-less, and the tail-fin is crescentic in shape. In their general appearance and in their habits the Dugongs differ little from the Manatees, and they are often killed and eaten. They attain a length of from eight to ten, twelve, or more feet, and are found chiefly on the coasts of the Indian Ocean. The bones are remarkable for their extreme density, their texture being nearly as close as ivory.

The Manatees and Dugongs, as before said, are the only living *Sirenia;* but besides these there is a very singular form, the *Rhytina Stelleri*, which is now extinct, having been exterminated by man within a comparatively recent period. This remarkable animal was discovered about the middle of the eighteenth century in a little island (Behring's Island) off the coast of Kamschatka. Upon this island the celebrated voyager Behring was wrecked, and he found the place inhabited by these enormous animals, which were subsequently described by M. Steller, who formed one of his party. The discovery, however, was fatal to the *Rhytina*, for the last appears to have been seen in the year 1768. The *Rhytina* was an animal of great size, measuring twenty-five feet in length, and twenty feet at its greatest circumference. There can hardly be said to have been any true teeth, but the jaws contained $\frac{1-1}{1-1}$ large lamelliform fibrous structures, which officiated as teeth, and may be looked upon as molars. The epidermis was extremely thick and fibrous, and hairs appear to have been wanting. There was a crescentic tail-fin, and the anterior limbs alone were present.

ORDER V. CETACEA.—In this order are the Whales, Dolphins, and Porpoises, all agreeing with the preceding in their complete adaptation to an aquatic life (figs. 195, 196). The body is completely fish-like in form; the anterior limbs are converted into swimming-paddles or "flippers"; the posterior limbs are completely absent; and there is a powerful, horizontally-flattened, caudal fin, sometimes accompanied by a dorsal fin as well. In all these characters the *Cetacea* agree with the *Sirenia*, except in the one last mentioned. On the other hand, the nostrils, which may be single or double, are always placed at the top of the head, constituting the so-called "blow-holes" or "spiracles"; and they are never situated at the end of a snout. The body is very sparingly furnished with hairs, or the adult may be completely hairless. The testes are retained throughout life within the abdomen and there are no vesiculæ seminales. The teats are two in number and are placed upon the groin. The head is generally of disproportionately large size, and is never separated from the body by any distinct constriction or neck. The lumbar region of the spine is long, and, as in the *Sirenia*, there is no sacrum, and the pelvis is only present in a rudimentary form. There are no clavicles, and some of the digits may possess more than three phalanges each. Lastly, the adult is either destitute of teeth or is monophyodont—that is to say, possesses but a single set of teeth, which are never replaced by others. When teeth are present, they are usually conical and numerous, and they are always of one kind only.

The *Cetacea* may be divided into the three families of the *Balænidæ* or Whalebone Whales, the *Delphinidæ* or Dolphins and Porpoises, and the *Catodontidæ* or Sperm Whales. Of these, the *Balænidæ* are often spoken of as the "toothless" Whales, whilst the other two families are called the "toothed" Whales (*Odontoceti*).

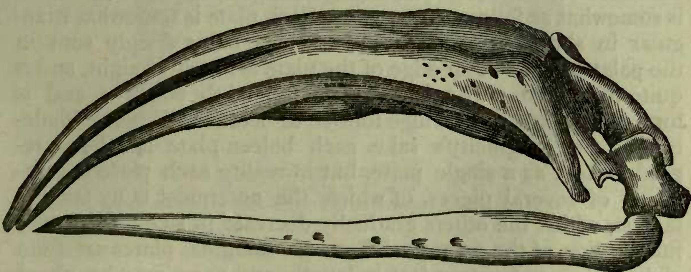


Fig. 193.—Skull of the Right Whale *Balæna mysticetus*)—after Owen.

Fam. 1. *Balænidæ.*—The *Balænidæ* or Toothless Whales are characterised by the total absence of teeth in the adult (fig. 193). Teeth, however, are present in the fœtal Whale, but they never cut the gum. The place of teeth is supplied by a number of plates of whalebone or "baleen" attached to the palate; hence the name of "whalebone Whales" often given to this family. They are the largest of living animals, and may be divided into the two sections of the *Smooth* Whales, in which the skin is smooth and there is no dorsal fin (as in the Greenland Whale), and the *Furrowed* Whales, in which the skin is furrowed and a dorsal fin is present (as in the so-called Finner Whales and Hump-backed Whales).

The Greenland or "Right" Whale (*Balæna mysticetus*) will illustrate almost all the leading points of interest in the family. The Greenland Whale is the animal which is sought after in the whale-fishery of Europe, and hence the name of "Right" Whale often applied to it. It is an inhabitant of the Arctic seas, and reaches a length of from forty to sixty feet. Of this enormous length, nearly one-third is made up of the head, so that the eye looks as if it were placed nearly in the middle of the body. The skin is completely smooth, and is destitute of hairs in the adult. The fore-limbs are converted into "flippers" or swimming-paddles, but the main organ of progression is the tail, which often measures from twenty to twenty-five feet in breadth. The mouth is of enormous size, the upper jaw somewhat smaller than the lower, and both completely destitute of teeth. Along the middle of the palate runs a strong keel bordered by two lateral depressions, one on each side. Arranged transversely in these lateral depressions are an enormous number of horny plates, constituting what is known as the "baleen" plates, from which the whalebone of commerce is derived. The arrangement of the plates of baleen is somewhat as follows (fig. 194):—Each plate is somewhat triangular in shape, the shortest side or base being deeply sunk in the palate. The outer edge of the plate is nearly straight, and is quite unbroken. The inner edge is slightly concave, and is furnished with a close fringe formed of detached fibres of whalebone. For simplicity's sake each baleen-plate has been regarded here as a single plate, but in reality each plate is composed of several pieces, of which the outermost is by far the largest, whilst the others gradually decrease in size towards the middle line of the palate. The large marginal plates are from eight to ten or fourteen feet in length, and there may be about two hundred on each side of the mouth.

The object of the whole series of baleen-plates with which the palate is furnished, is as follows:—The Whale is a strictly carnivorous or zoophagous animal, but owing to the absence of teeth, and the comparatively small calibre of the œsophagus, it lives upon very diminutive animals. The Whale, in fact, lives mostly upon the shoals of small Pteropodous Molluscs, *Ctenophora*, and *Medusæ*, which swarm in the Arctic seas. To obtain these, the Whale swims with the mouth opened, and thus fills the mouth with an enormous mass of water. The baleen-plates have the obvious function of a "screening-apparatus." The water is strained through the numerous plates of baleen, and all the minute animals which it contains are arrested and collected together by the inner fibrous edges of the baleen-plates. When, by a repetition of this process, the Whale has accumulated a sufficient quantity of food within the central cavity of the mouth, it is enabled to swallow it, without taking the water at the same time.

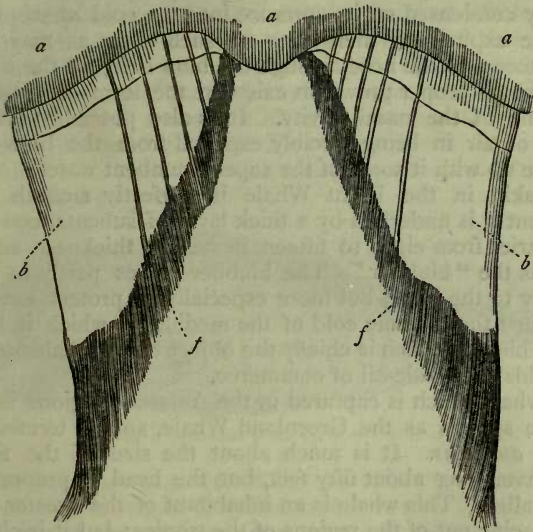


Fig. 194.—Diagram of the Baleen-plates of a Whale. *a a* Section of the palatal surface of the upper jaw, showing the strong median ridge or keel; *b b* Baleen-plates, sunk at their bases in the palate; *f f* Fibrous margin of Baleen-plates.

We have now to speak of a phenomenon which has given rise to a considerable amount of controversy, namely, what is known as the "blowing" or "spouting" of the whale. In all the Cetaceans the nose opens by a single or double aperture (the latter in the *Balænidæ*) upon the top of the head, and these external apertures or nostrils are known as the "blow-holes" or "spiracles." The act known to the whalers as "blowing" consists in the expulsion from the blow-holes of a jet of what is apparently water, or at any rate looks like it. The act is performed by the whale upon rising to the surface, and it is usually by this that the whereabouts of the animal is discovered. The old view as to what takes place in the act of blowing is, that the whale is really occupied in getting rid of the surplus water which it has taken in at the mouth and strained through the baleen-plates. The modern, and doubtless correct, view, however, is that the water which has been strained through the baleen really makes its escape at the side of the mouth, and does not enter the pharynx to be expelled through the nose. Upon this view the apparent column of water emitted from the blow-holes in the act of blowing consists really of the expired air from the lungs, the contained watery vapour of which is suddenly condensed on its entrance into the cold atmosphere. With the expired air there may be such water as may have gained access to the nose through the blow-hole, for the expulsion of which proper provision exists in the form of muscular diverticula of the nasal cavity. It is also possible that the column of air in being forcibly expelled from the blow-hole may take up with it some of the superincumbent water.

The skin in the Right Whale is perfectly smooth and naked, but it is underlaid by a thick layer of subcutaneous fat, which varies from eight to fifteen inches in thickness, and is known as the "blubber." The blubber serves partly to give buoyancy to the body, but more especially to protect the animal against the extreme cold of the medium in which it lives. It is the blubber which is chiefly the object of the whale-fishery, as it yields the whale-oil of commerce.

The whale which is captured in the Antarctic regions is not the same species as the Greenland Whale, and is termed the *Balæna australis.* It is much about the size of the Right Whale, averaging about fifty feet, but the head is proportionately smaller. This whale is an inhabitant of the greater part of the Pacific out of the regions of the tropics; but it is chiefly captured when approaching land, which the females do for the purpose of bringing forth their young.

The only remaining members of the *Balænidæ* which require notice are the Rorquals and Hump-backed Whales, constituting the group of the "Furrowed" Whales. These are collectively distinguished by having the skin furrowed or plaited to a greater or less extent, whilst the baleen-plates are short, and there is a dorsal fin. The specific determination of these animals is a matter of great difficulty, but there would appear to be two very well marked genera:—1. The genus *Megaptera*, including the so-called Hump-backed Whales, in which the flippers are of great length, from one-third to one-fifth of the entire length of the body. 2. The genus *Balænoptera*, comprising the so-called Rorquals or Piked Whales, in which the flippers are of moderate size.

In both genera there is a dorsal adipose fin, so that they are both "Finner" Whales. The *Balænopteræ* reach a gigantic size, being sometimes as much as eighty or one hundred feet in length. They are very active animals, however, and their whalebone is comparatively valueless, so that the whalers rarely meddle with them, though they are not uncommon, and are often driven ashore on our own coasts.

Fam. 2. *Catodontidæ.* — The family of the *Catodontidæ* or *Physeteridæ* comprises the Sperm Whales or Cachalots, with which we commence the series of the Toothed Whales (*Odontoceti*). They are characterised by the fact that the palate is destitute of baleen-plates, and the lower jaw possesses a series (about fifty-four) of pointed conical teeth, separated by intervals, and sunk in a common alveolar groove, which is only imperfectly divided by septa. The upper jaw is also in reality furnished with teeth, but, with a single partial exception, these do not cut the gum.

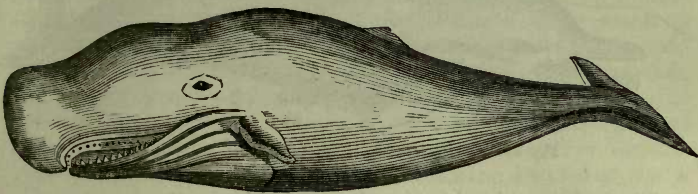


Fig. 195.—Spermaceti Whale (*Physeter macrocephalus*).

The best-known species of this family is the great Cachalot or Spermaceti Whale (*Physeter macrocephalus*, fig. 195). This animal is of enormous size, averaging from fifty to seventy feet in length, but the females are a good deal smaller than the males. The head is disproportionately large, as in the *Balænidæ*, forming nearly one-third of the entire length of the body. The snout forms a broad truncated muzzle, and the nostrils are placed near the front margin of this. The Sperm Whales live together in troops or "schools," and they are found in various seas, especially in the North Pacific. They are largely sought after, chiefly for the substance known as "spermaceti;" but besides this they yield oil and the singular body called "ambergris." The spermaceti is a fatty substance which has the power of concreting when exposed to the air. It is not only diffused through the entire blubber, but is also contained in special cavities of the head. The sperm-oil yielded by the blubber is exceedingly pure, and is free from the unpleasant odour of ordinary whale-oil. The ambergris is a peculiar substance which is found in masses in the intestine, and is probably of the nature of a biliary calculus, since it is said to be composed of a substance very nearly allied to cholesterine. It is used both as a perfume itself, and to mix with other perfumes.

Fam. 3. *Delphinidæ.*—This family includes the Dolphins, Porpoises, and Narwhal, and is characterised by usually possessing teeth in both jaws; the teeth being numerous, and conical in shape. The nostrils, as in the last family, are united, but they are placed further back, upon the top of the head. The single blow-hole or nostril is transverse and mostly crescentic or lunate in shape. The head is by no means so disproportionately large as in the former families, usually forming about one-seventh of the entire length of the body.

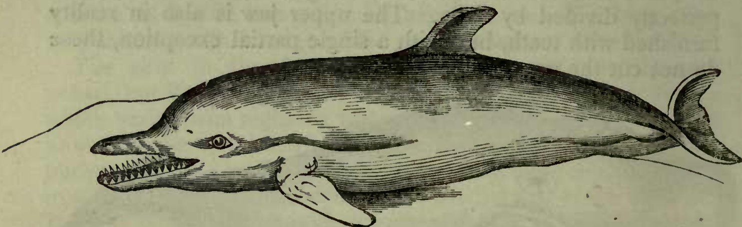


Fig. 196.—The common Dolphin (*Delphinus delphis*).

The most noticeable members of this family are the true Dolphins, the Porpoises, and the Narwhal.

The Dolphins have an elongated snout, separated from the head by a transverse depression. The common Dolphin (*Delphinus delphis*, fig. 196) is the best-known species. It averages from six to eight feet in length, and has the habit of swimming in flocks, often accompanying ships for many miles. The female, like most of the *Cetacea*, is uniparous. The Dolphin occurs commonly in all European seas, and is especially abundant in the Mediterranean.

The common Porpoise (*Phocæna communis*) is the commonest and smallest of all the *Cetacea*, rarely exceeding four feet in length. The head is blunt, and is not produced into a projecting muzzle. The Porpoise frequents the North Sea, and is commonly seen off our coasts. Another British species is the Grampus (*Phocæna orca*), but this is much larger, attaining a length of from eighteen to twenty feet. Nearly allied to the Grampus is the so-called "Caing" Whale, or, as it is sometimes termed, the "Bottle-nosed" Whale (*Globicephalus* or *Phocæna globiceps*). This species occurs not uncommonly round the Orkney and Shetland Islands, and attains a length of as much as twenty-four feet. It is gregarious in its habits, and is often killed for the sake of its oil.

Closely allied to the true Dolphins are two curious Cetaceans, belonging to different genera, but both inhabiting fresh waters. One of these is the Gangetic Dolphin (*Platanista Gangetica*), which inhabits the Ganges, especially near its mouth. This singular animal is characterised by the great length of its slender muzzle, and by the small size of the eyes. It attains the length of seven feet, and the blow-hole is a longitudinal fissure, and therefore quite unlike that of the typical *Delphinidæ.* The other fresh-water form is the *Inia Boliviensis*, which inhabits the rivers of Bolivia, and is found at a distance of more than two thousand miles from the sea. In its essential characters it differs little from its marine brethren, and it attains a length of from seven (female) to fourteen feet (male).

The last of the *Delphinidæ* is the extraordinary Narwhal or Sea-unicorn (*Monodon monoceros*). The Narwhal is an inhabitant of the Arctic seas, and attains a length of as much as fifteen feet, counting in the body alone. The dentition, however, is what constitutes the great peculiarity of the Narwhal. The lower jaw is altogether destitute of teeth, and the upper jaw in the females also exhibits no teeth externally, as a general rule at any rate, though there are two rudimentary incisors which do not cut the gum. In the males, the lower jaw is likewise edentulous, but the upper jaw is furnished with two molar teeth concealed in the gum, and with two incisors. Of these two upper incisors, that of the right side is generally rudimentary, and is concealed from view. The left upper incisor, on the other hand, is developed from a permanent pulp, and grows to an enormous size, continuing to increase in length throughout the life of the animal. It forms a tusk of from eight to ten feet in length, and it has its entire surface spirally twisted. As an abnormality, both the upper incisors may be developed in this way so as to form projecting tusks; and it is stated that the tusk is occasionally present in the female. The function of this extraordinary tooth is doubtless offensive.

CHAPTER LXXVII.

UNGULATA.

Order VI. Ungulata.—The order of the *Ungulata*, or Hoofed Quadrupeds, is one of the largest and most important of all the divisions of the *Mammalia*. It comprises three entire old orders —namely, the *Pachydermata*, *Solidungula*, and *Ruminantia*.

The first of these old divisions—that of the *Pachydermata*—included the Elephants, Rhinoceros, Hippopotamus, Tapirs, and the Pigs, all characterised, as the name implies, by their thick integuments. The name is still used to express this fact, though the order is now abandoned, and is merged with that of the *Ungulata;* the Elephants alone being removed to a separate order under the name of *Proboscidea.*

The second old order—that of the *Solidungula* or Solipedes—included the Horse, Zebra, and Ass, all characterised by the fact that the foot terminates in a single toe, encased in an expanded hoof. The name *Solidungula* is still retained for these animals, as a section of the *Ungulata.*

The third old order—that of the *Ruminantia*—includes all those animals, such as Oxen, Sheep, Goats, Camels, Giraffes, Deer, and others, which chew the cud or "ruminate," and have two functional toes to each foot, encased in hoofs. The name *Ruminantia* is still retained for these animals, as constituting a most natural group of the *Ungulata.*

All these various animals, then, are now grouped together into the single order of the *Ungulata*, or Hoofed Quadrupeds, and the following are the characters of the order :—

All the four limbs are present, and that portion of the toe which touches the ground is always encased in a greatly-ex-

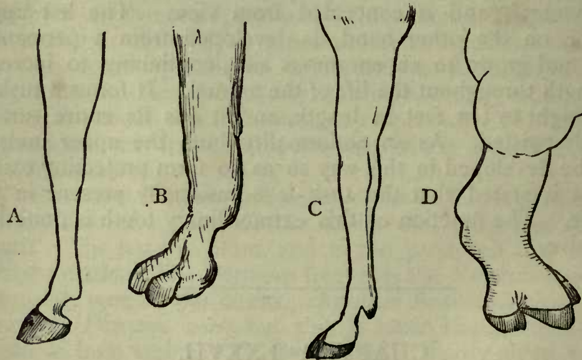


Fig. 197.—Ungulata. A, Perissodactyle foot of Zebra (*Solidungula*); B, Artiodactyle foot of Llama; C, Artiodactyle foot of Antelope; D, Perissodactyle foot of Rhinoceros.

panded nail, constituting a "hoof." There are never more than *four* full-sized toes to each limb. Owing to the encasement of the toes in hoofs, the limbs are useless for prehension, and only subserve locomotion; hence *clavicles* are always wanting in the entire order. There are always two sets of enamelled teeth, so that the animal is diphyodont. The molar teeth are massive and have broad crowns, adapted for grinding vegetable substances.

The order *Ungulata* is divided into two primary sections:—the *Perissodactyla*, in which the toes or hoofs are odd in number (one or three), and the *Artiodactyla*, in which the toes are even in number (two or four).

SECTION A. PERISSODACTYLA.—The section of the *Perissodactyle* Ungulates includes the Rhinoceros, the Tapirs, the Horse and its allies, and some extinct forms, all agreeing in the following characters:—

The hind-feet are odd-toed in all (fig. 197, A, D), and the fore-feet in all except the Tapirs. The dorso-lumbar vertebræ are never less than twenty-two in number. The femur has a third trochanter. The horns, if present, are not paired. Usually there is only one horn, but if there are two, these are placed in the middle line of the head, one behind the other (fig. 198). In neither case are the horns ever supported by bony horn-cores. The stomach is simple, and is not divided into several compartments; and there is a large and capacious cæcum.

The three existing genera of Perissodactyle Ungulates—namely, the Horse, Tapir, and Rhinoceros, are widely removed from one another in many important characters; but the intervals between them are filled up by an extensive series of fossil forms, commencing in the Lower Tertiary Strata.

Fam. 1. *Rhinoceridæ.*—This family comprises only a single genus, the genus *Rhinoceros*, unless, indeed, the little *Hyrax* is to be retained in this order. The Rhinoceroses are extremely large and bulky brutes, having a very thick skin, which is usually thrown into deep folds. The muzzle is rounded and blunt, and there are $\frac{7-7}{7-7}$ molars, with tuberculate crowns. There are no canines, but there are usually incisor teeth in both jaws. The feet are furnished with three toes each, encased in hoofs. The nasal bones support one or two horns, which are not paired. The horn is composed of longitudinal fibres, which are agglutinated together, and are of the nature of epidermic growths, somewhat analogous to hairs. When two horns are present, the hinder one is carried by the frontal bones, and is placed in the middle line of the head behind the anterior horn. The posterior horn is usually much shorter than the anterior one, and if not, it differs in shape. The Rhinoceroses live in marshy places, and subsist chiefly on the foliage of trees. They are exclusively confined at the present day to the warmer parts of the Old World; but an extinct species (*Rhinoceros tichorhinus*) formerly inhabited England, and ranged over the greater part of Europe. Of the one-horned species, the best known is the Indian Rhinoceros (*R. Indicus*), which was probably the "Unicorn" of the ancients. Another species with one horn (*R. Sondaicus*) inhabits Java. Of the two-horned species, one (*R. Sumatrensis*) is found in Sumatra, and is remarkable for the comparative absence of cutaneous folds. The best known, however, is the African Rhinoceros (*R. bicornis*), which occurs abundantly in Cape Colony and in the southern parts of the African continent (fig. 198.)

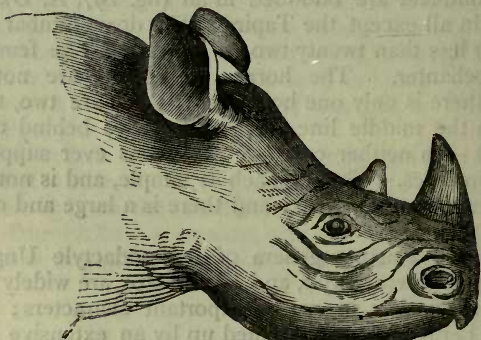


Fig. 198.—Head of two-horned Rhinoceros (*R. bicornis*).

Fam. 2. *Tapiridæ.*—The Tapirs are characterised by the possession of a short movable proboscis or trunk. The skin is hairy and very thick. The tail is extremely short. The fore-feet have *four* toes each, but these are unsymmetrical, and the hind-feet have only three toes, all encased in hoofs. The jaws are furnished with incisor teeth, ($\frac{3-3}{3-3}$), small canines, and $\frac{7-7}{6-6}$ molars.

Three species of Tapir are known, of which the most familiar is the American Tapir (*T. Americanus*), which inhabits the vast forests of South America. It is a large animal, something like a pig in shape, but brownish black in colour. It is nocturnal in its habits, and is strictly phytophagous. The proboscis is employed in conveying the food to the mouth, and the nostrils are placed at its extremity. It attains altogether a total length of from five to six feet. Another species, with longer hair (*T. villosus*), inhabits the Andes, and a still larger species (*T. Malayanus*) is found in Sumatra and Malacca.

Nearly allied to the Tapirs is the fossil genus *Palæotherium*, found in the Eocene Rocks of France and other countries. Many species of the genus are known, all seeming to have possessed a short proboscis like that of the Tapirs. All the feet, however, were tridactylous.

Fam. 3. *Solidungula* or *Equidæ*.—This family comprises the Horses, Asses, and Zebras, characterised by the fact that the feet have only a single perfect toe each, enclosed in a single broad hoof, without supplementary hoofs (fig. 197, A). There is a discontinuous series of teeth in each jaw; and in the males, canines are present, but these are wanting in the females. The dental formula is—

$$i\ \frac{3-3}{3-3};\ c\ \frac{1-1}{1-1};\ pm\ \frac{3-3}{3-3};\ m\ \frac{3-3}{3-3} = 40.$$

The skin is covered with hair, and the neck is furnished with a mane.

The family *Equidæ* is divided by Dr Gray into two sections or genera: *Equus*, comprising the Horse; and *Asinus*, comprising the Asses and Zebras.

The genus *Equus* is distinguished by the fact that the animal is not banded, and has no dorsal line, both the fore and hind legs have warts, and the tail is hairy throughout. The genus appears to contain no more than one well-marked species, as far as living forms are concerned—namely, the *Equus caballus*. From this single species appear to have descended all the innumerable varieties of horses which are employed by man. The native country of the horse appears to have been Central Asia, but all the known wild individuals at the present day appear to be descendants of domestic breeds.

The genus *Asinus* is characterised by the fact that there is always a distinct dorsal line, and the body is more or less banded, the fore-legs alone have warts, and the tail has a tuft of long hairs at its extremity. The Ass is probably a native of Asia (where the wild Ass is at present a native), and there appears to be little doubt but that the common Ass is merely the domesticated form of the wild Ass (*Equus onager*). The striped members of this section are known as Zebras and Quaggas, and are natives of the southern parts of Africa.

SECTION B. ARTIODACTYLA.—In this section of the Ungulates the number of the toes is even—either two or four—and the third toe in each foot forms a symmetrical pair with the fourth (fig. 197, B, C). The dorso-lumbar vertebræ are nineteen in number, and there is no third trochanter on the femur. If true horns are present, these are always in pairs, and are supported by a bony horn-core. The antlers of the Deer are also paired, but they are not to be regarded as true horns. The stomach is always more or less complex, or is divided into separate compartments, and the cæcum is comparatively small and simple.

The section *Artiodactyla* comprises the Hippopotamus, the Pigs, and the whole group of the Ruminants, including Oxen, Sheep, Goats, Antelopes, Camels, Llamas, Giraffes, Deer, &c. Besides these there is an extensive series of fossil forms commencing in the Eocene or Lower Tertiary period, and in many respects filling up the gaps between the living forms.

OMNIVORA.

1. *Hippopotamidæ.*—This group contains only the single genus *Hippopotamus*, characterised by the massive heavy body, the short blunt muzzle, the large head, and the presence of teeth of three kinds in both jaws. The incisors are $\frac{2-2}{2-2}$, the canines extremely large, $\frac{1-1}{1-1}$, and the molars $\frac{7-7}{7-7}$ or $\frac{6-6}{6-6}$, with crowns adapted for grinding vegetable substances. The feet are massive, and are terminated by four hoofed toes each. The eyes and ears are small, and the skin is extremely thick, and is furnished with few hairs. The tail is very short.

Several extinct species of *Hippopotamus* are known, but there is only one well-established living form, the *Hippopotamus amphibius*, and this is confined to the African continent. It is an enormously bulky and unwieldy animal, reaching a length of eleven or twelve feet. It is nocturnal in its habits, living upon grass and small shrubs, and it swims and dives with great facility. It is found in tolerable abundance in the rivers of Abyssinia, and occurs plentifully in South Africa. Another supposed species (*H. Liberiensis*) occurs on the west coast of Africa, but there is some doubt as to the specific distinctness of this.

2. *Suidæ.*—The group of the *Suidæ*, comprising the Pigs, Hogs, and Peccaries, is very closely allied to the preceding; but the feet have only two functional toes, the other two toes being placed at some elevation above the ground, and being rudimentary. All the three kinds of teeth are present, but they vary a good deal. The canines always are very large, and in

the males they usually constitute formidable tusks projecting from the sides of the mouth. The molars vary from three to seven on each side of the mouth $(\frac{3-3}{3-3}$ or $\frac{7-7}{7-7})$. The stomach is mostly slightly divided, and is not nearly so complex as in the Ruminants. The snout is truncated and cylindrical, and is capable of considerable movement. The skin is more or less abundantly covered with hair, and the tail is very short, or represented only by a tubercle.

Of the true Swine, the best known and most important is the Wild Boar (*Sus scrofa*), from which it is probable that all our domestic varieties of swine have sprung. The Wild Boar formerly inhabited this country, and is still abundant in many of the forests of Europe. It is often hunted, and the size and sharpness of its canines render it a tolerably formidable adversary, as is also its congener, the Indian Hog (*Sus Indicus*). Another curious form, closely related to the Wild Boar, is the Babyroussa (*Sus Babyrussa*), which inhabits the Malayan Peninsula, and some of the islands of the Indian Archipelago. It is remarkable for the great size and backward curvature of the upper canines.

The African Wart-hogs, forming the genus *Phacochœrus*, are distinguished by having a fleshy wart under each eye. They inhabit Abyssinia, the Guinea coast, and other parts of Africa.

The American Peccaries (*Dicotyles*) represent the Swine of the Old World. They are singular for having only three toes on the hind-feet, the outer of the two supplemental hoofs being wanting. They are exclusively confined to America, and the commonest species is the Collared Peccary (*Dicotyles torquatus*). They are not at all unlike small pigs either in their appearance or in their habits, and they are gregarious, generally occurring in small flocks.

Forming a kind of transition between the Swine and the true Ruminants, is the extinct group of the *Anoplotheridæ*, from the Lower Tertiary Rocks. The *Anoplotheria* were slender in form, with long tails, and feet terminated by two hoofed toes each, sometimes with small accessory hoofs. The dentition consisted of six incisors in each jaw, small canines not larger than the incisors, and seven molars on each side, there being no interval or diastema between the molars and the canines.

RUMINANTIA.

The last section of the *Artiodactyle* Ungulates is the great and natural group of the *Ruminantia*, or Ruminant animals.

This section comprises the Oxen, Sheep, Antelopes, Giraffes, Deer, Camels, &c., and is distinguished by the following characters:—

The foot is what is called "cloven," consisting of a symmetrical pair of toes encased in hoofs, and looking as if produced by the splitting into two equal parts of a single hoof. In addition to these functional toes, there are usually two smaller supplementary hoofs placed at the back of the foot. The metacarpal bones of the two functional toes of the fore-limb, and the metatarsal bones of the same toes of the hind-limb, coalesce to form a single bone, known as the "canon-bone." The stomach is complex, and is divided into several compartments, this being in accordance with their mode of eating. They all, namely, ruminate or "chew the cud"—that is to say, they first swallow their food in an unmasticated or partially-masticated condition, and then bring it up again, after a longer or shorter time, in order to chew it thoroughly.

This process of rumination is so characteristic of this group, that it will be necessary to describe the structure of the stomach, as showing the mechanism by which this singular process is effected. The stomach (fig. 199) is divided into four compartments, which are usually so distinct from one another that they have generally been spoken of as so many separate stomachs. The gullet opens at a point situated between the first and second of these cavities or "stomachs." Of these the largest lies on the left side, and is called the "rumen" or "paunch" (fig. 199, *r*.) This is a cavity of very large capacity, having its interior furnished with numerous hard papillæ or warts. It is the chamber into which the food is first received when it is swallowed, and here it is moistened and allowed to soak for some time. The second stomach, placed to the right of the paunch, is much smaller, and is known as the "reticulum" or "honeycomb-bag" (*h*). Its inner surface is reticulated, or is divided by ridges into a number of hexagonal or many-sided cells, somewhat resembling the cells of a honeycomb. The reticulum is small and globular, and it receives the food after it has lain a sufficient time in the paunch. The function of the reticulum is to compress the partially-masticated food into little balls or pellets, which are then returned to the mouth by a reversed action of the muscles of the œsophagus. After having been thoroughly chewed and prepared for digestion, the food is swallowed for the second time. On this occasion, however, the triturated food passes on into the third cavity (*p*), which is variously known as the "psalterium," "omasum," or (*Scotticé*) the "manyplies." The vernacular and the first of these technical names both refer to the fact that the inner lining of this cavity is thrown into a number of longitudinal folds, which are so close as to resemble the leaves of a book. The psalterium opens by a wide aperture into the fourth and last cavity, the "abomasum" (*a*), both appearing to be divisions of the pyloric

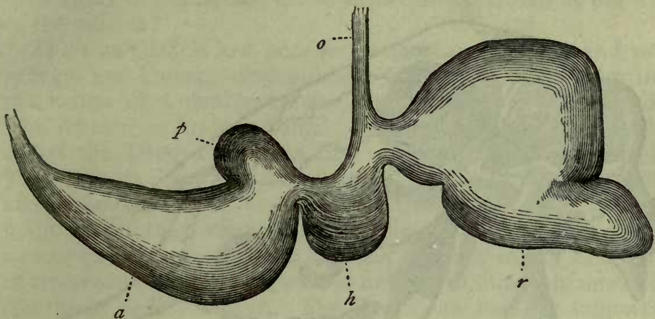


Fig. 199.—Stomach of a Sheep. *o* Gullet; *r* *Rumen* or Paunch; *h* Honeycomb-bag or *Reticulum*; *p* Manyplies or *Psalterium*; *a* Fourth Stomach or *Abomasum*.

portion of the stomach. The mucous membrane of the abomasum is thrown into a few longitudinal folds, and it secretes the true acid gastric juice. It terminates, of course, in the commencement of the small intestine—*i.e.*, the duodenum. The intestinal canal of Ruminants, as in most animals which live exclusively upon a vegetable diet, is of great relative length.

The dentition of the Ruminants presents peculiarities almost as great and as distinctive as those to be derived from the digestive system. In the typical Ruminants (*e.g.*, Oxen, Sheep, Antelopes), there are no incisor teeth in the upper jaw, their place being taken by a callous pad of hardened gum, against which the lower incisors impinge (fig. 200). There are also no upper canine teeth, and the only teeth in the upper jaw are six molars on each side. In the front of the lower jaw is a continuous and uninterrupted series of eight teeth, of which the central six are incisors, and the two outer ones are regarded by Owen as being canines. Upon this view, canine teeth are present in the lower jaw of the typical Ruminants, and they are only remarkable for being placed in the same series as the incisors, which they altogether resemble in shape, size, and direction. Behind this continuous series of eight teeth in the lower jaw there is a vacant space, which is followed behind by six molars on each side.

The dental formula, then, for a typical Ruminant animal is—

$$i\,\frac{0-0}{3-3};\; c\,\frac{0-0}{1-1};\; pm\,\frac{3-3}{3-3};\; m\,\frac{3-3}{3-3} = 32.$$

The departures from this typical formula occur in the *Camelidæ* and in some of the Deer. Most of the Deer conform in their

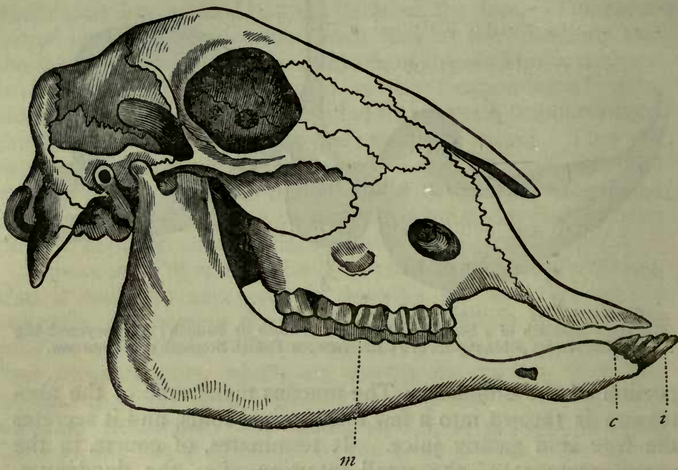


Fig. 200.—Skull of a hornless Sheep (after Owen). *i* Incisors; *c* Canines; *m* Molars and præmolars.

dentition to the above formula, but a few forms (*e.g.*, the Musk-deer) have canine teeth in the upper jaw. These upper canines, however, are mostly confined to the males; and if they occur in the females, they are of a small size. The dentition of the *Camelidæ* (Camels and Llamas) is still more aberrant; there being two upper incisors and upper canines as well. The lower canines also are more pointed and stand more erect than the lower incisors, so that they are easily recognisable. The group of the *Ruminantia* includes the families of the *Camelidæ* (Camels and Llamas), the *Moschidæ* (Musk-deer), the *Cervidæ* (Deer), the *Camelopardalidæ* (Giraffe), and the *Cavicornia* (Oxen, Sheep, Goats, Antelopes).

a. Camelidæ.—The Camels and Llamas constitute in many respects an aberrant group of the *Ruminantia*, especially in their dentition, the peculiarities of which have been spoken of above, and need not be repeated here. In their feet, too, the *Camelidæ* are peculiar. The feet are long and terminate in only two toes, which are covered by an imperfect nail-like hoof, covering no more than the upper surface of each toe. The two hinder supplementary toes, which are generally present in the Ruminants, are here altogether wanting; and the soles of the feet are covered by a callous horny integument upon which the animal walks. The head in all the *Camelidæ* is destitute of horns, and the nostrils can be closed at the will of the animal.

The true Camels are peculiar to Asia and Africa, and two species are known, distinguished from one another by the possession of a double or single adipose hump on the back. The African or Arabian Camel (*Camelus Dromedarius*) is often called the Dromedary, and has only one hump on its back. The two toes are united together by the callous sole; and the chest, shoulders, and knees are furnished with callous pads, upon which they rest when they lie down. The hump is almost entirely composed of fat, and appears to act as a kind of reserve supply of food, as it is noticed to diminish much in size upon long journeys. The Camel can likewise support a very prolonged deprivation of water, as the paunch is furnished with large cells, which the animal fills when it has access to water, and then makes use of subsequently as occasion may require. The structure of the Camel adapts it admirably for locomotion in the sandy deserts of Arabia and Africa; and as it is very docile and good-tempered, it is almost exclusively employed as a beast of burden in the countries in which it occurs.

The Bactrian Camel (*C. Bactrianus*) is distinguished by the possession of two humps; but in other respects it does not differ from the Dromedary. The two species are said to breed together, and the hybrid offspring is stated to be occasionally fertile. The place of the Camels is taken in the New World by the Llama and Alpaca, with two other nearly-allied forms. These animals form the genus *Auchenia*, and are in many respects similar to the true Camels. They are distinguished, however, by having no hump upon the back, and by the fact that the sole of the foot is destitute of a callous pad. The Llamas are chiefly found in Peru and Chili, and considerable doubt exists as to the number of species. They live in flocks in mountainous regions, and are much smaller than the Camels in size. The true Llama is kept as a domesticated animal, and used as a beast of burden. The Alpaca is still smaller than the Llama, and is not very unlike a sheep, having a long woolly coat. It is partially domesticated, and the wool is largely imported into Europe.

b. Moschidæ.—The second group is that of the Musk-deer, characterised by the total absence of horns in both sexes, and by the presence of canines in both jaws, those in the upper jaw being in the form of tusks in the males, but being much smaller in the females.

The true Musk-deer (*Moschus moschiferus*) is an elegant little animal, which inhabits the elevated plains of central Asia. It is remarkable for the fact that the male has a glandular sac on the abdomen, by which the well-known perfume, musk, is secreted.

c. Cervidæ.—This family is of much greater importance than that of the *Moschidæ*, including as it does all the true Deer. They are distinguished from the other Ruminants chiefly by the nature of the horns. With the single exception of the Reindeer, these appendages are confined to the males amongst the *Cervidæ*, and do not occur in the females. They do not consist, as in the succeeding group, of a hollow sheath of horn surrounding a central bony core, nor are they permanently retained by the animal. On the other hand, the horns, or, as they are more properly called, the *antlers*, of the *Cervidæ* are deciduous, and are solid. They are bony throughout, and are usually more or less branched, and they are annually shed and annually reproduced at the breeding season. They increase in size and in the number of branches every time they are reproduced, until in the old males they may attain an enormous size. The antlers are carried upon the frontal bone, and are produced by a process not at all unlike that by which injuries of osseous structures are made good in man. At first the antlers are covered with a sensitive hairy skin; but as development proceeds, the vessels of the skin are gradually obliterated, and the skin dies and peels off. In all the Deer there is a sebaceous gland, called the "lachrymal sinus," or "larmier," which is placed beneath each eye, and secretes a strongly-smelling waxy substance.

The *Cervidæ* are very generally distributed, but no member of the group has hitherto been discovered in either Australia or South Africa, their place in the latter continent seeming to be taken by the nearly-allied Antelopes (distinguished by their hollow horns).

Very many species of *Cervidæ* are known, and it is not possible to allude to more than two or three of the more familiar and important forms. Three species occur in Britain—namely, the Roebuck, Red-deer, and Fallow-deer, the last being a doubtful native. The Roebuck (*Capreolus capræa*) was once very generally distributed over Britain, but is almost confined to the wilder parts of Scotland at the present day. It is of small size, and the horns are without brow-tynes, and are of small size, with three terminal branches. The Red-deer, or Stag (*Cervus elephus*) is a much larger species, with well-developed spreading antlers. It is still found in the Lake-district and in Scotland, but it is gradually in process of extermination. The Red-deer of this country is represented in North America by a still larger species, known as the Wapiti (*Cervus Canadensis*).

The third British species is the Fallow-deer (*Dama platyceros*), characterised by the fact that the antlers are palmated—that is, dilated towards their extremities. It is a doubtful native, and is never found in a wild state at the present day. Allied to the Fallow-deer is a gigantic extinct species, the *Megaceros Hibernicus*, which inhabited Ireland, the Isle of Man, Scotland, and probably the greater part of Europe, up to a comparatively modern date, probably having survived into the human period. It is often, but incorrectly, spoken of as the Irish "Elk," but it is really a genuine Stag. The animal was of very great size, and was furnished with enormous spreading and palmate antlers, which measure from ten to twelve feet between the tips.

Of all the Deer, the largest living form is the true Elk (*Alces palmatus*), which is generally distributed over the northern parts of Europe, Asia, and America, being often spoken of as the Moose. The antlers in the Elk are of very large size, and are very broad, terminating in a series of points along their outer edges.

The only completely domesticated member of the *Cervidæ* is the Reindeer (*Cervus tarandus*), which is remarkable for the fact that the female is furnished with antlers similar to, but smaller than, those of the males. At the present day the Reindeer is exclusively confined to the extreme north of Europe and Asia, abounding especially in Lapland. Remains, however, of the Reindeer are known to occur over the greater part of Europe, extending as far south, at any rate, as the Alps, and occurring also in Britain. From this fact, taken along with many others, the existence of an extremely cold climate over the greater part of Europe at a comparatively recent period may be safely inferred. The Reindeer lives chiefly upon moss and a peculiar kind of lichen (*Lichen rangiferina*), and they are extensively used by the Laplanders both as beasts of burden and as supplying food.

d. Camelopardalidæ.—This family includes only a single living animal—the *Camelopardalis Giraffa*, or Giraffe—sometimes called the Camelopard, from the fact that the skin is spotted like that of the Leopard, whilst the neck is long, and gives it some distant resemblance to a Camel. There are no upper canines in the Giraffe, and both sexes possess two small frontal horns, which, however, are persistent, and remain permanently covered by a hairy skin. The neck is of extraordinary length, but, nevertheless, consists of no more than the normal seven cervical vertebræ. The fore-legs appear to be much longer than the hind-legs, and all are terminated by two toes each, the supplementary toes being altogether wanting. The tongue is very long and movable, and is employed in stripping leaves off the trees. The Giraffe is the largest of all the Ruminants, measuring as much as from fifteen to eighteen feet in height. It is a harmless and inoffensive animal, but defends itself very effectually, if attacked, by kicking. It is found in Nubia, Abyssinia, and the Cape of Good Hope.

Remains of gigantic Ruminants allied to the Giraffe have been found in France and Greece (*Helladotherium*); but the *Sivatherium*, sometimes referred to this family, appears to have been more nearly allied to the true Antelopes.

e. Cavicornia.—The last family of the Ruminants is that of the *Cavicornia* or *Bovidæ*, comprising the Oxen, Sheep, Goats, and Antelopes. This family includes the most typical Ruminants, and those of most importance to man. The upper jaw in all the *Cavicornia* is wholly destitute of incisors and canines, the place of which is taken by the hardened gum, against which the lower incisors bite. There are six incisors and two canines in the lower jaw, placed in a continuous series, and the molars are separated by a wide gap from the canines. There are six molars on each side of each jaw. Both sexes have horns, or the males only may be horned, but in either case these appendages are very different to the "antlers" of the *Cervidæ*. The horns, namely, are persistent, instead of being deciduous, and each consists of a bony process of the frontal bone—or "horn-core"—covered by a sheath of horn. The feet are cleft, but are furnished with accessory hoofs placed on the back of the foot.

The *Cavicornia* comprise the three families of the *Antilopidæ*, *Ovidæ*, and *Bovidæ*. The Antelopes form an extremely large section, with very many species. They are characterised by their slender deer-like form, their long and slender legs, and their simple cylindrical or twisted horns, which are usually confined to the males, but sometimes occur in the females as well. The Antelopes must on no account be confounded with the true Deer, to which they present many points of similarity. The structure of the horns, however, is quite sufficient to distinguish them. The Antelopes are especially numerous, both in individuals and in species, in Africa, in which country they appear to take the place of the true Deer (only one species of Deer being indigenous to Africa). Amongst the better-known African species of Antelopes are the Springbok, Hartebeest, Gnu, Eland, and Gazelle. The only European Antelope is the Chamois (*Rupicapra tragus*), which inhabits the Alps and other mountain-ranges of southern Europe.

The Sheep and Goats (*Ovidæ*) have mostly horns in both sexes, and the horns are generally curved, compressed, and turned more or less backwards. The body is heavier, and the legs shorter and stouter than in the true Antelopes. In the true Goats (*Capra*) both sexes have horns, and there are no lachrymal sinuses. The throat is furnished with long hair, forming a beard, and this appendage is usually present in both sexes, though sometimes in the males only. The goats live in herds, usually in mountainous and rugged districts. The domestic Goat (*Capra hircus*) is generally believed to be a descendant of a species which occurs in a wild state in Persia and in the Caucasus (the "Paseng," or *Capra ægagrus*). The true sheep (*Ovis*) are destitute of a beard, and the horns are generally twisted into a spiral. Horns may be present in both sexes, or in the males only. Lachrymal sinuses are almost invariably present. Numerous varieties of the domestic Sheep (*Ovis aries*) are known, but it is not certainly known from what wild species these were originally derived. The Merino Sheep (a Spanish breed) and the Thibet Sheep are particularly celebrated for their long and fine wool. With the exception of one species (the Big-horn, *Ovis montana*), all the Sheep appear to be originally natives of the Old World.

The true Oxen (*Bovidæ*) are distinguished by having simply rounded horns, which are not twisted in a spiral manner. There are no lachrymal sinuses. Most of the Oxen admit of being more or less completely domesticated, and some of them are amongst the most useful of animals, both as beasts of burden and as supplying food. The parent-stock of our numerous breeds of cattle is not known with absolute certainty; the nearest approach to British Wild Cattle being a celebrated breed which is still preserved in one or two places. These "Chillingham Cattle" are a fine wild breed, which at one time doubtless existed over a considerable part of Britain. They are pure white, with a black muzzle, the horns white, tipped with black. Another large Ox, which formerly existed in Britain, and abounded over the whole of Europe, is the Aurochs or Lithuanian Bison (*Bos bison*). The Aurochs is of very large size, considerably exceeding the common Ox in bulk. It still occurs in the forests of the Caucasus in a wild state, but it no longer occurs wild in Europe, if we except a herd maintained by the Czar in one of the forests of Lithuania. Nearly allied to the Aurochs is the American Bison or Buffalo (*Bison Americanus*). This species formerly occurred in innumerable herds in the prairies of North America, but it has been gradually driven westwards, and has been much reduced in numbers. Two other very well known forms are the Cape Buffalo (*Bubalus Caffer*) and the common Buffalo (*Bubalus bubalis*). The former of these occurs in southern and eastern Africa, and the latter is domesticated in India and in many parts of the south of Asia. The horns in both species are of large size, and their bases are confluent, so that the forehead is protected by a bony plate of considerable thickness.

The last of the Oxen which deserves notice is the curious Musk-ox (*Ovibos moschatus*). This singular animal is at the present day a native of Arctic America, and is remarkable for the great length of the hair. It is called the Musk-ox, because it gives out a musky odour. Like the Reindeer, the Musk-ox had formerly a much wider geographical range than it has at present; the conditions of climate which are necessary for its existence having at that time extended over a very much larger area than at present. The Musk-ox, in fact, in Post-tertiary times is known to have extended over the greater part of Europe, remains of it occurring abundantly in certain of the bone-caves of France.

CHAPTER LXXVIII.

HYRACOIDEA AND PROBOSCIDEA.

ORDER VII. HYRACOIDEA.—This is a very small order which has been constituted by Huxley for the reception of two or three little animals, which make up the single genus *Hyrax*. These have been usually placed in the immediate neighbourhood of the Rhinoceros, to which they have some decided affinities, and they are still retained by Owen in the section of the Perissodactyle Ungulates.

The order is distinguished by the following characters:— There are no canine teeth, and the incisors of the upper jaw are long and curved, and grow from permanent pulps, as they do in the Rodents (such as the Beaver, Rat, &c.) The molar teeth are singularly like those of the Rhinoceros. According to Huxley, the dental formula of the aged animal is—

$$i\ \frac{2-2}{2-2};\ c\ \frac{0-0}{0-0};\ pm\ \frac{4-4}{4-4};\ m\ \frac{3-3}{3-3} = 36.$$

The fore-feet are tetradactylous, the hind-feet tridactylous, and all the toes have rounded hoof-like nails, with the exception of the inner toes of the hind-feet, which have an obliquely-curved nail. There are no clavicles. The nose and ears are short, and the tail is represented by a mere tubercle. The placenta is deciduate and zonary, whereas in the Ungulates it is non-deciduate.

Two or three species of *Hyrax* are known, but they resemble one another in all essential particulars. They are all gregarious little animals, living in holes of the rocks, and capable of domestication. One species is said to be arboreal in its habits. The "coney" of Scripture is believed to be the *Hyrax Syriacus*, which occurs in the rocky parts of Syria and Palestine. Another species—the *Hyrax Capensis*—occurs commonly in South Africa, and is known by the colonists as the "badger."

ORDER VIII. PROBOSCIDEA.—The eighth order of Mammals is that of the *Proboscidea*, comprising no other living animals except the Elephants, but including also the extinct *Mastodon* and *Deinotherium*.

The order is characterised by the total absence of canine teeth; the molar teeth are few in number, large, and transversely ridged or tuberculate; incisors are always present, and grow from persistent pulps, constituting long tusks (fig. 201). In living Elephants there are two of these tusk-like incisors in the upper jaw, and the lower jaw is without incisor teeth. In the *Deinotherium* this is reversed, there being two tusk-like lower incisors and no upper incisors. In the Mastodons, the incisors are usually developed in the upper jaw, and form tusks, as in the Elephants, but sometimes there are both upper and lower incisors, and both are tusk-like. The nose is prolonged into a cylindrical trunk, movable in every direction, highly sensitive, and terminating in a finger-like prehensile lobe (fig. 201). The nostrils are placed at the extremity of the proboscis. The feet are furnished with five toes each, but these are only indicated externally by the divisions of the hoof. The feet are furnished with a thick pad of integument, forming the palms of the hand and the soles of the feet. There are no clavicles. The testes are abdominal throughout life. There are two teats, and these are placed upon the chest. The placenta is deciduate and zonary.

The recent Elephants are exclusively confined to the tropical regions of the Old World, in the forests of which they live in herds. Only two living species are known—the Asiatic Elephant (*Elephas Indicus*), and the African Elephant (*E. Africanus*). There can be no doubt, however, but that the Mammoth (*Elephas primigenius*) existed in Europe within the human period.

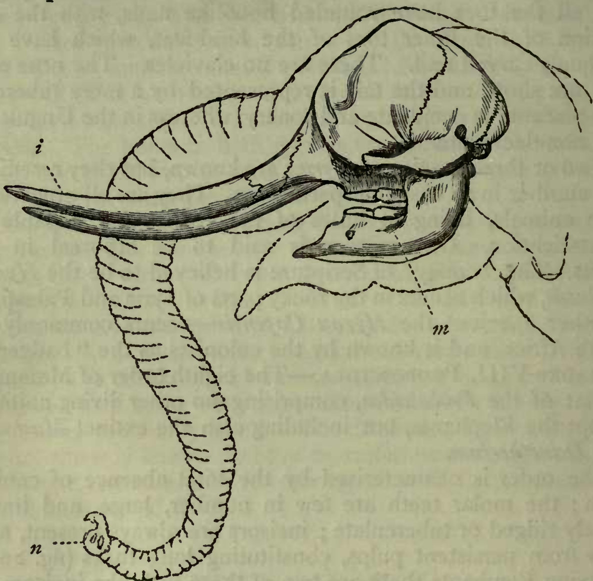


Fig. 201.—Skull of the Indian Elephant (*Elephas Indicus*). *i* Tusk-like upper incisors; *m* Lower jaw, with molars, but without incisors; *n* Nostrils, placed at the end of the proboscis. (After Owen).

In both the living Elephants the "tusks" are formed by an enormous development of the two upper incisors. The lower incisors are absent, and there are no other teeth in the jaws except the large molars, which are usually two in number on each side of each jaw. The molar teeth are of very large size, and are composed of a number of transverse plates of enamel united together by dentine. In the Indian Elephant the transverse ridges of enamel are narrow and undulating, whilst in the African Elephant they enclose lozenge-shaped intervals. The Indian Elephant is the only species which is now caught and domesticated, and as it will not breed in captivity, the demand for it is supplied entirely by the capture of adult wild individuals, which are taken chiefly by the assistance of those which have been already tamed. The Indian Elephant is distinguished by its concave forehead, its small ears, and the characters of the molars. The African Elephant, on the other hand, has a strongly convex forehead and great flapping ears. The African Elephant is chiefly hunted for the sake of its ivory, and there is too much reason to believe that the pursuit will ultimately end in the destruction of these fine animals. A great deal, however, of the ivory of commerce comes from Siberia, and is really derived from the tusks of the now extinct Mammoth, which formerly inhabited the north of Asia in great numbers.

The Elephants are all phytophagous, living almost entirely on the foliage of shrubs and trees, which they strip off by means of the prehensile trunk. As the tusks prevent the animal from drinking in the ordinary manner, the water is sucked up by the trunk, which is then inserted into the mouth, into which it empties its contents.

Many species of fossil Elephants are known, but the most familiar of them is the Mammoth (*Elephas primigenius*). This enormous animal is now wholly extinct, but it formerly abounded in the northern parts of Asia and over the whole of Europe. It occurred also in Britain, and unquestionably existed in the earlier portion of the human period, its remains having been found in a great number of instances in connection with human implements. From its great abundance in Siberia, it might have been safely inferred that the Mammoth was able to endure a much colder climate than either of the living species. This inference, however, has been rendered a certainty by the discovery of the body of more than one Mammoth embedded in the frozen soil of Siberia. These specimens had been so perfectly preserved that even microscopical sections of some of the tissues could be made; and in one case even the eyes were preserved. From these specimens we know that the body of the Mammoth was covered with long woolly hair.

Closely allied to the true Elephants are the *Mastodons*, characterised by the fact that the crowns of the molar teeth have nipple-shaped tubercles placed in pairs. Generally speaking, the two upper incisors formed long curved tusks, as in the Elephants, but in some cases there were two lower incisors as well. The various species of *Mastodon* all belong to the later Tertiary and Post-tertiary periods.

The last of the *Proboscidea* is a remarkable extinct animal, the *Deinotherium.* This extraordinary animal has hitherto only been found in Miocene deposits, and little is known of it except its enormous skull. Molars and præmolars were present in each jaw, and the upper jaw was destitute of canines and incisors. In the lower jaw were two very large tusk-like incisors, which were not directed forwards as in the true Elephants, but were bent abruptly downwards (fig. 202). The animal must have attained an enormous size, and it is probable that the curved tusks were used either in digging up roots or in mooring the animal to the banks of rivers, for it was probably aquatic or semi-aquatic in its habits.

Fig. 202.—Skull of *Deinotherium giganteum.*

CHAPTER LXXIX.

CARNIVORA.

Order IX. Carnivora.—The ninth order of Mammals is that of the *Carnivora*, comprising the *Feræ* or Beasts, of Prey, along with the old order of the *Pinnipedia*, or Seals and Walruses, these latter being now universally regarded as merely a group of the *Carnivora* modified to lead an aquatic life.

The *Carnivora* are distinguished by always possessing two sets of teeth, which are simply covered by enamel, and are always of three kinds—incisors, canines, and molars—differing from one another in shape and size. The incisors are generally $\frac{3-3}{3-3}$ (except in some seals); the canines are always $\frac{1-1}{1-1}$, and are invariably much larger and longer than the incisors. The præmolars and molars are mostly furnished with cutting or trenchant edges; but they graduate from a cutting to a tuberculate form, as the diet is strictly carnivorous, or becomes more or less miscellaneous. In the typical Carnivores (such as the Lion and Tiger), the last tooth but one in the upper jaw and the last tooth in the lower jaw are known as the "carnassial" or "sectorial" teeth, having a sharp cutting edge adapted for dividing flesh. A varying number, however, of the molars and præmolars may be "tuberculate," their crowns being adapted for bruising rather than cutting.

In all the *Carnivora* the clavicles are either altogether wanting, or are quite rudimentary. The toes are provided with sharp curved claws. The teats are abdominal; and the placenta is deciduate and zonular.

The order *Carnivora* is divided into three very natural sections:—

Section I. Pinnigrada or *Pinnipedia.* — This section comprises the Seals and Walruses, in which the fore and hind limbs are short, and are expanded into broad webbed swimming-paddles (fig. 203, B.) The hind-feet are placed very far back, nearly in a line with the axis of the body, and they are more or less tied down to the tail by the integuments.

Section II. Plantigrada.—This section comprises the Bears and their allies, in which the whole, or nearly the whole, of the foot is applied to the ground, so that the animal walks upon the *soles* of the feet (fig. 203, A.)

Section III. Digitigrada.—This section comprises the Lions, Tigers, Cats, Dogs, &c., in which the heel of the foot is raised entirely off the ground, and the animal walks upon the tips of the toes (fig. 203, C.)

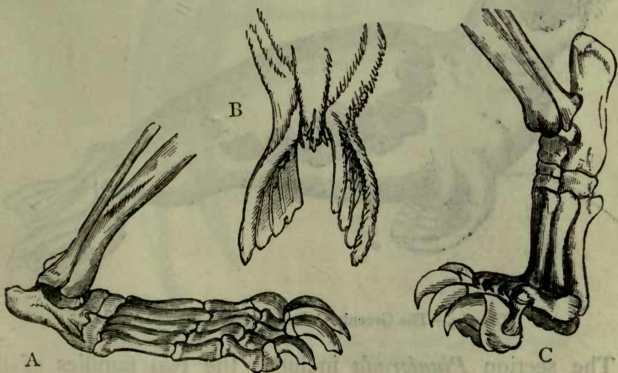


Fig. 203.—Feet of *Carnivora* (after Owen). A, *Plantigrada*, Foot of Bear; B, *Pinnigrada*, Hind-feet of Seal; C, *Digitigrada*, Foot of Lion.

Section I. Pinnigrada or Pinnipedia. — This section of the *Carnivora* comprises the amphibious Seals and Walruses, which differ from the typical Carnivores merely in points connected with their semi-aquatic mode of life. The body in these forms is elongated and somewhat fish-like in shape, covered with a short dense fur or harsh hairs, and terminated behind by a short conical tail. All the four limbs are present, but are very short, and the five toes of each foot are united together by a membrane, so that the feet form powerful swimming-paddles. The hind-feet are of large size, and are placed far back, their axis nearly coinciding with that of the body (figs. 203, 204). From this circumstance, and from the fact that the integument often extends between the hind-legs and the sides of the short tail, the hinder end of the body forms an admirable swimming-apparatus, similar in its action to the horizontal tail-fin of the *Cetacea* and *Sirenia*. The tips of the toes are furnished with strong claws, but their powers of terrestrial locomotion are very limited. The ears are of small size, and are mostly only indicated by small apertures, which the animal has the power of closing when under water. The bones are light and spongy, and beneath the skin is a layer of fat or blubber. The dentition varies, but teeth of three kinds are always present, in the young animal at any rate. The canines are always long and pointed, and the molars are generally furnished with sharp cutting edges.

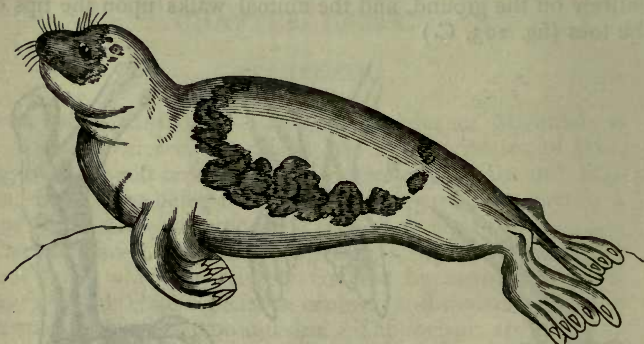


Fig. 204.—The Greenland Seal (*Phoca Grœnlandica.*)

The section *Pinnigrada* includes the two families of the Seals (*Phocidæ*) and Walruses (*Trichecidæ*). The Seals are distinguished by having incisor teeth in both jaws, and by the fact that the canine teeth are not disproportionately developed. They form a very numerous family, of which species are found in almost every sea out of the limits of the tropics. They abound, however, especially in the seas of the Arctic and Antarctic regions. They live for the most part upon fish, and when awake, spend the greater part of their time in the water. The body is covered with a short fur, interspersed with long bristly hairs; and the lips are furnished with long whiskers, which act as organs of touch. The Seals are very largely captured for the sake of their blubber.

The only common British Seal is the *Phoca vitulina*, which occurs not uncommonly on the northern shores of Scotland. It is yellowish-grey in colour, and measures from three to five feet in length. Other Seals attain a much greater length—the Great Seal measuring from eight to ten feet, and the Bottle-nosed Seal reaching a length of from twenty to twenty-five feet. The only Seals which possess external ears constitute the genus *Otaria*, and are almost exclusively confined to the seas of the southern hemisphere.

The second family of the Pinnigrade Carnivores is that of the *Trichecidæ*, comprising only the Walrus or Morse (*Trichecus rosmarus*). The chief peculiarity by which the Walrus is

Fig. 205.—Skull of the Walrus (*Trichecus rosmarus* (after Owen).
i Tusk-like upper incisors.

distinguished from the true Seals is found in the dentition. According to Owen, there are six incisors in the upper jaw and four in the lower; but these are only present in the young animal, and soon disappear, with the exception of the outermost pair of upper incisors. The upper canines are enormously developed, growing from persistent pulps, and constituting two large pointed tusks, which attain a length of over fifteen inches (fig. 205). The direction of the tusks is downwards and slightly outwards, and they project considerably below the chin. The adult animal has usually three simple molars with flat crowns behind the tusks in the upper jaw; and four similar teeth on each side of the lower jaw; but the first of these has been regarded as a lower canine.

Except as regards its dentition, the Walrus agrees in all essential respects with the Seals. It is a large and heavy animal, attaining a length of from ten to fifteen feet or upwards. The body is covered with short brownish or yellowish hair, and the face bears many long stiff bristles. There are no external ears. The chief use of the tusk-like canines appears to be that of assisting the unwieldy animal to get out of the water upon the ice; but they doubtless serve as weapons of offence and defence as well. The Walrus is hunted by whalers, both for its blubber, which yields an excellent oil, and for the ivory of the tusks. It is found, living in herds, in the Arctic seas, being especially abundant at Spitzbergen and Nova Zembla.

SECTION II. PLANTIGRADA.—The Carnivorous animals belonging to this section apply the whole or the greater part of the sole of the foot to the ground (fig. 203, A); and the portion of the sole so employed is destitute of hairs in most instances (the sole is hairy in the Polar Bear).

The typical family of the Plantigrade *Carnivora* is that of the *Ursidæ* or Bears, in which the entire sole of the foot is applied to the ground in walking. The *Ursidæ* are much less purely carnivorous than the majority of the order, and in accordance with their omnivorous habits, the teeth do not exhibit the typical carnivorous characters. The incisors and canines have the ordinary carnivorous form, but the "carnassial" or sectorial molar has a tuberculate crown instead of a sharp cutting edge. The dental formula is—

$$i\ \frac{3-3}{3-3};\ c\ \frac{1-1}{1-1};\ pm\ \frac{4-4}{4-4};\ m\ \frac{2-2}{3-3} = 42.$$

The claws are large, strong, and curved, but are not retractile. The tongue is smooth; the ears small, erect, and rounded; the tail short; the nose forms a movable truncated snout; and the pupil is circular.

As shown by their smooth tongues and tuberculate molars, the Bears are not peculiarly or strictly carnivorous. They eat flesh when they can obtain it, but a great part of their food is of a vegetable nature.

The Bears are very generally distributed over the globe, Australia alone having no representative of the family. The common Brown Bear (*Ursus Arctos*) was at one time an inhabitant of this country, and also existed over the whole of Europe. At the present day the Brown Bear is only found in the great forests of the north of Europe and in Asia. It feeds on roots, fruits, honey, insects, and, when it can obtain them, upon other Mammals. It attains a great age, and hybernates during the winter months. Very nearly allied to the Brown Bear is the Black Bear of America (*Ursus Americanus*). Both are of some commercial value, being hunted for the sake of their skins, fat, and tongues. A much larger American species is the Grizzly Bear (*Ursus ferox*), found in many parts of the American continent. It is about twice as large as the ordinary Bear, but it is said to subsist to a great extent upon vegetable food, such as acorns. The most remarkable, however, of the bears is the great White Bear (*Thalassarctos maritimus*), which is exclusively a native of the Arctic regions. It is a very large and powerful animal, the fur of which is quite white. The paws are very long, and the soles of the feet are covered with coarse hair, giving the animal a firm foothold upon the ice. The Polar Bear differs from the other *Ursidæ* in being exclusively carnivorous, since vegetable food would be wholly unattainable. It is as much at home in the water as on land, and lives chiefly upon seals and fish, and upon the carcases of Cetaceans.

It is a singular fact that the bones of a bear—the *Ursus spelæus* or Cave Bear—have been found in Britain and in many parts of Europe, along with the bones of other *Carnivora*, such as the Cave Lion and Cave Hyæna. The *Ursus spelæus* was a larger and more powerful animal than even the Polar Bear, and there can be no doubt that it existed in the earlier portion of the human period.

Nearly allied to the true bears are several small animals, of which the Racoons (*Procyon*), the Coati (*Nasua*), the Wah (*Ailurus*), and the Kinkajou (*Cercoleptes*) are the best known. The Racoons are natives of tropical and northern America, and have a decided external resemblance to the Bears. They have tolerably long tails, however, and sharp muzzles. The commonest species is the *Procyon lotor* of North America, which derives its specific name from its habit of washing its food before eating it. The place of the Racoon is taken in India by the Wah (*Ailurus fulgens*), which inhabits northern Hindostan. It is about the size of a large domestic cat, and is very prettily coloured, being chestnut brown above, and black inferiorly, with a white face and ears. The Kinkajous (*Cercoleptes*) are inhabitants of South America, and as is the case with so many of the animals of this continent, they are adapted for an arboreal life, to which end their tails are prehensile. The Coatis (*Nasua*) are very closely allied to the Racoons, and are exclusively confined to the American continent. All the above-mentioned little animals (with the exception of the Wah) present a singularly close resemblance to the Lemurs of the Old World, and appear to be their representatives in the western hemisphere.

The only remaining family of the *Plantigrada* is that of the *Melidæ* or Badgers, characterised by their elongated bodies and short legs, and by the fact that the carnassial tooth has a partly cutting edge, and is not wholly tuberculate as in the Bears.

The common Badger (*Meles taxus*), which may be regarded as the type of this group, occurs in Britain, and is one of the most inoffensive of animals. It is nocturnal in its habits, and is a very miscellaneous feeder, not refusing anything edible which may come in its way, though living mainly on roots and fruits. The Badger burrows with great ease, and can bite very severely. The Glutton (*Gulo Arcticus*), often called the Wolverine, is of common occurrence in the northern parts of Europe, Asia, and America. It is from two to three feet in length, and though doubtless a tolerably voracious animal, it is certainly not so much so as to deserve the name of Glutton. The Ratels or Honey-badgers (*Mellivora*) are much like the common Badger in their habits and appearance, but they get their name from their fondness for honey. They are natives of southern and eastern Africa.

SECTION III. DIGITIGRADA.—In this section of the *Carnivora* the heel is raised above the ground, with the whole or the greater part of the metacarpus, so that the animals walk more or less completely on the tips of the toes (fig. 203, C). No absolute line, however, of demarcation can be drawn between the Plantigrade and Digitigrade sections of the *Carnivora*, since many forms (*e. g.*, *Mustelidæ* and *Viverridæ*) exhibit transitional characters, and it has even been proposed to place these in a separate section, under the name of *Semi-plantigrada*.

The first family of the *Digitigrada* is that of the *Mustelidæ* or Weasels, including a number of small Carnivores, with short legs, elongated worm-like bodies, and a peculiar gliding mode of progression (hence the name of *Vermiformes*, sometimes applied to the group). Amongst the best known of the *Mustelidæ* are the common Weasel (*Mustela vulgaris*), the Pole-cat (*Mustela putorius*), and the Ferret, the last being only an albino variety of one of the Pole-cats. Many of the *Mustelidæ* are of great commercial importance, furnishing beautiful and highly-valued furs. Amongst these are the Ermine (*Mustela erminea*) and the Sable (*Mustela zibellina*).

Almost all the Weasels have a very disagreeable odour, produced by the secretion of greatly-developed and modified sebaceous glands, placed in the neighbourhood of the anus, and known as the anal glands. In this respect, however, the nearly-allied genus *Mephitis*, comprising the American Skunk, is *facile princeps*. The Skunk is a pretty little animal, with a long bushy tail, and when unmolested, it is perfectly harmless. If pursued or irritated, however, it has the power of ejecting the secretion of the anal glands to a greater or less distance with considerable force. The odour of this secretion is so powerful and persistent that no amount of washing will remove it from a garment, and its characters are said to be of the most intensely disagreeable description.

Also belonging to the family of the *Mustelidæ* and very nearly allied to the Weasels, are the Otters (*Lutra*), distinguished by the possession of webbed feet adapted for swimming. The common Otter (*Lutra vulgaris*) is a native of Britain, frequenting the banks of streams and lakes. It lives upon fish, and is highly destructive to Salmon.

The second family of the Semi-plantigrade Carnivores is that of the *Viverridæ*, the Civets and Genettes. They are all of moderate size, with sharp muzzles and long tails, and more or less striped, or banded, or spotted. The carnassial molar is trenchant; the canines are long, sharp, and pointed; and the tongue is roughened by numerous prickly papillæ. The claws are semi-retractile, and the pupils can contract, on exposure to light, till they resemble a mere line. In most of their characters, therefore, the Civets are much more highly carnivorous than are any of the preceding families, and they approach in many respects very close to the typical group of the *Digitigrada* (viz., the *Felidæ*); having especially very close affinities with the Hyænas. All the species of the family are furnished with anal glands, which secrete the peculiar fatty substance known as "civet."

The true Civet-cat is the *Viverra civetta*, a native of Africa, It is a small nocturnal animal, which climbs trees with facility, and feeds chiefly upon small mammals, reptiles, and birds, but also upon roots and fruits. It furnishes the greater part of the "civet" of commerce, which was formerly in great repute both as a perfume and as a medicinal agent. The Genette (*Viverra genetta*) is very closely related to the preceding, and is a native of Africa and southern Europe, being not uncommonly domesticated and kept like a cat. Another nearly-allied species is the Ichneumon (*Herpestes*), which is kept as a domestic animal in Egypt, and lives upon Snakes, Lizards, the eggs of the Crocodile, and small Mammals.

Forming a transition between the *Viverridæ* and the *Felidæ* is the family of the *Hyænidæ*, distinguished by the fact that, alone of all the *Carnivora*, both pairs of feet have only four toes each. The hind-legs are shorter than the fore-legs, so that the trunk sinks towards the hind-quarters, and the tail is short. The tongue is rough and prickly. The head is extremely broad, the muzzle rounded, and the muscles of the jaw extremely powerful and well developed. The claws are non-retractile. All the molars are trenchant except the last upper molar, which is tuberculate.

There are two well-known species of Hyæna, and the whole group is exclusively confined to the Old World. The best known species is the Striped Hyæna (*Hyæna striata*), which is found in North Africa, Asia Minor, Arabia, and Persia. It is an ill-conditioned ferocious beast, but will not attack man unless provoked. The Spotted Hyæna (*H. crocuta*) occurs solely in Africa, being especially abundant in Cape Colony. If the so-called Aardwolf (*Proteles*) is to be placed amongst the Hyænas, as is generally done, then the characters to be drawn from the feet are not invariable; since this singular animal has the fore-feet furnished with five toes, whilst the hind-feet are tetradactylous (as is the case in the Dogs).

An extinct Hyæna, considerably larger than either of the living forms, formerly existed in Britain and in various parts of Europe. It is known as the Cave Hyæna (*H. spelæa*), its remains having been principally found in caves.

The next family is that of the *Canidæ*, comprising the Dogs, Wolves, Foxes, and Jackals. The members of this family are characterised by having pointed muzzles, smooth tongues, and non-retractile claws. The fore-feet have five toes each, the hind-feet have only four. The molar teeth are $\frac{6-6}{7-7}$, sometimes $\frac{7-7}{7-7}$, and of these, two or three on each side are tuberculate.

The true Dogs (*i.e.*, the Dog and Wolf) have round pupils, and a tail which is of moderate length and rarely very hairy. The Foxes (*Vulpes*) have very long bushy tails, and the pupil contracts to a mere line.

The Dog (*Canis familiaris*) is only known to us at the present day as a domesticated animal. Such wild dogs as there are, are probably merely derived from the domestic dog; and the original stock, or stocks, from which our numerous varieties of dogs have sprung, is still uncertain. It is worth while remembering, however, all our varieties of dogs are capable of inter-

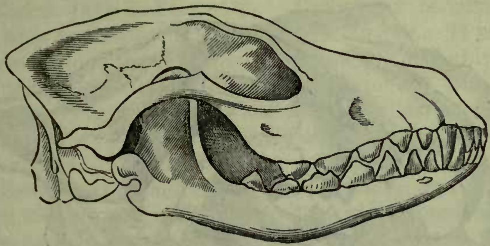


Fig. 206.—Skull of Jackal (*Canis aureus*).

breeding; and there is a strong probability that the Wolf is the parent stock of at least *some* of our domestic breeds. The Dog, in fact, will interbreed with both the Wolf and the Jackal.

The genus *Canis*, besides the Dog, contains the well-known Jackal (*Canis aureus*), and the Wolf (*Canis lupus*), and many writers place the Foxes in the same genus. The Foxes, however, are better considered as forming a separate genus (*Vulpes*), of which there are many species, all more or less like the common Fox (*Vulpes vulgaris*). One of the most remarkable species is the Arctic Fox, which abounds in the Arctic regions, and changes its colour with the season, being brown in summer and white in winter.

The last group of the *Digitigrada* is that of the *Felidæ* or Cat tribe, comprising the most typical members of the whole order of the *Carnivora*, such as the Lions, Tigers, Leopards, Cat, and Panthers. The members of this family all walk upon the tips of their toes, the soles of the feet being hairy, and the whole of the metacarpus and heel being raised above the ground (fig. 203, C). The jaws are short, and, owing to this fact, and to the great size of the muscles concerned in mastication, the head assumes a short and rounded form, with an abbreviated and rounded muzzle. The molars and præmolars are fewer in number than in any other of the *Carnivora* (hence the shortness of the jaws), and they are all trenchant, except the last molar in the upper jaw, which is tuberculate. According to Owen, the dental formula is—

$$i\ \frac{3-3}{3-3};\ c\ \frac{1-1}{1-1};\ pm\ \frac{3-3}{2-2};\ m\ \frac{1-1}{1-1} = 30.$$

The legs are nearly of equal size, and the hind-feet have only four toes each, whilst the fore-feet have five. All the toes are furnished with strong, curved, retractile claws, which, when not in use, are withdrawn within sheaths by the action of elastic ligaments, so as not to be unnecessarily blunted. The

Fig. 207.—Skull of Lion (*Felis leo*).

tongue is roughened and rendered prickly by the presence of horny papillæ, thus rendering it a most efficient rasp in licking the flesh from the bones of the prey. All the members of this group are exceedingly light upon their feet, and are excessively muscular, and they have all the habit of seizing their prey by suddenly springing upon it.

It is questionable if any good genera have hitherto been established in this family, and all the species may be considered as belonging to the single genus *Felis*.

The Lion (*Felis leo*) is too well known to require much special notice. Its colour is always uniform, generally a yellowish or reddish brown. The tail is terminated by a tuft of long hairs, and the male is usually furnished with a mane, which is very short, however, in an Indian form. The Lion is exclusively confined to the Old World, and is an inhabitant of Africa and all the southern parts of Asia. It is doubtful how far any valid species of Lions have as yet been established. The Lions are all nocturnal, and capture their prey by suddenly leaping upon it. They are by no means the generous and courageous animals they are generally considered to be; but, on the contrary, are cruel, cunning, and cowardly. They are enormously strong, and it is said that a full-grown Lion can run, and even leap, though carrying an ox in its jaws. Though now much restricted in its range, the Lion had formerly a much more extensive distribution, a form considerably larger than the modern species having formerly existed in Europe, and even in Britain (*Felis spelæa*).

In the Tigers (*Felis tigris*), the tail is without a tuft of hairs at its extremity, and the skin is marked with stripes or spots. The Royal or Bengal Tiger is a native of southern Asia, but occurs also in Java and Sumatra. The skin is reddish yellow, marked with numerous transverse black stripes. It is a large and powerful animal, and, upon the whole, is probably a more dangerous opponent than even the Lion.

Of the large Spotted Cats, the largest is the Jaguar (*Felis onca*) which inhabits South America and the southern parts of North America. It is a very large and powerful animal, said to be able to carry a bullock without difficulty, and it can both swim and climb with great facility. Another American species is the Puma (*Felis concolor*), in which the colour is uniformly reddish brown. It is exclusively confined to America, and though of large size (nine feet in length, including the tail), it is a very cowardly species, and is seldom or never known to attack man.

The Leopard (*Felis leopardus*) is another well-known species, smaller than the Tiger, and marked with black spots in place of stripes. It is a native of all the warmer parts of the Old World.

Of the smaller *Felidæ*, the best known are the Lynxes and the Cats, properly so called. Of these the Lynxes are distinguished by their short tails, and by the fact that the ears are furnished with a pencil of hairs. Several species are known inhabiting the Old World. In the true Cats (*Felis catus*), the tail is long, and the ears are not tufted. The Wild Cat formerly existed in Britain, but is now extinct in this country, though it still occurs in Europe, especially in the Hartz and Carpathian Mountains. It is a large and fierce animal, and appears to be quite a match for any man not possessing firearms. It seems tolerably certain that the Wild Cat is not the original stock of the domestic cat, the exact origin of which is uncertain.

CHAPTER LXXX.

RODENTIA.

Order X. Rodentia. — The tenth order of *Mammalia* is that of the *Rodentia*, or Rodent Animals, often spoken of as

Glires, comprising the Mice, Rats, Squirrels, Rabbits, Hares, Beavers, &c.

The *Rodentia* are characterised by the possession of two long curved incisor teeth in each jaw, separated by a wide interval from the molars. The lower jaw never has more than two of these incisors, and the upper jaw very rarely; but sometimes there are four upper incisors. There are no canine teeth, and the molars and præmolars are few in number (rarely more than four on each side of the jaw). The feet are usually furnished with five toes each, all of which are armed with claws; and the hallux, when present, does not differ in form from the other digits. The testes pass periodically from the abdomen into a temporary scrotum, and the placenta is discoidal and deciduate.

The most characteristic point about the Rodents is to be found in the structure of the incisors, which are adapted for continuous gnawing—hence the name of *Rodentia*. The incisor teeth are commonly two in each jaw, and they grow from persistent pulps, so that they continue to grow throughout the life of the animal. They are large, long, and curved (fig. 208, B), and are covered anteriorly by a plate of hard enamel. The back part of each incisor is composed only of the comparatively soft dentine, so that when the tooth is exposed to attrition, the soft dentine behind wears away more rapidly than the hard enamel in front. The result of this is that the crown of the tooth acquires by use a chisel-like shape, bevelled away behind, and the enamel forms a persistent cutting edge (fig. 208).

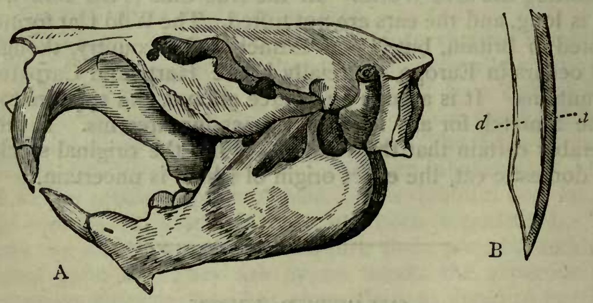


Fig. 208.—A, Skull of the Beaver (after Owen). B, Diagram of the incisor teeth of a Rodent, showing the chisel-shaped point: *a* Enamel; *d* Dentine.

The gnawing action of the incisors is assisted by the articulation of the lower jaw, the condyle of which is placed longitudinally and not transversely, so that the jaw slides backwards and forwards. The Rodents are almost all very small animals, and they are mostly very prolific. They subsist principally, if not entirely, upon vegetable matters, especially the harder parts of plants, such as the bark and roots. Many of them possess the power of building elaborate nests, and most of them hybernate. They are very generally distributed over the whole world, but no member of the order has hitherto been detected in rocks older than the Eocene Tertiary.

The Order *Rodentia* comprises a very large number of families, only the more important of which can be noticed here.

Fam. 1. *Leporidæ.*—In this family are the Hares (*Lepus timidus*), and Rabbits (*Lepus cuniculus*), distinguished amongst the Rodents by the possession of two small incisors in the upper jaw, placed behind the central chisel-shaped incisors, so that there are four upper incisors in all. The molars and præmolars are rootless, and the dental formula is—

$$i\,\frac{2-2}{1-1};\ c\,\frac{0-0}{0-0};\ pm\,\frac{3-3}{2-2};\ m\,\frac{3-3}{3-3} = 28.$$

The clavicles are imperfect. The fore-legs are furnished with five toes, and are considerably shorter than the hind-legs, which have only four toes. The two orbits communicate by an aperture in the septum. Generally there is a short erect tail.

The common Hare (*Lepus timidus*) is dispersed over the whole of Europe, but is not met with in Sweden and Norway, its place there being taken by the Mountain-hare (white in winter), which occurs commonly in Scotland. As a rule, the Hares occur in temperate regions, but some are found in Africa, and one species (*Lepus glacialis*) is a native of the Arctic regions. The Rabbit is also a native of temperate regions, but appears to thrive, to a more than average extent, in Australia.

Fam. 2. *Cavidæ.*—As examples of this family may be taken the Capybara (*Hydrochœrus capybara*), and the Guinea-pig (*Cavia aperœa*). In this family the body is covered with hair, without spines, and the tail is rudimentary. The Capybara is the largest of living Rodents, attaining a length of three or four feet. It is a South American form, leading a semi-aquatic life, to which end the feet are incompletely webbed. It is a harmless stupid animal, and is not unlike a small pig in appearance. The *Cavia aperœa* is likewise a South American animal, and is believed to be the parent stock of the Guinea-pigs so often kept as domestic pets in Europe.

Fam. 3. *Hystricidæ.*—In this family are the well-known Porcupines, distinguished from the other Rodents by the fact that the body is covered with long spines mixed with bristly hairs. They have four molars on each side of each jaw, and they possess imperfect clavicles.

The true Porcupines (*Hystrix*) have non-prehensile tails, which are mostly furnished with long hollow spines, but sometimes with scales and bristles. They are found in both the Old and New World, but the American species differ in several respects from those of the eastern hemisphere. They are all inhabitants of hot climates, with the exception of the common Porcupine (*H. cristata*) which occurs in southern Europe and in the north of Africa.

The nearly-allied genus *Cercolabes* is South American, and it is distinguished from the preceding by the possession of a long prehensile tail. In fact, *Cercolabes*, like so many of the inhabitants of this wonderful continent, is adapted for an arboreal life, instead of being confined to the ground.

Fam. 4. *Castoridæ.*—The best-known example of this family is the Beaver (*Castor fiber*). The distinctive peculiarities of the family are the possession of distinct clavicles, the possession of five toes to each foot, and the fact that the hinder feet are webbed, adapting the animal to a semi-aquatic life.

The Beaver is a large Rodent, attaining a length of from two and a half to three feet. Naturally it is a social animal, living in societies, and this is still the case in America; but in northern Europe and Asia, where the animal has been much hunted, it leads a sôlitary life. When living in social communities the beavers build dams across the rivers, as well as habitations for themselves, by gnawing across the branches of trees or shrubs, and weaving them together, the whole being afterwards plastered with mud. In this last operation the tail, which is flattened and scaly, is employed very much as a mason uses his trowel. There is no doubt but that the Beaver shows extraordinary ingenuity in these and similar operations; but there can be equally little doubt as to the greatly-exaggerated stories which have been set afloat in this connection. The Beaver is hunted chiefly for the sake of the skin, but also for the substance known as *castoreum*. This is a fatty substance, secreted by peculiar glands, and employed as a therapeutic agent.

There are two other members of the *Castoridæ* which are likewise largely captured for the sake of their skins. One of these is the Musquash (*Fiber Zibethicus*), which inhabits North America, and the other is the Coypu (*Myopotamus coypus*), which inhabits burrows in the banks of rivers in Chili. It is distinguished from the true Beaver by having a hairy and not a scaly tail.

Fam. 5. *Muridæ.*—The fifth family of Rodents is that of the *Muridæ*, comprising the Rats, Mice, and Lemmings. In this family the tail is long, always thinly haired, sometimes naked and scaly. The lower incisors are narrow and pointed, and there are complete clavicles. The hind-feet are furnished with five toes, the fore-feet with four, together with a rudimentary pollex.

The Rats (*Mus rattus* and *Mus decumanus*), the common Mouse (*Mus musculus*), the Field-mouse (*Mus sylvaticus*), and the Harvest-mouse (*Mus messorius*), are all well-known British examples of this family, and are too familiar to require any description.

A less familiar example of this family is the Lemming (*Myodes lemmus*). This curious little Rodent is found inhabiting the mountainous regions of Norway and Sweden. It is chiefly remarkable for migrating at certain periods, generally towards the approach of winter, in immense multitudes and in a straight line, apparently in obedience to some blind mechanical impulse. In these journeys the Lemmings march in parallel columns, and nothing will induce them to deviate from the straight line of march.

Fam. 6. *Dipodidæ.*—The sixth family of the Rodents, which is sufficiently important to need notice, is that of the *Dipodidæ* or Jerboas, mainly characterised by the disproportionate length of the hind-limbs as compared with the fore-limbs. The tail also is long and hairy, and there are complete clavicles. The Jerboas live in troops, and owing to the great length of the hind-legs, they can leap with great activity and to great distances. They are all of small size, and inhabit Russia, North Africa, and North America.

Fam. 7. *Myoxidæ.*—The members of this family are commonly known as Dormice, and they are often included in the following family of the Squirrels and Marmots. They only require to be mentioned, as they must not be confounded with the true Mice (*Muridæ*) on the one hand, or the Shrew-mice (*Soricidæ*) on the other; the latter, indeed, belonging to another order (*Insectivora*). The common Dormouse (*Myoxus avellanarius*) is a British species, and must be familiarly known to almost everybody.

Fam. 8. *Sciuridæ.*—This is the last family of Rodents which calls for any special mention, and it comprises the true Squirrels, the Flying Squirrels, and the Marmots.

The true Squirrels (*Sciurus*) are familiarly known in the person of our own common species (*Sciurus vulgaris*). Numerous species more or less closely allied to our Squirrel occur in other countries, and they are especially abundant in North America.

In the genus *Pteromys*, or Flying Squirrels, there is a peculiar modification by which the animal can take extended leaps from tree to tree. The skin, namely, extends in the form of a broad membrane between the hind and fore legs, and this acts as a kind of parachute, supporting the animal in the air. There is, however, no power whatever of true flight, and the structure is identically the same as what we have previously seen in the Flying Phalangers (*Petaurus*), which take the place of the Flying Squirrels on the Australian continent. The Flying Squirrels are found in southern Asia, Polynesia, the north-east of Europe, and Siberia.

The Marmots (*Arctomys*), unlike the true Squirrels, are terrestrial in their habits, and live in burrows. Various intermediate forms, however, are known by which a transition is effected between the typical Squirrels and the Marmots. There are numerous species of this family inhabiting various parts of Europe and northern Asia, and generally distributed over the whole of North America.

CHAPTER LXXXI.

CHEIROPTERA.

ORDER XI. CHEIROPTERA.—This order is undoubtedly "the most distinctly circumscribed and natural group" in the whole class of the *Mammalia*. In many respects, however, it would be advantageous to regard the *Cheiroptera* as a sub-order of the next order (namely the *Insectivora*) specially modified to lead an aerial life; just as the *Pinnigrada* are regarded as a mere section of the *Carnivora* specially modified to suit an aquatic life.

The *Cheiroptera* are essentially characterised by the fact that the anterior limbs are longer than the posterior, the digits of the fore-limb, with the exception of the pollex, being enormously elongated (fig. 209). These elongated fingers are united by an expanded membrane or "patagium," which is also extended between the fore and hind limbs and the sides of the body, and in many cases passes also between the hind-limbs and the tail. The patagium thus formed is naked, or nearly so, on both sides, and it serves for flight. Of the fingers of the hand, the pollex, and sometimes the next finger as well, are unguiculate, or furnished with claws; but the other digits are destitute of nails. In the hind-limbs all the toes are unguiculate, and the hallux is not in any respect different from the other digits. Well-developed clavicles are always present, and the radius has no power of rotation upon the ulna. The mammary glands are two in number, and are placed upon the chest. There are teeth of three kinds, and the canines are always well developed. The *Cheiroptera* are cosmopolitan in their distribution, and the oldest known species is from the Eocene Rocks.

The Bats are all crepuscular and nocturnal in their habits, and are sometimes carnivorous, sometimes frugivorous. The eyes are small, but the ears are very large, and their sense of touch is most acute. During the day they retire to caves or crevices amongst the rocks, where they suspend themselves by means of the short thumbs, which are provided with curved claws. In their flight, though they can fly in the genuine and proper sense of the term, and can turn with great ease, they

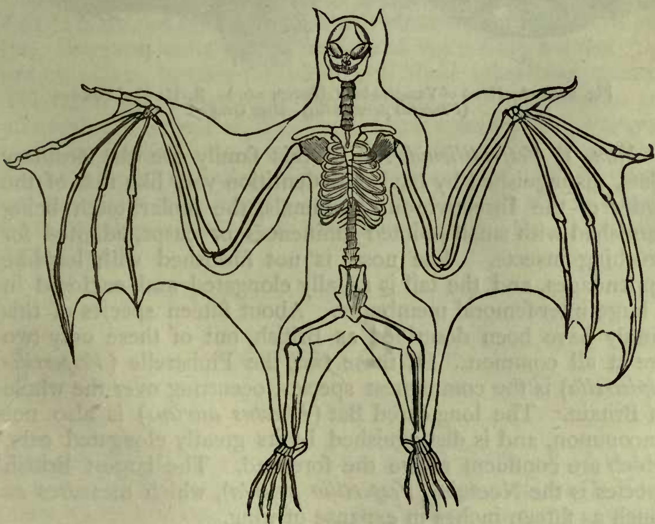


Fig. 209.—Skeleton of Fox-bat (*Pteropus*)—after Owen.

are by no means as rapid and as active as are the true birds. The tail is sometimes short, sometimes moderately long, and is usually included in a continuation of the leathery patagium, which stretches between the hind-legs, and is termed the "inter-femoral membrane." The body is covered with hair, but the patagium is usually hairless, or nearly so. Most of the Bats hybernate.

The *Cheiroptera* are conveniently divided into the two sections of the *Insectivora* and *Frugivora*, according as the diet consists of insects or of fruits.

SECTION A. INSECTIVORA.—In this section are the three families of the *Vespertilionidæ*, *Rhinolophidæ*, and *Phyllostomidæ*.

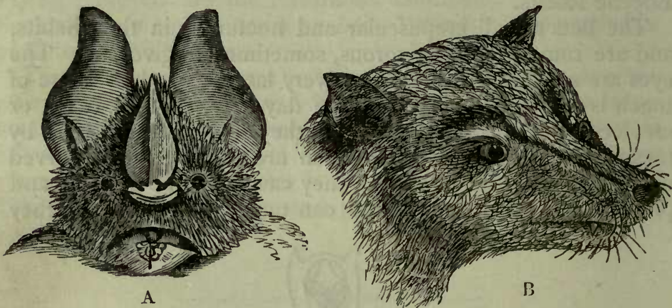


Fig. 210.—A, Head of Vampire-bat (*Alectops ater*). B, Head of Fox-bat (*Pteropus personatus*)—after Gray.

Fam. 1. *Vespertilionidæ.*—In this family are the ordinary Bats, distinguished by having a dentition very like that of the order of the Insectivorous Mammals, the molar teeth being furnished with small pointed eminences or cusps, adapted for crushing insects. The nose is not furnished with leaf-like appendages, and the tail is usually elongated and enclosed in a large inter-femoral membrane. About fifteen species of this family have been described as British, but of these only two are at all common. Of these two, the Pipistrelle (*Vespertilio pipistrella*) is the commonest species, occurring over the whole of Britain. The long-eared Bat (*Plecotus auritus*) is also not uncommon, and is distinguished by its greatly elongated ears, which are confluent above the forehead. The largest British species is the Noctule (*Vespertilio noctula*), which measures as much as fifteen inches in expanse of wing.

Fam. 2. *Rhinolophidæ.*—The second family of the Insectivorous Bats is that of the *Rhinolophidæ* or Horse-shoe Bats, which in most respects are very similar to the *Vespertilionidæ*, but are distinguished by the possession of a complex leaf-like apparatus appended to the nose. Of this family, two British species are known—the Greater and Lesser Horse-shoe Bats (*Rhinolophus ferrum-equinum* and *R. hipposideros*).

Fam. 3. *Phyllostomidæ.*—This is the only remaining family of the Insectivorous Bats, and comprises the well-known Vampire-bats (fig. 210, A) distinguished by having leaf-like nasal appendages, and by the fact that the ears are of small size; whereas in the preceding they are always very large (*Rhinolophus*), and are often confluent above the forehead (*Megaderma.*) They are all of large size, and are natives of South America. The Vampire-bat (*Phyllostoma spectrum*) has an expanse of wing of two feet and a half, and lives chiefly upon insects. It also has the habit of sucking the blood of sleeping animals, appearing sometimes to attack even man, though apparently never doing any substantial or lasting injury.

SECTION B. FRUGIVORA.—In the fruit-eating section of the *Cheiroptera* are only the *Pteropidæ* or the Fox-bats, so called from the resemblance of the head to that of a fox (fig. 210, B). The head in these bats is long and pointed. The ears are of moderate size, and the nose is destitute of any appendages. Cutting incisors and canines are present in both jaws, and the Fox-bats do not refuse to eat small birds or mammals. They live, however, mostly upon fruits, and the molars are therefore not cuspidate, but are furnished with blunt tubercular crowns. The tail is very short, or is entirely absent. The *Pteropidæ* are amongst the largest of the Bats,—one species—the *Pteropus edulis*, or Kalong—attaining a length of from four to five feet from the tip of one wing to that of the other. The *Pteropidæ* are especially characteristic of the Pacific Archipelago—Java, Sumatra, Borneo, &c.—but they also occur in Asia, Australia, and Africa.

CHAPTER LXXXII.

INSECTIVORA.

ORDER XII. INSECTIVORA.—The twelfth order of Mammals is that of the *Insectivora*, comprising a number of small Mammals which are very similar to the Rodents in many respects, but want the peculiar incisors of that order, and are likewise always furnished with clavicles.

In the *Insectivora*, all the three kinds of teeth are usually present, but the exact nature of the dentition varies considerably in different cases. The incisors and canines present little special, but the molars are always furnished with numerous small-pointed eminences or cusps, adapted for crushing insects. With one exception, clavicles are always present in a complete form. All the feet are usually furnished with five toes; all the toes are furnished with claws; and the animal walks on the soles of the feet, or is plantigrade. The testes pass periodically from the abdomen into a temporary scrotum; and the placenta is deciduate and discoidal. They are all of small size, and are found everywhere, except in the continents of South America and Australia, where their place is filled by Marsupials.

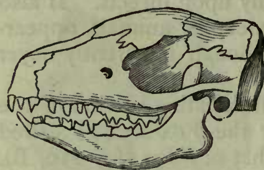


Fig. 211.—Insectivora. Skull of the common Hedgehog (*Erinaceus Europæus*).

The three leading families of the *Insectivora* are the *Talpidæ* or Moles, the *Soricidæ* or Shrew-mice, and the *Erinaceidæ* or Hedgehogs.

Fam. 1. *Talpidæ.* — The body in this family is covered with hair; the feet are formed for digging and burrowing, and the toes are furnished with strong curved claws. There are no external ears; and the eyes in the adult are rudimentary, and more or less completely useless as organs of vision.

The common Mole (*Talpa Europæa*) is the only British species of the family, and a representative form (*Condylura*) occurs in North America. One of the most remarkable of the *Talpidæ* is the Golden Mole (*Chrysochloris aureus*) of Africa. In form and habits this species resembles the common Mole, but the hairs of the fur have the property of dispersing the rays of light, and thus of giving rise to beautiful metallic colours, such as are produced by the "setæ" of the Sea-mice (*Aphrodite*) amongst the Annelides.

Fam. 2. *Soricidæ.*—The *Soricidæ* or Shrew-mice are distinguished by having the body covered with hair, and the feet not adapted for digging; whilst there are external ears, and the eyes are well developed. Of all the *Insectivora*, no division is more abundant or more widely distributed than that of the Shrew-mice. In general form and appearance the Shrews very closely resemble the true Mice (*Muridæ*) and the Dormice (*Myoxidæ*), but they are in reality widely different, and must not be confounded with them. The common Shrew (*Sorex araneus*) and the Water-shrew (*Sorex fodiens*) are both well-known species of this family. The smallest known Mammal is one of the Shrews (*Sorex Etruscus*), which is not more than two and a half inches in length, counting in the tail.

Fam. 3. *Erinaceidæ.*—The last family of the *Insectivora* is that of the Hedgehogs, characterised by the fact that the upper part of the body is covered with prickly spines, the feet are not adapted for digging, and they have the power of rolling themselves into a ball at the approach of danger. The common Hedgehog (*Erinaceus Europæus*) is in every way a typical example of this family, but is too well known to require any description.

GALEOPITHECIDÆ.

Before passing on to the *Quadrumana*, mention must be made here of a very singular animal which forms a kind of connecting link between the orders of the *Insectivora* and *Quadrumana*, having been sometimes placed in the one and sometimes in the other, or having been regarded as the type of a separate order. The order includes only the single genus *Galeopithecus*, comprising the so-called "Flying Lemurs." All the *Galeopitheci* inhabit the Indian Archipelago, but the best known is the *Galeopithecus volans* of Java, Sumatra, and Borneo. The most characteristic point in this singular animal is the presence of a flying-membrane, presenting some superficial resemblance to the patagium of the Bats, but in reality very much the same as the integumentary expansions of the Flying Squirrels and Flying Phalangers. This membrane in the *Galeopithecus* extends as a broad expansion from the nape of the neck to the arms, from the arms to the hind-legs, and from the hind-legs to the tail, forming an inter-femoral membrane. The fingers are not elongated, and do not support a patagium, as in the Bats, so that the animals have no power of true flight, and can simply take extended leaps from tree to tree. The feet are furnished with five toes each, united by a membrane, but neither the hallux nor the pollex are opposable to the other digits. The dentition is complicated, and consists of incisors and molars, and, according to Owen, canines also, the dental formula being—

$$i\,\frac{2-2}{3-3};\; c\,\frac{1-1}{1-1};\; pm\,\frac{2-2}{2-2};\;\; m\,\frac{3-3}{3-3} = 34.$$

The *Galeopitheci* live chiefly upon small birds and insects, but also partially upon fruits.

CHAPTER LXXXIII.

QUADRUMANA.

ORDER XIII. QUADRUMANA.—The thirteenth order of Mammals is that of the *Quadrumana*, comprising the Apes, Monkeys, Baboons, Lemurs, &c., characterised by the following points :—

The hallux (innermost toe of the hind-limb) is separated from the other toes, and is opposable to them, so that the hind-feet become prehensile hands. The pollex (innermost toe of the fore-limbs) may be wanting, but when present, it also is usually opposable to the other digits, so that the animal becomes truly *quadrumanous*, or four-handed.

The incisor teeth generally are $\frac{2-2}{2-2}$, and the molars $\frac{3-3}{3-3}$, with broad and tuberculate crowns. Perfect clavicles are present. The teats are two in number, and are pectoral in position, and the placenta is discoidal and deciduate.

The Quadrumana are divided by Owen into three very natural groups, separated from one another by their anatomical characters and by their geographical distribution as follows :—

Section A. Strepsirhina.—The members of this section are characterised by the nostrils being curved or twisted, whilst the second digit of the hind-limb has a claw. This section includes the true Lemurs and a number of allied forms. It is chiefly referable to Madagascar as its geographical centre ; but it spreads westwards into Africa, and eastwards into the Indian Archipelago.

Section B. Platyrhina.—This section includes those Quadrumana in which the nostrils are placed far apart ; the thumbs of the fore-feet are either wanting, or, if present, are not opposable to the other digits ; and the tail is generally prehensile. The Platyrhine Monkeys are exclusively confined to South America.

Section C. Catarhina.—In this section the nostrils are oblique, and placed close together. The thumb of the fore-limb (pollex), with one exception, is present, and is always opposable to the other digits. The Catarhine Monkeys are restricted entirely to the Old World, and, with the single exception of a Monkey which inhabits the Rock of Gibraltar, they are exclusively confined to Africa and Asia. It is in the Catarhine section of the *Quadrumana* that we have the highest group of the Monkeys—that, namely, of the Anthropoid or Tail-less Apes.

STREPSIRHINA.

This section of the *Quadrumana*, as before said, is characterised by the possession of twisted or curved nostrils, placed at the end of the snout. The incisor teeth are generally much modified, and are in number $\frac{3-3}{3-3}$ as a rule; the præmolars are $\frac{3-3}{3-3}$ or $\frac{2-2}{2-2}$, and the molars are tuberculate. The second digit of the hind-limb has a claw, and both fore and hind feet have five toes each, all the thumbs being generally opposable. In the true Lemurs, all the digits, except the second toe of the hind-feet, are furnished with nails.

This section is often called that of the *Prosimiæ*, and it includes several families, of which the Aye-Ayes, Pottos, and true Lemurs are the most important. In many works the *Galeopithecus* is also placed in this section.

The family of the Aye-Ayes (*Cheiromydæ*) includes only a single animal, the *Cheiromys Madagascariensis*. In appearance, the Aye-Aye is not very unlike a large Squirrel, having a hairy body and a long bushy tail. There are no canines, and the molars are separated by a wide interval from the incisors. The fore-feet have five toes, armed with strong claws, but the pollex is scarcely opposable to the other digits. The hind-feet have also five toes, of which the hallux is opposable, and the second digit is furnished with a long claw. As far as is yet known, the *Cheiromys* is entirely confined to Madagascar.

In the *Nycticebidæ* are the Loris and the Pottos, in which there is no tail, or but a rudimentary one, the ears are short and rounded, and the eyes are large and are placed close together. The species of this family are all of small size, and are exclusively confined to the eastern portion of the Old World, occurring in Java, Ceylon, the southern parts of Asia, and other localities in the same geographical area. They are nocturnal in their habits, living mostly in trees, and feeding upon insects; and from the slowness with which some of them progress, they are sometimes spoken of as "Slow Lemurs."

The largest and most important of the families of the *Strepsirhina* is that of the *Lemuridæ* or true Lemurs. In this family the muzzle is elongated, the feet are all furnished with opposable thumbs, and the nails on all the toes are flat, with the exception of the second toe of the hind-foot, in which there is a long and pointed claw. The body is covered with a soft fur, and the tail is usually of considerable length, and is covered with hair. They are easily domesticated, and though capable of biting pretty severely, their disposition is gentle and docile. They are mostly about the size of cats, and not unlike them in appearance, being often termed "Madagascar cats" by sailors. They are found exclusively in the great forests of Madagascar, moving about amongst the trees with great activity, by means of their prehensile tails. They appear to fill in Madagascar the place occupied by the higher *Quadrumana* upon the adjoining continent of Africa. The largest species is the Indri, which has very long hind-legs, and stands as much as three feet in height.

PLATYRHINA.

The section of the Platyrhine Monkeys is exclusively confined to South America, and one of its leading characters is to be found in the almost universal possession of a prehensile tail; this being an adaptive character by which they are suited to the arboreal life which so many of the South American Mammals are forced to lead. The nostrils are simple, wide apart, and placed nearly at the extremity of the snout. The præmolars are $\frac{3-3}{3-3}$ in number, and have blunt tubercles. The thumbs of the fore-hands are either wanting altogether, or, if present, are not opposable.

The Platyrhine Monkeys are divided into the two sections of the *Hapalidæ* and *Cebidæ*.

Fam. 1. *Hapalidæ.*—In this family the number of teeth is the same as in the Old World Monkeys and in Man, but there is an additional præmolar on each side of each jaw, and a molar less. According to Owen, the dental formula of the Marmoset is—

$$i\,\frac{2-2}{2-2};\ c\,\frac{1-1}{1-1};\ pm\,\frac{3-3}{3-3};\ m\,\frac{2-2}{2-2} = 32.$$

The molars, however, are tuberculate, and though the number of teeth is the same as in the Catarhine Monkeys, in their other characters the Marmosets are genuine Platyrhines. The hind-feet have an opposable hallux with a flat nail, but all the other toes are unguiculate, and the pollex is hardly opposable. The tail is long, but is not prehensile.

The *Hapalidæ* are all small monkeys, mostly about as big as Squirrels, and they are exclusively South American, occurring especially in Brazil. The best-known species is the common Marmoset (*Hapale penicillata*), but several species are domesticated and kept as pets.

Fam. 2. *Cebidæ.*—In this family are all the typical Platyrhine Monkeys, in which the dentition differs from that of the *Hapalidæ* in having an additional molar, so that the molars are the same as in the *Catarhina* and in Man, but the præmolars are more numerous. The dental formula is—

$$i\,\frac{2-2}{2-2};\; c\,\frac{1-1}{1-1};\; pm\,\frac{3-3}{3-3};\; m\,\frac{3-3}{3-3} = 36.$$

There are neither cheek-pouches nor "callosities;" and the face is usually more or less naked, though sometimes whiskered. The tail is long, and is mostly prehensile; though in rare instances it is non-prehensile, and has its extremity clothed with hairs. The thumb of the fore-hand may be wanting, and, if present, is not opposable. All the fingers are furnished with flat nails. Their diet is miscellaneous, consisting partly of insects and partly of fruit.

The *Cebidæ* are exclusively confined to the warmer parts of South America, in the vast forests of which they are met with in large troops, climbing amongst the trees. The Spider Monkeys (*Ateles*), the Howling Monkeys (*Mycetes*), the Capuchin Monkey (*Cebus*), and the Squirrel Monkey (*Callithrix*), may serve as typical examples of this section of the *Quadrumana*.

Catarhina.

The third and highest section of the *Quadrumana* is that of the *Catarhina* or Old World Monkeys. In this section the nostrils are oblique, and are placed close together, and the septum narium is narrow. The thumbs of all the feet are opposable, so that the animal is strictly quadrumanous. In *Colobus* alone the anterior thumbs (pollex) are wanting. The dental formula is the same as in man, viz.:—

$$i\,\frac{2-2}{2-2};\; c\,\frac{1-1}{1-1};\; pm\,\frac{2-2}{2-2};\; m\,\frac{3-3}{3-3} = 32.$$

The incisors, however, are projecting and prominent, and the canines—especially in the males—are large and pointed. Moreover, the teeth form an uneven series, interrupted by a diastema or interval. The tail is never prehensile, and is sometimes absent. Cheek-pouches are often present, and the skin covering the *tubera ischii* is almost always callous and destitute of hair, constituting the so-called "natal callosities." With the single exception of a Monkey which inhabits the

Rock of Gibraltar, all the *Catarhina* are natives of Africa and Asia.

There are three well-marked groups or tribes of the Catarhine Monkeys. In the first of these the tail is long, and there are both cheek-pouches and natal callosities. In this tribe is the genus *Semnopithecus*, all the species of which are natives of Asia and its islands. One of the best-known species is the Sacred Monkey of the Hindoos (*Semnopithecus entellus*). Closely allied to the *Semnopitheci* is the genus *Colobus*, in which alone, of all the Catarhine Monkeys, the pollex is either altogether absent or totally rudimentary. Also referable to this division is the genus *Macacus* or *Inuus* (comprising the Macaques), which includes most of the Monkeys which are ordinarily brought to this country. It is a Macaque which occurs at the Rock of Gibraltar, and is the only wild Monkey which is found in Europe at the present day.

The second tribe of the Catarhine Monkeys is that of the Baboons (*Cynocephalus* and *Papio*). In these forms the tail is often short, and is often quite rudimentary. The head is large, and the muzzle is greatly prolonged, having the nostrils at its extremity. The natal callosities are generally large and conspicuous, and usually of some bright colour. The Baboons are large strong animals, extremely unattractive in outward appearance, and of great ferocity. More than any other of the Monkeys, they employ the fore-limbs in terrestrial progression, running upon all fours with the greatest ease. They are all inhabitants of Africa, and one of them, the Mandrill (*Papio Maimon*), attains very nearly the height of a man.

The third family of the Catarhine Monkeys is that of the Anthropomorphous or Anthropoid Apes, so called from their making a nearer approach in anatomical structure to man than is the case with any other Mammal. The members of this family are Apes, in which there is no tail, and cheek-pouches are absent, whilst in some cases there are also no natal callosities. The hind-limbs are short—shorter than the fore-limbs — and the animal can progress in an erect or semi-erect position. At the same time, the thumbs of the hind-feet (hallux) are opposable to the other digits, so that the hind-feet are prehensile hands. The spine shows a single curve, and articulates with the back part of the skull. The canine teeth of the males are long, strong, and pointed; but this is not the case with the females. The structure, therefore, of the canine teeth is to be regarded in the light of a sexual peculiarity, and not as having any connection with the nature of the food.

In this tribe are the Gibbons (*Hylobates*), the Orang-outang (*Simia satyrus*), the Chimpanzee, and the Gorilla.

The Gibbons form the genus *Hylobates*, and they belong to southern Asia, and the Indian Archipelago. The anterior limbs are extremely long, and the hands nearly or quite reach the ground when the animal stands in an erect posture. There is no tail, but there are natal callosities. The body is covered with a thick fur. One of the best known of the Gibbons is the Siamang (*Hylobates syndactylus*), which has been sometimes regarded as making a nearer approach to man than any other of the Monkeys. It is a native of Sumatra.

In the Orang (*Simia satyrus*) there are neither cheek-pouches nor natal callosities, and the hips are covered with hair. As in the Gibbons, the arms are excessively long, reaching considerably below the knee when the animal stands in an erect posture. The hind-legs are very short, and there is no tail. When young, the head of the Orang is not very different from that of an average European child; but, as the animal grows, the facial bones become gradually produced, whilst the cranium remains in a tolerably stationary condition; great bony ridges are developed for the attachment of the muscles of the jaws and face; the incisors project; and ultimately the muzzle becomes as pronounced and well-marked a feature as in the typical *Carnivora* (fig. 212, A). The Orangs are all inhabitants of Sumatra, Borneo, and the other larger islands of the Indian Archipelago.

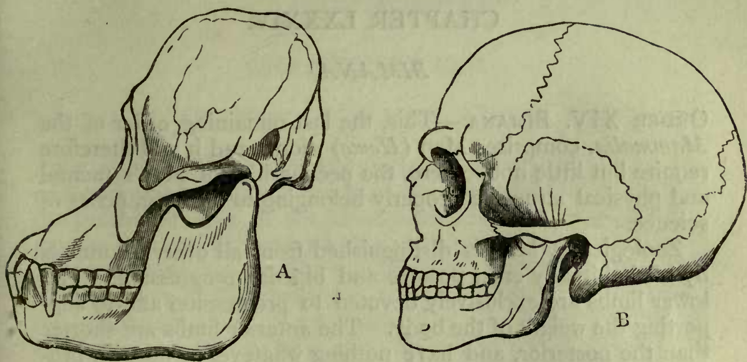


Fig. 212.—A, Skull of the Orang-outang. B, Skull of an adult European.

The genus *Troglodytes* contains the Chimpanzee (*T. niger*) and the Gorilla (*T. Gorilla*). The Chimpanzee is a native of western Africa, and has the arms much shorter, proportionately, than in the Gibbons and Orangs. Still they are much longer than the hind-limbs, and they reach beneath the knee when the animal stands erect. The ears in the Chimpanzee are large, and the body is covered with dark-brown hair. The animal can stand erect, but the natural mode of progression is on all-fours. The hands are naked to the wrist, and the face is also naked and is much wrinkled.

The Gorilla is in most respects the same as the Chimpanzee, but is much larger, attaining a height of fully five feet. The hind-limbs are short, and the ears small. It is an enormously strong and ferocious animal, and is found in Lower Guinea and in the interior of equatorial Africa. The Gorilla is now generally regarded as the most human of the Anthropoid Apes.

CHAPTER LXXXIV.

BIMANA.

ORDER XIV. BIMANA.—This, the last remaining order of the *Mammalia*, comprises Man (*Homo*) alone, and it will therefore require but little notice here, the peculiarities of Man's mental and physical structure properly belonging to other branches of science.

Zoologically, Man is distinguished from all other Mammals by his habitually erect posture and bipedal progression. The lower limbs are exclusively devoted to progression and to supporting the weight of the body. The anterior limbs are shorter than the posterior, and have nothing whatever to do with progression. The thumb is opposable, and the hands are prehensile, the fingers being provided with nails. The toes of the hind-limb are also furnished with nails, but the *hallux* is not opposable to the other digits, and the feet are therefore useless as organs of prehension. The foot is broad and plantigrade, and the whole sole is applied to the ground in walking.

The dentition consists of thirty-two teeth, and these form a nearly even and uninterrupted series, without any interval or diastema. The dental formula is—

$$i\,\frac{2-2}{2-2};\ c\,\frac{1-1}{1-1};\ pm\,\frac{2-2}{2-2};\ m\,\frac{3-3}{3-3} = 32.$$

The brain is more largely developed and more abundantly furnished with large and deep convolutions than is the case with any other Mammal. The mammæ are pectoral, and the placenta is discoidal and deciduate.

Man is the only terrestrial Mammal in which the body is not provided with a covering of hair.

The zoological or *anatomical* distinctions between Man and the other Mammals are thus seen to be of no very striking nature, and certainly *of themselves* would not entitle us to consider Man as forming more than a distinct *order*. When, however, we take into account the vast and illimitable *psychical* differences, both intellectual and moral—differences which *must* entail corresponding structural distinctions—between Man and the highest *Quadrumana*, it becomes a question whether the group *Bimana* should not have the value of a distinct sub-kingdom; whilst there can be little hesitation in giving Man at any rate a class to himself.

CHAPTER LXXXV.

DISTRIBUTION OF MAMMALIA IN TIME.

As a matter of course, the remains of Mammals are scanty, and occupy but a small space in the geological record, since the greater number of the *Mammalia* are terrestrial, and the greater number of the stratified fossiliferous deposits are marine. The Mammals, too, are the most highly organised of the entire sub-kingdom of the *Vertebrata;* and therefore, in obedience to the well-known law of succession, they ought to make their appearance upon the globe at a later period than any of the lower classes of the *Vertebrata*. Such, in point of fact, is to a great extent the case; and if the geological record were perfect, the law would doubtless be carried out to its full extent.

It is in the upper portion of the Triassic Rocks—that is to say, not long after the commencement of the Mesozoic or Secondary epoch—that Mammals for the first time make their appearance; four species being now known in a zone of rocks which are placed at the summit of the Trias, just where this formation begins to pass into the Lias. The earliest of these —the oldest known of all the Mammals—appears at the upper part of the Upper Trias (Keuper) and also at its very summit (Penarth beds), and has been described under the name of *Microlestes antiquus*. The nearest ally of *Microlestes* amongst existing Mammals would seem to be the Marsupial and insectivorous *Myrmecobius*, or Banded Ant-eater of Australia. As only the teeth, however, of *Microlestes* have hitherto been discovered, it is impossible to decide positively whether this primeval Mammal was Marsupial or Placental.

The next traces of Mammals occur in the Stonesfield Slate (Lower Oolites), and here four species, all of small size, are known to occur. Most of these were Marsupial, but it is possible that one was placental. They form the genera *Amphilestes*, *Amphitherium*, *Phascolotherium*, and *Stereognathus*. After the Stonesfield Slate another interval succeeds, in which no Mammalian remains have hitherto been found; but in the freshwater formation of the Middle Purbeck, at the top, namely, of the Oolitic series, as many as fourteen small Mammals have been discovered. These constitute the genera *Plagiaulax*, *Triconodon*, and *Galestes*. Another gap then follows, no Mammal having hitherto been discovered in any portion of the Cretaceous series (with doubtful exceptions).

Leaving the Mesozoic and entering upon the Kainozoic period, remains of Mammals are never absent from any of the geological formations. From the base of the Eocene Rocks up to the present day remains of Mammals invariably occur, constantly increasing in number and importance, till we arrive at the fauna now in existence upon the globe.

The number of known fossil Mammals is so great, and they exhibit so many peculiarities and divergences from existing forms, that it will be impossible here to do more than simply point out the leading facts known as to the distribution of each order of Mammals in past time.

Order I. Monotremata.—The Monotremes are not known to be represented at all in past time; and this need not excite any surprise, seeing that the order is represented at the present day by no more than two genera, both confined to a single geographical region. Upon theoretical grounds, however, it may be expected that we shall ultimately discover that the antiquity of the order *Monotremata* is extremely high.

Order II. Marsupialia.—This is probably the oldest of the Mammalian orders; but owing to the detached and fragmentary condition of almost all Mammalian remains—consisting mostly of the ramus of the lower jaw, or of separate teeth—it is not possible to state this with absolute certainty. The *Microlestes* of the Trias, the oldest, or nearly the oldest, of the Mammals, was *probably* a Marsupial; but the evidence upon this point is not conclusive. In the Triassic Rocks of America, also, perhaps at a lower horizon than that at which *Microlestes* occurs in Europe, has been found the jaw of a small Mammal, which is probably Marsupial, and has been named *Dromatherium* (fig. 213).

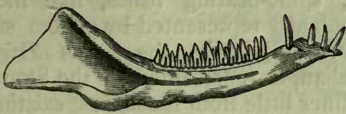


Fig. 213.—Lower jaw of *Dromatherium sylvestre* (after Emmons). From rocks, supposed to be of Triassic age, in North Carolina.

In the next mammaliferous horizon, however—namely, that of the Stonesfield Slate in the Lower Oolites—there is no doubt but that some of the Mammalian remains, if not all, belong to small Marsupials (fig. 214). From this horizon the two genera *Phascolotherium* and *Amphitherium*, are almost certainly referable to the *Marsupialia;* the latter seeming to be most nearly related to the living *Myrmecobius*, whilst the former finds its nearest living ally in the Opossums of America. The *Stereognathus* of the Stonesfield Slate is in a doubtful position. It may have been Marsupial, but, upon the whole, Professor Owen is inclined to believe that it was placental, hoofed, and herbivorous.

Fig. 214.—Oolitic Mammals, natural size. 1. Lower jaw and teeth of *Phascolotherium ;* 2. of *Triconodon ;* 3. of *Amphitherium ;* 4. of *Plagiaulax.*

With the occurrence of small Marsupials in England within the Oolitic period, it is interesting to notice how the fauna of that time approached in other respects to that now inhabiting Australia. At the present day, Australia is almost wholly tenanted by Marsupials ; upon its land-surface flourish *Araucariæ* and Cycadaceous plants, and in its seas swims the Port-Jackson Shark (*Cestracion Philippi*) ; whilst the Molluscan genus *Trigonia* is nowadays exclusively confined to the Australian coasts. In England at the time of the deposition of the Stonesfield Slate, we must have had a fauna and flora very closely resembling what we now see in Australia. The small

Marsupials, *Amphitherium* and *Phascolotherium*, prove that the Mammals were the same in order; cones of Araucarian pines, with tree-ferns and fronds of Cycads occur throughout the Oolitic series; spine-bearing fishes, like the Port-Jackson Shark, are abundantly represented by genera such as *Acrodus* and *Strophodus;* and, lastly, the genus *Trigonia*, now exclusively Australian, is represented in the Stonesfield Slate by species which differ little from those now existing.

In the Middle Purbeck beds (Upper Oolite), where fourteen species of Mammals are known to exist, it is probable that all were Marsupial. All the Purbeck Mammalia were of small size, the largest being no bigger than a pole-cat or hedgehog. They form the genera *Plagiaulax*, *Triconodon*, and *Galestes*, of which *Plagiaulax* is believed to be most nearly allied to the living Kangaroo-rat (*Hypsiprymnus*) of Australia.

In the Tertiary series of rocks Marsupials are of rare occurrence; but an Opossum, closely allied to the existing American forms, has been discovered in the Eocene Rocks of France (Gypseous series of Montmartre), and has been named the *Didelphys gypsorum*.

The next occurrence of Marsupials is in the later Tertiary (Pliocene) and in the Post-tertiary epoch; and here they are represented by some very remarkable forms. The remains in question have been found in the bone-caves of Australia—the country in which Marsupials now abound above every other part of the globe; and they show that Australia, at no distant geological period, possessed a Marsupial fauna, much resembling that which it has at present, but comparatively of a much more gigantic size. In the remains from the Australian bone-caves almost all the most characteristic living Marsupials of Australia and Van Diemen's Land are represented; but the extinct forms are usually of much greater size. We have Wombats, Phalangers, Flying Phalangers, and Kangaroos, with carnivorous Marsupials resembling the recent *Thylacinus* and *Dasyurus*. The two most remarkable of these extinct forms are *Diprotodon* and *Thylacoleo*. In most essential respects *Diprotodon* resembled the Kangaroos, the dentition, especially, showing many points of affinity. The hind-limbs, however, of *Diprotodon* were by no means so disproportionately long as in the Kangaroos. In size *Diprotodon* must have many times exceeded the largest of the living Kangaroos, since the skull measures three feet in length (fig. 215.) *Thylacoleo* was a carnivorous and predacious Marsupial, equally gigantic when compared with living forms. *Thylacoleo*, in fact, must have been, on a moderate estimate, at least as large as a Lion;

the largest living carnivorous Marsupial being no larger than a shepherd's dog. The flesh-tooth or carnassial molar of *Thylacoleo* measures two inches and a quarter across, or very nearly double the measurement of the same tooth in the largest existing Lion.

Fig. 215.—Skull of *Diprotodon Australis.*

Order III. Edentata.—The Edentates, like the Marsupials, are singularly circumscribed at the present day. No member of the order is at the present day indigenous in Europe. Tropical Asia and Africa have the Scaly Ant-eaters or Pangolins; and in Africa occurs the Edentate genus *Orycteropus*. South America, however, is the metropolis of the *Edentata*, the order being there represented by the Sloths, the Armadillos, and the true Ant-eaters. It is also in South America that by far the greater number of extinct Edentates have been found; and, as in the case of the Australian Marsupials, the fossil forms are gigantic in size compared with their living representatives.

The Sloths (*Bradypodidæ*) of the present day were represented in Post-tertiary times by a group of gigantic forms referable to the genera *Mylodon*, *Megalonyx*, and *Megatherium*.

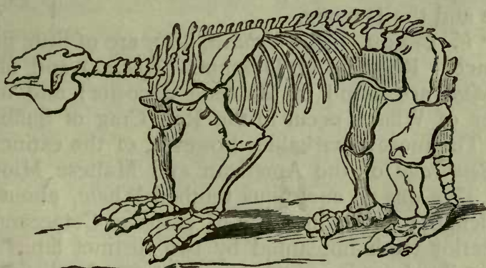


Fig. 216.—*Megatherium*. From the Upper Tertiaries of South America (Pleistocene).

Of these, *Mylodon* attained a length of eleven feet, and *Megatherium* (fig. 216) was eighteen feet in length, with bones as massive, or more so, than the Elephant.

In the same way, the little banded Armadillos of South America were formerly represented by gigantic species, constituting the genus *Glyptodon*. The *Glyptodons* (fig. 217) differed from the living Armadillos in having no bands in their armour, so that they must have been unable to roll themselves up. It is rare at the present day to meet with any Armadillo over two or three feet in length; but the length of the *Glyptodon clavipes*, from the tip of the snout to the end of the tail, was more than nine feet.

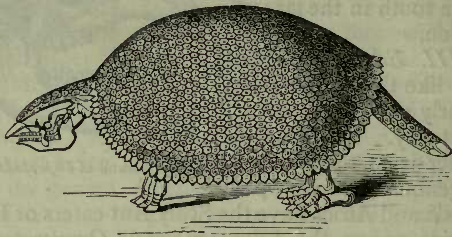


Fig. 217.—*Glyptodon clavipes.* Pleistocene deposits of South America.

All these gigantic South American Edentates occur in Post-tertiary deposits. Older, however, than any of these is the *Macrotherium.* This is a gigantic Edentate, intermediate in some respects between the *Pangolins* and *Orycteropus*, and found in certain lacustrine deposits of France, of Miocene age.

Order IV. Sirenia.—This order contains only the living Manatees and Dugongs, and is of little geological importance. The *Halitherium*, however, of the Eocene, Miocene, and Pliocene Rocks is a large form, intermediate between the African Manatee and the Dugong.

Order V. Cetacea.—The *Cetacea*, also, are of little geological importance. Remains of Dolphins (*Ziphius*) and of Whales (*Balænodon*) are found in Miocene deposits; and numerous ear-bones of Whales occur in the Red Crag of Suffolk (Pliocene). The most remarkable, however, of the extinct *Cetacea* is the *Zeuglodon* of the American and Maltese Miocene deposits. This was an enormous toothed Whale, about seventy feet in length; but unlike any of existing Cetaceans, it had the posterior teeth implanted by two distinct fangs or roots. By Owen, *Zeuglodon* is regarded as the type of a distinct family, intermediate between the *Cetacea* and the *Sirenia.*

Order VI. Ungulata.—The Hoofed Mammals are represented in past time by so many extinct forms that it will be wholly impossible here to do more than merely allude to some of the more important genera.

The earliest-known Ungulates occur in the Eocene Rocks, where the order is represented by very numerous and interesting forms, the more important of which are *Pliolophus*, *Palæotherium*, and *Anoplotherium.*

Of the section of the Ungulates comprising the living Horse, Zebra, and Ass (*Solidungula*), the earliest fossil example is the *Hipparion* of the Miocene Rocks. This genus differed from the existing *Equidæ* in the presence of two small toes with hoofs, one on each side of the single functional toe, which alone remains in living horses. In the Pliocene period appear, for the first time, remains of horses which, like the present form, possessed only a single toe encased in a single hoof. It is interesting to observe that one of the Pliocene horses (*Equus curvidens*) occurs in South America; though this continent certainly possessed no native horse at the time of its discovery by the Spaniards.

Of the *Rhinoceridæ*, a hornless species (*Acerotherium*) occurs in Miocene and Pliocene strata; but the best-known fossil species is the two-horned woolly Rhinoceros (*R. tichorhinus*). This curious species occurs in Post-pliocene deposits, and must have ranged over the greater part of Europe. It was adapted to a temperate climate, and, like the Mammoth, possessed a thick covering of mixed wool and hair. This has been demonstrated by the discovery of a frozen carcass in Siberia.

Of the *Hippopotamidæ* the earliest-known species is the *Hippopotamus major* of the Pliocene period. This form agreed in all essential respects with the living *H. amphibius* of Africa, but it must have ranged over the whole of southern Europe.

Of the *Suida*, or Pig tribe, various extinct forms are known from the Eocene and Miocene Rocks, where the family is represented by the genera *Chæropotamus*, *Anthracotherium*, *Hyopotamus*, and *Hippohyus*.

As regards the past existence of the Ruminants, the *Cervidæ*, or Stag tribe, is represented, for the first time in the Miocene period, by the genus *Dorcatherium*. The best-known species, however, of this family is the *Megaceros Hibernicus*, or so-called Irish Elk (fig. 218), which is not a true Elk, but is intermediate between the Fallow-deer and Reindeer. Of the Giraffe family —represented at the present day by a single African species— a form has been discovered in the Pliocene Rocks of Greece, and has been described under the name of *Helladotherium*. Somewhat similar forms have been found in the Pliocene deposits of the Sivalik Hills of India.

The earliest-known Antelopes are Miocene, but the largest and most extraordinary fossil examples of this family are two gigantic four-horned Antelopes, which occur in the Pliocene strata of the Sivalik Hills of India, and have been described under the names of *Sivatherium* and *Bramatherium*.

The *Bovidæ*, or Ox tribe, has hitherto only occurred in rocks not older than the Pliocene or Post-pliocene. At this latter period England alone possessed four oxen—viz., the Lithua-

Fig. 218.—The Irish Elk (*Megaceros Hibernicus*).

nian Aurochs (*Bos bison* or *Bos priscus*), the Wild Bull or Urus (*Bos primigenius*), the *Bos antiquus*, and a small aboriginal species, the *Bos longifrons*, believed by Owen to be "the source of the domesticated cattle of the Celtic races before the Roman invasion."

Order VII. Hyracoidea.—This little order, represented at the present day by no more than the single genus *Hyrax*, is not known to have any fossil representatives.

Order VIII. Proboscidea.—This order, including no other living forms than the Elephants, came into existence in the Miocene period, where it is represented by all its three sections, *Deinotherium*, *Mastodon*, and *Elephas*.

The *Deinotherium* (fig. 202) was a gigantic Miocene Mammal, probably something like the living Elephants, but having no incisors in the upper jaw. In place of these, the *lower* jaw was furnished with two long tusk-like incisors, which were bent downwards.

In most essential respects the Mastodons (fig. 219) resemble the Elephants, but the molar teeth were furnished with nipple-shaped eminences. Usually there are two tusk-shaped upper incisors, but sometimes lower incisors are present as well. Four Mastodons occur in the Miocene of Europe, and three in that of India.

No Elephant has yet been discovered in the Miocene Rocks of Europe, but six species are known from Miocene strata in India. In the Pliocene period, Europe possessed its Elephants (viz., *E. priscus* and *E. meridionalis*); but the best known of

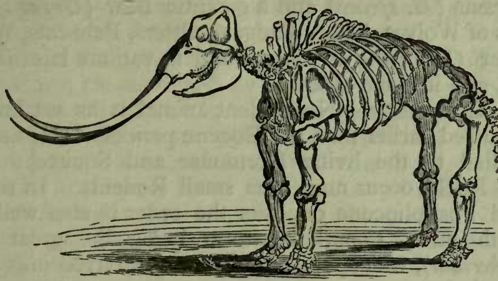


Fig. 219.—Skeleton of *Mastodon*.

the extinct Elephants, as well as the most modern, is the Mammoth (*E. primigenius*, fig. 220). The Mammoth enjoyed

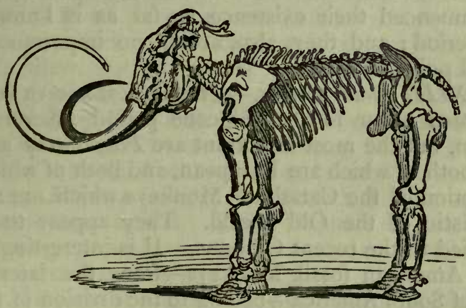


Fig. 220.—Skeleton of the Mammoth (*Elephas primigenius*).

a very extended geographical distribution, remains of it occurring in Britain, continental Europe, Siberia, and throughout a large portion of North America. There can also be no question but that the Mammoth existed in the earlier portion of the human period.

Order IX. Carnivora.—If the little *Microlestes* of the Upper Trias be Marsupial, as is most probably the case, then the order *Carnivora* is comparatively modern, the earliest undoubted remains having been found in the Eocene Rocks. The tribe of the *Felidæ* is represented in the Miocene period by the large *Machairodus*, with sabre-shaped upper canines.

Species of this genus must have been as large as a Lion. In the later Pliocene and Post-pliocene deposits occur the remains of a large Lion—the Cave-lion or *Felis spelæa*—along with which, in Britain and continental Europe, are the bones of a large Hyæna (*H. spelæa*) and a gigantic Bear (*Ursus spelæus*). Remains of Wolves, Foxes, Badgers, Otters, Pole-cats, Weasels, and other *Carnivora* are also found in various later Tertiary deposits, and in bone-caves.

Order X. Rodentia.—No Rodent animal is as yet known to have occurred earlier than the Eocene period. Here are found forms allied to the living Dormouse and Squirrel. In the Miocene Rocks occur numerous small Rodents. In the Pliocene and Post-pliocene deposits the order is also well represented, the most remarkable form being the great Beaver (*Trogontherium*), which appears to have survived into the historical period.

Order XI. Cheiroptera.—The earliest-known indications of Bats are in the Eocene period, but the order is of no geological importance.

Order XII. Insectivora.—The Insectivorous Mammals, likewise, commenced their existence, so far as is known, in the Eocene period; and they, also, are of no importance from a geological point of view.

Order XIII. Quadrumana.—The earliest-known remains of *Quadrumana* occur in the Miocene period. Several genera are known, but the most important are *Pliopithecus* and *Dryopithecus*, both of which are European, and both of which belong to the section of the Catarhine Monkeys which are at present characteristic of the Old World. They appear to be most nearly allied to the recent Gibbons. It is interesting to notice that the American fossil Monkeys—from the later Tertiary deposits of South America—belong to the division of the *Quadrumana* now peculiar to that continent — to the section, namely, of the Platyrhine Monkeys.

Geographical Succession of Organic Forms.

A few words may be said here on a law which may be called the "law of the geographical succession of organic forms," and which is illustrated more completely by the *Mammalia* than by any other extinct animals. An examination, namely, of the facts of the geological distribution of Mammals leads to the striking generalisation that "the present distribution of organic *forms* dates back to a period anterior to the origin of existing *species*" (Lyell). In other words, though the extinct Mammals of the later geological deposits of any given country differ *specifically* from those now existing in the same country, they are nevertheless referable to the same *orders*, and are in every respect more closely allied to the present Mammalian fauna than to that of any other country. A few examples will render this perfectly clear.

Australia at the present day is an altogether peculiar zoological province, characterised by the abundance and variety of Marsupials which inhabit it. In the Post-tertiary deposits of Australia, however, we are presented with proofs that Marsupials were just as characteristic of Australia during late geological epochs as they are now. In the Post-pliocene period we know that Australia was occupied by Kangaroos, Kangaroo-rats, Wombats, Phalangers, and Carnivorous Marsupials, in every way *representing* the living Marsupials in zoological value, but *specifically* distinct, and generally of gigantic size.

In the same way, South America at the present day is especially characterised by a Mammalian fauna, containing many peculiar forms, the *Edentata* being especially conspicuous, and having a larger representation than in any other region. Similar but distinct forms, however, are found to have existed in South America anterior to the creation of any existing species. Thus, the modern Sloths of South America are represented by the colossal *Mylodon*, *Megalonyx*, and *Megatherium*. The little armour-plated Armadillos are represented by the equally colossal *Glyptodon*. The Llamas—representing in South America the Camels of the Old World—are represented by the curious extinct genus *Macrauchenia*. The Platyrhine Monkeys have their extinct representatives. Fossil Tapirs take the place of the two existing species; and the Peccaries are represented by at least five extinct species of *Dicotyles*.

Similarly, India is at present the only country in which four-horned Antelopes occur; and it is in the Sivalik Hills that there have been found the two gigantic four-horned Antelopes, which constitute the genera *Sivatherium* and *Bramatherium*.

In Europe, again, the Mammalian fauna of the later Tertiary periods is much more closely allied to that now characterising the Old World, than to that of the New. We have the Lion, Bear, Wolf, Fox, and other well-known *Carnivora*. Elephants, Rhinoceroses, and Hippopotami, then as now, are characteristic Old World forms. The Ruminants are equally characteristic of the eastern hemisphere, though not exclusively confined to it, and they have numerous and varied representatives in later Tertiary deposits. The Giraffe is represented by the *Helladotherium*, and the Bactrian Camel by the *Merycotherium* of the

Siberian Drift. The fossil *Quadrumana*, too, of Europe, all belong to the Catarhine section of the order.

It is unnecessary to pursue the subject further, but no law is more firmly established than this: "That with extinct as with existing Mammalia, particular forms were assigned to particular provinces; and that the same forms were restricted to the same provinces at a former geological period as they are at the present day" (Owen). It is to be borne in mind, however, that the law, as just stated, holds good for the later Tertiary period only, and does not apply, in any manner that admits of being traced, to the earlier geological epochs.

TABULAR VIEW OF THE CHIEF SUB-DIVISIONS OF THE SUB-KINGDOM VERTEBRATA.

SUB-KINGDOM VI.—VERTEBRATA.

CLASS I. PISCES.

Order 1. Pharyngobranchii.
2. Marsipobranchii.
3. Teleostei.
4. Ganoidei.
5. Elasmobranchii.
6. Dipnoi.

CLASS II. AMPHIBIA.

Order 1. Labyrinthodontia.
2. Ophiomorpha.
3. Urodela.
4. Anoura.

CLASS III. REPTILIA.

Order 1. Chelonia.
2. Ophidia.
3. Lacertilia.
4. Crocodilia.
5. Ichthyopterygia.
6. Sauropterygia.
7. Anomodontia.
8. Pterosauria.
9. Deinosauria.

CLASS IV. AVES.

Order 1. Natatores.
2. Grallatores.
3. Cursores.
4. Rasores.

Sub-order a. Gallinacei.
b. Columbacei.
5. Scansores.
6. Insessores.
Sub-order a. Conirostres.
b. Dentirostres.
c. Tenuirostres.
d. Fissirostres.
7. Raptores.
8. Saururæ.

CLASS V. MAMMALIA.
Division A. Ornithodelphia.
Order 1. Monotremata.
Division B. Didelphia.
Order 2. Marsupialia.
Division C. Monodelphia.
Order 3. Edentata.
4. Sirenia.
5. Cetacea.
6. Ungulata.
Section Perissoaactyla.
a. Multungula.
b. Solidungula.
Section Artiodactyla.
a. Omnivora.
b. Ruminantia.
7. Hyracoidea.
8. Proboscidea.
9. Carnivora.
a. Pinnigrada.
b. Plantigrada.
c. Digitigrada.
10. Rodentia.
11. Cheiroptera.
12. Insectivora.
13. Quadrumana.
a. Strepsirhina.
b. Platyrhina.
c. Catarhina.
14. Bimana.

GLOSSARY.

ABDOMEN (Lat. *abdo,* I conceal). The posterior cavity of the body, containing the intestines and others of the viscera. In many Invertebrates there is no separation of the body-cavity into thorax and abdomen, and it is only in the higher *Annulosa* that a distinct abdomen can be said to exist.

ABERRANT (Lat. *aberro,* I wander away). Departing from the regular type.

ABNORMAL (Lat. *ab,* from; *norma,* a rule). Irregular; deviating from the ordinary standard.

ABOMASUM. The fourth cavity of the complex stomach of the Ruminants.

ABRANCHIATE (Gr. *a,* without; *bragchia,* gills). Destitute of gills or branchiæ.

ACALEPHÆ (Gr. *akalephe,* a nettle). Applied formerly to the Jelly-fishes or Sea-nettles, and other Radiate animals, in consequence of their power of stinging, derived from the presence of microscopic cells, called "thread-cells," in the integument.

ACANTHOCEPHALA (Gr. *acantha,* a thorn; *kephale,* head). A class of parasitic worms in which the head is armed with spines.

ACANTHOMETRINA (Gr. *akantha;* and *metra,* the womb). A family of *Protozoa,* characterised by having radiating silicious spines.

ACANTHOPTERYGIA (Gr. *akantha,* spine; *pterux,* wing). A group of bony fishes with spinous rays in the front part of the dorsal fin.

ACARINA (Gr. *akari,* a mite). A division of the *Arachnida,* of which the Cheese-mite is the type.

ACEPHALOUS (Gr. *a,* without; *kephale,* head). Not possessing a distinct head.

ACETABULA (Lat. *acetabulum,* a cup). The suckers with which the cephalic processes of many *Cephalopoda* (Cuttle-fishes) are provided.

ACETABULUM. The cup-shaped socket of the hip-joint in Vertebrates.

ACRITA (Gr. *akritos,* confused). A term sometimes employed as synonymous with *Protozoa,* or the lowest division of the animal kingdom.

ACTINOMERES (Gr. *aktin,* a ray; *meros,* a part). The lobes which are mapped out on the surface of the body of the *Ctenophora,* by the ctenophores, or comb-like rows of cilia.

ACTINOSOMA (Gr. *aktin;* and *soma,* body). Employed to designate the entire body of any *Actinozoön,* whether this be simple (as in the Sea-anemones), or composed of several zoöids (as in most Corals).

ACTINOZOA (Gr. *aktin;* and *zoön,* an animal). That division of the *Cœlenterata* of which the Sea-anemones may be taken as the type.

ADELARTHROSOMATA (Gr. *adelos,* hidden; *arthros,* joint; *soma,* body). An order of the *Arachnida.*

AGAMIC (Gr. *a,* without; *gamos,* marriage). Applied to all forms of reproduction in which the sexes are not directly concerned.

ALLANTOIDEA. The group of *Vertebrata* in which the fœtus is furnished with an allantois, comprising the Reptiles, Birds, and Mammals.

ALLANTOIS (Gr. *allas,* a sausage). One of the "membranes" of the fœtus in certain Vertebrates.

ALVEOLI (Lat. dim. of *alvus*, belly). Applied to the sockets of the teeth.

AMBULACRA (Lat. *ambulacrum*, a place for walking). The perforated spaces or "avenues" through which are protruded the tube-feet, by means of which locomotion is effected in the *Echinodermata*.

AMBULATORY (Lat. *ambulo*, I walk). Formed for walking. Applied to a single limb, or to an entire animal.

AMETABOLIC (Gr. *a*, without; *metabole*, change). Applied to those insects which do not possess wings when perfect, and which do not, therefore, pass through any marked metamorphosis.

AMNION (Gr. *amnos*, a lamb). One of the fœtal membranes of the higher Vertebrates.

AMNIOTA. The group of *Vertebrata* in which the fœtus is furnished with an amnion, comprising the Reptiles, Birds, and Mammals.

AMŒBA (Gr. *amoibos*, changing). A species of Rhizopod, so called from the numerous changes of form which it undergoes.

AMŒBIFORM. Resembling an *Amœba* in form.

AMORPHOZOA (Gr. *a*, without; *morphe*, shape; *zoön*, animal). A name sometimes used to designate the *Sponges*.

AMPHIBIA (Gr. *amphi*, both; *bios*, life). The Frogs, Newts, and the like, which have gills when young, but can always breathe air directly when adult.

AMPHICŒLOUS (Gr. *amphi*, at both ends; *koilos*, hollow). Applied to vertebræ which are concave at both ends.

AMPHIDISCS (Gr. *amphi*, at both ends; *diskos*, a quoit, or round plate). The spicula which surround the gemmules of *Spongilla*, and resemble two toothed wheels united by an axle.

AMPHIOXUS (Gr. *amphi*, at both ends; *oxus*, sharp). The Lancelet, a little fish, which alone constitutes the order *Pharyngobranchii*.

AMPHIPNEUSTA (Gr. *amphi*, both; *pneo*, I breathe). Applied to the "perennibranchiate" Amphibians which retain their gills through life.

AMPHIPODA (Gr. *amphi*, and *pous*, a foot). An order of *Crustacea*.

ANAL (Lat. *anus*, the vent). Connected with the anus, or situated near the anus.

ANALLANTOIDEA. The group of *Vertebrata* in which the embryo is not furnished with an allantois.

ANALOGOUS. Applied to parts which perform the same function.

ANAMNIOTA. The group of *Vertebrata* in which the embryo is destitute of an amnion.

ANARTHROPODA (Gr. *a*, without; *arthros*, a joint; *pous*, foot). That division of *Annulose* animals in which there are no articulated appendages.

ANCHYLOSIS or ANKYLOSIS (Gr. *ankulos*, crooked). The union of two bones by osseous matter, so that they become one bone, or are immovably joined together.

ANDROGYNOUS (Gr. *anēr*, a man; *gune*, a woman). Synonymous with hermaphrodite, and implying that the two sexes are united in the same individual.

ANDROPHORES (Gr. *anēr*, a man; and *phero*, I carry). Applied to medusiform gonophores of the *Hydrozoa*, which carry the spermatozoa, and differ in form from those in which the ova are developed.

ANNELIDA (a Gallicised form of *Annulata*). The Ringed worms, which form one of the divisions of the *Anarthropoda*.

ANNULATED. Composed of a succession of rings.

ANNULOIDA (Lat. *annulus*, a ring; Gr. *eidos*, form). The sub-kingdom comprising the *Echinodermata* and the *Scolecida* (=*Echinozoa*).

ANNULOSA (Lat. *annulus*). The sub-kingdom comprising the *Anarthropoda* and the *Arthropoda* or *Articulata*, in all of which the body is more or less evidently composed of a succession of rings.

ANOMODONTIA (Gr. *anomos*, irregular; *odous*, tooth). An extinct order of Reptiles, often called *Dicynodontia*.

ANOMURA (Gr. *anomos*, irregular; *oura*, tail). A tribe of Decapod *Crustacea*, of which the Hermit-crab is the type.

ANOPLURA (Gr. *anoplos*, unarmed; *oura*, tail). An order of Apterous Insects.
ANOURA (Gr. *a*, without; *oura*, tail). The order of *Amphibia* comprising the Frogs and Toads, in which the adult is destitute of a tail. Often called *Batrachia*.
ANTENNÆ (Lat. *antenna*, a yard-arm). The jointed horns or feelers possessed by the majority of the *Articulata*.
ANTENNULES (dim. of *Antennæ*). Applied to the smaller pair of antennæ in the *Crustacea*.
ANTIBRACHIUM (Gr. *anti*, in front of; *brachion*, the arm). The fore-arm of the higher Vertebrates, composed of the *radius* and *ulna*.
ANTLERS. Properly the branches of the horns of the Deer tribe (*Cervidæ*), but generally applied to the entire horns.
ANTLIA (Lat. *antlia*, a pump). The spiral trunk or proboscis with which Butterflies and other Lepidopterous Insects suck up the juices of flowers.
APHANIPTERA (Gr. *aphanos*, inconspicuous; *pteron*, a wing). An order of Insects, comprising the Fleas.
APLACENTALIA. The section of the *Mammalia*, comprising the two divisions of the *Didelphia* and *Monodelphia*, in which the young is not furnished with a placenta.
APODA (Gr. *a*, without; *poda*, feet). Applied to those fishes which have no ventral fins. Also to the footless *Cæciliæ* amongst the *Amphibia*.
APODAL. Devoid of feet.
APODEMATA (Gr. *apodaio*, I portion off). Applied to certain chitinous septa which divide the tissues in *Crustacea*.
APTERA (Gr. *a*, without; *pteron*, a wing). A division of Insects, which is characterised by the absence of wings in the adult condition.
APTEROUS. Devoid of wings.
APTERYX (Gr. *a*, without; *pterux*, a wing). A wingless bird of New Zealand, belonging to the order *Cursores*.
ARACHNIDA (Gr. *arachne*, a spider). A class of the *Articulata*, comprising Spiders, Scorpions, and allied animals.
ARBORESCENT. Branched like a tree.
ARCHÆOPTERYX (Gr. *archaios*, ancient; *pterux*, wing). The singular fossil bird which alone constitutes the order of the *Saururæ*.
ARCHENCEPHALA (Gr. *archo*, I overrule; *egkephalos*, brain). The name applied by Owen to his fourth and highest group of *Mammalia*, comprising Man alone.
ARENACEOUS. Sandy, or composed of grains of sand.
ARTICULATA (Lat. *articulus*, a joint). A division of the animal kingdom, comprising Insects, Centipedes, Spiders, and Crustaceans, characterised by the possession of jointed bodies or jointed limbs. The term *Arthropoda* is now more usually employed.
ARTIODACTYLA (Gr. *artios*, even; *daktulos*, a finger or toe). A division of the hoofed quadrupeds (*Ungulata*) in which each foot has an even number of toes (two or four).
ASCIDIOIDA (Gr. *askos*, a bottle; *eidos*, form). A synonym of *Tunicata*, a class of Molluscous animals, which have the shape, in many cases, of a two-necked bottle.
ASEXUAL. Applied to modes of reproduction in which the sexes are not concerned.
ASIPHONATE. Not possessing a respiratory tube or siphon. (Applied to a division of the *Lamellibranchiate* Molluscs.)
ASTEROID (Gr. *aster*, a star; and *eidos*, form). Star-shaped, or possessing radiating lobes or rays like a star-fish.
ASTEROIDEA. An order of *Echinodermata*, comprising the Star-fishes, characterised by their rayed form.
ASTOMATOUS (Gr. *a*, without; *stoma*, mouth). Not possessing a mouth.
ATLAS (Gr. the God who holds up the earth). The first vertebra of the neck, which articulates with and supports the skull.
ATRIUM (Lat. a hall). Applied to the great chamber or "cloaca," into which the intestine opens in the *Tunicata*.

AURELIA (Lat. *aurum*, gold). Applied to the chrysalides of some *Lepidoptera*, on account of their exhibiting a golden lustre.
AURICLE (Lat. dim. of *auris*, ear). Applied to one of the cavities of the heart, by which blood is driven into the ventricle.
AUTOPHAGI (Gr. *autos*, self; *phago*, I eat). Applied to birds whose young can run about and obtain food for themselves as soon as they escape from the egg.
AVES (Lat. *avis*, a bird). The class of the Birds.
AVICULARIUM (Lat. *avicula*, dim. of *avis*, a bird). A singular appendage, often shaped like the head of a bird, found in many of the *Polyzoa*.
AXIS (Gr. *axon*, a pivot). The second vertebra of the neck, upon which the skull and atlas usually rotate.
AZYGOS (Gr. *a*, without; *zugos*, yoke). Single; without a fellow.

BACTERIUM (Gr. *bakterion*, a staff). A kind of staff-shaped filament which appears in organic infusions after they have been exposed to the air.
BALANIDÆ (Gr. *balanos*, an acorn). A family of sessile *Cirripides*, commonly called "Acorn-shells."
BALEEN (Lat. *balæna*, a whale). The horny plates which occupy the palate of the true or "whale-bone" Whales.
BATIDES (Gr. *batos*, a bramble). The family of the *Elasmobranchii* comprising the Rays.
BATRACHIA (Gr. *batrachos*, a frog). Often loosely applied to any of the *Amphibia*, but sometimes restricted to the Amphibians as a class, or to the single order of the *Anoura*.
BIFID. Cleft into two parts; forked.
BILATERAL. Having two symmetrical sides.
BIMANA (Lat. *bis*, twice; *manus*, a hand). The order of *Mammalia* comprising Man alone.
BIPEDAL (Lat. *bis*, twice; *pes*, foot). Walking upon two legs.
BIRAMOUS (Lat. *bis*, twice; *ramus*, a branch). Applied to a limb which is divided into two branches (*e.g.*, the limbs of Cirripedes).
BIVALVE (Lat *bis*, twice; *valvæ*, folding-doors). Composed of two plates or valves; applied to the shell of the *Lamellibranchiata* and *Brachiopoda*, and to the carapace of certain *Crustacea*.
BLASTOIDEA (Gr. *blastos*, a bud; and *eidos*, form). An extinct order of *Echinodermata*, often called *Pentremites*.
BRACHIOPODA (Gr. *brachion*, an arm; *pous*, the foot). A class of the *Molluscoida*, often called "Lamp-shells," characterised by possessing two fleshy arms continued from the sides of the mouth.
BRACHIUM (Gr. *brachion*, arm). Applied to the upper arm of Vertebrates.
BRACHYURA (Gr. *brachus*, short; *oura*, tail). A tribe of the Decapod *Crustaceans* with short tails (*i.e.*, the Crabs).
BRACTS. (*See* Hydrophyllia.)
BRADYPODIDÆ (Gr. *bradus*, slow; *poda*, feet). The family of *Edentata* comprising the Sloths.
BRANCHIA (Gr. *bragchia*, the gill of a fish). A respiratory organ adapted to breathe air dissolved in water.
BRANCHIATE. Possessing gills or branchiæ.
BRANCHIFERA (Gr. *bragchia*, gill; and *phero*, I carry). A division of *Gasteropodous Molluscs*, in which the respiration is aquatic, and the respiratory organs are mostly in the form of distinct gills.
BRANCHIO-GASTEROPODA (= Branchifera).
BRANCHIOPODA (Gr. *bragchia*; and *pous*, foot). A legion of *Crustacea*, in which the gills are supported by the feet.
BRANCHIOSTEGAL (Gr. *bragchia*, gill; *stego*, I cover). Applied to a membrane and rays by which the gills are protected in many fishes.
BREVILINGUIA (Lat. *brevis*, short; *lingua*, tongue). A division of the *Lacertilia*.
BREVIPENNATÆ (Lat. *brevis*, short; *penna*, a wing). A group of the Natatorial Birds.

Bronchi (Gr. *brogchos,* the windpipe). The branches of the windpipe (*trachea*), by which the air is conveyed to the vesicles of the lung.
Bruta (Lat. *brutus,* heavy, stupid). Often used to designate the Mammalian order of the *Edentata.*
Bryozoa (Gr. *bruon,* moss; *zoön,* animal). A synonym of *Polyzoa,* a class of the *Molluscoida.*
Buccal (Lat. *bucca,* mouth or cheeks). Connected with the mouth.
Bursiform (Lat. *bursa,* a purse; *forma,* shape). Shaped like a purse; subspherical.
Byssiferous. Producing a byssus.
Byssus (Gr. *bussos,* flax). A term applied to the silky filaments by which the *Pinna,* the common Mussel, and certain other bivalve *Mollusca,* attach themselves to foreign objects.

Caducibranchiate (Lat. *caducus,* falling off; Gr. *bragchia,* gill). Applied to those Amphibians in which the gills fall off before maturity is reached.
Caducous. Applied to parts which fall off or are shed during the life of the animal.
Cæcal (Lat. *cæcus,* blind). Terminating blindly, or in a closed extremity.
Cæcum (Lat. *cæcus*). A tube which terminates blindly.
Cæspitose (Lat. *cæspes,* a turf). Tufted.
Cainozoic. (*See* Kainozoic.)
Calcar (Lat. a spur). Applied to the "spurs" of Rasorial birds; and also to the rudiments of the hind-limbs in certain Snakes.
Calcareous (Lat. *calx,* lime). Composed of carbonate of lime.
Calice. The little cup in which the polype of a coralligenous Zoophyte (*Actinozoön*) is contained.
Calycophoridæ (Gr. *kalux,* a cup; and *phero,* I carry). An order of the Oceanic *Hydrozoa,* so called from their possessing bell-shaped swimming organs (*nectocalyces*).
Calyx (Lat. *calyx,* a cup). Applied to the cup-shaped body of *Vorticella* (*Protozoa*), or of a *Crinoid* (*Echinodermata*).
Campanularida (Lat. *campanula,* a bell). An order of Hydroid Zoophytes.
Canine (Lat. *canis,* a dog). The eye-tooth of Mammals, or the tooth which is placed at or close to the præmaxillary suture in the upper jaw, and the corresponding tooth in the lower jaw.
Capitulum (Lat. dim. of *caput,* head). Applied to the body of a Barnacle (*Lepadidæ*), from its being supported upon a stalk or peduncle.
Carapace. A protective shield. Applied to the upper shell of Crabs, Lobsters, and many other *Crustacea;* also to the case with which certain of the *Infusoria* are provided. Also the upper half of the immovable case in which the body of a Chelonian is protected.
Carinatæ (Lat. *carina,* a keel). Applied by Huxley to all those birds in which the sternum is furnished with a median ridge or keel.
Carnivora (Lat. *caro,* flesh; *voro,* I devour). An order of the *Mammalia.*
Carnivorous (Lat. *caro,* flesh; *voro,* I devour). Feeding upon flesh.
Carnose (Lat. *caro*). Fleshy.
Carpophaga (Gr. *karpos,* fruit; *phago,* I eat). A section of the *Marsupialia.*
Carpus (Gr. *karpos,* the wrist). The small bones which intervene between the fore-arm and the metacarpus.
Catarhina (Gr. *kata,* downwards; *rhines,* nostrils). A group of the *Quadrumana.*
Caudal (Lat. *cauda,* the tail). Belonging to the tail.
Cavicornia (Lat. *cavus,* hollow; *cornu,* a horn). The "hollow-horned" Ruminants, in which the horn consists of a central bony "horn-core" surrounded by a horny sheath.
Centrum (Gr. *kentron,* the point round which a circle is described by a pair of compasses). The central portion or "body" of a vertebra.
Cephalic (Gr. *kephale,* head). Belonging to the head.
Cephalo-branchiate (Gr. *kephale;* and *bragchia,* gill). Carrying gills upon

the head. Applied to a section of the *Annelida,* which, like the *Serpulæ,* have tufts of external gills placed upon the head.

CEPHALOPHORA (Gr. *kephale;* and *phero,* I carry). Used synonymously with *Encephala,* to designate those *Mollusca* which possess a distinct head.

CEPHALOPODA (Gr. *kephale;* and *poda,* feet). A class of the *Mollusca,* comprising the Cuttle-fishes and their allies, in which there is a series of arms ranged round the head.

CEPHALOTHORAX (Gr. *kephale;* and *thorax,* chest). The anterior division of the body in many *Crustacea* and *Arachnida,* which is composed of the coalesced head and chest.

CERE. The naked space found at the base of the bill of some birds.

CERVICAL (Lat. *cervix,* neck). Connected with the region of the neck.

CESTOIDEA (Gr. *kestos,* a girdle). An old name for the *Tæniada,* a class of Intestinal Worms with flat bodies like tape (hence the name Tapeworms).

CESTRAPHORI (Gr. *kestra,* a weapon; *phero,* I carry). The group of *Elasmobranchii* represented at the present day by the Port Jackson Shark.

CETACEA (Gr. *kētos,* a whale). The order of Mammals comprising the Whales and Dolphins.

CHÆTOGNATHA (Gr. *chaite,* bristle; *gnathos,* jaw). An order of the *Anarthropoda,* comprising only the oceanic genus *Sagitta.*

CHEIROPTERA (Gr. *cheir,* hand; *pteron,* a wing). The order of Mammals comprising the Bats.

CHELÆ (Gr. *chele,* a claw). The prehensile claws with which some of the limbs are terminated in certain *Crustacea,* such as the Crab, Lobster, &c.

CHELATE. Possessing chelæ; applied to a limb.

CHELICERÆ (Gr. *chele,* a claw; and *keras,* a horn). The prehensile claws of the Scorpion, supposed to be homologous with antennæ.

CHELONIA (Gr. *chelone,* a tortoise). The order of Reptiles comprising the Tortoises and Turtles.

CHELONOBATRACHIA (Gr. *chelone,* a tortoise; *batrachos,* a frog). Sometimes applied to the Amphibian order of the *Anoura* (Frogs and Toads).

CHILOGNATHA (Gr. *cheilos,* a lip; and *gnathos,* a jaw). An order of the *Myriapoda.*

CHILOPODA (Gr. *cheilos;* and *poda,* feet). An order of the *Myriapoda.*

CHITINE (Gr. *chiton,* a coat). The peculiar chemical principle, nearly allied to horn, which forms the exoskeleton in many Invertebrate Animals, especially in the *Arthropoda* (*Crustacea, Insecta,* &c.)

CHLOROPHYLL (Gr. *chloros,* green; and *phyllos,* a leaf). The green colouring matter of plants.

CHROMATOPHORES (Gr. *chroma,* complexion, or colour; and *phero,* I carry). Little sacs which contain pigment-granules, and are found in the integument of Cuttle-fishes.

CHRYSALIS (Gr. *chrusos,* gold). The motionless pupa of butterflies and moths, so called because sometimes exhibiting a golden lustre.

CHYLAQUEOUS FLUID. A fluid consisting partly of water derived from the exterior, and partly of the products of digestion (chyle), occupying the body-cavity or perivisceral space in many Invertebrates (*Annelides, Echinoderms,* &c.), and sometimes having a special canal-system for its conduction (chylaqueous canals).

CHYLE (Gr. *chulos,* juice). The milky fluid which is the result of the action of the various digestive fluids upon the food.

CHYLIFIC (Gr. *chulos,* juice [chyle]; and Lat. *facio,* I make). Producing chyle. Applied to one of the stomachs, when more than one is present. The word is of mongrel origin; and "chylopoietic" is more correct.

CHYME (Gr. *chumos,* juice). The acid pasty fluid produced by the action of the gastric juice upon the food.

CHYME-MASS. The central, semi-fluid sarcode in the interior of an *Infusorian.*

CILIA (Lat. *cilium,* an eyelash). Microscopic, hair-like filaments, which have the power of lashing backwards and forwards, thus creating currents in the surrounding or contiguous fluid, or subserving locomotion in the animal which possesses them.

CILIOGRADA (Lat. *cilium;* and *gradior*, I walk). Synonymous with *Ctenophora*, an order of *Actinozoa.*

CINCLIDES (Gr. *kigklis*, a lattice). Special apertures in the column-walls of some Sea-anemones (*Actiniæ*), which probably serve for the emission of the cord-like "craspeda."

CIRRI (Lat. *cirrus*, a curl). Tendril-like appendages, such as the feet of Barnacles and Acorn-shells (*Cirripedes*), the lateral processes on the arms of *Brachiopoda*, &c.

CIRRIFEROUS or CIRRIGEROUS. Carrying cirri.

CIRRIPEDIA, CIRRHIPEDIA, or CIRRHOPODA (Lat. *cirrus*, a curl; and *pes*, a foot). A sub-class of *Crustacea* with curled jointed feet.

CIRROSTOMI (Lat. *cirrus*, a tendril; Gr. *stoma*, mouth). Sometimes used to designate the *Pharyngobranchii.*

CLADOCERA (Gr. *klados*, a branch; *keras*, a horn). An order of *Crustacea* with branched antennæ.

CLAVATE (Lat. *clavus*, a club). Club-shaped.

CLAVICLE (Lat. *clavicula*, a little key). The "collar-bone," forming one of the elements of the pectoral arch of Vertebrates.

CLOACA (Lat. a sink). The cavity into which the intestinal canal and the ducts of the generative and urinary organs open in common, in some Invertebrates (*e.g.*, in Insects), and also in many Vertebrate animals.

CLYPEIFORM (Lat. *clypeus*, a shield; and *forma*, shape). Shield-shaped; applied, for example, to the carapace of the King-crab.

CNIDÆ (Gr. *knide*, a nettle). The urticating cells, or "thread-cells," whereby many *Cœlenterate* animals obtain their power of stinging.

COCCOLITHS (Gr. *kokkos*, a berry; *lithos*, stone). Minute oval or rounded bodies, which are found either free or attached to the surface of coccospheres.

COCCOSPHERES (Gr. *kokkos;* and *sphaira*, a sphere). Spherical masses of sarcode, enclosed in a delicate calcareous envelope, and bearing coccoliths upon their external surface. Both coccospheres and coccoliths are imbedded in a diffused plasmodium of sarcode, the whole constituting a low *Rhizopodic* organism.

COCCYGEAL. Connected with the coccyx.

COCCYX (Gr. *kokkux*, a cuckoo). The terminal portion of the spinal column in man, so called from its resemblance to a cuckoo's beak.

COCOON (French *cocon*, the cocoon of the silkworm; connected with Fr. *coque*, shell, which is derived from the Lat. *concha*). The outer covering of silky hairs with which the pupa or chrysalis of many insects is protected.

CODONOSTOMA (Gr. *kodon*, a bell; *stoma*, mouth). The aperture or mouth of the disc (nectocalyx) of a *Medusa*, or of the bell (gonocalyx) of a medusiform gonophore.

CŒLENTERATA (Gr. *koilos*, hollow; *enteron*, the bowel). The sub-kingdom which comprises the *Hydrozoa* and *Actinozoa.* Proposed by Frey and Leuckhart in place of the old term *Radiata*, which included other animals as well.

CŒNENCHYMA (Gr. *koinos*, common; *enchuma*, tissue). The common calcareous tissue which unites together the various corallites of a compound corallum.

CŒNŒCIUM (Gr. *koinos*, common; *oikos*, house). The entire dermal system of any *Polyzoön:* employed in place of the terms polyzoary or polypidom.

CŒNOSARC (Gr. *koinos*, common; *sarx*, flesh). The common organised medium by which the separate polypites of a compound *Hydrozoön* are connected together.

COLEOPTERA (Gr. *koleos*, a sheath; *pteron*, wing). The order of Insects (Beetles) in which the anterior pair of wings are hardened, and serve as protective cases for the posterior pair of membranous wings.

COLUBRINA (Lat. *coluber*, a snake), A division of the *Ophidia.*

COLUMBACEI (Lat. *columba*, a dove). The division of Rasorial birds comprising the Doves and Pigeons.

COLUMELLA (Lat. dim. of *columna*, a column). In Conchology, the central axis round which the whorls of a spiral univalve are wound. Amongst the *Actinozoa*, it is the central axis or pillar which is found in the centre of the thecæ of many corals.

COLUMN. Applied to the cylindrical body of a Sea-anemone (*Actinia*); also to the jointed stem or peduncle of the stalked *Crinoids*.

COMMISSURAL (Lat. *committo*, I solder together). Connecting together; usually applied to the nerve-fibres which unite different ganglia.

CONCHA (Lat. a shell). The external ear by which sounds are collected and transmitted to the internal ear.

CONCHIFERA (Lat. *concha*, a shell; *fero*, I carry). Shell-fish. Applied in a restricted sense to the bivalve Molluscs, and used as a synonym for *Lamellibranchiata*.

CONDYLE (Gr. *kondulos*, a knuckle). The surface by which one bone articulates with another. Applied especially to the articular surface or surfaces by which the skull articulates with the vertebral column.

CONIROSTRES (Lat. *conus*, a cone; *rostrum*, a beak). The division of Perching birds with conical beaks.

COPEPODA (Gr. *kope*, an oar; *poda*, feet). An order of *Crustacea*.

CORACOID (Gr. *korax*, a crow; *eidos*, form). One of the bones which enters into the composition of the pectoral arch in Birds, Reptiles, and Monotremes. In most Mammals it is a mere process of the scapula, having, in man, some resemblance in shape to the beak of a crow.

CORALLIGENOUS. Producing a corallum.

CORALLITE. The corallum secreted by an *Actinozoön* which consists of a single polype; or the portion of a composite corallum which belongs to, and is secreted by, an individual polype.

CORALLUM (from the Latin for Red Coral). The hard structures deposited in, or by, the tissues of an *Actinozoön*—commonly called a "coral."

CORIACEOUS (Lat. *corium*, hide). Leathery.

CORPUS CALLOSUM (Lat. the "firm body"). The great band of nervous matter which unites the two hemispheres of the brain in the Mammals.

CORPUSCULATED (Lat. *corpusculum*, a little body or particle). Applied to fluids which, like the blood, contain floating solid particles or "corpuscles."

CORTICAL LAYER. The layer of consistent sarcode, which in the *Infusoria* encloses the chyme-mass, and is surrounded by the cuticle. Sometimes called the "parenchyma of the body."

COSTÆ (Lat. *costa*, a rib). Applied amongst the *Crinoidea* to designate the rows of plates which succeed the inferior or basal portion of the cup (pelvis). Amongst the *Corals* the "costæ" are vertical ridges which occur on the outer surface of the theca, and mark the position of the septa within.

COSTAL (Lat. *costa*, a rib). Connected with the ribs.

CRANIUM (Gr. *kranion*, the skull). The bony or cartilaginous case in which the brain is contained.

CRASPEDA (Gr. *kraspedon*, a margin or fringe). The long, convoluted cords, containing thread-cells, which are attached to the free margins of the mesenteries of a Sea-anemone.

CREPUSCULAR (Lat. *crepusculum*, dusk). Applied to animals which are active in the dusk or twilight.

CRINOIDEA (Gr. *krinos*, a lily; *eidos*, form). An order of *Echinodermata*, comprising forms which are usually stalked, and sometimes resemble lilies in shape.

CROCODILIA (Gr. *krokodeilos*, a crocodile). An order of Reptiles.

CROP. A partial dilatation of the gullet, technically called "ingluvies."

CRUSTACEA (Lat. *crusta*, a crust). A class of articulate animals, comprising Crabs, Lobsters, &c., characterised by the possession of a hard shell or crust, which they cast periodically.

CTENOCYST (Gr. *kteis*, a comb; *kustis*, a bag or cyst). The sense-organ (probably auditory) which occurs in the *Ctenophora*.

CTENOID (Gr. *kteis*, a comb; *eidos*, form). Applied to those scales of fishes, the hinder margins of which are fringed with spines or comb-like projections.

CTENOPHORA (Gr. *kteis*, a comb; and *phero*, I carry). An order of *Actinozoa*, comprising oceanic creatures, which swim by means of "ctenophores," or bands of cilia arranged in comb-like plates.
CURSORES (Lat. *curro*, I run). An order of *Aves*, comprising birds destitute of the power of flight, but formed for running vigorously (*e.g.*, the Ostrich and Emeu).
CUSPIDATE. Furnished with small pointed eminences or "cusps."
CUTICLE (Lat. *cuticula*, dim. of *cutis*, skin). The pellicle which forms the outer layer of the body amongst the *Infusoria*. The outer layer of the integument generally.
CUTIS (Lat. skin). The inferior vascular layer of the integument, often called the *cutis vera*, the *corium*, or the *derma*.
CYCLOID (Gr. *kuklos*, a circle; *eidos*, form). Applied to those scales of fishes which have a regularly circular or elliptical outline with an even margin.
CYCLOSTOMI. Sometimes used to designate the Hag-fishes and Lampreys, forming the order *Marsipobranchii.*
CYST (Gr. *kustis*, a bladder or bag). A sac or vesicle.
CYSTICA. The embryonic forms (scolices) of certain intestinal worms (tapeworms), which were described as a distinct order, until their true nature was discovered.
CYSTOIDEA (Gr. *kustis*, a bladder; and *eidos*, form). An extinct order of *Echinodermata.*

DECAPODA (Gr. *deka*, ten; *poda*, feet). The division of *Crustacea* which have ten ambulatory feet; also the family of Cuttle-fishes, in which there are ten arms or cephalic processes.
DECIDUOUS (Lat. *decido*, I fall off). Applied to parts which fall off or are shed during the life of the animal.
DECOLLATED (Lat. *decollo*, I behead). Applied to univalve shells, the apex of which falls off in the course of growth.
DEINOSAURIA (Gr. *deinos*, terrible; *saura*, lizard). An extinct order of Reptiles.
DENDRIFORM, DENDRITIC, DENDROID (Gr. *dendron*, a tree). Branched like a tree, arborescent.
DENTIROSTRES (Lat. *dens*, a tooth; *rostrum*, a beak). The group of Perching Birds in which the upper mandible of the beak has its lower margin toothed.
DERMA (See "Cutis").
DERMAL (Gr. *derma*, skin). Belonging to the integument.
DERMOSCLERITES (Gr. *derma*, skin; *skleros*, hard). Masses of spicules which occur in the tissues of some of the *Alcyonidæ* (*Actinozoa*).
DESMIDIÆ. Minute fresh-water plants, of a green colour, without a siliceous epidermis.
DEUTEROZOÖIDS (Gr. *deuteros*, second; *zoön*, animal; *eidos*, form). The zoöids which are produced by gemmation from zoöids.
DEXTRAL (Lat. *dextra*, the right hand). Right-handed; applied to the direction of the spiral in the greater number of univalve shells.
DIAPHRAGM (Gr. *diaphragma*, a partition). The "midriff," or the muscle which in *Mammalia* forms a partition between the cavities of the thorax and abdomen.
DIASTEMA (Gr. *dia*, apart; *histemi*, to place). A gap or interval, especially between teeth.
DIASTOLE (Gr. *diastello*, I separate or expand). The expansion of a contractile cavity such as the heart, which follows its contraction or "systole."
DIATOMACEÆ (Gr. *diatemno*, I sever). An order of minute plants, which are provided with siliceous envelopes.
DIBRANCHIATA (Gr. *dis*, twice; *bragchia*, gill). The order of *Cephalopoda* (comprising the Cuttle-fishes, &c.) in which only two gills are present.
DICYNODONTIA (Gr. *dis*, twice; *kuon*, dog; *odous*, tooth). An extinct order of Reptiles.
DIDELPHIA (Gr. *dis*, twice; *delphus*, womb). The subdivision of Mammals comprising the Marsupials.

DIGIT (Lat. *digitus*, a finger). A finger or toe.

DIGITIGRADA (Lat. *digitus; gradior*, I walk). A subdivision of the *Carnivora*.

DIGITIGRADE. Walking upon the tips of the toes, and not upon the soles of the feet.

DIMEROSOMATA (Gr. *dis; meros*, part; *soma*, body). An order of *Arachnida*, comprising the true Spiders, so called from the marked division of the body into two regions, the cephalothorax and abdomen. The name *Araneida* is often employed for the order.

DIMYARY (Gr. *dis*, twice; *muon*, muscle). Applied to those bivalve Molluscs (*Lamellibranchiata*) in which the shell is closed by two adductor muscles.

DIŒCIOUS (Gr. *dis*, twice; *oikos*, house). Having the sexes distinct; applied to species which consist of male and female individuals.

DIPHYOZOÖIDS. Detached reproductive portions of adult *Calycophoridæ*, an order of oceanic *Hydrozoa*.

DIPHYODONT (Gr. *dis*, twice; *phuo*, I generate; *odous*, tooth). Applied to those Mammals which have two sets of teeth.

DIPNOI (Gr. *dis*, twice; *pnoe*, breath). The order of fishes represented by the *Lepidosiren*.

DIPTERA (Gr. *dis*, twice; *pteron*, wing). An order of Insects characterised by the possession of two wings.

DISCOID (Gr. *diskos*, a quoit; *eidos*, form). Shaped like a round plate or quoit.

DISCOPHORA (Gr. *diskos*, a quoit; *phero*, I carry). This term is applied to the *Medusæ*, or Jelly-fishes, from their form; and is sometimes used to designate the order of the Leeches (*Hirudinea*), from the suctorial discs which these animals possess.

DISSEPIMENTS (Lat. *dissepio*, I partition off). Partitions. Used in a restricted sense to designate certain imperfect transverse partitions, which grow from the septa of many corals.

DISTAL. Applied to the quickly growing end of the hydrosoma of a *Hydrozoön;* the opposite, or "proximal," extremity growing less rapidly, and being the end by which the organism is fixed, when attached at all.

DIURNAL (Lat. *dies*, day). Applied to animals which are active during the day.

DIVERTICULUM (Lat. *diverticulum*, a bye-road). A lateral tube with a blind extremity, springing from the side of another tube.

DORSAL (Lat. *dorsum*, back). Connected with the back.

DORSIBRANCHIATE (Lat. *dorsum*, the back; Gr. *bragchia*, gill). Having external gills attached to the back; applied to certain *Annelides* and *Molluscs*. The term is of mongrel composition, and "notobranchiate" is more correctly employed.

ECDERON (Gr. *ek*, out; *deros*, skin). The outer plane of growth of the external integumentary layer (viz., the ectoderm or epidermis).

ECDYSIS (Gr. *ekdusis*, a stripping off). A shedding or moulting of the skin.

ECHINOCOCCI (Gr. *echinos*, a hedgehog; *kokkos*, a berry). The larval forms (scolices) of the tapeworm of the dog (*Tænia echinococcus*), commonly known as "hydatids."

ECHINODERMATA (Gr. *echinos;* and *derma*, skin). A class of animals comprising the Sea-urchins, Star-fishes, and others, most of which have spiny skins.

ECHINOIDEA (Gr. *echinos;* and *eidos*, form). An order of *Echinodermata*, comprising the Sea-urchins.

ECHINULATE. Possessing spines.

ECTOCYST (Gr. *ektos*, outside; *kustis*, a bladder). The external investment of the cœnœcium of a *Polyzoön*.

ECTODERM (Gr. *ektos*, and *derma*, skin). The external integumentary layer of the *Cœlenterata*.

ECTOSARC (Gr. *ektos; sarx*, flesh). The outer transparent sarcode-layer of certain *Rhizopods*, such as the *Amœba*.

EDENTATA (Lat. *e-*, without; *dens*, tooth). An order of *Mammalia* often called *Bruta*.

EDENTULOUS. Toothless, without any dental apparatus. Applied to the mouth of any animal, or to the hinge of the bivalve Molluscs.

EDRIOPHTHALMATA (Gr. *hedraios*, sitting; *ophthalmos*, eye). The division of *Crustacea* in which the eyes are sessile, and are not supported upon stalks.

ELASMOBRANCHII (Gr. *elasma*, a plate; *bragchia*, gill). An order of Fishes, including the Sharks and Rays.

ELYTRA (Gr. *elutron*, a sheath). The chitinous anterior pair of wings in Beetles, which form cases for the posterior membranous wings. Also applied to the scales or plates on the back of the Sea-mouse (*Aphrodite*).

EMBRYO (Gr. *en*, in; *bruo*, I swell). The earliest stage at which the young animal is recognisable in the impregnated ovum.

ENCEPHALON (Gr. *egcephalos*, brain). The portion of the cerebro-spinal nervous axis contained within the cranium.

ENCEPHALOUS (Gr. *en*, in; *kephale*, the head). Possessing a distinct head. Usually applied to all the *Mollusca* proper, except the *Lamellibranchiata*.

ENCYSTATION (Gr. *en*, in; *kustis*, a bag). The transformation undergone by certain of the *Protozoa*, when they become motionless, and surround themselves by a thick coating or cyst.

ENDERON (Gr. *en*, in; *deros*, skin). The inner plane of growth of the outer integumentary layer (viz., the ectoderm, or epidermis).

ENDOCYST (Gr. *endon*, within; *kustis*, a bag). The inner membrane or integumentary layer of a *Polyzoön*. In *Cristatella*, where there is no "ectocyst," the endocyst constitutes the entire integument.

ENDODERM (Gr. *endon;* and *derma*, skin). The inner integumentary layer of the *Cœlenterata*.

ENDOPODITE (Gr. *endon;* and *pous*, foot). The inner of the two secondary joints into which the typical limb of a *Crustacean* is divided.

ENDOSARC (Gr. *endon;* and *sarx*, flesh). The inner molecular layer of sarcode in the *Amœba*, and other allied *Rhizopods*.

ENDOSKELETON (Gr. *endon*, and *skeletos*, dry). The internal hard structures, such as bones, which serve for the attachment of muscles, or the protection of organs, and which are not a mere hardening of the integument.

ENSIFORM (Lat. *ensis*, a sword; *forma*, shape). Sword-shaped.

ENTOMOPHAGA (Gr. *entoma*, insects; *phago*, I eat). A section of the Marsupialia.

ENTOMOSTRACA (Gr. *entoma*, insects; *ostrakon*, a shell). Literally Shelled Insects, applied to a division of *Crustacea*.

ENTOZOA (Gr. *entos*, within; *zoön*, animal). Animals which are parasitic in the interior of other animals.

EOCENE (Gr. *eos*, dawn; *kainos*, new or recent). The lowest division of the Tertiary Rocks, in which species of existing shells are to a small extent represented.

EPIDERMIS (Gr. *epi*, upon; *derma*, the true skin). The outer non-vascular layer of the skin, often called the scarf-skin or *cuticle*.

EPIMERA (Gr. *epi*, upon; *mēron*, thigh). The lateral pieces of the dorsal arc of the somite of a *Crustacean*.

EPIPODIA (Gr. *epi*, upon; *pous*, the foot). Muscular lobes developed from the lateral and upper surfaces of the "foot" of some *Molluscs*.

EPIPODITE (Gr. *epi*, upon; *pous*, foot). A process developed upon the basal joint, or "protopodite," of some of the limbs of certain *Crustacea*.

EPISTERNA (Gr. *epi*, upon; *sternon*, the breast-bone). The lateral pieces of the inferior or ventral arc of the somite of a *Crustacean*.

EPISTOME (Gr. *epi;* and *stoma*, mouth). A valve-like organ which arches over the mouth in certain of the *Polyzoa*.

EPITHECA (Gr. *epi;* and *theke*, a sheath). A continuous layer surrounding the thecæ in some Corals, and being the external indications of tabulæ.

EPIZOA (Gr. *epi*, upon; *zoön*, animal). Animals which are parasitic upon other animals. In a restricted sense, a division of *Crustacea* which are parasitic upon fishes.

EQUILATERAL (Lat. *æquus*, equal; *latus*, side). Having its sides equal. Usually applied to the shells of the *Brachiopoda*. When applied to the spiral shells of the *Foraminifera*, it means that all the convolutions of the shell lie in the same plane.

EQUIVALVE (Lat. *æquus*, equal; *valvæ*, folding doors). Applied to shells which are composed of two equal pieces or valves.

ERRANTIA (Lat. *erro*, I wander). An order of *Annelida*, often called *Nereidea*, distinguished by their great locomotive powers.

EURYPTERIDA (Gr. *eurus*, broad; *pteron*, wing). An extinct sub-order of *Crustacea*.

EXOPODITE (Gr. *exo*, outside; *pous*, foot). The outer of the two secondary joints into which the typical limb of a *Crustacean* is divided.

EXOSKELETON (Gr. *exo*, outside; *skeletos*, dry). The external skeleton, which is constituted by a hardening of the integument, and is often called a "dermoskeleton."

FASCICULATED (Lat. *fasciculus*, a bundle). Arranged in bundles.

FAUNA (Lat. *Fauni*, the rural deities of the Romans). The general assemblage of the animals of any region or district.

FEMUR. The thigh-bone, intervening between the pelvis and the bones of the leg proper (*tibia* and *fibula*).

FIBULA (Lat. a brooch). The outermost of the two bones of the leg in the higher *Vertebrata;* corresponding to the *ulna* of the fore-arm.

FILIFORM (Lat. *filum*, a thread; *forma*, shape). Thread-shaped.

FISSILINGUIA (Lat. *findo*, I cleave; *lingua*, tongue). A division of *Lacertilia*, with bifid tongues.

FISSION (Lat. *findo*, I cleave). Multiplication by means of a process of self-division.

FISSIPAROUS (Lat. *findo;* and *pario*, I produce). Giving origin to fresh structures by a process of fission.

FISSIROSTRES (Lat. *findo*, I cleave; *rostrum*, beak). A sub-order of the Perching-birds.

FLAGELLUM (Lat. for whip). The lash-like appendage exhibited by many *Infusoria*, which are therefore said to be "flagellate."

FLORA (Lat. *Flora*, the goddess of flowers). The general assemblage of the plants of any region or district.

FOOT-JAWS. The limbs of *Crustacea*, which are modified to subserve mastication.

FOOT-SECRETION. The term applied by Mr Dana to the sclerobasic corallum of certain *Actinozoa*.

FOOT-TUBERCLES. The unarticulated appendages of the *Annelida*, often called parapodia.

FORAMINIFERA (Lat. *foramen*, an aperture; *fero*, I carry). An order of *Protozoa*, usually characterised by the possession of a shell perforated by numerous pseudopodial apertures.

FRUGIVOROUS (Lat. *frux*, fruit; *voro*, I devour). Living upon fruits.

FURCULUM (Lat. dim. of *furca*, a fork). The "merry-thought" of birds, or the V-shaped bone formed by the united clavicles.

FUSIFORM (Lat. *fusus*, a spindle; and *forma*, shape). Spindle-shaped, or pointed at both ends.

GALLINACEI (Lat. *gallina*, a fowl). Sometimes applied to the whole order of the Rasorial Birds, but properly restricted to that section of the order of which the common Fowl is a typical example.

GANGLION (Gr. *gagglion*, a knot). A mass of nervous matter containing nerve-cells, giving origin to nerve-fibres.

GANOID (Gr. *ganos*, splendour, brightness). Applied to those scales or plates which are composed of an inferior layer of true bone covered by a superior layer of polished enamel.

GANOIDEI. An order of Fishes.

GASTEROPODA (Gr. *gaster*, stomach; *pous*, foot). The class of the *Mollusca* comprising the ordinary univalves, in which locomotion is usually effected by a muscular expansion of the under surface of the body (the "foot").

Gemmæ (*gemma*, a bud). The buds produced by any animal, whether detached or not.
Gemmation. The process of producing new structures by budding.
Gemmiparous (Lat. *gemma*, a bud; *pario*, I produce). Giving origin to new structures by a process of budding.
Gemmules (Lat. dim. of *gemma*). The ciliated embryos of many *Cœlenterata;* also the seed-like reproductive bodies or "spores" of *Spongilla.*
Gephyrea (Gr. *gephura*, a bridge). A class of the *Anarthropoda,* comprising the Spoon-worms (*Sipunculus*) and their allies.
Gizzard. A muscular division of the stomach in Birds, Insects, &c.
Gladius (Lat. a sword). Applied to the horny endoskeleton or "pen" of certain Cuttle-fishes.
Glenoid (Gr. *glene*, a cavity; *eidos*, form). A shallow cavity; applied especially to the shallow articular cavity in the shoulder-blade to which the head of the humerus is jointed.
Gnathites (Gr. *gnathos*, a jaw). The masticatory organs of *Crustacea.*
Gonoblastidia (Gr. *gonos*, offspring; *blastidion*, dim. of *blastos*, a bud). The processes which carry the reproductive receptacles, or "gonophores," in many of the *Hydrozoa.*
Gonocalyx (Gr. *gonos;* and *kalux*, cup). The swimming-bell in a medusiform gonophore, or the same structure in a gonophore which is not detached.
Gonophore (Gr. *gonos*, and *phero*, I carry). The generative buds, or receptacles of the reproductive elements, in the *Hydrozoa,* whether these become detached or not.
Gonosome (Gr. *gonos;* and *soma*, body). Applied as a collective term to the reproductive zoöids of a *Hydrozoön.*
Gonotheca (Gr. *gonos;* and *theke*, a case). The chitinous receptacle within which the gonophores of certain of the *Hydrozoa* are produced.
Grallatores (Lat. *grallæ*, stilts). The order of the long-legged Wading Birds.
Granivorous (Lat. *granum*, a grain or seed; *voro*, I devour). Living upon grains or other seeds.
Graptolitidæ (Gr. *grapho*, I write; *lithos*, stone). An extinct sub-class of the *Hydrozoa.*
Gregarinida (Lat. *gregarius*, occurring in numbers together). A class of the *Protozoa.*
Guard. The cylindrical fibrous sheath with which the internal chambered shell (phragmacone) of a *Belemnite* is protected.
Gymnolæmata (Gr. *gumnos*, naked; *laima*, the throat). An order of the *Polyzoa* in which the mouth is devoid of the valvular structure known as the "epistome."
Gymnophiona (Gr. *gumnos*, naked; *ophis*, a snake). The order of the *Amphibia* comprising the snake-like *Cæciliæ.*
Gymnophthalmata (Gr. *gumnos;* and *ophthalmos*, the eye). Applied by Edward Forbes to those *Medusæ* in which the eye-specks at the margin of the disc are unprotected. The division is now abandoned.
Gymnosomata (Gr. *gumnos;* and *soma*, the body). The order of *Pteropoda* in which the body is not protected by a shell.
Gynophores (Gr. *gune*, woman; *phero*, I carry. The generative buds, or gonophores, of *Hydrozoa,* which contain ova alone, and differ in form from those which contain spermatozoa.
Gyrencephala (Gr. *guroo*, I wind about; *egkephalos*, brain). Applied by Owen to a section of the Mammalia in which the cerebral hemispheres are abundantly convoluted.

Hæmal (Gr. *haima*, blood). Connected with the bloodvessels, or with the circulatory system.
Hæmatocrya (Gr. *haima*, blood; *cruos*, cold). Applied by Owen to the "cold-blooded" Vertebrates—viz., the Fishes, Amphibia, and Reptiles.
Hæmatotherma (Gr. *haima*, blood; *thermos*, warm). Applied by Owen to the "warm-blooded" Vertebrates—viz., Birds and Mammals.
Hallux (Lat. *allex*, the thumb or great toe). The innermost of the five

digits which normally compose the *hind* foot of a Vertebrate animal. In man, the great toe.

HALTERES (Gr. *halteres,* weights used by athletes to steady themselves in leaping). The rudimentary filaments or "balancers" which represent the posterior pair of wings in the *Diptera,* an order of Insects.

HAUSTELLATE (Lat. *haurio,* I drink). Adapted for sucking or pumping up fluids; applied to the mouth of certain *Crustacea* and *Insecta.*

HECTOCOTYLUS (Gr. *hekaton,* a hundred; *kotulos,* a cup). The metamorphosed reproductive arm of certain of the male Cuttle-fishes. In the *Argonaut* the arm becomes detached, and was originally described as a parasitic worm.

HELMINTHOID (Gr. *helmins,* an intestinal worm). Worm-shaped, vermiform.

HEMELYTRA (Gr. *hemi,* half; *elutron,* a sheath). The wings of certain insects, in which the apex of the wing is membranous, whilst the inner portion is chitinous, and resembles the elytron of a beetle.

HEMIMETABOLIC (Gr. *hemi,* half; *metabole,* change). Applied to those Insects which undergo an incomplete metamorphosis.

HEMIPTERA (Gr. *hemi;* and *pteron,* wing). An order of Insects in which the anterior wings are sometimes "hemelytra."

HERMAPHRODITE (Gr. *Hermes,* Mercury; *Aphrodite,* Venus). Possessing the characters of both sexes combined.

HETEROCERCAL (Gr. *heteros,* diverse; *kerkos,* tail). Applied to the tail of Fishes when it is unsymmetrical, or composed of two unequal lobes.

HETEROGANGLIATE (Gr. *heteros,* diverse; *gagglion,* a knot). Possessing a nervous system in which the ganglia are scattered and unsymmetrical (as in the *Mollusca,* for example).

HETEROMORPHIC (Gr. *heteros; morphe,* form). Differing in form or shape.

HETEROPHAGI (Gr. *heteros,* other; *phago,* I eat). Applied to Birds the young of which are born in a helpless condition, and require to be fed by the parents for a longer or shorter period.

HEXAPOD (Gr. *hexa,* six; *pous,* foot). Possessing six legs; applied to the *Insecta.*

HILUM (Lat. *hilum,* a little thing). A small aperture (as in the gemmules of sponges), or a small depression (as in *Noctiluca*).

HIRUDINEA (Lat. *hirudo,* a horse-leech). The order of *Annelida* comprising the Leeches.

HISTOLOGY (Gr. *histos,* a web; *logos,* a discourse). The study of the tissues; more especially of the minuter elements of the body.

HOLOCEPHALI (Gr. *holos,* whole; *kephale,* head). A sub-order of the *Elasmobranchii* comprising the *Chimæræ.*

HOLOMETABOLIC (Gr. *holos,* whole; *metabole,* change). Applied to Insects which undergo a complete metamorphosis.

HOLOSTOMATA (Gr. *holos,* whole; *stoma,* mouth). A division of *Gasteropodous Molluscs,* in which the aperture of the shell is rounded, or "entire."

HOLOTHUROIDEA (Gr. *holothourion;* and *eidos,* form). An order of *Echinodermata* comprising the Trepangs.

HOMOCERCAL (Gr. *homos,* same; *kerkos,* tail). Applied to the tail of Fishes when it is symmetrical, or composed of two equal lobes.

HOMOGANGLIATE (Gr. *homos,* like; *gagglion,* a knot). Having a nervous system in which the ganglia are symmetrically arranged (as in the *Annulosa,* for example).

HOMOLOGOUS (Gr. *homos;* and *logos,* a discourse). Applied to parts which are constructed upon the same fundamental plan.

HOMOMORPHOUS (Gr. *homos;* and *morphe,* form). Having a similar external appearance or form.

HUMERUS. The bone of the upper arm (*brachium*) in the Vertebrates.

HYALINE (Gr. *hualos,* crystal). Crystalline or glassy.

HYDATIDS (Gr. *hudatis,* a vesicle). The vesicle containing the larval forms (*Echinococci*) of the tapeworm of the dog.

HYDRAFORM. Resembling the common fresh-water polype (*Hydra*) in form.

HYDROCAULUS (Gr. *hudra*, a water-serpent, and *kaulos*, a stem). The main stem of the cœnosarc of a *Hydrozoön*.

HYDROCYSTS (Gr. *hudra;* and *kustis*, a cyst). Curious processes attached to the cœnosarc of the *Physophoridæ*, and termed "feelers" (*fühler* and *taster* of the Germans).

HYDRŒCIUM (Gr. *hudra;* and *oikos*, a house). The chamber into which the cœnosarc in many of the *Calycophoridæ* can be retracted.

HYDROIDA (Gr. *hudra;* and *eidos*, form). The sub-class of the *Hydrozoa*, which comprises the animals most nearly allied to the *Hydra*.

HYDROPHYLLIA (Gr. *hudra;* and *phyllon*, a leaf). Overlapping appendages or plates which protect the polypites in some of the Oceanic *Hydrozoa* (*Calycophoridæ* and *Physophoridæ*). They are often termed "bracts," and are the "*deckstücke*" of the Germans.

HYDRORHIZA (Gr. *hudra;* and *rhiza*, root). The adherent base or proximal extremity of any *Hydrozoön*.

HYDROSOMA (Gr. *hudra;* and *soma*, body). The entire organism of any *Hydrozoön*.

HYDROTHECA (Gr. *hudra;* and *theke*, a case). The little chitinous cups in which the polypites of the *Sertularida* and *Campanularida* are protected.

HYDROZOA (Gr. *hudra;* and *zoön*, animal). The class of the *Cœlenterata*, which comprises animals constructed after the type of the *Hydra*.

HYMENOPTERA (Gr. *humen*, a membrane; *pteron*, a wing). An order of Insects (comprising Bees, Ants, &c.) characterised by the possession of four membranous wings.

HYOID (Gr. *U; eidos*, form). The bone which supports the tongue in Vertebrates, and derives its name from its resemblance in man to the Greek letter U.

HYPOSTOME (Gr. *hupo*, under; *stoma*, mouth). The upper lip, or "labrum," of certain *Crustacea* (*e.g.*, Trilobites).

HYRACOIDEA (Gr. *hurax*, a shrew; *eidos*, form). An order of the *Mammalia* constituted for the reception of the single genus *Hyrax*.

ICHTHYODORULITE (Gr. *ichthus*, fish; *dorus*, spear; *lithos*, stone). The fossil fin-spines of Fishes.

ICHTHYOMORPHA (Gr. *ichthus; morphe*, shape). An order of Amphibians, often called *Urodela*, comprising the fish-like Newts, &c.

ICHTHYOPHTHIRA (Gr. *ichthus; phtheir*, a louse). An order of *Crustacea* comprising animals which are parasitic upon Fishes.

ICHTHYOPSIDA (Gr. *ichthus; opsis*, appearance). The primary division of *Vertebrata*, comprising the Fishes and Amphibia. Often spoken of as the *Branchiate Vertebrata*.

ICHTHYOPTERYGIA (Gr. *ichthus; pterux*, wing). An extinct order of Reptiles.

ICHTHYOSAURIA (Gr. *ichthus; saura*, lizard). Synonymous with *Ichthyopterygia*.

ILIUM. The haunch-bone, one of the bones of the pelvic arch in the higher Vertebrates.

IMAGO (Lat. an image or apparition). The perfect insect, after it has undergone its metamorphoses.

IMBRICATED. Applied to scales or plates which overlap one another like tiles.

INCISOR (Lat. *incido*, I cut). The cutting teeth fixed in the intermaxillary bones of the *Mammalia*, and the corresponding teeth in the lower jaw.

INEQUILATERAL. Having the two sides unequal, as in the case of the shells of the ordinary bivalves (*Lamellibranchiata*). When applied to the shells of the *Foraminifera*, it implies that the convolutions of the shell do not lie in the same plane, but are obliquely wound round an axis.

INEQUIVALVE. Composed of two unequal pieces or valves.

INFUNDIBULUM (Lat. for funnel). The tube formed by the coalescence or apposition of the epipodia in the *Cephalopoda*. Commonly termed the "funnel," or "siphon."

INFUSORIA (Lat. *infusum*, an infusion). A class of *Protozoa*, so called because they are often developed in organic infusions.

INGUINAL (Lat. *inguen*, groin). Connected with, or situated upon, the groin.

INOPERCULATA (Lat. *in*, without; *operculum*, a lid). The division of pulmonate *Gasteropoda* in which there is no shelly or horny plate (operculum) by which the shell is closed when the animal is withdrawn within it.

INSECTA (Lat. *inseco*, I cut into). The class of Articulate animals commonly known as Insects.

INSECTIVORA (Lat. *insectum*, an insect; *voro*, I devour). An order of Mammals.

INSECTIVOROUS. Living upon Insects.

INSESSORES (Lat. *insedeo*, I sit upon). The order of the Perching Birds, often called *Passeres*.

INTERAMBULACRA. The rows of plates in an *Echinoderm* which are not perforated for the emission of the "tube-feet."

INTERMAXILLÆ, or PRÆMAXILLÆ. The two bones which are situated between the two superior maxillæ in *Vertebrata*. In man, and some monkeys, the præmaxillæ anchylose with the maxillæ, so as to be irrecognisable in the adult.

INTUSSUSCEPTION (Lat. *intus*, within; *suscipio*, I take up). The act of taking foreign matter into a living being.

INVERTEBRATA (Lat. *in*, without; *vertebra*, a bone of the back). Animals without a spinal column or backbone.

ISCHIUM (Gr. *ischion*, the hip). One of the bones of the pelvic arch in Vertebrates.

ISOPODA (Gr. *isos*, equal; *poda*, feet). An order of *Crustacea* in which the feet are like one another and equal.

JUGULAR (Lat. *jugulum*, the throat). Connected with, or placed upon, the throat. Applied to the ventral fins of fishes when they are placed beneath or in advance of the pectorals.

KAINOZOIC (Gr. *kainos*, recent; *zoe*, life). The Tertiary period in Geology, comprising those formations in which the organic remains approximate more or less closely to the existing fauna and flora.

KERATODE (Gr. *keras*, horn; *eidos*, form). The horny substance of which the skeleton of many sponges is made up.

KERATOSA. The division of Sponges in which the skeleton is composed of keratode.

LABIUM (Lat. for lip). Restricted to the lower lip of Articulate animals.

LABRUM (Lat. for lip). Restricted to the upper lip of Articulate animals.

LABYRINTHODONTIA (Gr. *labyrinthos*, a labyrinth; *odous*, tooth). An extinct order of *Amphibia*, so called from the complex microscopic structure of the teeth.

LACERTILIA (Lat. *lacerta*, a lizard). An order of *Reptilia* comprising the Lizards and Slow-worms.

LÆMODIPODA (Gr. *laima*, throat; *dis*, twice; *poda*, feet). An order of *Crustacea*, so called because they have two feet placed far forwards, as it were under the throat.

LAMELLIBRANCHIATA (Lat. *lamella*, a plate; Gr. *bragchia*, gill). The class of *Mollusca*, comprising the ordinary bivalves, characterised by the possession of lamellar gills.

LAMELLIROSTRES (Lat. *lamella*, a plate; *rostrum*, beak). The flat-billed Swimming Birds (*Natatores*), such as Ducks, Geese, Swans, &c.

LARVA (Lat. a mask). The insect in its first stage after its emergence from the egg, when it is usually very different from the adult.

LARYNX. The upper part of the wind-pipe, forming a cavity with appropriate muscles and cartilages, situated beneath the hyoid bone, and concerned in Mammals in the production of vocal sounds.

LENTICULAR (Lat. *lens*, a bean). Shaped like a biconvex lens.

LEPIDOPTERA (Gr. *lepis*, a scale; *pteron*, a wing). An order of Insects, comprising Butterflies and Moths, characterised by possessing four wings which are usually covered with minute scales.

LEPIDOTA (Gr. *lepis*, a scale). Formerly applied to the order *Dipnoi*, containing the Mud-fishes (*Lepidosiren*).

LEPTOCARDIA (Gr. *leptos*, slender, small; *cardia*, heart). The name given by Müller to the order of Fishes comprising the Lancelet, now called *Pharyngobranchii*.
LIGAMENTUM NUCHÆ (Lat. *nucha*, the nape of the neck). The band of elastic fibres by which the weight of the head in *Mammalia* is supported.
LIGULA (Lat. *ligula*, a little tongue). The upper flexible portion of the labium or lower lip in Insects.
LINGUAL (Lat. *lingua*, the tongue). Connected with the tongue.
LISSENCEPHALA (Gr. *lissos*, smooth; *egkephalos*, brain). A primary division of *Mammalia*, according to Owen, in which the cerebral hemispheres are smooth or have few convolutions.
LITHOCYSTS (Gr. *lithos*, a stone; *kustis*, a cyst). The sense-organs or "marginal bodies" of the *Lucernarida* or *Steganophthalmate Medusæ*.
LONGIPENNATÆ (Lat. *longus*, long; *penna*, wing). A group of the Natatorial birds.
LONGIROSTRES (Lat. *longus; rostrum*, beak). A group of the Wading birds.
LOPHOPHORE (Gr. *lophos*, a crest; and *phero*, I carry). The disc or stage upon which the tentacles of the *Polyzoa* are borne.
LOPHYROPODA (Gr. *lophouros*, having stiff hairs; and *poda*, feet). An order of *Crustacea*.
LORICA (Lat. a breast-plate). Applied to the protective case with which certain *Infusoria* are provided.
LORICATA (Lat. *lorica*, a cuirass). The division of Reptiles comprising the *Chelonia* and *Crocodilia*, in which bony plates are developed in the skin (*derma*).
LUCERNARIDA (Lat. *lucerna*, a lamp). An order of the *Hydrozoa*.
LUMBAR (Lat. *lumbus*, loin). Connected with the loins.
LUNATE (Lat. *luna*, moon). Crescentic in shape.
LYENCEPHALA (Gr. *luo*, I loose; *egkephalos*, brain). A primary division of Mammals, according to Owen.

MACRODACTYLI (Gr. *makros*, long; *daktulos*, a finger). A group of the Wading birds.
MACRURA (Gr. *makros*, long; *oura*, tail). A tribe of Decapod *Crustaceans* with long tails (*e.g.*, the Lobster, Shrimp, &c.)
MADREPORIFORM. Perforated with small holes, like a coral; applied to the tubercle by which the ambulacral system of the *Echinoderms* mostly communicates with the exterior.
MALACOSTRACA (Gr. *malakos*, soft; *ostrakon*, shell). A division of *Crustacea*. Originally applied by Aristotle to the entire class *Crustacea*, because their shells were softer than those of the *Mollusca*.
MALLOPHAGA (Gr. *mallos*, a fleece; *phago*, I eat). An order of Insects which are mostly parasitic upon birds.
MAMMALIA (Lat. *mamma*, the breast). The class of Vertebrate animals which suckle their young.
MANDIBLE (Lat. *mandibulum*, a jaw). The upper pair of jaws in Insects; also applied to one of the pairs of jaws in *Crustacea* and Spiders, to the beak of Cephalopods, the lower jaw of Vertebrates, &c.
MANTLE. The external integument of most of the Mollusca, which is largely developed, and forms a cloak in which the viscera are protected. Technically called the "pallium."
MANUBRIUM (Lat. a handle). The polypite which is suspended from the roof of the swimming-bell of a *Medusa*, or from the gonocalyx of a medusiform gonophore amongst the *Hydrozoa*.
MANUS (Lat. the hand). The hand of the higher Vertebrates.
MARSIPOBRANCHII (Gr. *marsipos*, a pouch; *bragchia*, gill). The order of Fishes comprising the Hag-fishes and Lampreys, with pouch-like gills.
MARSUPIALIA (Lat. *marsupium*, a pouch). An order of Mammals in which the females mostly have an abdominal pouch in which the young are carried.
MASTAX (Gr. mouth). The muscular pharynx or "buccal funnel" into which the mouth opens in most of the *Rotifera*.
MASTICATORY (Lat. *mastico*, I chew). Applied to parts adapted for chewing.

MAXILLÆ (Lat. jaws). The inferior pair or pairs of jaws in the *Arthropoda* (Insects, Crustacea, &c.) The upper jaw-bones of Vertebrates.

MAXILLIPEDES (Lat. *maxillæ*, jaws; *pes*, the foot). The limbs in *Crustacea* and *Myriapoda* which are converted into masticatory organs, and are commonly called "foot-jaws."

MEDULLA (Lat. marrow). Applied to the marrow of bones, or to the spinal cord, with or without the adjective "*spinalis*."

MEDUSÆ. An order of *Hydrozoa*, commonly known as Jelly-fishes (*Discophora*, or *Acalephæ*), so called because of the resemblance of their tentacles to the snaky hair of the Medusa. Many *Medusæ* are now known to be merely the gonophores of *Hydrozoa*.

MEDUSIFORM. Resembling a *Medusa* in shape.

MEDUSOID. Like a *Medusa;* used substantively to designate the medusiform gonophores of the *Hydrozoa*.

MEMBRANA NICTITANS (Lat. *nicto*, I wink). The third eyelid of Birds, &c.

MENTUM (Lat. the chin). The basal portion of the labium or lower lip in Insects.

MEROSTOMATA (Gr. *mēron*, thigh; *stoma*, mouth). An order of *Crustacea* in which the appendages which are placed round the mouth, and which officiate as jaws, have their free extremities developed into walking or prehensile organs.

MESENTERIES (Gr. *mesos*, intermediate; *enteron*, intestine). In a restricted sense, the vertical plates which divide the somatic cavity of a Sea-anemone (*Actinia*) into chambers.

MESOPODIUM (Gr. *mesos*, middle; *pous*, foot). The middle portion of the "foot" of Molluscs.

MESOSTERNUM (Gr. *mesos*, intermediate; *sternon*, the breast-bone). The middle portion of the sternum, intervening between the attachment of the second pair of ribs and the xiphoid cartilage (*xiphisternum*).

MESOTHORAX (Gr. *mesos;* and *thorax*, the chest). The middle ring of the thorax in Insects.

MESOZOIC (Gr. *mesos;* and *zoe*, life). The Secondary period in Geology.

METACARPUS (Gr. *meta*, after; *karpos*, the wrist). The bones which form the "root of the hand," and intervene between the wrist and the fingers.

METAMORPHOSIS (Gr. *meta*, implying change; *morphe*, shape). The changes of form which certain animals undergo in passing from their younger to their fully-grown condition.

METAPODIUM (Gr. *meta*, after; *pous*, the foot). The posterior lobe of the foot in *Mollusca;* often called the "operculigerous lobe," because it develops the operculum when this structure is present.

METASTOMA (Gr. *meta*, after; *stoma*, mouth). The plate which closes the mouth posteriorly in the *Crustacea*.

METATARSUS (Gr. *meta*, after; *tarsos*, the instep). The bones which intervene between the bones of the ankle (*tarsus*) and the digits in the hind-foot of the higher Vertebrates.

METATHORAX (Gr. *meta*, after; *thorax*, the chest). The posterior ring of the thorax in Insects.

MIMETIC (Gr. *mimetikos*, imitative). Applied to organs or animals which resemble each other in external appearance, but not in essential structure.

MOLARS (Lat. *mola*, a mill). The "grinders" in man, or the teeth in diphyodont Mammals which are not preceded by milk-teeth.

MOLLUSCA (Lat. *mollis*, soft). The sub-kingdom which includes the Shell-fish proper, the *Polyzoa*, the *Tunicata*, and the Lamp-shells; so called from the generally soft nature of their bodies.

MOLLUSCOIDA (*Mollusca;* Gr. *eidos*, form). The lower division of the *Mollusca*, comprising the *Polyzoa*, *Tunicata*, and *Brachiopoda*.

MONADS (Gr. *monas*, unity). Microscopical organisms of an extremely simple character, developed in organic infusions.

MONOCULOUS. Possessed of only one eye.

MONODELPHIA (Gr. *monos*, single; *delphus*, womb). The division of *Mammalia* in which the uterus is single.

MONŒCIOUS (Gr. *monos*, single; *oikos*, house). Applied to individuals in which the sexes are united.
MONOMYARY (Gr. *monos*, single; *muon*, muscle). Applied to those bivalves (*Lamellibranchiata*) in which the shell is closed by a single adductor muscle.
MONOPHYODONT (Gr. *monos; phuo*, I generate; *odous*, tooth). Applied to those Mammals in which only a single set of teeth is ever developed.
MONOTHALAMOUS (Gr. *monos;* and *thalamos*, chamber). Possessing only a single chamber. Applied to the shells of *Foraminifera* and *Mollusca*.
MONOTREMATA (Gr. *monos; trema*, aperture). The order of Mammals comprising the Duck-mole and *Echidna*, in which the intestinal canal opens into a "cloaca" common to the ducts of the urinary and generative organs.
MULTILOCULAR (Lat. *multus*, many; *loculus*, a little purse). Divided into many chambers.
MULTIVALVE. Applied to shells which are composed of many pieces.
MULTUNGULA (Lat. *multus*, many; *ungula*, hoof). The division of Perissodactyle Ungulates, in which each foot has more than a single hoof.
MYELON (Gr. *muelos*, marrow). The spinal cord of Vertebrates.
MYRIAPODA (Gr. *murios*, ten thousand; *poda*, feet). A class of *Arthropoda* comprising the Centipedes and their allies, characterised by their numerous feet.

NACREOUS (Fr. *nacre*, mother-of-pearl, originally Oriental). Pearly, of the texture of mother-of-pearl.
NATATORES (Lat. *nare*, to swim). The order of the Swimming birds.
NATATORY (Lat. *nare*, to swim). Formed for swimming.
NAUTILOID. Resembling the shell of the *Nautilus* in shape.
NECTOCALYX (Gr. *necho*, I swim; *kalux*, cup). The swimming-bell or "disc" of a *Medusa* or Jelly-fish.
NEMATELMIA (Gr. *nema*, thread; *helmins*, a worm). The division of *Scolecida* comprising the Round-worms, Thread-worms, &c.
NEMATOCYSTS (Gr. *nema*, thread; *kustis*, a bag). The thread-cells of the *Cœlenterata*. (*See* Cnidæ).
NEMATOIDEA (Gr. *nema*, thread; *eidos*, form). An order of *Scolecida* comprising the Thread-worms, Vinegar-eels, &c.
NEMATOPHORES (Gr. *nema*, thread; *phero*, I carry). Cæcal processes found on the cœnosarc of certain of the *Sertularida*, containing numerous thread-cells at their extremities.
NEMERTIDA (Gr. *Nemertes*, proper name). A division of the *Turbellarian Worms*, commonly called "Ribbon-worms."
NERVURES (Lat. *nervus*, a sinew). The ribs which support the membranous wings of insects.
NEURAL (Gr. *neuron*, a nerve). Connected with the nervous system.
NEURAPOPHYSIS (Gr. *neuron*, a nerve; *apophusis*, a projecting part). The "spinous process" of a vertebra, or the process formed at the point of junction of the neural arches.
NEUROPODIUM (Gr. *neuron*, a nerve; *pous*, the foot). The ventral or inferior division of the "foot-tubercle" of an *Annelide;* often called the "ventral oar."
NEUROPTERA (Gr. *neuron;* and *pteron*, a wing). An order of Insects characterised by four membranous wings with numerous reticulated nervures (*e.g.*, Dragon-flies).
NEUTER (Lat. neither the one nor the other). Having no fully developed sex.
NIDIFICATION (Lat. *nidus*, a nest; *facio*, I make). The building of a nest.
NOCTURNAL (Lat. *nox*, night). Applied to animals which are active by night.
NORMAL (Lat. *norma*, a rule). Conforming to the ordinary standard.
NOTOBRANCHIATA (Gr. *notos*, the back; and *bragchia*, gill). Carrying the gills upon the back; applied to a division of the *Annelida*.
NOTOCHORD (Gr. *notos*, back; *chorde*, string). A cellular rod which is developed in the embryo of Vertebrates immediately beneath the spinal cord, and which is usually replaced in the adult by the vertebral column. Often it is spoken of as the "chorda dorsalis."

NOTOPODIUM (Gr. *notos,* the back; and *pous,* the foot). The dorsal division of one of the foot-tubercles or parapodia of an *Annelide;* often called the "dorsal oar."

NUCLEATED. Possessing a nucleus or central particle.

NUCLEOLUS. 1. The minute solid particle in the interior of the nucleus of some cells. 2. The minute spherical particle attached to the exterior of the "nucleus," or ovary, of certain *Infusoria,* performing the functions of a testicle.

NUCLEUS (Lat. *nucleus,* a kernel). 1. The solid or vesicular body found in many cells. 2. The solid rod, or band-shaped body, found in the interior of many of the *Protozoa,* and having, in certain of them, the functions of an ovary. 3. The "madreporiform tubercle" of the *Echinodermata.* 4. The embryonic shell which is retained to form the apex of the adult shell in many of the *Mollusca.*

NUDIBRANCHIATA (Lat. *nudus,* naked; and Gr. *bragchia,* gill). An order of the *Gasteropoda* in which the gills are naked.

NYMPHS. The active pupæ of certain Insects.

OCCIPITAL. Connected with the *occiput,* or the back part of the head.

OCEANIC. Applied to animals which inhabit the open ocean (=pelagic).

OCELLI (Lat. diminutive of *oculus,* eye). The simple eyes of many Echinoderms, Spiders, Crustaceans, Molluscs, &c.

OCTOPODA (Gr. *octo,* eight; *pous,* foot). The tribe of Cuttle-fishes with eight arms attached to the head.

ODONTOCETI (Gr. *odous,* tooth; *ketos,* whale). The "toothed" Whales, in contradistinction to the "whalebone" Whales.

ODONTOID (Gr. *odous; eidos,* form). The "odontoid process" is the centrum or body of the first cervical vertebra (*atlas*). It is detached from the atlas, and is usually anchylosed with the second cervical vertebra (*axis*), and it forms the pivot upon which the head rotates.

ODONTOPHORE (Gr. *odous,* tooth; *phero,* I carry). The so-called "tongue," or masticatory apparatus of *Gasteropoda, Pteropoda,* and *Cephalopoda.*

ŒSOPHAGUS. The gullet or tube leading from the mouth to the stomach.

OLIGOCHÆTA (Gr. *oligos,* few; *chaite,* hair). An order of *Annelida,* comprising the Earth-worms, in which there are few bristles.

OMASUM (Lat. bullock's tripe). The third stomach of Ruminants, commonly called the *psalterium,* or many-plies.

OMNIVOROUS (Lat. *omnia,* everything; *voro,* I devour). Feeding indiscriminately upon all sorts of food.

OPERCULATA (Lat. *operculum,* a lid). A division of pulmonate *Gasteropoda,* in which the shell is closed by an operculum.

OPERCULUM. A horny or shelly plate developed in certain *Mollusca* upon the hinder part of the foot, and serving to close the aperture of the shell when the animal is retracted within it; also the lid of the shell of a *Balanus* or Acorn-shell; also the chain of flat bones which cover the gills in many fishes.

OPHIDIA (Gr. *ophis,* a serpent). The order of Reptiles comprising the Snakes.

OPHIDOBATRACHIA (Gr. *ophis; batrachos,* a frog). Sometimes applied to the order of Snake-like amphibians comprising the *Cæciliæ.*

OPHIOMORPHA (Gr. *ophis; morphe,* shape). The order of *Amphibia* comprising the *Cæciliæ.*

OPHIUROIDEA (Gr. *ophis,* snake; *oura,* tail; *eidos,* form). An order of *Echinodermata,* comprising the Brittle-stars and Sand-stars.

OPISTHOBRANCHIATA (Gr. *opisthen,* behind; *bragchia,* gill). A division of *Gasteropoda,* in which the gills are placed on the posterior part of the body.

OPISTHOCŒLOUS (Gr. *opisthen,* behind; *koïlos,* hollow). Applied to vertebræ, the bodies of which are hollow or concave behind.

ORAL (Lat. *os,* mouth). Connected with the mouth.

ORNITHODELPHIA (Gr. *ornis,* a bird; *delphus,* womb). The primary division of Mammals comprising the *Monotremata.*

ORTHOPTERA (Gr. *orthos,* straight; *pteron,* wing). An order of Insects.

OSCULA (Lat. diminutive of *os*, mouth). 1. The large apertures by which a sponge is perforated ("exhalant apertures"). 2. The suckers with which the *Tæniada* (Tapeworms and Cystic Worms) are provided.

OSSICULA (Lat. diminutive of *os*, bone). Literally small bones. Often used to designate any hard structures of small size, such as the calcareous plates in the integument of the Star-fishes.

OSTRACODA (Gr. *ostrakon*, a shell). An order of small Crustaceans which are enclosed in bivalve shells.

OTOLITHS (Gr. *ous*, ear; and *lithos*, stone). The calcareous bodies connected with the sense of hearing, even in its most rudimentary form.

OVARIAN VESICLES or CAPSULES. The gonophores or generative buds of the *Hydrozoa*.

OVARY (OVARIUM). The organ by which ova are produced.

OVIPAROUS (Lat. *ovum*, an egg; and *pario*, I bring forth). Applied to animals which bring forth eggs, in contradistinction to those which bring forth their young alive.

OVIPOSITOR (Lat. *ovum* and *pono*, I place). The organ possessed by some insects, by means of which the eggs are placed in a position suitable for their development.

OVISAC. The external bag or sac in which certain of the Invertebrates carry their eggs after they are extruded from the body.

OVOVIVIPAROUS (Lat. *ovum*, egg; *vivus*, alive; *pario*, I produce). Applied to animals which retain their eggs within the body until they are hatched.

OVUM (Lat. an egg). The germ produced within the ovary, and capable under certain conditions of being developed into a new individual.

PACHYDERMATA (Gr. *pachus*, thick; *derma*, skin). An old Mammalian order constituted by Cuvier for the reception of the Rhinoceros, Hippopotamus, Elephant, &c.

PALÆONTOLOGY (Gr. *palaios*, ancient; and *logos*, discourse). The science of fossil remains or of extinct organised beings.

PALÆOZOIC (Gr. *palaios*, ancient; and *zoe*, life). Applied to the oldest of the great geological epochs.

PALLIUM (Lat. *pallium*, a cloak). The mantle of the *Mollusca*. *Pallial:* relating to the mantle. *Pallial line* or *impression:* the line left in the dead shell by the muscular margin of the mantle. *Pallial shell:* a shell which is secreted by, or contained within, the mantle, such as the "bone" of the Cuttle-fishes.

PALLIOBRANCHIATA (Lat. *pallium;* and Gr. *bragchia*, gill). An old name for the *Brachiopoda*, founded upon the belief that the system of tubes in the mantle constituted the gills.

PALPI (Lat. *palpo*, I touch). Processes supposed to be organs of touch, developed from certain of the oral appendages in Insects, Spiders, and Crustacea, and from the sides of the mouth in the Acephalous Molluscs.

PAPILLA (Lat. for nipple). A minute soft prominence.

PARAPODIA (Gr. *para*, beside; *poda*, feet). The unarticulated lateral locomotive processes or "foot-tubercles" of many of the *Annelida*.

PARIETAL (Lat. *paries*, a wall). Connected with the walls of a cavity or of the body.

PARIETOSPLANCHNIC (Lat. *paries:* Gr. *splagchna*, viscera). Applied to one of the nervous ganglia of the *Mollusca*, which supplies the walls of the body and the viscera.

PARTHENOGENESIS (Gr. *parthenos*, a virgin; and *gignomai*, to be born). Strictly speaking, confined to the production of new individuals from virgin females by means of ova without the intervention of a male. Sometimes used also to designate asexual reproduction by gemmation or fission.

PATAGIUM (Lat. the border of a dress). Applied to the expansion of the integument by which Bats, Flying Squirrels, and other animals support themselves in the air.

PATELLA. The knee-cap or knee-pan. A sesamoid bone developed in the tendon of insertion of the great extensor muscles of the thigh.

PECTINATE (Lat. *pecten*, a comb). Comb-like; applied to the gills of certain *Gasteropods;* hence called *Pectinibranchiata.*

PECTORAL (Lat. *pectus*, chest). Connected with, or placed upon, the chest.

PERENNIBRANCHIATA (Lat. *perennis*, perpetual; Gr. *bragchia*, gill). Applied to those *Amphibia* in which the gills are permanently retained throughout life.

PEDAL (Lat. *pes*, the foot). Connected with the foot of *Mollusca.*

PEDICELLARIÆ (Lat. *pedicellus*, a louse). Certain singular appendages found in many *Echinoderms*, attached to the surface of the body, and resembling a little beak or forceps supported on a stalk.

PEDICLE (Lat. dim. of *pes*, the foot). A little stem.

PEDIPALPI (Lat. *pes*, foot; and *palpo*, I feel). An order of *Arachnida* comprising the Scorpions, &c.

PEDUNCLE (Lat. *pedunculus*, a stem or stalk). In a restricted sense applied to the muscular process by which certain *Brachiopods* are attached, and to the stem which bears the body (capitulum) in Barnacles.

PEDUNCULATE. Possessing a peduncle.

PELAGIC (Gr. *pelagos*, sea). Inhabiting the open ocean.

PELVIS (Lat. for basin). Applied, from analogy, to the basal portion of the cup (*calyx*) of *Crinoids.* The bony arch with which the hind limbs are connected in Vertebrates.

PERGAMENTACEOUS (Lat. *pergamena*, parchment). Of the texture of parchment.

PERICARDIUM (Gr. *peri*, around; *kardia*, heart). The serous membrane in which the heart is contained.

PERIDERM (Gr. *peri*, around; and *derma*, skin). The hard cuticular layer which is developed by the cœnosarc of certain of the *Hydrozoa.*

PERIGASTRIC (Gr. *peri*, around; and *gaster*, stomach). The perigastric space is the cavity which surrounds the stomach and other viscera, corresponding to the abdominal cavity of the higher animals.

PERIOSTRACUM (Gr. *peri;* and *ostrakon*, shell). The layer of epidermis which covers the shell in most of the *Mollusca.*

PERIPLAST (Gr. *peri;* and *plasso*, I mould). The intercellular substance or matrix in which the organised structures of a tissue are imbedded.

PERISOME (Gr. *peri;* and *soma*, body). The coriaceous or calcareous integument of the *Echinodermata.*

PERISSODACTYLA (Gr. *perissos*, uneven; *daktulos*, finger). Applied to those Hoofed Quadrupeds (*Ungulata*) in which the feet have an uneven number of toes.

PERISTOME (Gr. *peri;* and *stoma*, mouth). The space which intervenes between the mouth and the margin of the calyx in *Vorticella;* also the space between the mouth and the tentacles in a Sea-anemone (*Actinia*); also the lip or margin of the mouth of a univalve shell.

PERIVISCERAL (Gr. *peri;* and Lat. *viscera*, the internal organs). Applied to the space surrounding the viscera.

PETALOID. Shaped like the petal of a flower.

PHALANGES (Gr. *phalanx*, a row). The small bones composing the digits of the higher *Vertebrata.* Normally each digit has three phalanges.

PHARYNGOBRANCHII (Gr. *pharugx*, pharynx; *bragchia*, gill). The order of Fishes comprising only the Lancelet.

PHARYNX. The dilated commencement of the gullet.

PHRAGMACONE (Gr. *phragma*, a partition; and *konos*, a cone). The chambered portion of the internal shell of a *Belemnite.*

PHYLACTOLÆMATA (Gr. *phulasso*, I guard; and *laima*, throat). The divison of *Polyzoa* in which the mouth is provided with the arched valvular process known as the "epistome."

PHYLLOCYSTS (Gr. *phullon*, leaf; and *kustis*, a cyst). The cavities in the interior of the "hydrophyllia" of certain of the Oceanic *Hydrozoa.*

PHYLLOPODA (Gr. *phullon*, leaf; and *pous*, foot). An order of *Crustacea.*

PHYOGEMMARIA (Gr. *phuo*, I produce; and Lat. *gemma*, bud). The small gonoblastidia of *Velella*, one of the *Physophoridæ.*

PHYSOGRADA (Gr. *phusa*, bellows or air-bladder; and Lat. *gradior*, I walk).

Applied formerly to the *Physophoridæ*, an order of Oceanic *Hydrozoa*, in which a "float" is present.

PHYSOPHORIDÆ (Gr. *phusa*, air-bladder; and *phero*, I carry). An order of Oceanic *Hydrozoa*.

PHYTOID (Gr. *phuton*, a plant; and *eidos*, form). Plant-like.

PHYTOPHAGOUS (Gr. *phuton*, a plant; and *phago*, I eat). Plant-eating, or herbivorous.

PINNATE (Lat. *pinna*, a feather). Feather-shaped, or possessing lateral processes.

PINNIGRADA (Lat. *pinna*, a feather; *gradior*, I walk). The group of *Carnivora* comprising the Seals and Walruses, adapted for an aquatic life. Often called *Pinnipedia*.

PINNULÆ (Lat. dim. of *pinna*). The lateral processes of the arms of *Crinoids*.

PISCES (Lat. *piscis*, a fish). The class of Vertebrates comprising the Fishes.

PLACENTA (Lat. a cake). The "after-birth," or the organ by which a vascular connection is established in the higher *Mammalia* between the mother and the fœtus.

PLACENTAL. Possessing a placenta; or connected with the placenta.

PLACOID (Gr. *plax*, a plate; *eidos*, form). Applied to the irregular bony plates, grains, or spines which are found in the skin of various fishes (*Elasmobranchii*).

PLAGIOSTOMI (Gr. *plagios*, transverse; *stoma*, mouth). The Sharks and Rays, in which the mouth is transverse, and is placed on the under surface of the head.

PLANARIDA (Gr. *planē*, wandering). A sub-order of the *Turbellaria*.

PLANTIGRADE (Lat. *planta*, the sole of the foot; *gradior*, I walk). Applying the sole of the foot to the ground in walking.

PLANULA (Lat. *planus*, flat). The oval ciliated embryo of certain of the *Hydrozoa*.

PLASTRON. The lower or ventral portion of the bony case of the Chelonians.

PLATYELMIA (Gr. *platus*, broad; and *helmins*, an intestinal worm). The division of *Scolecida* comprising the Tapeworms, &c.

PLATYRHINA (Gr. *platus*, broad; *rhines*, nostrils). A group of the *Quadrumana*.

PLEURA (Gr. the side). The serous membrane covering the lung in the air-breathing Vertebrates.

PLEURON (Gr. *pleuron*, a rib). The lateral extensions of the shell of *Crustacea*.

PLUTEUS (Lat. a pent-house). The larval form of the *Echinoidea*.

PNEUMATIC (Gr. *pneuma*, air). Filled with air.

PNEUMATOCYST (Gr. *pneuma*, air; and *kustis*, cyst). The air-sac or float of certain of the Oceanic *Hydrozoa* (*Physophoridæ*).

PNEUMATOPHORE (Gr. *pneuma*, air; and *phero*, I carry). The proxima dilatation of the cœnosarc in the *Physophoridæ* which surrounds the pneumatocyst.

PNEUMOSKELETON (Gr. *pneuma;* and *skeletos*, dry). The hard structures which are connected with the breathing organs (*e.g.*, the shell of Molluscs).

PODOPHTHALMATA (Gr. *pous*, foot; and *ophthalmos*, eye). The division of Crustacea in which the eyes are borne at the end of long foot-stalks.

PODOSOMATA (Gr *pous*, foot; *soma*, body). An order of *Arachnida*.

POEPHAGA (Gr. *poē*, grass; *phago*, I eat). A group of the Marsupials.

POLLEX (Lat. the thumb). The innermost of the five normal digits of the anterior limb of the higher Vertebrates. In man, the thumb.

POLYCYSTINA (Gr. *polus*, many; and *kustis*, a cyst). An order of *Protozoa*, with foraminated siliceous shells.

POLYGASTRICA (Gr. *polus;* and *gaster*, stomach). The name applied by Ehrenberg to the *Infusoria*, under the belief that they possessed many stomachs.

POLYPARY. The hard chitinous covering secreted by many of the *Hydrozoa*.

POLYPE (Gr. *polus*, many; *pous*, foot). Restricted to the single individual of a simple *Actinozoön*, such as a Sea-anemone, or to the separate zoöids of a compound *Actinozoön*. Often applied indiscriminately to any of the *Cœlenterata*, or even to the *Polyzoa*.

POLYPIDE. The separate zoöid of a *Polyzoön.*
POLYPIDOM. The dermal system of a colony of a *Hydrozoön,* or *Polyzoön.*
POLYPITE. The separate zoöid of a *Hydrozoön.*
POLYSTOME (Gr. *polus,* many; and *stoma,* mouth). Having many mouths; applied to the *Acinetæ* amongst the *Protozoa.*
POLYTHALAMOUS (Gr. *polus;* and *thalamos,* chamber). Having many chambers; applied to the shells of *Foraminifera* and *Cephalopoda.*
POLYZOA (Gr. *polus;* and *zoön,* animal). A division of the *Molluscoida,* comprising compound animals, such as the Sea-mat. Sometimes called *Bryozoa.*
POLYZOARIUM. The dermal system of the colony of a *Polyzoön* (= Polypidom).
PORCELLANOUS. Of the texture of porcelain.
PORIFERA (Lat. *porus,* a pore; and *fero,* I carry). Sometimes used to designate the *Foraminifera,* or the *Sponges.*
POST-ANAL. Situated behind the anus.
POST ŒSOPHAGEAL. Situated behind the gullet.
POST-ORAL. Situated behind the mouth.
PRÆ-MAXILLÆ (see *Intermaxillæ*).
PRÆMOLARS (Lat. *præ,* before; *molares,* the grinders). The molar teeth of Mammals which succeed the molars of the milk set of teeth. In man, the bicuspid teeth.
PRÆ-ŒSOPHAGEAL. Situated in front of the gullet.
PRÆ-STERNUM. The anterior portion of the breast-bone, corresponding with the *manubrium sterni* of human anatomy, and extending as far as the point of articulation of the second rib.
PRESSIROSTRES (Lat. *pressus,* compressed; *rostrum,* beak). A group of the Grallatorial Birds.
PROBOSCIDEA (Lat. *proboscis,* the snout). The order of Mammals comprising the Elephants.
PROBOSCIS (Lat. or Gr. the snout). Applied to the spiral trunk of *Lepidopterous Insects,* to the projecting mouth of certain *Crinoids,* and to the central polypite in the *Medusæ.*
PROCŒLOUS (Gr. *pro,* front; *koilos,* hollow). Applied to vertebræ, the bodies of which are hollow or concave in front.
PROGLOTTIS (Gr. for the tip of the tongue). The generative segment or joint of a Tapeworm.
PRO-LEGS. The false abdominal feet of Caterpillars.
PRONATION (Lat. *pronus,* lying on the face, prone). The act of turning the palm of the hand downwards.
PROPODIUM (Gr. *pro,* before; *pous,* foot). The anterior part of the foot in Molluscs.
PROSCOLEX (Gr. *pro,* before; *skolex,* worm). The first embryonic stage of a Tapeworm.
PROSOBRANCHIATA (Gr. *proson,* in advance of; *bragchia,* a gill). A division of Gasteropodous Molluscs in which the gills are situated in advance of the heart.
PROSOMA (Gr. *pro,* before; *soma,* body). The anterior part of the body.
PROTHORAX (Gr. *pro;* and *thorax,* chest). The anterior ring of the thorax of insects.
PROTOPODITE (Gr. *protos,* first; and *pous,* foot). The basal segment of the typical limb of a *Crustacean.*
PROTOPHYTA (Gr. *protos;* and *phuton,* plant). The lowest division of plants.
PROTOPLASM (Gr. *protos;* and *plasso,* I mould). The elementary basis of organised tissues. Sometimes used synonymously for the "sarcode" of the *Protozoa.*
PROTOZOA (Gr. *protos;* and *zoön,* animal). The lowest division of the animal kingdom.
PROVENTRICULUS (Lat. *pro,* in front of; *ventriculus,* dim. of *venter,* belly). The cardiac portion of the stomach of birds.
PROXIMAL (Lat. *proximus,* next). The slowly-growing, comparatively-fixed extremity of a limb or of an organism.

PSALTERIUM (Lat. a stringed instrument). The third stomach of Ruminants. (See *Omasum*.)
PSEUDEMBRYO (Gr. *pseudos*, false; *embruon*, embryo). The larval form of an *Echinoderm.*
PSEUDOBRANCHIA (Gr. *pseudos*, false; *bragchia*, gill). A supplementary gill found in certain fishes, which receives arterialised blood only, and does not, therefore, assist in respiration.
PSEUDOHÆMAL (Gr. *pseudos*, false; and *haima*, blood). Applied to the vascular system of *Annelida*.
PSEUDO-HEARTS. Certain contractile cavities connected with the atrial system of *Brachiopoda*, and long considered to be hearts.
PSEUDO-NAVICELLÆ (Gr. *pseudos*, false; and *Navicula*, a genus of Diatoms). The embryonic forms of the *Gregarinidæ*, so called from their resemblance in shape to the *Navicula*.
PSEUDOPODIA (Gr. *pseudos;* and *pous*, foot). The extensions of the body-substance which are put forth by the *Rhizopoda* at will, and which serve for locomotion and prehension.
PSEUDOVA (Gr. *pseudos;* Lat. *ovum*, egg). The egg-like bodies from which the young of the viviparous *Aphis* are produced.
PTEROPODA (Gr. *pteron*, wing; and *pous*, foot). A class of the *Mollusca* which swim by means of fins attached near the head.
PTEROSAURIA (Gr. *pteron*, wing; *saura*, lizard). An extinct order of Reptiles.
PUBIS (Lat. *pubes*, hair). The share-bone; one of the bones which enter into the composition of the pelvic arch of Vertebrates.
PULMONARIA. A division of *Arachnida* which breathe by means of pulmonary sacs.
PULMONATE. Possessing lungs.
PULMONIFERA (Lat. *pulmo*, a lung; and *fero*, I carry). The division of *Mollusca* which breathe by means of a pulmonary chamber.
PULMOGASTEROPODA (= Pulmonifera).
PUPA (Lat. a doll). The stage of an insect immediately preceding its appearance in a perfect condition. In the pupa-stage it is usually quiescent—when it is often called a "chrysalis"—but it is sometimes active—when it is often called a "nymph."
PYLORUS (Gr. *puloros*, a gate-keeper). The valvular aperture between the stomach and the intestine.
PYRIFORM (Lat. *pyrus*, a pear; and *forma*, form). Pear-shaped.

QUADRUMANA (Lat. *quatuor*, four; *manus*, hand). The order of Mammals comprising the Apes, Monkeys, Baboons, Lemurs, &c.

RADIATA (Lat. *radius*, a ray). Formerly applied to a large number of animals which are now placed in separate sub-kingdoms (*e.g.*, the *Cœlenterata*, the *Echinodermata*, the *Infusoria*, &c.)
RADIOLARIA (Lat. *radius*, a ray). A division of *Protozoa*.
RADIUS (Lat. a spoke or ray). The innermost of the two bones of the fore-arm of the higher Vertebrates. It carries the thumb, when present, and corresponds with the tibia of the hind-limb.
RAMUS (Lat. a branch). Applied to each half or branch of the lower jaw or mandible of Vertebrates.
RAPTORES (Lat. *rapto*, I plunder). The order of the Birds of Prey.
RASORES (Lat. *rado*, I scratch). The order of the Scratching Birds (Fowls, Pigeons, &c.)
RATITÆ (Lat. *rates*, a raft). Applied by Huxley to the Cursorial Birds which do not fly, and have, therefore, a raft-like sternum without any median keel.
RECTUM (Lat. *rectus*, straight). The terminal portion of the intestinal canal, opening at the surface of the body at the anus.
REPTILIA (Lat. *repto*, I crawl). The class of the *Vertebrata* comprising the Tortoises, Snakes, Lizards, Crocodiles, &c.
RETICULARIA (Lat. *reticulum*, a net). Employed by Dr Carpenter to desig-

nate those *Protozoa*, such as the *Foraminifera*, in which the pseudopodia run into one another and form a network.

RETICULUM (Lat. a net). The second division of the complex stomach of Ruminants, often called the "honeycomb bag."

REVERSED. Applied to spiral univalves, in which the direction of the spiral is the reverse of the normal—*i.e.*, *sinistral*.

RHIZOPHAGA (Gr. *rhiza*, root; *phago*, I eat). A group of the Marsupials.

RHIZOPODA (Gr. *rhiza*, a root; and *pous*, foot). The division of *Protozoa* comprising all those which are capable of emitting pseudopodia.

RHYNCHOLITES (Gr. *rhunchos*, beak; and *lithos*, stone). Beak-shaped fossils, consisting of the mandibles of *Cephalopoda*.

RODENTIA (Lat. *rodo*, I gnaw). An order of the Mammals; often called *Glires* (Lat. *glis*, a dormouse).

ROSTRUM (Lat. *rostrum*, beak). The "beak" or suctorial organ formed by the appendages of the mouth in certain insects.

ROTATORIA (= Rotifera).

ROTIFERA (Lat. *rota*, wheel; and *fero*, I carry). A class of the *Scolecida* (*Annuloida*) characterised by a ciliated "trochal disc."

RUGOSA (Lat. *rugosus*, wrinkled). An extinct order of Corals.

RUMEN (Lat. the throat). The first cavity of the complex stomach of Ruminants; often called the "paunch."

RUMINANTIA (Lat. *ruminor*, I chew the cud). The group of Hoofed Quadrupeds (*Ungulata*) which "ruminate" or chew the cud.

SACRUM. The vertebræ (usually anchylosed) which unite with the haunch-bones (*ilia*) to form the pelvis.

SAND-CANAL (= STONE-CANAL). The tube by which water is conveyed from the exterior to the ambulacral system of the *Echinodermata*.

SARCODE (Gr. *sarx*, flesh; *eidos*, form). The jelly-like substance of which the bodies of *Protozoa* are composed. It is an albuminous body containing oil-granules, and is sometimes called "animal protoplasm."

SARCOIDS (Gr. *sarx;* and *eidos*, form). The separate amœbiform particles which in the aggregate make up the "flesh" of a Sponge.

SAURIA (Gr. *saura*, a lizard). Any lizard-like Reptile is often spoken of as a "Saurian;" but the term is sometimes restricted to the Crocodiles alone, or to the Crocodiles and Lacertilians.

SAUROBATRACHIA (Gr. *saura; batrachos*, frog). Sometimes applied to the order of the tailed Amphibians (*Urodela*).

SAUROPSIDA (Gr. *saura;* and *opsis*, appearance). The name given by Huxley to the two classes of the Birds and Reptiles collectively.

SAUROPTERYGIA (Gr. *saura; pterux*, wing). An extinct order of Reptiles, called by Huxley *Plesiosauria*, from the typical genus *Plesiosaurus*.

SAURURÆ (Gr. *saura; oura*, tail). The extinct order of Birds comprising only the *Archæopteryx*.

SCANSORES (Lat. *scando*, I climb). The order of the Climbing Birds (Parrots, Woodpeckers, &c.)

SCAPHOGNATHITE (Gr. *skaphos*, boat; and *gnathos*, jaw). The boat-shaped appendage (epipodite) of the second pair of maxillæ in the Lobster; the function of which is to spoon out the water from the branchial chamber.

SCAPULA (Lat. for shoulder-blade). The shoulder-blade of the pectoral arch of Vertebrates; in a restricted sense, the row of plates in the cup of *Crinoids*, which give origin to the arms, and are usually called the "axillary radials."

SCLERENCHYMA (Gr. *skleros*, hard; and *enchuma*, tissue). The calcareous tissue of which a coral is composed.

SCLERITES (Gr. *skleros*). The calcareous spicules which are scattered in the soft tissues of certain *Actinozoa*.

SCLEROBASIC (Gr. *skleros*, hard; *basis*, pedestal). The coral which is produced by the outer surface of the integument in certain *Actinozoa* (*e.g.*, Red Coral), and forms a solid axis which is invested by the soft parts of the animal. It is called "foot-secretion" by Mr Dana.

SCLERODERMIC (Gr. *skleros;* and *derma,* skin). Applied to the corallum which is deposited within the tissues of certain *Actinozoa,* and is called "tissue-secretion" by Mr Dana.

SCLEROTIC (Gr. *skleros,* hard). The outer dense fibrous coat of the eye.

SCOLECIDA (Gr. *skolēx,* worm). A division of the *Annuloida.*

SCOLEX (Gr. *skolēx*). The embryonic stage of Tapeworm, formerly known as a "Cystic Worm."

SCUTA (Lat. *scutum,* a shield). Applied to any shield-like plates; especially to those which are developed in the integument of many Reptiles.

SELACHIA or SELACHII (Gr. *selachos,* a cartilaginous fish, probably a shark The sub-order of *Elasmobranchii* comprising the Sharks and Dog-fishes.

SEPIOSTAIRE. The internal shell of the Cuttle-fish, commonly known as the "cuttle-bone."

SEPTA. Partitions.

SERPENTIFORM. Resembling a serpent in shape.

SERTULARIDA (Lat. *sertum,* a wreath). An order of *Hydrozoa.*

SESSILE (Lat. *sedo,* I sit). Not supported upon a stalk or peduncle; attached by a base.

SETÆ (Lat. bristles). Bristles, or long stiff hairs.

SETIFEROUS. Supporting bristles.

SETIGEROUS (= Setiferous).

SETOSE. Bristly.

SILICEOUS (Lat. *silex,* flint). Composed of flint.

SINISTRAL (Lat. *sinistra,* the left hand). Left-handed; applied to the direction of the spiral in certain shells, which are said to be "reversed."

SINUS (Lat. *sinus,* a bay). A dilated vein or blood-receptacle.

SIPHON (Gr. *siphon,* a tube). Applied to the respiratory tubes in the *Mollusca;* also to other tubes of different functions.

SIPHONOPHORA (Gr. *siphon;* and *phero,* I carry). A division of the *Hydrozoa,* comprising the Oceanic forms (*Calycophoridæ* and *Physophoridæ*).

SIPHONOSTOMATA (Gr. *siphon;* and *stoma,* mouth). The division of *Gasteropodous Molluscs,* in which the aperture of the shell is not "entire," but possesses a notch or tube for the emission of the respiratory siphon.

SIPHUNCLE (Lat. *siphunculus,* a little tube). The tube which connects together the various chambers of the shell of certain *Cephalopoda* (*e.g.,* the Pearly Nautilus).

SIPUNCULOIDEA (Lat. *siphunculus,* a little siphon). A class of *Anarthropoda* (*Annulosa*).

SIRENIA (Gr. *seiren,* a mermaid). The order of *Mammalia* comprising the Dugongs and Manatees.

SOLIDUNGULA (Lat. *solidus,* solid; *ungula,* a hoof). The group of Hoofed Quadrupeds comprising the Horse, Ass, and Zebra, in which each foot has only a single solid hoof. Often called *Solipedia.*

SOMATIC (Gr. *soma,* body). Connected with the body.

SOMATOCYST (Gr. *soma;* and *kustis,* a cyst). A peculiar cavity in the cœnosarc of the *Calycophoridæ* (*Hydrozoa*).

SOMITE (Gr. *soma*). A single segment in the body of an Articulate animal.

SPERMARIUM. The organ in which spermatozoa are produced.

SPERMATOPHORES (Gr. *sperma,* seed; *phero,* I carry). The cylindrical capsules of the *Cephalopoda,* which carry the spermatozoa; sometimes called the "moving filaments of Needham."

SPERMATOZOA (Gr. *sperma,* seed; and *zoön,* animal). The microscopic filaments which form the essential generative element of the male.

SPICULA (Lat. *spiculum,* a point). Pointed needle-shaped bodies.

SPINNERETS. The organs by means of which Spiders and Caterpillars spin threads.

SPIRACLES (Lat. *spiro,* I breathe). The breathing-pores, or apertures of the breathing-tubes (tracheæ) of Insects. Also the single nostril of the Hag-fishes, the "blow-hole" of Cetaceans, &c.

SPLANCHNOSKELETON (Gr. *splagchna,* viscera; *skeletos,* dry). The hard structures occasionally developed in connection with the internal organs or viscera.

SPONGE-PARTICLES. (*See* Sarcoids.)

SPONGIDA (Gr. *spoggos*, a sponge). The division of *Protozoa* commonly known as sponges.

SPORES (Gr. *spora*, seed). Germs, usually of plants; in a restricted sense, the reproductive "gemmules" of certain Sponges.

SPOROSACS (Gr. *spora*, seed; and *sakkos*, a bag). The simple generative buds of certain *Hydrozoa*, in which the medusoid structure is not developed.

SQUAMATA (Lat. *squama*, a scale). The division of Reptiles comprising the *Ophidia* and *Lacertilia* in which the integument develops horny scales, but there are no dermal ossifications.

STATOBLASTS (Gr. *statos*, stationary; *blastos*, bud). Certain reproductive buds developed in the interior of *Polyzoa*, but not liberated until the death of the parent organism.

STEGANOPHTHALMATA (Gr. *steganos*, covered; and *ophthalmos*, the eye). Applied by Edward Forbes to certain *Medusæ*, in which the sense-organs ("marginal bodies") are protected by a sort of hood. The *Steganophthalmata* are now separated from the true *Medusidæ*, and placed in a separate division under the name *Lucernarida*.

STELLERIDA (Lat. *stella*, star). Sometimes employed to designate the order of the Star-fishes

STELLIFORM. Star-shaped.

STEMMATA (Gr. *stemma*, garland). The simple eyes, or "ocelli," of certain animals, such as Insects, Spiders, and Crustacea.

STERNUM (Gr. *sternon*). The breast-bone.

STIGMATA. The breathing-pores in *Insects* and *Arachnida*.

STOLON (Gr. *stolos*, a sending forth). Offshoots.—The connecting processes of sarcode, in *Foraminifera;* the connecting tube in the social *Ascidians;* the processes sent out by the cœnosarc of certain *Actinozoa*.

STOMAPODA (Gr. *stoma*, mouth; *pous*, foot). An order of *Crustacea*.

STOMATODE (Gr. *stoma*). Possessing a mouth. The *Infusoria* are thus often called the Stomatode *Protozoa*.

STREPSIPTERA (Gr *strepho*, I twist; and *pteron*, wing). An order of Insects in which the anterior wings are represented by twisted rudiments.

STREPSIRHINA (Gr. *strepho*, I twist; *rhines*, nostrils). A group of the Quadrumana, often spoken of as *Prosimiæ*.

STROBILA (Gr. *strobilos*, a top, or fir-cone). The adult tapeworm with its generative segments or proglottides; also applied to one of the stages in the life-history of the *Lucernarida*.

STYLIFORM (Lat. *stylus*, a pointed instrument; *forma*, form). Pointed in shape.

SUB-CALCAREOUS. Somewhat calcareous.

SUB-CENTRAL. Nearly central, but not quite.

SUB-PEDUNCULATE. Supported upon a very short stem.

SUB-SESSILE. Nearly sessile, or without a stalk.

SUPINATION (Lat. *supinus*, lying with the face upwards). The act of turning the hand with the palm upwards.

SUTURE (Lat. *suo*, I sew). The line of junction of two parts which are immovably connected together. Applied to the line where the whorls of a univalve shell join one another; also to the lines made upon the exterior of the shell of a chambered *Cephalopod* by the margins of the septa.

SWIMMERETS. The limbs of *Crustacea*, which are adapted for swimming.

SYMPHYSIS (Gr. *sumphusis*, a growing together). Union of two bones in which there is no motion or but a very limited amount.

SYNAPTICULÆ (Gr *sunapto*, I fasten together). Transverse props sometimes found in Corals, extending across the loculi like the bars of a grate.

SYSTOLE (Gr. *sustello*, I contract). Applied to the contraction of any contractile cavity, especially the heart.

TABULÆ (Lat. *tabula*, a tablet). Horizontal plates or floors found in some Corals, extending across the cavity of the "theca," from side to side.
TACTILE (Lat. *tango*, I touch). Connected with the sense of touch.
TÆNIADA (Gr. *tainia*, a ribbon). The division of *Scolecida* comprising the Tapeworms.
TÆNIOID (Gr. *tainia;* and *eidos*, form). Ribbon-shaped, like a tapeworm.
TARSO-METATARSUS. The single bone in the leg of Birds produced by the union and anchylosis of the lower or distal portion of the tarsus with the whole of the metatarsus.
TARSUS (Gr. *tarsos*, the flat of the foot). The small bones which form the ankle (or "instep" of man), and which correspond with the wrist (*carpus*) of the anterior limb.
TECTIBRANCHIATA (Lat. *tectus*, covered ; and Gr. *bragchia*, gills). A division of *Opisthobranchiate Gasteropoda* in which the gills are protected by the mantle.
TEGUMENTARY (Lat. *tegumentum*, a covering). Connected with the integument or skin.
TELEOSTEI (Gr. *teleios*, perfect; *osteon*, bone). The order of the "Bony" Fishes.
TELSON (Gr. *telson*, a limit). The last joint in the abdomen of *Crustacea;* variously regarded as a segment without appendages, or as an azygos appendage.
TENUIROSTRES (Lat. *tenuis*, slender; *rostrum*, beak). A group of the Perching Birds characterised by their slender beaks.
TERGUM (Lat. for back). The dorsal arc of the somite of an Arthropod.
TERRICOLA (Lat. *terra*, earth ; and *colo*, I inhabit). Employed occasionally to designate the Earth-worms (*Lumbricidæ*).
TEST (Lat. *testa*, shell). The shell of *Mollusca*, which are for this reason sometimes called "*Testacea ;*" also, the calcareous case of *Echinoderms;* also, the thick leathery outer tunic in the *Tunicata*.
TESTACEOUS. Provided with a shell or hard covering.
TESTIS (Lat. *testis*, the testicle). The organ in the male animal which produces the generative fluid or semen.
TETRABRANCHIATA (Gr. *tetra*, four ; *bragchia*, gill). The order of *Cephalopoda*, characterised by the possession of four gills.
THALASSICOLLIDA (Gr. *thalassa*, sea ; *kolla*, glue). A division of *Protozoa*.
THECA (Gr. *theke*, a sheath). A sheath or receptacle.
THECOSOMATA (Gr. *theke ;* and *soma*, body). A division of *Pteropodous Molluscs*, in which the body is protected by an external shell.
THERIOMORPHA (Gr. *ther*, beast ; *morphe*, shape). Applied by Owen to the order of the Tail-less Amphibians (*Anoura*.)
THORAX (Gr. a breastplate). The chest.
THREAD-CELLS. (*See* Cnidæ.)
THYSANURA (Gr. *thusanoi*, fringes ; and *oura*, tail). An order of Apterous Insects.
TIBIA (Lat. a flute). The shin-bone, being the innermost of the two bones of the leg, and corresponding with the *radius* in the anterior extremity.
TOTIPALMATÆ (Lat. *totus*, whole ; *palma*, the palm of the hand). A group of Wading Birds in which the hallux is united to the other toes by membrane, so that the feet are completely webbed.
TRACHEA (Gr. *tracheia*, the rough wind-pipe). The tube which conveys air to the lungs in the air-breathing Vertebrates.
TRACHEÆ. The breathing-tubes of Insects and other Articulate animals.
TRACHEARIA. The division of *Arachnida* which breathe by means of tracheæ.
TREMATODA (Gr. *trema*, a pore). An order of *Scolecida*.
TRICHOCYSTS (Gr. *thrix*, hair ; and *kustis*, a cyst). Peculiar cells found in certain *Infusoria*, and very nearly identical with the "thread-cells" of *Cœlenterata*.
TRILOBITA (Gr. *treis*, three ; *lobos*, a lobe). An extinct order of *Crustaceans*.
TRITOZOÖIDS (Gr. *tritos*, third ; *zöon*, animal ; and *eidos*, form). The zoöid

produced by a deuterozoöid; that is to say, a zoöid of the third generation.

Trochal (Gr. *trochos*, a wheel). Wheel-shaped; applied to the ciliated disc of the *Rotifera*.

Trochanter (Gr. *trecho*, I turn). A process of the upper part of the thigh-bone (*femur*) to which are attached the muscles which rotate the limb. There may be two, or even three, trochanters present.

Trochoid (Gr. *trochos*, a wheel; and *eidos*, form). Conical with a flat base; applied to the shells of *Foraminifera* and *Univalve Molluscs*.

Trophi (Gr. *trophos*, a nourisher). The parts of the mouth in insects which are concerned in the acquisition and preparation of food. Often called "instrumenta cibaria."

Trophosome (Gr. *trepho*, I nourish; and *soma*, body). Applied collectively to the assemblage of the nutritive zoöids of any *Hydrozoön*.

Truncated (Lat. *trunco*, I shorten). Abruptly cut off; applied to univalve shells, the apex of which breaks off, so that the shell becomes "decollated."

Tubicola (Lat. *tuba*, a tube; and *colo*, I inhabit). The order of *Annelida* which construct a tubular case in which they protect themselves.

Tubicolous. Inhabiting a tube.

Tunicata (Lat. *tunica*, a cloak). A class of *Molluscoida* which are enveloped in a tough leathery case or "test."

Turbellaria (Lat. *turbo*, I disturb). An order of *Scolecida*.

Turbinated (Lat. *turbo*, a top). Top-shaped; conical, with a round base.

Ulna (Gr. *olene*, the elbow). The outermost of the two bones of the fore-arm, corresponding with the *fibula* of the hind-limb.

Umbellate (Lat. *umbella*, a parasol). Forming an umbel—*i.e.*, a number of nearly equal *radii* all proceeding from one point.

Umbilicus (Lat. for navel). The aperture seen at the base of the axis of certain univalve shells, which are then said to be "perforated" or "umbilicated."

Umbo (Lat. the boss of a shield). The beak of a bivalve shell.

Umbrella. The contractile disc of one of the *Lucernarida*.

Uncinate (Lat. *uncinus*, a hook). Provided with hooks or bent spines.

Unguiculate (Lat. *unguis*, nail). Furnished with claws.

Ungulata (Lat. *ungula*, hoof). The order of *Mammals* comprising the Hoofed Quadrupeds.

Ungulate. Furnished with expanded nails constituting hoofs.

Unilocular (Lat. *unus*, one; and *loculus*, a little purse). Possessing a single cavity or chamber. Applied to the shells of *Foraminifera* and *Mollusca*.

Univalve (Lat. *unus*, one; *valvæ*, folding doors). A shell composed of a single piece or valve.

Urodela (Gr. *oura*, tail; *delos*, visible). The order of the tailed Amphibians (Newts, &c.)

Urticating Cells (Lat. *urtica*, a nettle). (*See* Cnidæ).

Vacuoles (Lat. *vacuus*, empty). The little cavities formed in the interior of many of the *Protozoa* by the presence of little particles of food, usually surrounded by a little water. These are properly called "food-vacuoles," and were supposed to be stomachs by Ehrenberg. Also the clear spaces which are often seen in the tissues of many *Cœlenterata*.

Varices (Lat. *varix*, a dilated vein). The ridges or spinose lines which mark the former position of the mouth in certain univalve shells.

Vascular (Lat. *vas*, a vessel). Connected with the circulatory system.

Velum (Lat. a sail). The membrane which surrounds and partially closes the mouth of the "disc" of *Medusæ*, or medusiform gonophores.

Ventral (Lat. *venter*, the stomach). Relating to the inferior surface of the body.

Ventricle (Lat. dim. of *venter*, stomach). Applied to one of the cavities of the heart, which receives blood from the auricle.

VERMES (Lat. *vermis*, a worm). Sometimes employed at the present day in the same, or very nearly the same, sense as *Annuloida*, or as *Annuloida* plus the *Anarthropoda*.

VERMIFORM (Lat. *vermis*, worm; and *forma*, form). Worm-like.

VERTEBRA (Lat. *verto*, I turn). One of the bony segments of the vertebral column or back-bone.

VERTEBRATA. (Lat. *vertebra*, a bone of the back, from *vertere*, to turn). The division of the Animal Kingdom, roughly characterised by the possession of a back-bone.

VESICLE (Lat. *vesica*, a bladder). A little sac or cyst.

VIBRACULA (Lat. *vibro*, I shake). Long filamentous appendages found in many *Polyzoa*.

VIBRIONES (Lat. *vibro*, I shake). The little moving filaments developed in organic infusions.

VIPERINA (Lat. *vipera*, a viper). A group of the Snakes.

VIVIPAROUS (Lat. *vivus*, alive; and *pario*, I bring forth). Bringing forth young alive.

WHORL. The spiral turn of a univalve shell.

XIPHISTERNUM (Gr. *xiphos*, sword; *sternon*, breast-bone). The inferior or posterior segment of the sternum, corresponding with the "xiphoid cartilage" of human anatomy.

XIPHOSURA (Gr. *xiphos*, a sword; and *oura*, tail). An order of *Crustacea*, comprising the *Limuli* or King-Crabs, characterised by their long sword-like tails.

XYLOPHAGOUS (Gr. *xulon*, wood; and *phago*, I eat). Eating wood; applied to certain *Mollusca*.

ZOÖID (Gr. *zoön*, animal; and *eidos*, like). The more or less completely independent organisms, produced by gemmation or fission, whether these remain attached to one another or are detached and set free.

ZOOPHYTE (Gr. *zoön*, animal; *phuton*, plant). Loosely applied to many plant-like animals, such as Sponges, Corals, Sea-anemones, Sea-mats, &c.

ZOOSPORES (Gr. *zoön*, animal; and *spora*, seed). The ciliated locomotive germs of some of the lowest forms of plants (*Protophyta*).

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THE END.

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