Zoology of the vertebrate animals / by Alex. Macalister.

THE

LONDON SCIENCE CLASS-BOOKS

EDITED BY

G. CAREY FOSTER. F.R.S.
AND
PHILIP MAGNUS. B.Sc. B.A.

RTEBRATA

BY

TESSOR A. MACALISTER.

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THE LONDON SCIENCE CLASS-BOOKS

ELEMENTARY SERIES

EDITED BY

PROF. G. C. FOSTER, F.R.S. AND PHILIP MAGNUS, B.Sc. B.A.

VERTEBRATA

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ZOOLOGY

OF THE

VERTEBRATE ANIMALS

BY

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THE UNIVERSITY OF DUBLIN

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1878

EDITORS' PREFACE.

NOTWITHSTANDING the large number of scientific works which have been published within the last few years, it is very generally acknowledged by those who are practically engaged in Education, whether as Teachers or as Examiners, that there is still a want of Books adapted for school purposes upon several important branches of Science. The present SERIES will aim at supplying this deficiency. The works comprised in the SERIES will all be composed with special reference to their use in school-teaching; but, at the same time, particular attention will be given to making the information contained in them trustworthy and accurate, and to presenting it in such a way that it may serve as a basis for more advanced study.

In conformity with the special object of the Series, the attempt will be made in all cases to bring out the educational value which properly belongs to the study of any branch of Science, by not merely treating of its

acquired results, but by explaining as fully as possible the nature of the methods of inquiry and reasoning by which these results have been obtained. Consequently, although the treatment of each subject will be strictly elementary, the fundamental facts will be stated and discussed with the fulness needed to place their scientific significance in a clear light, and to show the relation in which they stand to the general conclusions of Science.

In order to ensure the efficient carrying-out of the general scheme indicated above, the Editors have endeavoured to obtain the co-operation, as Authors of the several treatises, of men who combine special knowledge of the subjects on which they write with practical experience in Teaching.

The volumes of the Series will be published, if possible, at a uniform price of 1*s.* 6*d.* It is intended that eventually each of the chief branches of Science shall be represented by one or more volumes.

G. C. F.
P. M.

PREFACE.

It has been the Author's design in this volume to present in as simple a form as possible the leading characters of Vertebrate Animals. Although the book is intended for pupils who have already mastered some of the elementary principles of General Biology, yet, as far as possible, all unnecessary technicalities have been dispensed with, and explanations have been given, either in the text or in the glossary, of such terms as have been unavoidably used.

In a practical science such as Zoology, it is only by the examination of specimens that any knowledge of the science worth acquiring can be obtained, and the function of a book is to assist in practical study. This has been borne in mind in compiling

these pages. Great care has moreover been taken to select only such facts for discussion as are of fundamental importance. As types of the different classes of vertebrated animals are easily obtainable, the pupil is recommended to verify these facts for himself.

ALEXANDER MACALISTER.

ANATOMICAL MUSEUM,
UNIVERSITY OF DUBLIN:
Oct. 2, 1877.

CONTENTS.

CHAPTER V.

ORDER 3. GANOID FISHES. ORDER 4. BONY FISHES. ORDER 5. DIPNOI.

CHAPTER VI.

CLASS 2. AMPHIBIA.

CHAPTER VII.

CLASSIFICATION OF AMPHIBIA.

CHAPTER VIII.

CLASS 3. REPTILES.

CHAPTER IX.

LIZARDS AND SNAKES.

CHAPTER X.

TORTOISES AND CROCODILES.

CHAPTER XI.

CLASS 4. AVES (BIRDS).

CHAPTER XII.

CLASSIFICATION OF BIRDS.

CHAPTER XIII.

CLASSIFICATION OF BIRDS (*continued*).

CHAPTER XIV.

CLASS 5. MAMMALIA.

CHAPTER XV.

CLASSIFICATION OF MAMMALS.

CHAPTER XVI.

PLACENTAL MAMMALS.

CHAPTER XVII.

PLACENTAL MAMMALS (*continued*).

CHAPTER XVIII.

CHAPTER XIX.

VERTEBRATA.

CHAPTER I.

CHARACTERS OF VERTEBRATE ANIMALS. ACRANIA.

1. **Introductory.**—The animals which make up the sub-kingdom Vertebrata are the fishes, reptiles, birds, and quadrupeds; and as they present to us a greater number of interesting points in structure, function, and habits than all the other sub-kingdoms put together, and as they are for the most part of large size and of complex organisation, they require a more careful and detailed study than do the animals which make up the other sub-kingdoms. On this account, Vertebrata, though in reality constituting only a subdivision equivalent to any of the other sub-kingdoms, such as Mollusca, Polystomata, or Vermes, are yet often treated, and naturally so, as if they equalled all the other sub-kingdoms collectively.

2. **General characters of vertebrate animals.**—Every vertebrate animal possesses in the centre of its body an axis or rod of cartilage, which forms a

skeleton or support; below[1] is a longitudinal body-cavity, containing the organs of digestion, circulation, respiration, &c.; above is a second, smaller, longitudinal cavity or canal, in which lie the brain and spinal marrow, the central organs of the nervous system; these send out laterally along their whole extent numerous pairs of nerve-cords to supply the different parts of the body. Thus on cross-section the body of a vertebrate animal appears like two tubes, the smaller being above the larger, and the cartilaginous axis appears in the middle of the horizontal partition which divides them from each other.

In the young conditions of the tunicated worms there is an approach to this arrangement, but in these the gristly rod does not extend sufficiently far forward to separate the *neural* (or nervous system-holding) and *visceral cavities.*

To the central axis of cartilage the name *notochord* is given, and it is enveloped in a sheath of several layers. In the majority of vertebrates the notochord is present only as a temporary and transitory structure, for, in the process of growth, parts of its sheath enlarge and encroach on the axis itself, so as to obliterate it eventually in whole or in part. These enlargements begin in the form of a succession of paired lateral thickenings along the whole length of the sheath, which extend above and below the notochord, and become converted into rings around it, and ultimately by extension inwards they become discs.

[1] The animal is supposed to be placed with its length horizontal and its mouth forwards.

The chain of these rings or disks, around or replacing the notochord, which forms the axis in the adult stage of all but the lowest of the vertebrates, is called the *vertebral column*, and each disk, with the parts immediately joined to it, is called a *vertebra* (fig. 2).

Each vertebra has attached to it behind a ring or arch (made up of two lateral projections or *processes*) which surrounds the spinal marrow, and forms the wall of the *neural cavity*. This arch is called the *neural arch*.

The mouth opens at the foremost end of the body in all vertebrates, and communicates internally with a cavity called the *pharynx*, on whose walls, directly or indirectly, the blood-vessels are arranged for the purposes of respiration. This part of the digestive canal [1] is pierced by slits at some period in the life of each vertebrate.

Below the pharynx is a narrow part of the digestive canal, called the *œsophagus*, which passes between the spinal column above and the heart below, and leads into the stomach, from whence the intestinal canal is continued, to open at the posterior end of the body ; directly below the stomach the duct of the liver opens in all vertebrates, and this organ is peculiar in this sub-kingdom, in that the vein which conveys the impure blood back from the digestive organs enters this gland and breaks up within it into a network of fine vessels, which, reuniting, pass back from hence to the heart. The vessel which thus

[1] The digestive or alimentary canal is a tube traversing the whole length of the body, in which the food is digested, and its nourishing part taken into the blood.

conveys the blood from the alimentary canal to the liver is called the *vena portæ.*

3. **Primary divisions of vertebrates** (*headless form*).—There are two primary divisions of vertebrate animals ; the first of these includes only one form, and that the smallest and simplest in the sub-kingdom, remarkable principally for its extremely simple organisation. This little creature is named the lancelet, or technically the *Amphioxus lanceolatus*, and is so called on account of its lancet-like shape, and from its being pointed at both ends. It is a small, flattened, fish-like animal, about an inch and a half long, about a quarter of an inch in depth and an eighth in thickness, found in sandbanks in our own seas. It has been taken in abundance off the S.W. coast of Ireland, in the Mediterranean, and even in the Indian and Pacific Oceans.

This animal has no head, and the notochord stretches from the front to the hinder point ; the neural canal and its enclosed spinal marrow likewise extend for the whole length. The mouth is a longitudinal slit, bordered with stiff, bristle-like filaments ;

FIG. 1.

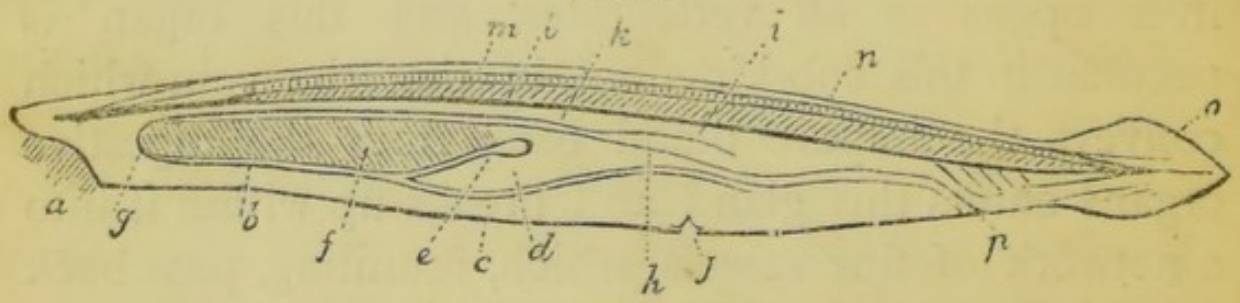


Diagram of *Amphioxus.*
a, mouth ; *b*, *f*, *g*, respiratory region ; *c*, body cavity ; *d*, liver ; *h–p*, digestive canal ; *l*, notochord ; *m*, spinal marrow.

and the pharynx has many lateral slits in its wall,

through which the water which enters the mouth escapes into the space between the wall of the body and that of the pharynx. To this space the name 'atrium' is given, and it opens externally by a median pore or outlet placed on the under edge, and in front of the end of the intestine (fig. 1, *j*).

The liver is a simple sac, and the heart is a single dilated tube (*e*), like that of some worms; it sends branches backwards to the pharyngeal wall, one along each slit, and these join dorsally below the notochord, making a dorsal aorta or large blood-vessel, which gives off branches to the different parts of the body.

Though there is no brain, yet two of the foremost of the many nerves emitted from the spinal marrow supply structures which may be regarded as rudimentary sense-organs. Thus there is in the middle of the foremost end of the animal a small pit, possibly an organ of smell, and two or more lateral pigment-spots in front of and above the mouth, which may be organs of sight. There is a narrow membranous fringe or fin around the tail, but there are no limbs, and the blood is colourless.

The division of Vertebrata which contains this singularly aberrant form is named *Acrania* (headless), to distinguish it from that which includes the entire remaining series, which is called *Craniota* (head-bearing).

CHAPTER II.

CRANIOTA.

4. **General characters of head-bearing vertebrates.** The head-bearing vertebrates are characterised by the enlargement of the anterior end of the central axis of the nervous system into a series of swellings which collectively make up the *brain*. To contain this brain the fore part of the neural canal is enormously dilated, and its walls are converted into a gristly, membranous, or bony case, called the skull, and in this part of the body the organs of sense are chiefly seated. The brain in its simplest form consists of three thick-walled cavities in a series from before backwards, the walls of the three being named respectively the fore, mid, and hind brain. The rest of the neural canal behind the skull remains as a narrow tube enclosed in the canal, which is bounded by the neural arches of the vertebræ. In the sides of the wall of the cranial or skull cavity the organs of the special senses are placed in a series from before backwards;-foremost of them is the organ of smell; secondly, that of sight; thirdly, that of hearing. Each of these organs consists primarily of a pouch of skin bulging towards the inside of the body, and receiving a nerve from the brain. Passing out from the brain there are also other nerves, which are distributed to the parts of the foremost end of the body. Around these organs and nerves the cartilage which forms the primitive skull becomes disposed so as to protect them; and

when, as is often the case, the cartilage becomes converted into bone, the several pieces of which the osseous skull consists are so grouped around these nerves and sense organs that the bony cranium appears as if its bones were arranged in a succession of segments. These have been mistaken for true vertebral divisions, but are really due to a secondary grouping of parts in the course of growth, and are not primary morphological elements. Appended to the under or mouth side of the cranium, and to the fore part of the vertebral column, we find a series of lateral arches, which unite below in the medial line, and thus close in the sub-vertebral cavity in front. To these arches the name 'visceral arches,' is given ; and very often between these arches there are slits opening inwards ; these are called visceral slits. The number of these arches varies in many vertebrates, but there may be as many as ten or twelve. The foremost is in front of the part of the skull which begins at the front end of the notochord (for this structure does not in craniotes extend beyond the region of the mid-brain), and its two elements pass forwards in the middle line to unite in front; to these the name *cornua trabeculæ* is given. The second arch lies behind, below, and a little outside the cornua trabeculæ, and forms part of the deeper or palatine portion of the upper jaw in most vertebrates (or the whole upper jaw in sharks) ; its lower end forms the lower jaw, or parts thereof. The third or hyoid arch is that bony system on which the tongue is based ; and the succeeding ones can be easily distinguished in fishes as the arches of bones which bear the gills, but, except

the foremost of this set, the others are rudimental in the higher animals. The visceral slit between the first and second of these arches is the mouth; the other visceral slits remain either as the gill fissures in fishes, or else become closed at an extremely early period of embryonic life. The remnant of the first pair of visceral slits behind the mouth we find in the form of the ear passages in higher vertebrates. These visceral arches never extend backwards behind the heart.

5. **Limbs and ribs.** — Vertebrate animals have never more than four limbs, which are placed two in front and two behind. The fore limbs are usually placed a short way behind the head; the hind limbs at or immediately behind the posterior end of the visceral cavity. Each limb has a bony or gristly axis or skeleton, and this consists of two parts—first, a girdle or half-zone of bone, which is embedded in the lateral muscles, and is often attached to the vertebral column; secondly, a limb ray or projecting part made up of several sets of cartilages in a series. Some vertebrates, like whales and some lizards, have only two fore limbs and no hind limbs; others, like boas and pythons, have rudimentary hind limbs and no fore limbs; others, like most of the snakes, have no limbs at all. These limbs are always turned towards the hæmal or ventral side of the body.

In the wall of the visceral cavity, following the visceral arches, but quite separate from them, there are usually long slender bones, jointed at the back to the vertebral column, and forming supports for the wall of this space. These bones are named ribs, and the part of the body surrounded by them

is called the thorax; the region between the thorax and the head is called the neck—a very short space in fishes and whales, long in many birds. The part of the vertebral column which projects behind the visceral cavity is named the caudal or tail region, and in it there are usually V-like bony arches, suspended to the lower surface of the vertebral bodies, within which a caudal blood-vessel is protected.

FIG. 2.

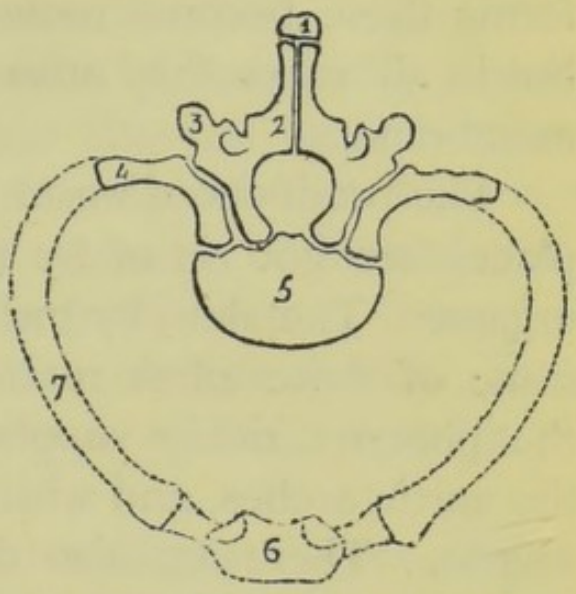


Diagram of a vertebra, with its body (5), rib (7), and breast bone (6).

6. **Secreting organs.**—All vertebrate animals of this division have a solid glandular liver for secreting the bile, an important fluid used in the process of digestion. They have all red blood, the colour depending on the presence of certain minute coloured corpuscles. The circulation of the blood is maintained by a muscular heart, which never possesses fewer than two chambers, one of which is for the collection and reception of the blood from the veins, and is called the *auricle*; the other, which is named the *ventricle*, propels the blood into the large blood-vessels or aortic arches, of which there are usually (in some period of life at least) more than three pairs.

In vertebrates the lining membrane of the mouth (which is named the *mucous membrane*), clothing the upper and lower jaws, and sometimes the similar membrane over other bones, developes processes or

papillæ, which become converted into a very hard kind of bones for the purpose of seizing and dividing their food ; these are known as teeth. In higher forms these become rooted in the subjacent bones, but in all cases they arise as papillæ of the mucous membrane.

The products of waste (which is constantly taking place) are got rid of by means of certain purifying organs. The skin, by means of its glands, removes some of these effete matters ; so do certain areas of the pharynx, richly supplied with blood-vessels from the aortic arches, and which are called the respiratory organs. There are also developed certain glandular tubes in the hinder portion of the visceral cavity, of the same nature, and built on the same plan, as the segmental tubes of worms, which eliminate from the blood the nitrogenised waste products ; these organs are called kidneys.

7. **Primary and secondary segments.**—In the body of a vertebrate animal there is to be seen the remains of a primary segmentation into a chain of successional divisions ; thus many organs or parts are repeated in a series, such as the vertebræ, the nervous system, the muscle masses (as can be seen in fishes), and the tubes which constitute the kidney. At the same time there is such a tendency to concentration noticeable that this segmental symmetry is only to be seen in the lower forms, or in the embryonic stages of the higher, secondary modes of aggregation of parts masking completely the original systems of segments. For example, while in the embryo the primitive vertebræ can be distinguished clearly from

each other, in the adult what appear to be the vertebral segments are really due to a secondary cleaving occurring in a later stage, after the originally separate primary segments have become fused.

As we ascend in the scale of complexity among vertebrates, we find as a rule that the head becomes more and more highly organised, and that there is a tendency towards the concentration of its elements, and that the fore parts of the body become more and more subservient to it. This reaches its climax in man, where we find the anterior pair of limbs entirely set apart to wait on the head.

There are five classes of vertebrate animals—fishes, amphibians, reptiles, birds, and mammals.

CHAPTER III.

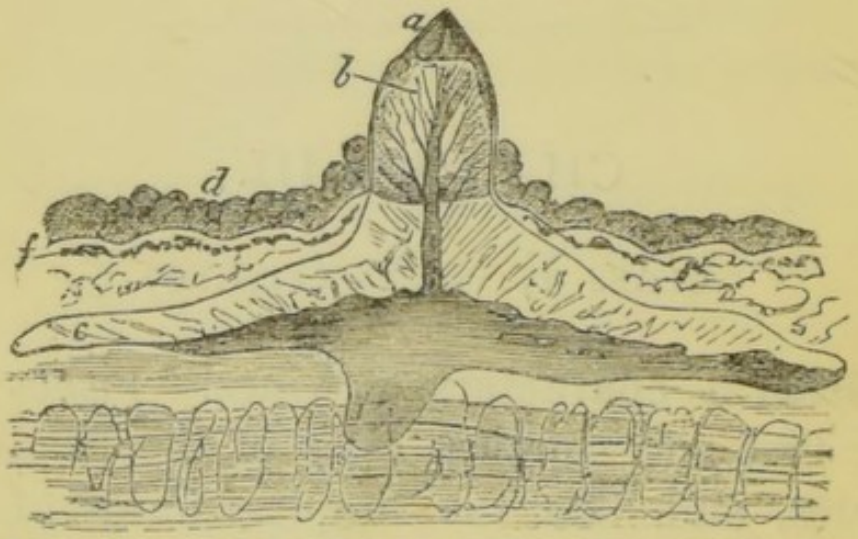
CLASS I, PISCES (FISHES).

8. **General characters of fishes.**—Fishes constitute the first and simplest class of the head-bearing vertebrates, and, like the simplest forms of all the other sub-kingdoms, they are aquatic in habit, and all their organs are adapted for a watery home. Thus in shape they are for the most part of an elongated flattened outline, pointed in front, tapering behind, so as to afford as little resistance as possible in traversing the water ; the fore part of the body, or head, is joined to the trunk directly, without the intervention of a narrow neck, and to the hinder ex-

tremity of the vertebral column is appended a flattened tail, which, by moving like a scull or screw-propeller, can drive the body forward. The limbs are also, in fishes, developed into fanlike bars, the fins.

9. **Scales.**—The surface of the body in fishes has only a scanty *epidermis*, or outer layer of skin, which is generally of a mucous or slimy consistence; beneath this is the *dermis*, or inner skin, whose surface consists of numerous thin, flattened scales. These structures, so characteristic of fishes, are composed of bony plates, which are ossifications of flat dermal processes, often containing or bearing little tooth-like points, composed of the same material as true teeth. In some fishes, like sharks, the entire scale consists of this *dentine* or tooth

FIG. 3.

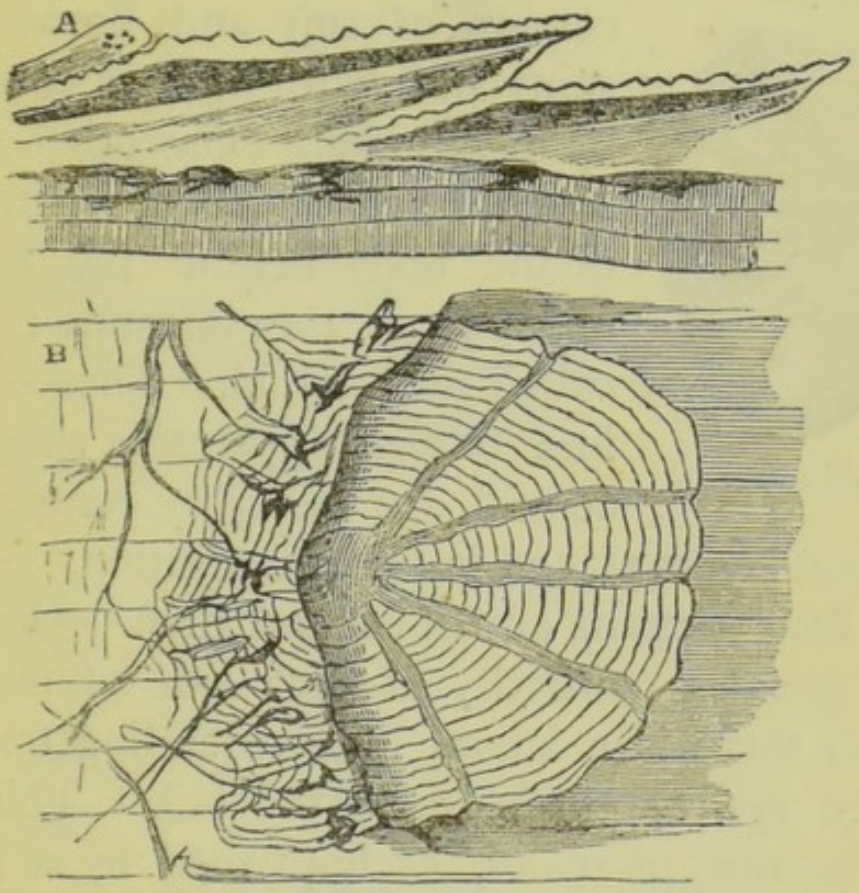


Placoid scale of dog-fish (vertical section magnified).
a, enamel layer; *b*, dentine of spine on scale.

structure (fig. 3); in others the bony element, which forms around the tooth, covers or entirely supersedes the dentinal, but in its essential nature the coating of scales or dermal exoskeleton of fishes may be regarded as consisting of or containing ossified papillæ, which in their structure are identical with the tissue of ordi-

nary teeth.[1] Many scales are of beautiful forms, and they vary very much in outline and surface, some-

FIG. 4.



Cycloid scale of roach magnified; seen in section A, and on surface B.

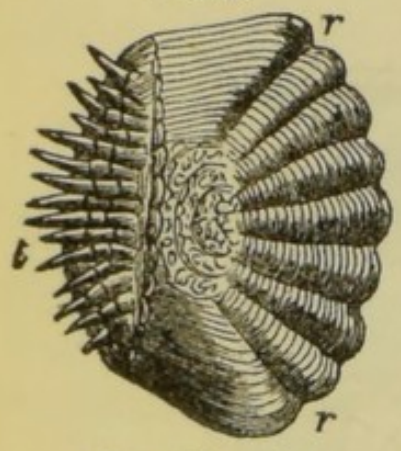
times being flat and smooth-edged (fig. 4), or else spinose, ridged, or comblike (fig. 5). These structures can be examined and their varieties observed with the aid of a pocket-lens. The scales of the pike, sole, and perch are especially characteristic forms.

10. **Fins.**—Along the middle line of the body of a fish there are usually developed extensions of the dermal

[1] It would perhaps be more correct to say that *teeth* are really in nature a special set of dermal papillæ of the same nature as those which cover the surface of the skin in some fishes, and which, covering the jaw arches, are set apart for grasping and dividing food; but the relationship is put conversely, as the tooth form is the more familiar.

exoskeleton in the form of median fins. Of these one extends along the upper or dorsal edge, and is named the dorsal fin, consisting of a succession of soft and branched or spiny and hard fin-rays connected by membrane. The other is present on the under or ventral side of the body behind the terminal opening of the intestine; this is called the anal fin. These median fins, though apparently single and central, are in reality composed of two lateral layers placed in close apposition.

FIG. 5.



Ctenoid scale.

11. **Sense-organs of the lateral line.**—Along the line of greatest convexity of each side of the body of a fish there is a lateral line, extending from behind the eye to the side of the tail. This consists of a row of scales, each pierced by a minute tube leading into a small simple or branched sac filled with a gelatinous material, in which the extremity of a nerve is embedded. These are organs of sense, and are probably capable of being impressed by several forms of vibration.

12. **Backbone and tail.**—The vertebral column of fishes usually consists of a chain of biconcave vertebral bodies, bearing on their upper surfaces neural arches which are surmounted by long neural spines. On the under side the vertebræ bear ribs towards the front, and V-shaped bones towards the hinder part of the body. The hindmost of the tail vertebræ may either gradually diminish to a point, as in the African mudfish (fig. 14), or they may undergo modification, being replaced by a rodlike bone which turns sharply upwards,

as in the tails of most of the bony fishes. The median fin is continued around the tail end of the vertebral

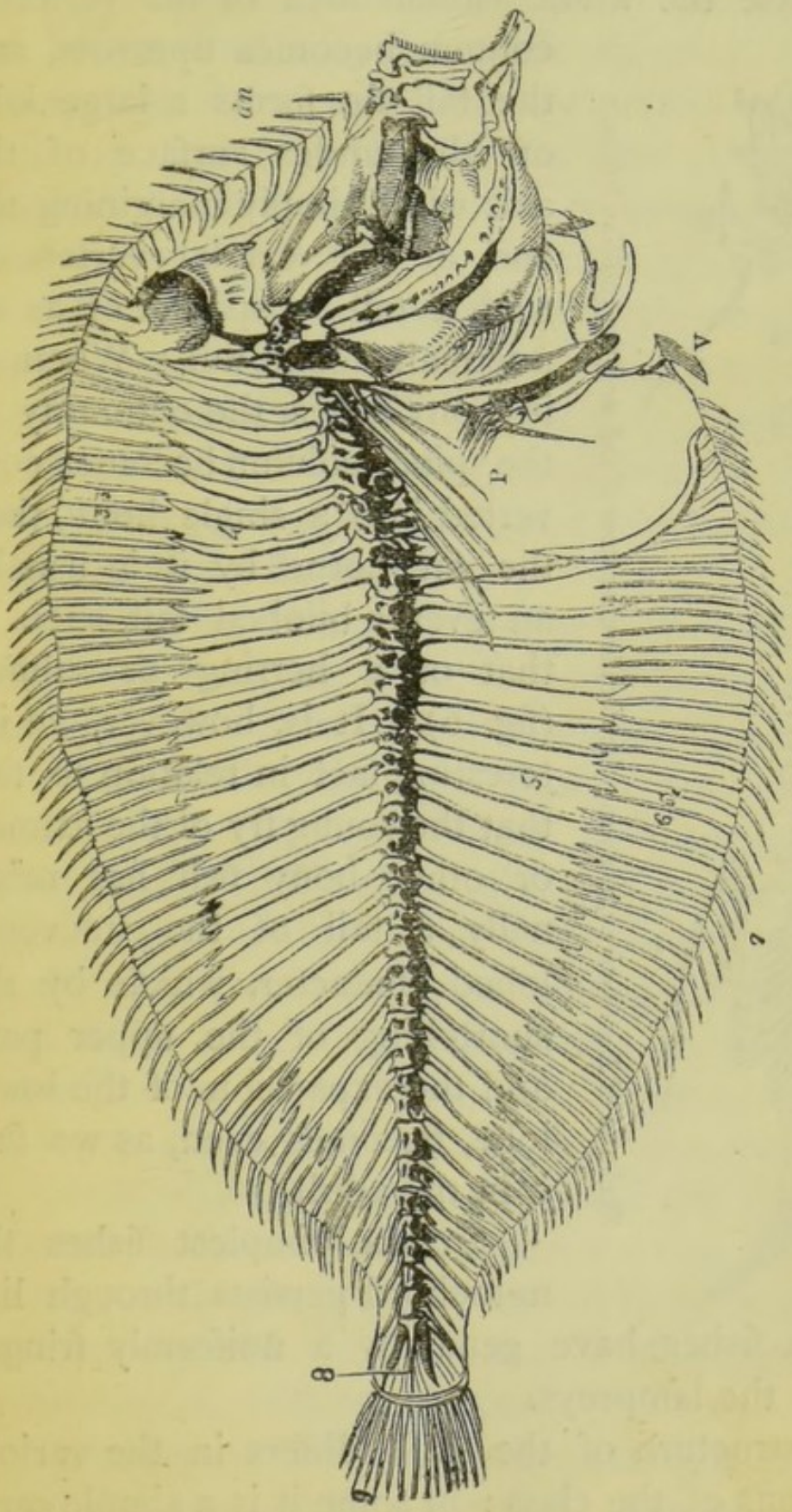


FIG. 6.

Skeleton of a sole.

dn, dorsal fin-rays ; 3, interspinous bones on which the dorsal fins are supported ; 4, spinous processes of the vertebræ ; 5, hæmal spines of the vertebræ ; 6, interspinous bones of the anal fin ; 7, anal fin-rays 8, hypural bones ; 9, tail fin-rays ; P, pectoral fin ; V, ventral fin.

column, and sometimes appears as a simple uniform fringe evenly distributed around the pointed vertebral axis, or else the whole caudal area of the vertebral column becomes upturned and the tail fin forms a large lobe on the under surface of the axis while simply margining the end of the caudal vertebræ; such a tail is spoken of as an unequally lobed tail. When, as in bony fishes, the extremity of the spinal column becomes converted into a single bone, then the fin borne by it is usually an evenly bilobed tail, such as that of a herring or salmon (fig. 6). It is, however, an interesting fact in relation to this that the young fry of the salmon or other bony fish has originally a tail of the unevenly lobed character, which by the shortening of the upper part, and the expansion of the lower lobe, becomes even, as we find it in the adult.

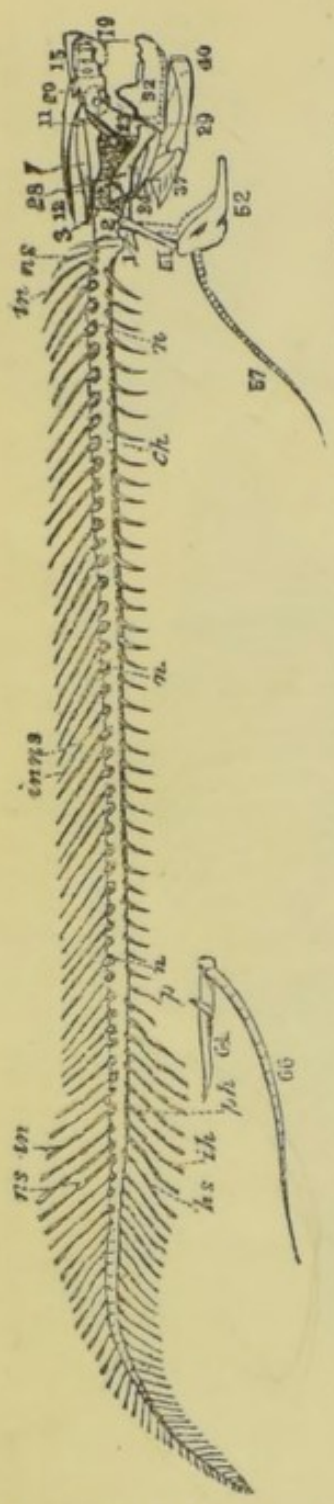


FIG. 7. Skeleton of *Lepidosiren*, showing the simple character of tail and the rod-like limbs.

In the simplest fishes the notochord persists through life, and such fishes have generally a uniformly fringed tail, as in the lampreys.

The structure of the skull differs in the various subdivisions of the class: in some it is a simple carti-

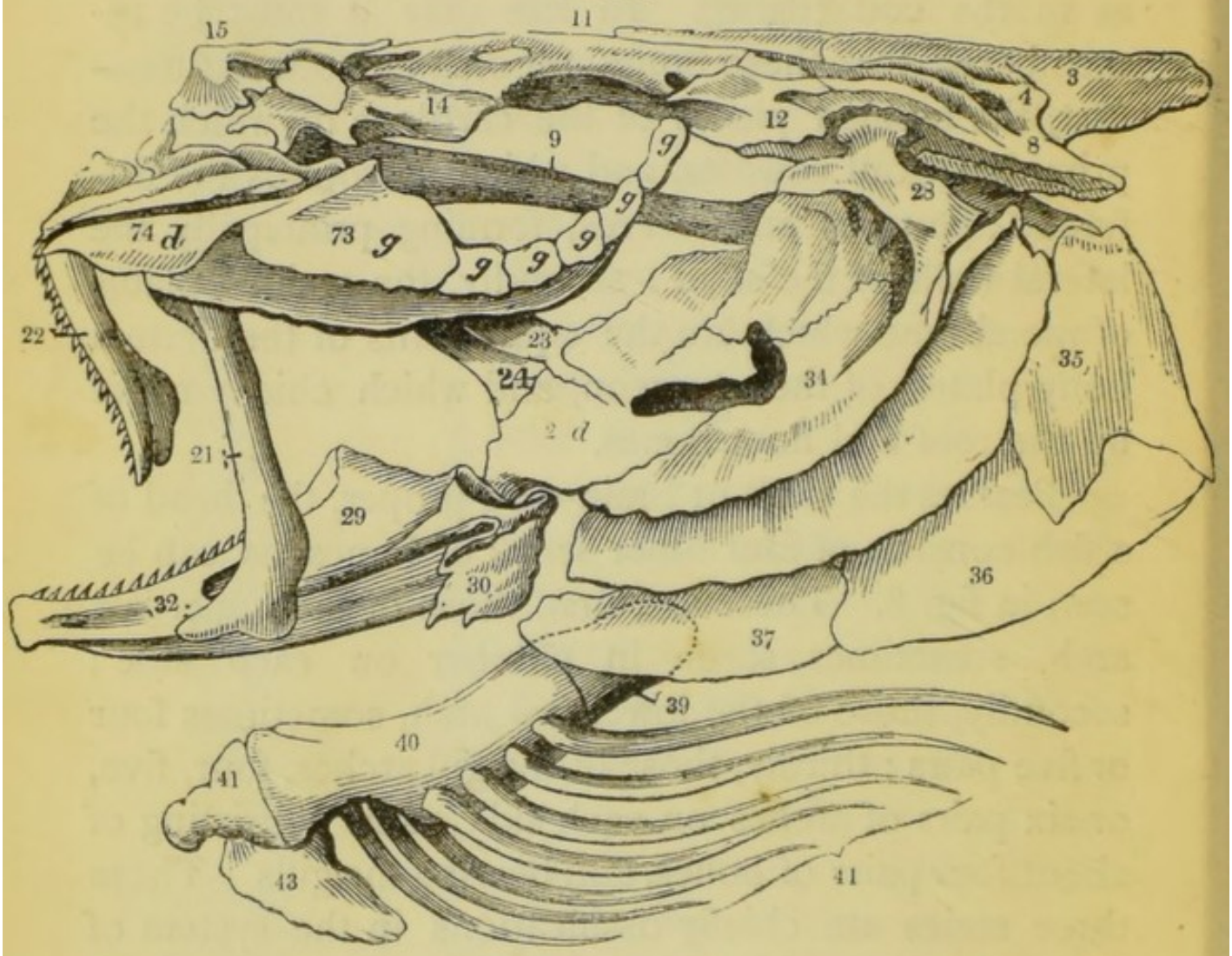
laginous box, as in lampreys and sharks; in others this cartilaginous box is covered and protected by a series of bony dermal plates, as in the sturgeon, or the whole skull may be made up of a number of closely articulated and perfectly united bony pieces as in the cod (fig. 8). In this case it must be remembered that these bones are of a twofold nature—first, the ossified pieces of the cartilage of which the primitive skull consists, and which surrounds the different apertures and nerves, forming principally the lateral walls of the skull ; secondly, the ossified plates of membrane which are the equivalents of the dermal bony plates of the sturgeon, and which chiefly make up the roof and floor bones.

Besides the skull or brain-case proper, the head of a fish consists of four other series of bones, as can be seen in fig. 8. These are, first, those of the upper jaw arch, sometimes seven in number on each side ; secondly, those of the lower jaw arch, sometimes four or five pairs ; thirdly, those of the gill arches, four, five, or six pairs of arches on each side, each consisting of about four pairs of bones, and bearing the gills. These three series are chiefly ossifications in the system of visceral arches before referred to. Besides these, there is a fourth group of bones, those of the *operculum* or gill cover, which overlap and cover the gill arches ; of these there are four or more, making up the gill cover on each side. It is thus not to be wondered at that the skeleton of the head of a fish presents an appearance of great complexity.

The limbs of fishes are converted into fins, and of these there are usually two pairs. The fore limbs, or

pectoral fins, are placed directly behind the head, to which indeed the shoulder girdle is in most fishes united by small dermal ossifications. The hind limbs are called the *ventral* fins, and are rarely as well de-

FIG. 8.



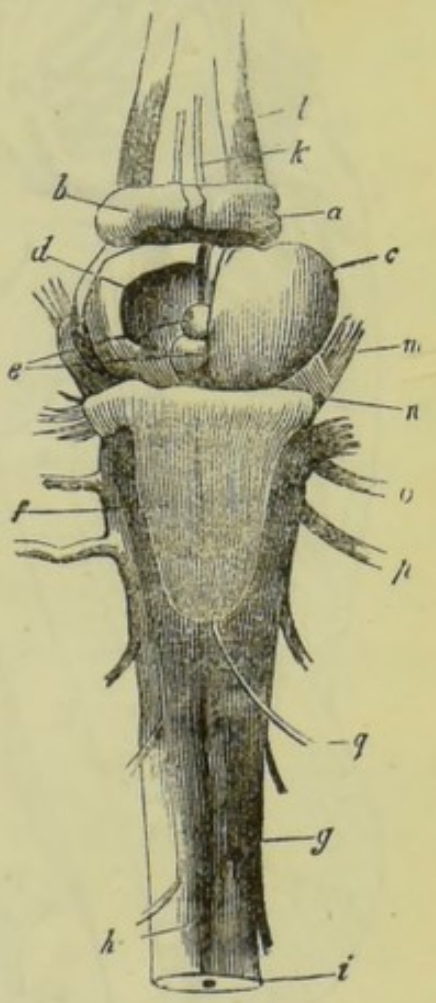
Skull of Cod.

3, supra-occipital bone; 4, opisthotic; 8, post-temporal; 11, frontal; 9, parasphenoid bone; *g*, *g*, sub-orbital bones; 22, premaxilla; 21, maxilla; 24, pterygoid; 28, hyomandibular; 29, articular piece of lower jaw; 23, dentary bone; 39, 40, 41, 43, hyoid arch; 44, branchio-stegal rays; 34, 35, 36, 37, opercular bones.

veloped as the fore limbs, and the pelvic girdle is seldom attached to the vertebral column. The fins are of use in directing the motion of fishes, while the tail is the principal organ of propulsion.

13. **Internal organs of fishes.**—The brain of fishes (fig. 9) is small, not filling the cranial cavity. It consists of a succession of little knobs or ganglia arranged in a chain from before backwards. Of these the foremost are connected with the sense of smell, the second consist of the fore-brain hemispheres or cerebrum, the third are the optic lobes from which the nerves of sight arise, the fourth constitute the mid-brain and the fifth the hind brain.

FIG. 9.



Brain of Cod.

l, nerves of sight; *k*, nerves of smell; *a*, foremost lobe of brain; *c*, second lobe or cerebrum; *f*, cere bellum; *h*, hind brain or medulla oblongata; *m*, fifth pair of nerves; *n*, nerves of hearing; *o*, ninth pair of nerves; *p*, tenth or vagus nerve.

Beneath and behind the head lie the gills (fig. 10), which consist of numerous vascular fringes arranged in platelike layers attached to the visceral arches, and bathed by the water which enters the mouth and escapes through the visceral slits. The heart is situated in the middle of what we might call the throat, a very short distance behind the lower jaw. This organ consists of a thin-walled auricle, receiving the veins which convey to it the impure blood from the body, and a large thick-walled ventricle for propelling the blood into the gills. This latter is

sometimes prolonged at its outlet into a conical part full of valves, called the arterial cone, which ends in the large main blood-vessel, or aorta. The arterial cone is well developed in sharks.

Sometimes, as in most of our common fishes, the aorta at its

FIG. 10.

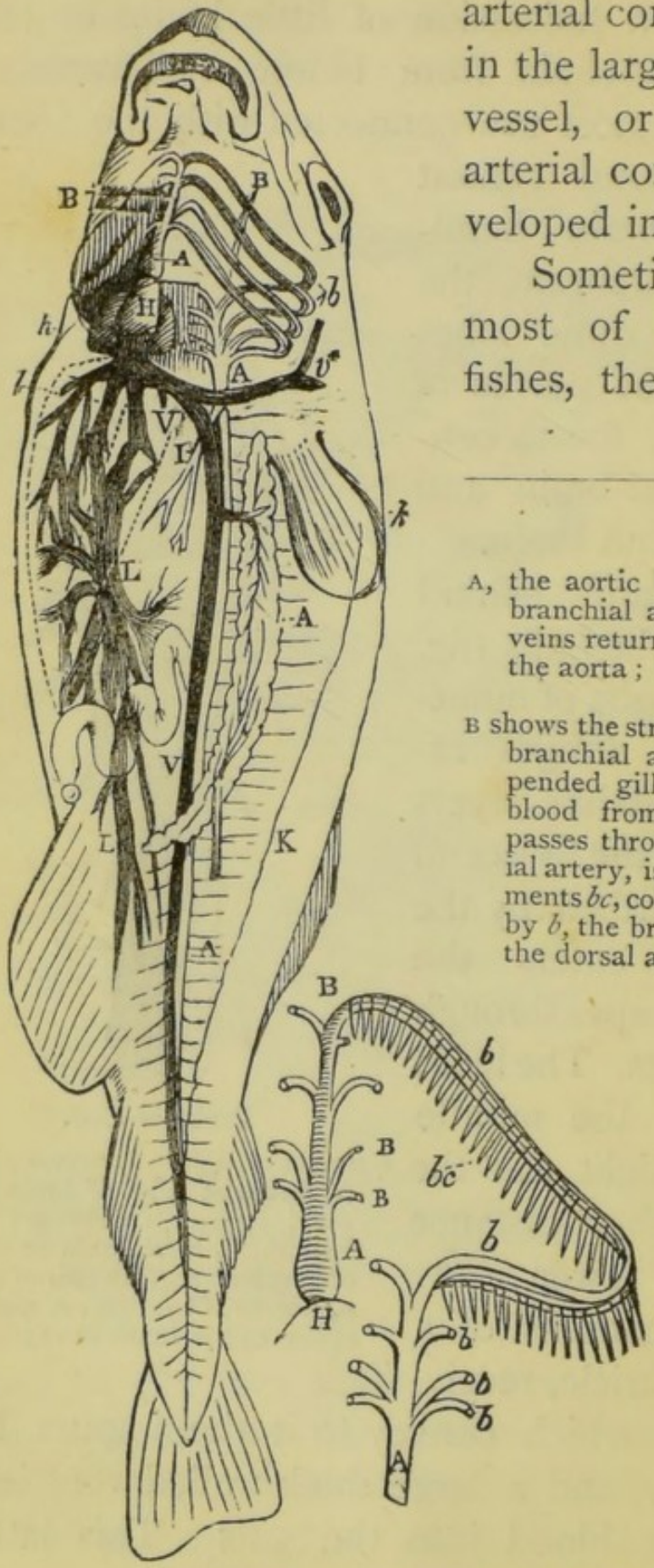


Diagram of the circulation in a fish.

A, the aortic bulb; H, heart; B, branchial arches; *b*, branchial veins returning the blood to A, the aorta; V, V, the veins.

B shows the structure of one of the branchial arches, with its appended gill filaments, *bc*. The blood from the aortic bulb passes through B, the branchial artery, is aerated in the filaments *bc*, collected and returned by *b*, the branchial vein, into A, the dorsal aorta.

commencement is swollen into an aortic bulb, from which come off at least three pairs of branchial or gill arteries ; these pass in the form of arches, right and left, to the gills, and there break up into fine branches in the soft, fringe-like folds. Here the blood, being exposed to the air dissolved in the water, absorbs oxygen and gives out carbonic acid, and is thus purified.

The purified blood, returning from the gills by the branchial veins , enters the dorsal vessel or aorta, which sends it to the different organs of the body to supply the viscera.

The blood of fishes is generally of the same temperature as the medium wherein they live, or only slightly warmer, and hence it usually feels cold to the touch. It contains corpuscles, or little microscopic bodies, of an oval shape and with a central nucleus.

Though the respiration of fishes is accomplished by means of the air which is dissolved in water, yet it is supplemented in some of them by direct exposure of the gills to the atmosphere, and some fishes are killed if prevented from rising to the surface.

In most fishes there is a large sac filled with air, placed beneath the vertebral column at the anterior part of the body cavity, and communicating by a duct with the digestive organs. This is called the swimming-bladder, or the air-bladder, and, by expanding or compressing it, the fish can rise or sink in the water. This sac commences its existence in the embryo as an outgrowth from the neck end of the alimentary canal.

Fishes are oviparous, that is, their young are produced from eggs, and for the most part they are enormously prolific. The egg-organ of the cod sometimes contains over a million eggs, and some other fishes are equally fruitful; the eggs are of small size, and contain very little food yolk. The majority of fishes are marine; those found in fresh water are, as a rule, simpler in organisation and retain many of the embryonic characters of the class. About 13,000 different species of fish are known, and they are divided into five orders.

CHAPTER IV.

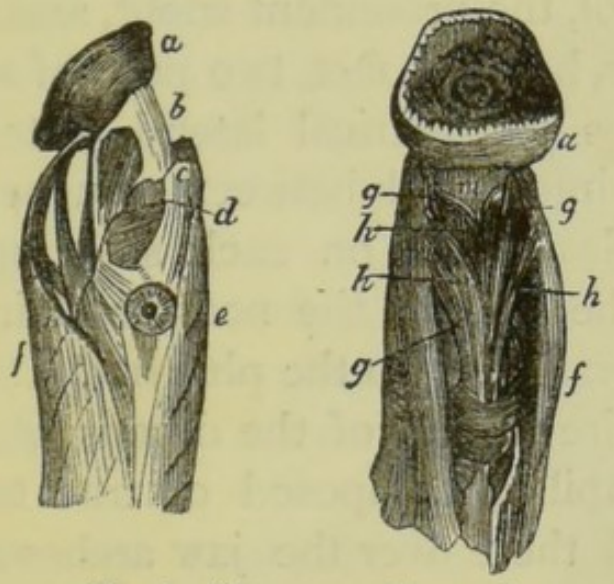
ORDER 1, LAMPREYS; ORDER 2, SHARKS.

14. **Order 1, Marsipobranchii (Lampreys).**—This, the most lowly organised order, consists of wormlike, limbless, scaleless fishes with no lower jaw, a circular suctorial mouth, a persistent notochord, and gills in the form of lateral pouches. They are also remarkable among fishes for having circular blood corpuscles.

The most familiar examples are the little freshwater lamprey, the large sea lamprey, and that curious parasite the glutinous hag, which, by means of its large, jagged tooth, bores its way into the body of the cod, ling, or other large fish, and lives therein, feeding on the juices of its prey. In all these there is but

one median pitlike nostril, and the hag is remarkable among fishes for having a passage of communication between the bottom of this pit and the posterior part of the cavity of the mouth. No such communication exists in other fishes, in which the nose is a simple depression or cavity on the surface of the head, lined by a plaited mucous membrane and crossed over by a bridge of skin. The teeth in lampreys are horny and conical; they are shown in fig. 11.

FIG. 11.



Head of lamprey dissected.

a, b, c, cartilages of the mouth; *d, e, f, g, h,* muscles attached to the cartilages.

The name *Marsipobranchii* is given to this group on account of the pouchlike nature of the gills, which are in six or seven pairs, arranged in two lateral rows, and open by small holes on the surface.

15. **Order 2, Selachia (Sharks).**—The second order includes the sharks and rays, the largest individuals in the entire class of fishes; but, notwithstanding their size, these exhibit in respect to many points of organisation what may be considered as

elementary characters—that is, they display in their permanent state points of structure which other more specialised fishes present only in the embryonic stages. They are for the most part marine, and the skeleton remains almost entirely cartilaginous and never becomes truly ossified. The notochord, however, rarely persists, being generally replaced by an axis of biconcave, often calcified, cartilaginous disks or vertebral bodies.

The jaws in sharks are usually placed beneath, not at the front of, the prominent snout, and they are both cartilaginous, being, in fact, two parts of a visceral arch. The gills are symmetrical lateral plates of vascular membrane, interposed between pouches which have a row of holes or slits on each side, opening superficially on the side of the neck, and internally by a row of perforations into the pharynx.

The entire surface of the dermis is covered with toothlike papillæ, composed of true tooth-tissue or dentine, and these over the jaw arches are large and developed into functional teeth, which are sometimes of formidable size and proportions. There are several rows of these, and as they are gradually worn away with use, they replace each other from within outwards. This form of dermal scales on the surface of the body is named *placoid* (fig. 3).

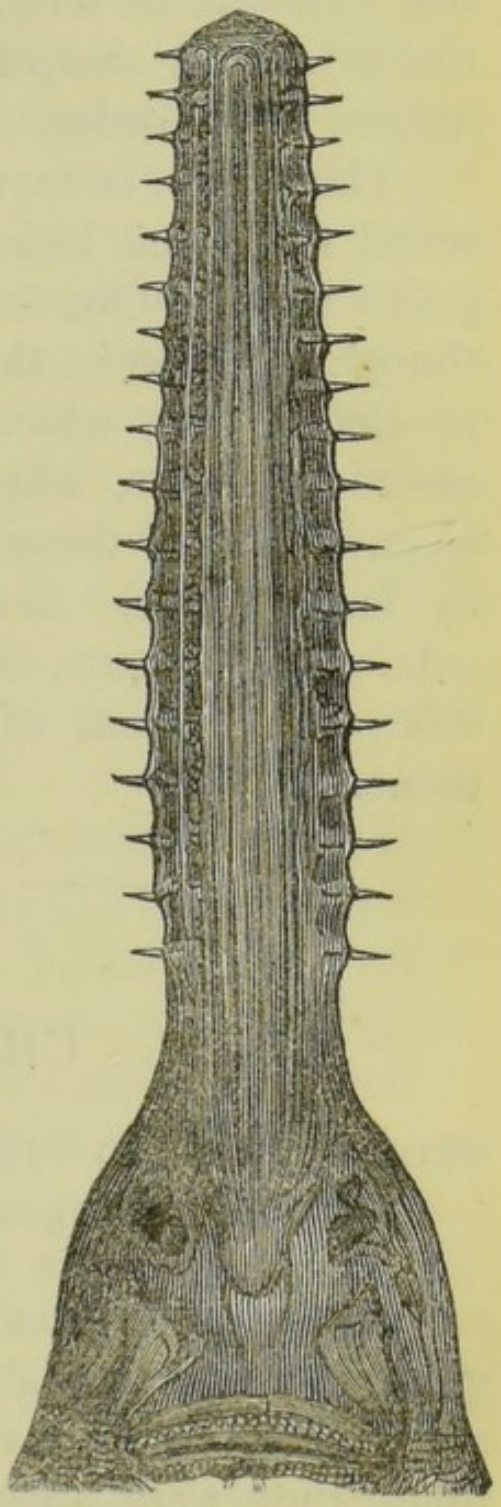
The vertebral axis is prolonged into the upper lobe of the tail, which thus, on account of the large size of the lower lobe, belongs to the unevenly lobed or *heterocercal* type, not like the uniform marginal fringe of the lampreys. The fins are often armed with single, strong, and sometimes serrated spines, which are used as weapons of offence.

The heart in sharks has a long arterial cone. The intestine, though short, is very capacious, and has the extent of its inner surface increased enormously by means of a long spiral fold of its lining mucous membrane, which stretches throughout almost its whole extent. Like the lampreys, sharks are devoid of a swimming-bladder.

Some sharks are viviparous (that is, produce their young alive); in others the young are extruded within curious horny tendril-bearing cases, which are often picked up along the sea-shore, and are commonly called 'mermaids' purses.'

The commonest examples of this order are the dog-fishes, sharks, and rays. One of the largest forms is the great basking shark of the North Atlantic; this fish is not at all uncommon on the west coast of Ireland, where it is called the sun-fish, and is often captured for the sake of the enormous quantity of oil extracted from its liver. It often exceeds thirty feet in length, and a specimen of this size will yield ninety gallons of oil from its liver. The

FIG. 12.



Beak of saw-fish seen from below, showing its mouth, nostrils, and lateral teeth.

gigantic Rhinodon of the Indian Ocean has been met with sixty feet in length. The hammer-headed shark, with its extraordinary bilobed head, and the saw-fish (fig. 12), with its long, flattened, bony snout bearing a row of strong, sharp teeth on each side, are also examples of the order.

The skates, or rays, are remarkable for their flattened form, due largely to the enormous size of the pectoral fins. One form, rarely found in British seas, though common in the Mediterranean, is the torpedo or electric ray, which has near its head two large electric batteries, whereby the fish can give severe electric shocks; these organs are joined to the brain by large nerves, and consist of closely apposed columnar elements, which morphologically are considered to consist of extremely modified muscular tissue.

CHAPTER V.

ORDER 3, GANOID FISHES; ORDER 4, BONY FISHES; ORDER 5, DIPNOI.

16. **Order 3, Ganoidei.**—The living fishes of this group are very few (about thirty), and most of them are inhabitants of rivers or of lakes but in former times they were apparently numerous and rich in species, as the fossil remains of six hundred species are already known. They are characterised by possessing ganoid scales—that is, brightly polished plates

covered with a lamina of an enamel-like substance. They have likewise unsymmetrical tails and a ventricular arterial cone. The gills are free, and are placed on bony gill-arches, under cover of *opercula* or gill-flaps, not in pouches nor on plates. Some, like the sturgeons, have a persistent notochord ; others, like the Californian bony pike, have fully ossified vertebral bodies. The other forms included in this order are the Polypterus of the Nile and the reed fish of Calabar, as well as several rare and curious American species. Many of the fossil forms were of large size and of extraordinary shapes ; their remains abound in some of the old red sandstone formations. All living forms have a swimming-bladder, which in the sturgeon yields the isinglass[1] of commerce.

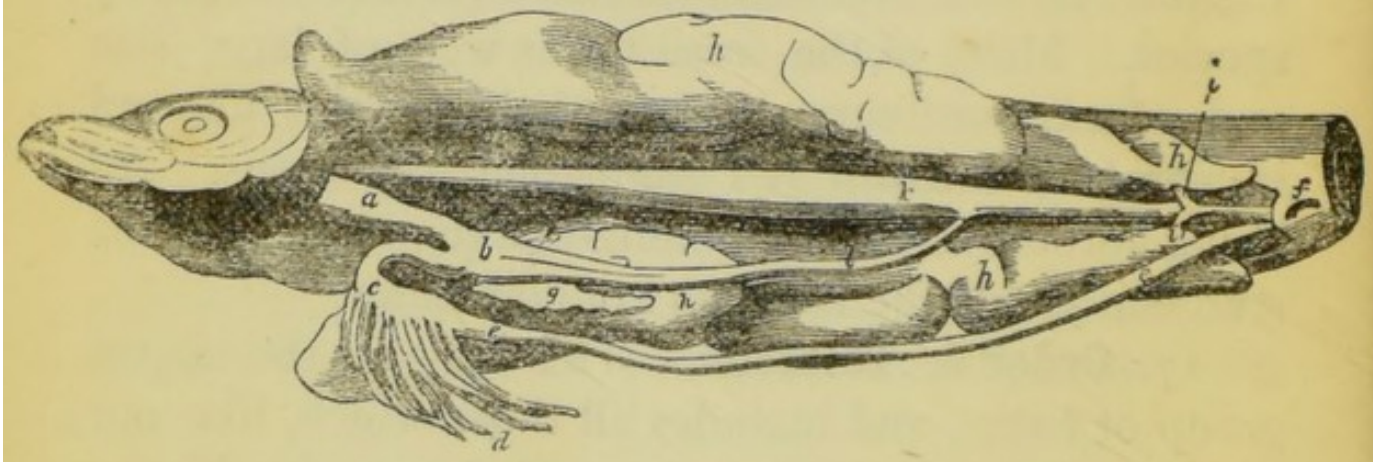
17. **Order 4, Teleostei.**—This is by far the largest group of fishes, and includes all those which, like our common fishes, possess a bony skeleton with biconcave vertebral bodies. The tail consists of two even lobes supported on a sharply upturned and continuously ossified end of the vertebral column (fig. 6). The body has usually a uniform coating of smooth or ribbed or spinose scales, which rarely have an enamelled surface. The gills consist of free, usually comblike, filaments on bony branchial arches (fig. 10), arranged under the flaplike gill-cover or operculum. There is no arterial cone, the mouth of the ventricle having but one row of valves.

This order of fishes is divided into the following six sub-orders :—

[1] *Isinglass* is a corruption of the German *Hausenblase*, from *Hausen*, a sturgeon, and *Blase*, a bladder—i.e. sturgeon's bladder.

SUB-ORDER 1, PHYSOSTOMI, or those in which the swimming-bladder communicates, in the adult, with the digestive canal by means of a duct. In these also all the fin rays are soft and jointed, except perhaps the foremost ray of each fin, which may be spinose from a fusion of its separate elements. In this group are included the pike, carp, goldfish, herring, salmon, trout, and most of our fresh-water

FIG. 13.



Viscera of herring.

a, œsophagus; *b*, *c*, stomach, with its appendages, *d*; *e*, intestine; *l*, duct of the swimming-bladder, *k*; *h*, ovary.

fishes, such as the barbel, tench, roach, ide, minnow, &c. Some of these physostome fishes have no ventral fins—for example, the eels, a few of which, like the prettily marked Helen's eel of the Mediterranean, are also devoid of pectoral fins. One genus of eels, the Gymnotus, of the large rivers of South America, has a powerful electric organ, formed of some of the modified body muscles. This apparatus stretches along almost the entire body, and as the fish sometimes reaches the length of six feet, the organ is of very considerable size, and is capable of giving violent electric shocks. Two other genera of physostome

fishes have also electric organs; one of these is a genus of river fishes—*Malapterurus*, from the Nile—the other—*Mormyrus*, also African—has a very small electric organ near the tail.

Some fishes belonging to a curious marine group of this sub-order—the Scopelidæ—are remarkable not only for the brilliancy of their lustre, but for the fact of their possessing several pairs of accessory eyes on the gill covers. One other species of physostome fish—*Amblyopsis* which inhabits the Mammoth Cave of Kentucky—is remarkable for the rudimentary condition of its eyes, which are covered with a layer of skin, and are hence functionless.

SUB-ORDER 2, ANACANTHINI.—This subdivision includes those soft-finned fishes which have either no swimming-bladder or have one that has no duct. In these not even the foremost fin-rays are spinous, but all are soft-jointed and branched. They are for the most part marine, and include many of the commonest of our sea fishes, such as the cod, haddock, whiting, saith, lithe, ling, &c. One interesting group—that of the flat fishes—is remarkable for the want of symmetry displayed in the body, which is extremely compressed, and the animal in progression invariably lies on one side, swimming with one side up and the other directed downwards. These fishes usually keep near or on the bottom, and the upper side is usually dark or coloured while the lower side is white. To accommodate the structures of the animal to this extraordinary habit, the eyes are twisted round both to the one side of the head—viz. that which is uppermost—so are the nostrils, and the

mouth is also usually awry, so as to give the greatest amount of facility of swallowing consistent with position. As in this distorted position the dorsal and anal fins are disposed as lateral fringes, they functionally replace the paired fins as directors of motion, and hence the pectoral and ventral fins are usually small or deficient. One interesting feature in these fishes is that their embryos at a very early stage are perfectly symmetrical, and gradually develope the one-sided torsion as growth progresses, the displaced eye having been traced by observers in its curious pilgrimage around the front of the obliquely growing head from the under to the upper side. The turbot, plaice, flounder, sole, dab, and fluke are well-known examples; the largest species inhabiting our seas is the halibut, which sometimes has been known to attain the weight of over 500 pounds. Another curious point is noteworthy—viz. that though in each genus the side to which the eyes are displaced is usually constant, yet erratic reversed examples are occasionally met with. Thus while in the flounder and plaice the eyes are usually on the right, in such *reversed* cases they are found looking to the left; such abnormalities are easily understood by the light of the embryonic development of the group.

One genus of fish of this sub-order, named *Fierasfer*, is parasitic within the bodies of certain sea-cucumbers, or holothurians, and star-fishes, and is found in the Indian Ocean.

SUB-ORDER 3, ACANTHOPTERI. — Spiny-finned fishes with a ductless swimming-bladder, or else none. This is the most numerous and most specialised group

of bony fishes. The scale-clothing of this class is usually remarkable for the comblike or spiny surface and hinder margin of each scale, whereby they are distinguished from the circular smooth scales of the physostome fishes. The most familiar examples are the perches of our streams; the bull-heads and gurnards, known by their spiny heads, found along our coasts; the sticklebacks, so interesting on account of the nests constructed by the males for the protection of the young; the mullets, which have the singular property of changing colour when they are dying; the mackerels, breams, braizes, blennies, gobies, &c.

Some of these fishes are laterally compressed, like flat fish, but without showing any distortion of the heads, such as the John d'Ory and Archer fishes; the latter are East Indian fishes, and owe their name to their habit of shooting at flies by forcibly ejecting drops of water from their long snouts. The sword-fish, which sometimes attains the length of sixteen feet, is closely allied to the mackerel, and is remarkable for the long, swordlike upper jaw. The common lump-sucker, the little red or brown Lepadogaster of our shores, and the tropical Remora are remarkable as being provided with sucking disks, whereby they can adhere with great tenacity to foreign bodies. Fistularia (the tobacco-pipe fish) is remarkable for his long tubular snout, as is also the allied trumpet-fish. Trachinus (the weever) is said to be able to inflict poisonous wounds.

There are three aberrant groups of spiny-finned fishes, which constitute the remaining three sub-orders.

The first of these, or sub-order 4, is called *Pharyn-*

gognathi, or pharynx-jaw-bearing fishes, on account of the presence of a single medial tooth-bearing bone in the pharynx, made up of the united lateral remains of one of the hindmost of the visceral arches, which does not bear gills. The flying fishes, distinguished by their long pectoral fins; the gar-pikes and parrot fishes; the wrasses or rock fishes, so common along our shores, are the most familiar examples of the group. They are small or moderate-sized fishes, with spiny fins, and often with strong conical teeth in the jaws.

Sub-order 5 consists of the sea horses and pipe fishes, which differ from all other fishes in having the gill filaments in symmetrical clusters or tufts on the gill arches, not in comblike plates; hence they are called *Lophobranchii*, or tufted-gilled fishes. Their bodies are clad with bony plates, and are often of eccentric angular shapes. They have no ribs, their jaws are toothless, and the males in some species are provided with pouches on the front of the abdomen, into which they collect the eggs on their being laid by the females, and within which the young are hatched.

The sixth sub-order, *Plectognathi*, or soldered jaws, consists of spiny-finned fishes in which the bones of the upper jaw are consolidated together instead of remaining separate; these are the singular globe-fishes, whose spiny bodies are capable of inflation, and whose bare, ivory-like teeth give them such a remarkable appearance. The file fishes also, with their rough, branched spines and tough skin and the angular box-fishes, which belong to this order, are likewise among

the most singularly shaped of tropical fishes. One remarkable species—the sun fish—a large globular fish with an extraordinarily thick skin, sometimes reaches the weight of 400 pounds.

18. **Order 5, Dipnoi.**—This, the last and in some respects most interesting order, includes three living fishes, which form a transition to the next class. These fishes differ from all the foregoing in having the swimming-bladder developed as an accessory respiratory organ ; the blood returning from it being received into a small additional auricle of the heart placed to the left of the main auricle. They have a covering of horny scales, and the alimentary canal has a spiral valve. They also exhibit the peculiarity of possessing tubular nasal passages which perforate the upper lip, opening into the mouth. One of the fishes of this order is the African mud fish, or *Protopterus* of the Gambia; another is the *Lepidosiren* (fig. 14), of South America ; and the third is the

FIG. 14.

(The mud fish, *Lepidosiren*).

Ceratodus, of the rivers of Queensland. In several respects these fishes present characteristics which are identical with the embryonic conditions of many of the higher groups of animals. The characters of the skeleton can be seen in fig. 7.

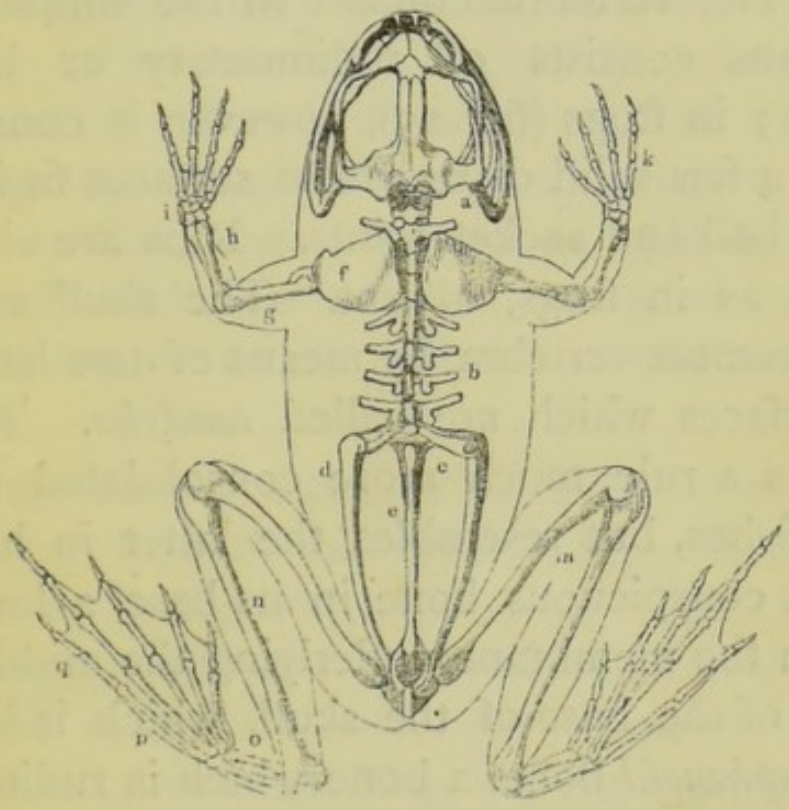
CHAPTER VI.

CLASS 2, AMPHIBIA.

19. **Characters of Amphibia.**—The class *Amphibia*, to which we are structurally conducted by the last order of fishes, consists of cold-blooded animals, usually of small size. This is at present the poorest in species of all the classes of vertebrata, yet, as in the case of the ganoid fishes, at earlier periods in the world's history the animals of this class vastly exceeded their present representatives in number, size, and complexity. Like fishes, they are characterised by having a feeble development of the outer skin, or epidermis, but, unlike them, they have no dermal clothing of scales, and the surface is generally smooth, naked, and often glandular. Some of them, in the embryonic or tadpole stage of their existence, possess rudiments of the system of sense organs, like those of the lateral line in fishes, but none of them are retained in the adult state. Amphibians, moreover, have no functional fin-rays, though sometimes they have marginal membranous fringes, as in the common newt or tadpole, and even rudimentary rays, as in the

toe-webs ot some salamanders. They also undergo regular metamorphoses, beginning life as little fish-like creatures with large flat heads and external gills. To this stage the name tadpole is commonly given. Then, as development progresses, the air sacs (which correspond to the swimming-bladder in fishes) grow, become large, vascular, and capable of acting as

FIG. 15.



Skeleton of frog.

a, skull; *b*, vertebræ; *c*, sacrum; *d*, ilium; *e*, urostyle; *f*, suprascapula; *g*, humerus; *h*, fore-arm bones; *i*, wrist bones; *m*, thigh bone; *n*, leg bones; *o*, elongated first pair of ankle bones; *p*, *q*, foot bones.

breathing organs, which are then called lungs; and ultimately, in the adult state, a pulmonary or direct air-breathing system supplants the gill or branchial system of earlier life. The two-chambered larval heart at the same time becomes three-chambered, developing a special auricle in the left side for the reception of the blood which has been purified in

the lungs, and is returned from hence into the heart. It may also be noted that, during this process of development in the common frog the digestive canal, which in the tadpole is long and spirally coiled, becomes shorter and straighter The blood of amphibians is remarkable for the large size of the oval red corpuscles which it contains, those in Proteus being $\frac{1}{400}$th of an inch in diameter, those in the frog being $\frac{1}{800}$th. The vertebral column in the simplest of the amphibians consists of rudimentary or biconcave vertebræ ; in frogs (fig. 15), however, it consists of a chain of a few solid disks whose surfaces fit into each other by ball and socket joints. Ribs are either very short or, as in frogs, absent. The skull articulates to the foremost vertebra by means of two lateral articular surfaces which are called *condyles*. The skull is also, as a rule, much more consolidated than the skull in fishes, but resembles the latter in having, as the most conspicuous bone in its base, a long ossification in the membrane underlying the middle of the cartilage of the base of the skull, which is known as the *parasphenoid* bone, a bone which is rudimental or absent in all higher forms. Amphibians also differ from fishes in having a middle ear, closed by a tympanic membrane, and not merely the internal ear cavity which constitutes the ear in fishes. Their nasal cavities open posteriorly into the pharynx. They have usually four limbs, which consist of parts comparable with those in higher animals, and very unlike the fins in fishes.

There are three orders of amphibians at present represented by living forms on the globe.

CHAPTER VII.

CLASSIFICATION OF AMPHIBIA.

20. **Order 1, Gymnophiona.**—A small group of worm-like forms, with no limbs, rudimental eyes (hence they are called *Cœcilia*), which are found in tropical countries burrowing in the ground. These, with one exception, have the body provided with dermal scales. They are usually marked with superficial rings like an earth-worm, and range in size from one to two feet, rarely exceeding this length. At present only a few species exist, but many fossil forms have been found which probably resembled these in structure.

A large and structurally complex order of fossil amphibians, named Labyrinthodonts, formerly inhabited the earth, which in some respects seem to have been related to the Cœcilians, but were much larger, and many of them were defended by dermal coats of bony mail something like the armour clothing of a crocodile.

21. **Order 2, Urodela.**—Limb-bearing amphibians provided with a permanent tail, which is retained during life. There are two sections in this order, in one of which the animals retain their embryonic gills through their whole existence, and are thus perennially or permanently branchiate, while in their adult condition they also possess lungs, which become developed gradually in process of growth. In the other section the gills are only transitory or caducous,

wasting and disappearing on the development of the lungs. Of the former, or *perennibranchiate* section we have interesting examples in the sirens or mud eels of Carolina, which are provided with only two limbs representing the fore limbs of other vertebrates. Another form, the proteus, inhabits the Cave of Adelsberg and other caves in Carinthia, &c., and is, like all other cave-dwellers, blind and blanched; its weak fore legs are provided with three toes, while the hind limbs possess only two. The curious axolotl (fig. 16) of Mexico is an interesting form, as it has proved to be a permanent tadpole which in certain conditions only undergoes its further metamorphosis into the salamander-like form of its adult state.

FIG. 16.

Diagram of the axolotl, showing its gills, *b*, and lungs, P.

In some perennibranchs the outer gills disappear,

and are replaced by an internal series, or gills of the type of those developed in fishes. This modification in the structure of these organs is of considerable interest from a morphological point of view, when we remember that in sharks there are originally in the embryo distinct external gills, which are lost as the shark attains his more perfect organisation, and are replaced by the permanent gills, which are formed directly on the aortic arches. From these conditions it seems as if external gills were a more primitive or embryonic form, and internal gills a more specialised modification of respiratory organs. The amphibians which show these internal gills are the giant *Sieboldia* of Japan, which reaches a length of four feet, and the amphiuma and menopoma of North America. The caducibranchiate tailed amphibians are the salamanders and newts, the latter of which are common in our ditches, where their metamorphoses can easily be traced. The common newt is interesting on account of the bright colours which it exhibits at certain stages, and for the remarkable dorsal crest which it also occasionally possesses.

22. **Order 3, Anura.**—The largest group of the Amphibia consist of the frogs and toads, or the tailless forms. In these, the larva or tadpole loses during its development all traces not only of its gills, but also of its tail; the hinder limbs are also in these more perfectly developed than the fore, and the two proximal bones of the ankle are elongated, so as to make what appears to be an independent third portion of the hind limb. The fore arm and the leg proper also differ from those of urodeles and of the higher verte-

brates in that there are only single bones in these regions, the separate bones, *radius* and *ulna*, which are present in these parts of other vertebrates being here united. The frogs, toads, pipas, and tree frogs are the most striking examples of this order.

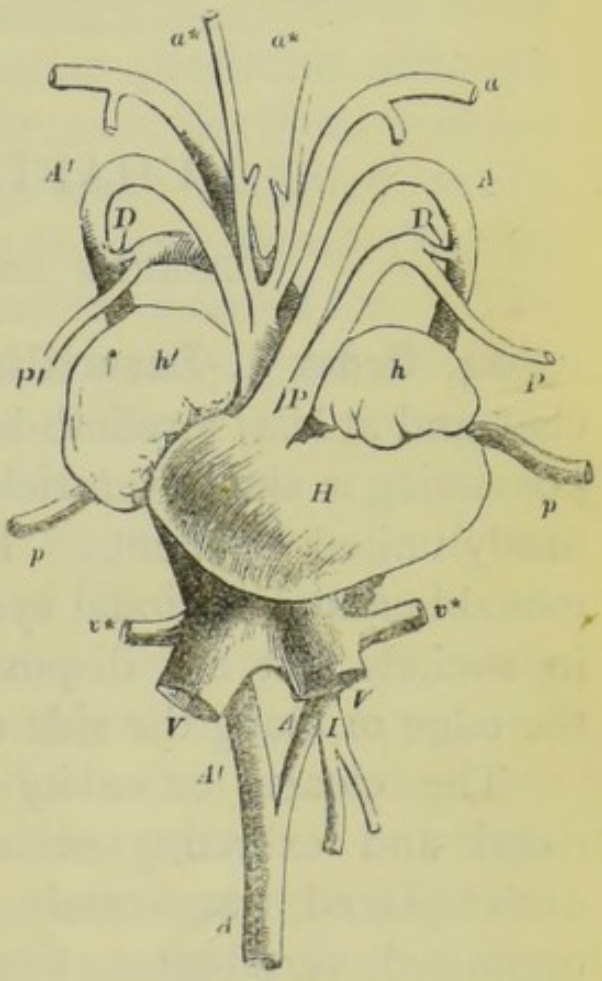
CHAPTER VIII.

CLASS 3, REPTILES.

23. **Characters of Reptilia.**—Tortoises, lizards, snakes, and crocodiles are the leading forms included in this large third class of vertebrate animals, a class often confounded with the amphibians, but differing therefrom in many striking and characteristic respects. Reptiles are invariably provided with a very distinct epidermic clothing of scales which differ essentially from the dermal scales of the foregoing groups. The scales of reptiles being epidermal, and not parts of the dermis or true skin, are often shed and replaced, as in snakes, and they are sometimes hard and thick, as in the tortoise shell of commerce and in the mail clothing of the crocodile. This firm covering may be supplemented by a dermal bony layer, as in crocodiles or tortoises, but these indurations of the dermis are never superficial. The blood is cold; the aortic arches never bear gills, nor is there ever branchial respiration in any stage of existence among the animals of this group. The heart consists of three cavities, two auricles and one ventricle; but the latter is often

more or less perfectly divided by a septum, so as to act as if it were a double chamber (fig. 17). There are always at least two aortic arches, right and left, which usually unite subvertebrally to form one dorsal aorta. The notochord never persists in the adult, and in most living reptiles the vertebral bodies unite with each other by ball and socket joints, and are very rarely biconcave. The skull joins the vertebral column by a *single* median articular eminence or condyle, and there is no parasphenoid bone, the bones of the middle of the base of the skull being developed in the cartilage of the base itself, not in the membrane beneath the cartilage. The lower jaw articulates, as in the amphibians, with the end of the preceding visceral arch; and a bone at its extremity called the quadrate bone is interposed between the palatine part of that arch and the skull.

FIG. 17.



Heart of turtle.
H, ventricle; *h*, *h'*, auricles.

Many reptiles are ovoviviparous; others are oviparous. Like the amphibians, the reptiles at the present day, though still numerous, give us a very faint idea of their former grandeur of size and complexity. In the Mesozoic age they held the same position on the globe

that the Mammalia do at the present period. Only four orders of reptiles are represented in the existing terrestrial fauna; at least five orders, and these including the giants of the class, have perished.

CHAPTER IX.

LIZARDS AND SNAKES.

24. **Order 1, Lacertilia.**—The lizards are scale-clad, and at least forelimb-bearing reptiles, with a heart possessing a single ventricle, and with a lower jaw of firmly united segments. The eyes are provided with movable and functional eyelids, and the teeth are not in sockets, but are disposed in rows either around the edge or along the side of the jaws.

The cloaca, or cavity into which the digestive canal and excreting orifices open, has usually its outlet placed transversely. Like most of the lowly organised vertebrates, lizards display a remarkable power in restoring lost parts, and in connection with this we perceive in them a facility for making their escape from capture by breaking off their extremities. Thus a lizard taken by the tail will often break off that process and escape, the fracture taking place not between two of the vertebræ which make up the organ, but actually through the middle of a vertebra, as there is a medial cartilaginous plate in the caudal vertebræ of some. In one specimen in the writer's possession a lizard whose tail was cracked, but not

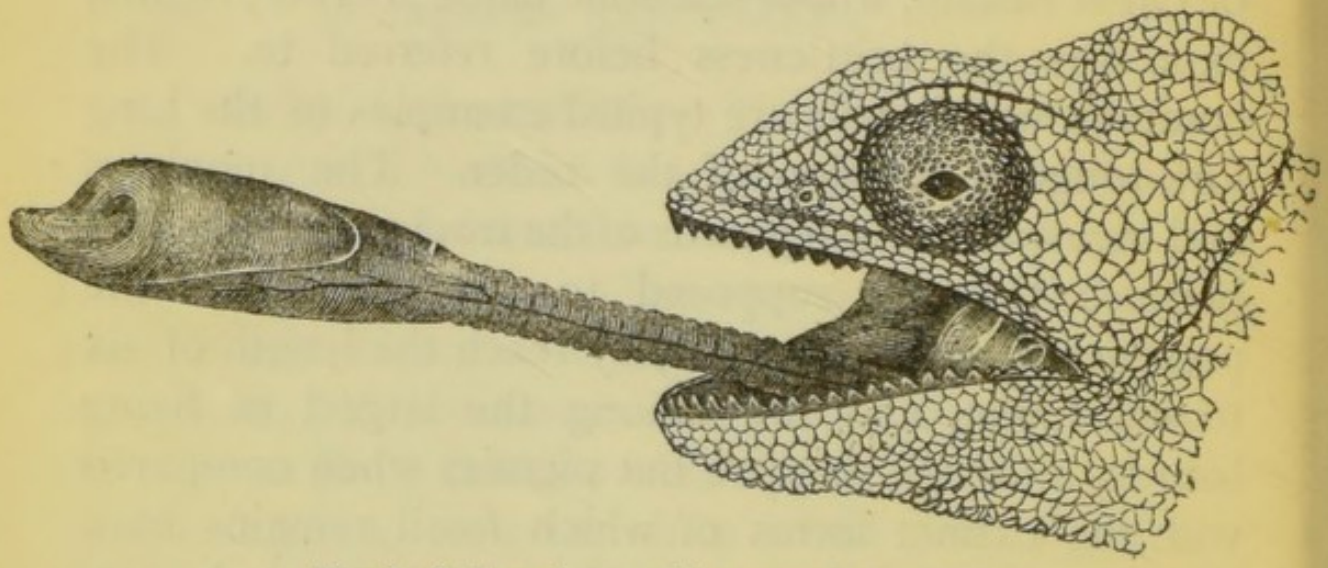
broken off, developed at the crack an accessory tail, while the original tail yet remained and became repaired at its injured part, thus giving a bifid extremity to the tail.

Some lizards are snakelike and ringed, like the amphisbænas, with no projecting limb-rays, but in all these traces of the limb girdles are persistent, although they may not show superficially, as in the blind worm—a pretty and innocent, though much maligned, native of Great Britain, whose scientific name *Anguis fragilis*, expresses the brittleness before referred to. The common wall-lizards are typical examples of the long fork-tongued division of the order. The monitors and teguexins, or safeguards of the tropics, are so called because they are supposed to give warning of the presence of crocodiles. They reach the length of six to eight feet, and are among the largest of living lizards, although they are but pigmies when compared with the extinct forms of which fossil remains have been found, sometimes exceeding thirty feet in length.

The American iguanas are large-sized lizards which are used as food; they usually bear tufted crests on the back, and have thick short tongues. Some lizards have large lateral flaps of skin: thus the frilled lizard of Australia bears on each side of the neck a wide fold of skin like a ruff or Queen Elizabeth collar; others, like the little flying dragon, bear on each side a winglike fold, supported on extended ribs, and these, together with the long conical chin-pouch, give this creature a very extraordinary appearance. The appropriately named *Moloch horridus* of Australia bristles most repulsively with conical spines,

as do many other genera. The geckos of India are remarkable for the suckers which they bear on the ends of their fingers, whereby they can walk up perpendicular walls and along ceilings. The last group of lizards, the chameleons, are interesting for their proverbial quality of changing colour, due to the expansion and contraction of certain pigment-bearing connective tissue bodies in the skin. They also

FIG. 18.



Head of chameleon, with protruded tongue.

possess circular eyelids, and a very long tongue (fig. 18) capable of being protruded with lightning-like rapidity.

25. **Order 2, Ophidia (Snakes).**—These dreaded animals may be regarded in some respects as special modifications of the lizard type. They are scale-clad and limbless, not having even a remnant of the shoulder girdle persistent. The sternum and sternal apparatus have also vanished, and the skeleton consists of a long vertebral column, often of several hundred joints or vertebræ, each of which bears two ribs, one on each side.

The vertebræ have each a concavity on the anterior side of each body, into which the ball or convexity of the hinder surface of the foregoing body fits. There are also two pairs of articular facets on the processes of each vertebra, so that the entire spine combines flexibility with amazing strength. The ribs are capable of being moved forwards and backwards, and the ventral surface of the animal's body is covered with flat, horny shields, into which muscles run from the tip of each rib. The rapid, even, gliding motion in serpents is accomplished by the successive advances of these ventral scutes, and the drawing of the body forwards towards them, while the slightly projecting hinder edges of the scutes serve as fixed points by catching the surface of the ground. The brain case is firmly built up of singularly united bones; but the bones of the upper and lower jaw-arches are loose, united together by means of fibrous tissue, and hence capable of an extreme degree of stretching during the swallowing of food, which these animals bolt in large masses.

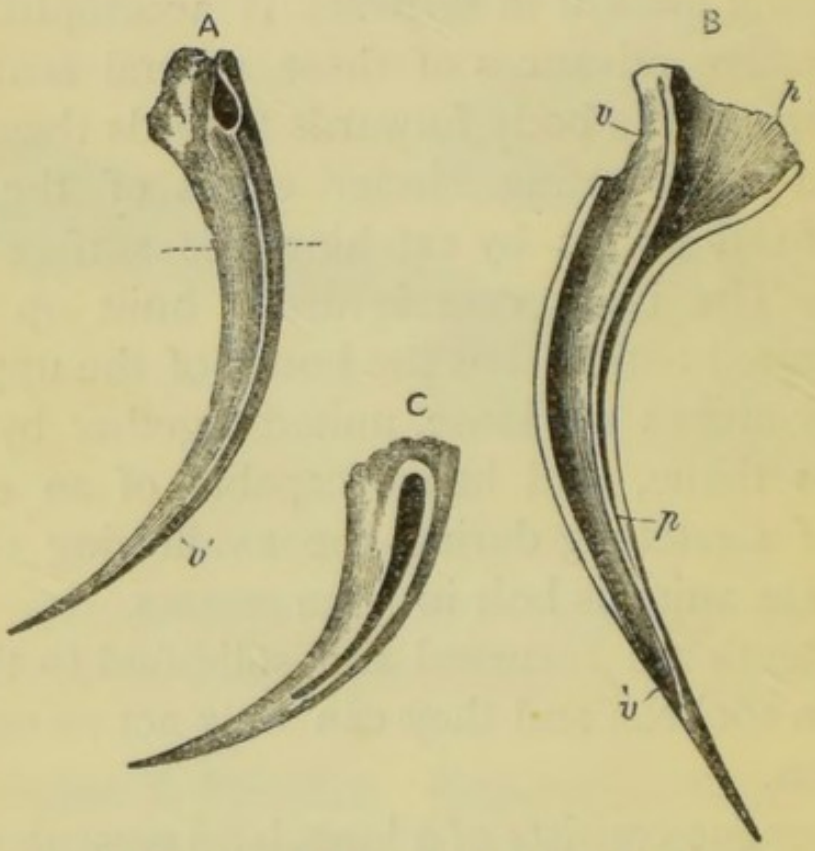
The teeth are recurved and solidified to the jaw, not set in sockets, and they can only act as organs of prehension.

The tongue consists of a long, bifid muscular organ, capable of being rapidly protruded, or of being drawn back into a sheath when not in use. The windpipe is long and protected by complete gristly rings; only one lung is usually large and developed, the other is rudimental or simply saccular, and they are never symmetrical. The digestive canal is capacious and short, and the cloacal opening is transverse. The

eyelids are confluent and transparent, forming the clear glassy surface of the eye, and thus giving to the serpent the stony, unwinking stare peculiar to them.

The boas of the New World, and pythons of the East, are remarkable among snakes for their size and for the strength of their teeth, as well as for the possession of two rudimentary hind limbs in the form of spur-like processes placed one on each side of the cloaca. Some of these serpents, like the anaconda of

FIG. 19.



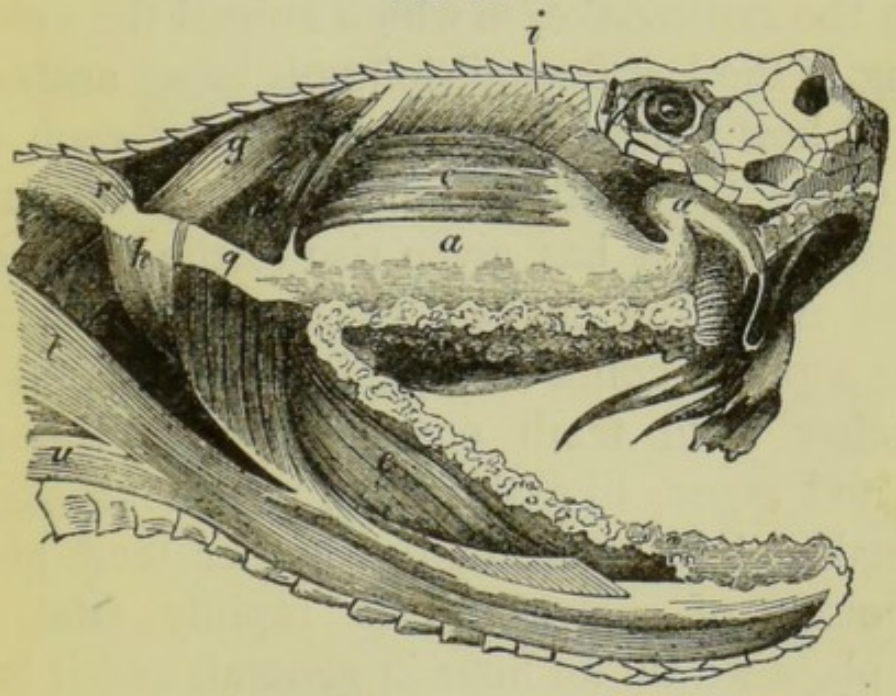
Poison fangs showing their internal hollows.

America, have been known to reach the length of forty feet, and even larger specimens are described.

The Colubrine snakes, such as the common English ringed snake (*Tropidonotus natrix*), are all harmless creatures, mostly of small size, and having all the teeth solid, not grooved.

26. **Poisonous Snakes.**—The most remarkable, though not the most numerous group of serpents, are those provided with poison-fangs, the vipers and rattlesnakes. Of these the best known is the common viper (*Pelias berus*), not uncommon in the south-west of Scotland, and easily recognised by its dark green colour, and by the zigzag black line in the middle of the back. Like most other poisonous snakes, it has

FIG. 20.



Poison apparatus of rattlesnake
a, poison bag and duct; *e*, *i*, *g*, *t*, *u*, muscles of jaw.

a flat triangular head, and in its mouth there can be seen the two long grooved maxillary teeth in which are the channels for the poison. These are the only large teeth in the mouth, all the others being small and obscure. They are placed far forwards in the upper jaw, and are movable along with the movable maxilla, being bent upwards towards the palate in the closed position of the mouth, while in the gaping state they project, being arched downwards, ready to be

inserted into the victim about to be struck. The groove in the tooth leads into a canal which traverses the base of the poison fang, and is continued by a duct into a cavity or sac, which receives the tubular ducts of the poison gland (fig. 20). In the act of striking, the muscles which close the jaws squeeze the poison sac and drive the poison through the duct into the tooth, and thence into the wound.

The poison apparatus is constructed on the same plan in the rattlesnake, in which animal the epidermal clothing of the last few tail-joints is loose, and consists of hard, horny rings loosely embracing each other; these cause the rattling noise, during the animal's locomotion, which has given rise to the name of this dreaded American snake. Other poisonous snakes like the asp, the cobra di capello, and the coral snake, have other solid teeth coexisting with the poison fangs, and some, like the dipsads, tree snakes, and sand snakes, have some of the hinder teeth grooved. The poison of snake-bites is rapidly fatal, death taking place within an hour in general, and it is computed that over 10,000 deaths take place annually from this cause among human beings.

The water snakes inhabit the Pacific and Indian Ocean, and have flat tails. They possess strong ungrooved teeth behind the true poison fangs. In one species, allied to the coral snake (*Callophis intestinalis*), the poison gland extends into the abdomen.

One curious group of non-poisonous snakes possess teeth on the anterior surface of the neck vertebræ in addition to feeble jaw teeth. These animals feed on eggs, and use these teeth for breaking them while

in the act of swallowing, so that all the material of the egg may be saved for food. Snakes are rare in cold and more abundant in warm climates; they are also more numerous in continental than in insular regions.

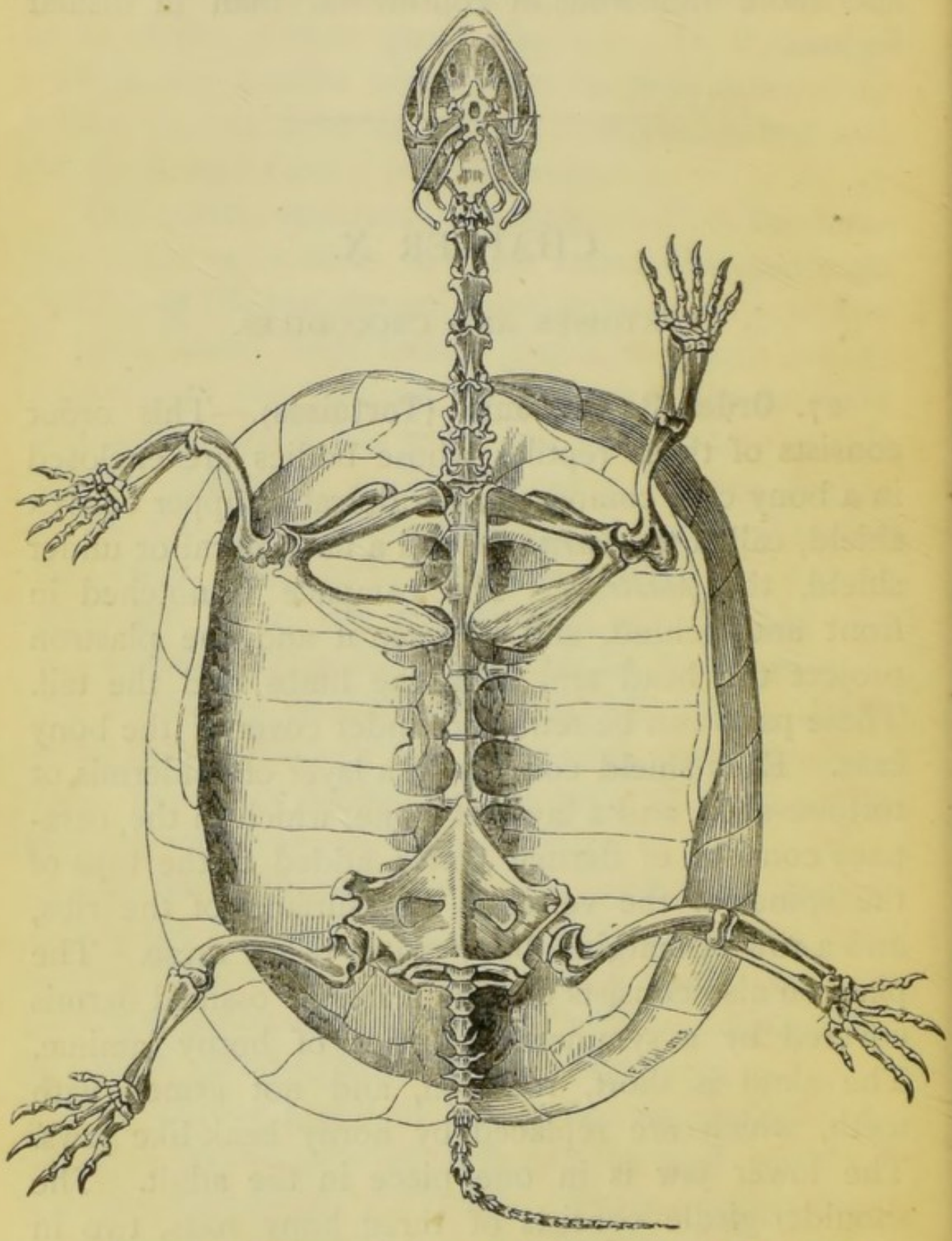
CHAPTER X.

TORTOISES AND CROCODILES.

27. **Order 3, Chelonia (Tortoises).**—This order consists of those reptiles whose bodies are enclosed in a bony case composed of a dorsal or upper convex shield, called the *carapace* and a flat ventral or under shield, the *plastron.* The carapace is notched in front and behind, and between it and the plastron project the head and neck, the limbs, and the tail. These parts can be retracted under cover of the bony case. Each shield consists of a layer of epidermis or tortoise-shell, and a layer of bone, which in the carapace consists of dermal plates added to the tops of the spines of the vertebræ, the surfaces of the ribs, and a row of marginal bony plates below these. The plastron also consists of nine plates of ossified dermis covered by a symmetrical series of horny laminæ. The skull is short, rounded, and not armed with teeth, which are replaced by horny beak-like jaws. The lower jaw is in one piece in the adult. The shoulder-girdle consists of three bony rods, two in

front, and one behind ; these are included within the carapace, as also is the pelvic girdle.

FIG. 21.



Skeleton of European tortoise, the plastron or under-shell removed.

The land forms included under this order are tortoises, such as the common Greek tortoise, which live on land and have stumpy feet with short nails. The aquatic forms or turtles, such as the green turtle used in making turtle soup, and the hawks-bill turtle used for its 'tortoise shell,' are known by their webbed feet. The largest tortoises of the present day only measure a few feet in length, but in ancient days tortoises reached enormous sizes; thus the *Colossochelys*, or giant fossil tortoise of India, sometimes reached a length of over thirteen feet. Tortoises are slow in growth, and attain to extraordinary ages. They are for the most part vegetable feeders, differing in this respect from most other reptiles.

28. **Order 4, Crocodilia.**—These, the highest in organisation of the entire class, are inhabitants of the rivers of tropical countries, and are among the largest of living reptiles. They have a rough, hard, scaly coat of epidermis which is placed dorsally on a dermal bony surface. The vertebral column is provided with ribs, and is composed of vertebræ hollow in front and convex behind. The skull is long, and covered with peculiar sculptured markings. The teeth are seated in sockets in one row, and are renewed several times in succession. The heart has a complete septum or partition in the ventricle dividing it into two distinct cavities, but the aortic arches still communicate with each other at their bases. The feet are webbed and possess strong claws, and there are dermal glands in the throat secreting a peculiar musky material. The forms included are the crocodiles of the Nile and Indian rivers, with their long

tapering snouts, in which the longest teeth of the lower jaw notch the sides of the upper jaw. The alligators of the New World have heads oval or rounded in front, and in all of them the lower jaw teeth are hidden by the edge of the upper, when the mouth is closed. The gavial of the Ganges has a long, slender-pointed head, and is the smallest of the group.

Of all the reptiles the crocodiles are those which in point of structure approach most closely to the birds. They have a gizzard-like stomach, a nictitating membrane in the eye, an immovable joint between the tibia or leg bone and the first bone of the tarsus or ankle, a single carotid or neck-artery, and many other structural peculiarities which show their superiority over other reptiles. Among the orders of the reptile class now extinct, there was one which included bipedal forms which had possibly a kangaroo-like mode of progression, and one of flying reptiles, which indicated a still closer relationship to the birds.

CHAPTER XI.

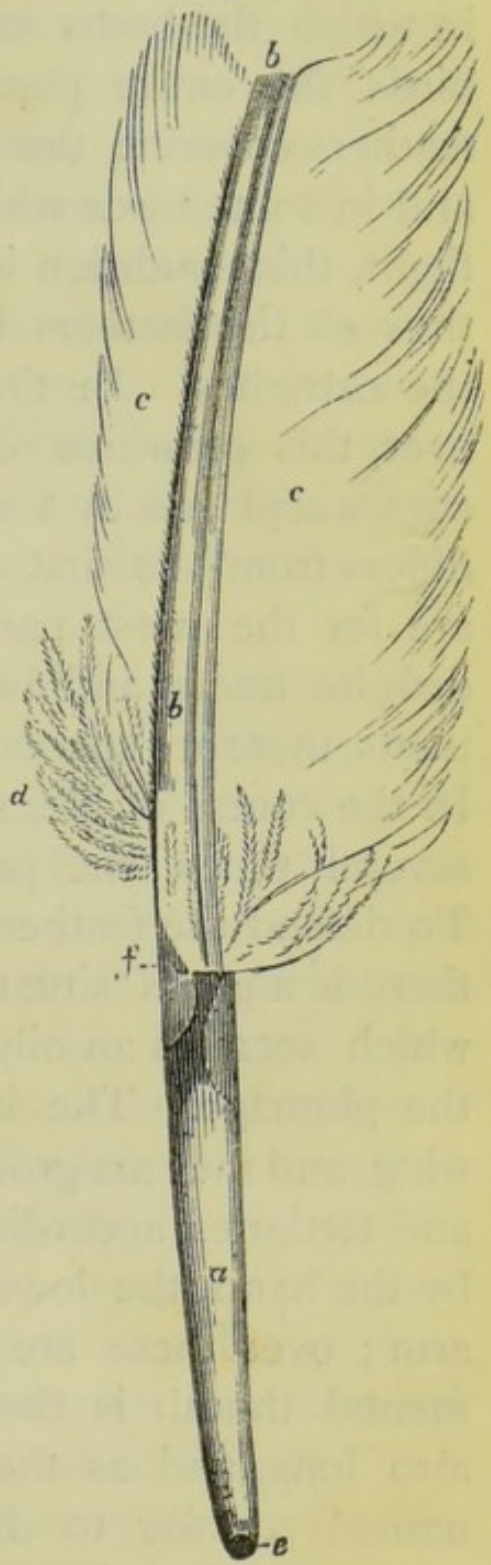
CLASS IV.—AVES (BIRDS).

29. **General Characters.**—These familiar vertebrates are characterised by possessing an epidermal clothing of feathers, warm blood, a four-chambered heart, no teeth, and in general an adaptation for aerial locomotion. The mode of progression on the earth

is strictly bipedal, as the fore-limbs never touch the ground, being modified into wings. Like reptiles they are oviparous and their eggs are of large size ; in most cases also the young are for a certain period under the care of the mother, by whose agency they are provided with food.

30. **Feathers.** — Feathers are epidermal processes secreted by long grooved papillæ and they are of several sorts. The strong distinct feathers, which have a central axis and lateral expansions or vanes, are called contour-feathers, while the smaller soft feathers which clothe the intimate surface of the skin, which have soft or woolly processes and no axis, are called down-feathers. In each contour-feather we notice, firstly, the hole at the base (fig. 22, *e*) where it is thickened around the base of the papilla ; secondly, the slit-like hole, *f*, marking the region above which the sheath of the papilla has split ; thirdly, the rachis, or the square solid axis, *b* ; fourthly, the flat expanded lamina, or vane, *c*, composed of separate barbs, the margins of each of

Fig. 22.



Contour-feather.

a, barrel ; *b*, rachis ; *c*, vanes ; *f*, upper umbilicus and after-shaft ; *e*, lower umbilicus.

which are joined to their neighbours by numerous hooklets.

In this respect contour-feathers differ from down, in which the barbs are all discontinuous. In young birds the entire plumage consists of simple down-feathers covering the whole surface almost uniformly, and in some birds which do not possess the power of flight, this condition is more or less perpetuated, and thus all the feathers have discontinuous barbs, as in the ostriches. In the great majority of birds, however, this primitive surface clothing is shed and becomes replaced by a second growth of feathers, which differs from the first in that the component feathers are for the most part contour-feathers, arranged in definite tracts, and between these *pterylæ*, or feather tracts, there are spaces quite devoid of contour-feathers. In the course of life, many birds change their feathers several times, the process being called 'moulting.' To defend the feathers from the influence of moisture there is a gland situated on each side of the tail bone which secretes an oily material of use in lubricating the plumage. The largest feathers are those of the wing, and they are grouped into primaries, secondaries, and tertiaries, according as they are borne respectively by the hand, the lower, or the upper end of the fore-arm ; over these are the scapulars, and on the rudimental thumb is the *alula*. The tail feathers are also long, and as they are used in steering they are named *rectrices* to distinguish them from the oar-feathers of the wing.

The papillæ which secrete the feathers are long, vascular, and deeply grooved on the surface ; the

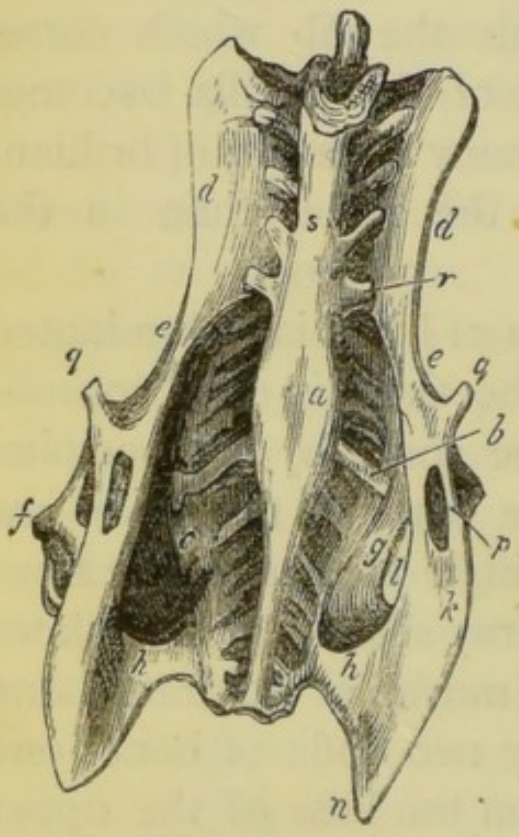
protoplasmic matter exuded by the surface of the papillæ is collected into these channels, it then hardens and forms in the first place a hollow cylinder of horny matter, with ridges fitting into the papillary grooves and thin areas between. As growth takes place most actively at the base of the papilla, this horny sheath is pushed off the surface of the papilla, upon which it shrinks still more, and the horny cylinder splits along its thinnest side, whereupon the two lateral laminæ flatten out as the vanes, while the rib which corresponded to the main groove of the papilla becomes the rachis. The feathers of many birds are of brilliant colours, usually brighter in the males than in the females.

31. **Bones.**—The skeleton of birds is well adapted for their aerial existence. The skull is early consolidated, and articulates with the spine by one occipital condyle. The ten or twelve parts of the lower jaw are also early united into a single piece and the front of the jaw is enclosed in a horny sheath; it articulates to the skull by means of a movable quadrate bone which is kept in its place by two rods of bone, one on the outside stretching from the base of the upper beak (the jugal arch), the other on the inside stretching from the palate (the pterygoid arch). The upper mandible, or beak, is also encased in a horny layer at whose base are the nostrils, very often surrounded by a thick leathery skin, which is called the *cere*.

The neck is usually long and exceedingly flexible, made up of from nine to twenty-three vertebræ; its length and that of the bill usually bears some proportion to the length of the legs. The breast-bone bears

in front a prominent keel, to which the muscles which elevate and depress the wing are attached, and this is only absent in such birds as do not fly, as the ostrich, emu, and New Zealand ground parrot. The wings are fastened to a very strong shoulder-girdle, which consists of three parts ; firstly, of a V-shaped *furculum*, or merrythought, which consists of the two collar-bones united together in the middle line ; secondly, of the coracoid bone, a stout bony rod which fits into a groove in the top of the breast-bone and stretches from thence upwards and backwards to the shoulder joint ; thirdly, the scapula, or scythe-blade-like bone, which joints with the coracoid at the shoulder, and descends backwards over the dorsal ribs, slung in its place by muscles. The wing bones consist of, firstly, an arm bone, or humerus ; secondly, two forearm bones ; thirdly, a consolidated hand made up of several (never more than four) united fingers, of which only the thumb in general bears a claw, rarely the thumb and index fingers, as in the cassowary. The ribs are few and are fastened together by lateral spurs, or processes. The portions of the ribs which articulate with the vertebral column are separate from those that unite with the breast bone.

FIG. 23.



Pelvis of bird.

a, sacrum ; *b*, lumbar vertebræ ; *d*, ilium ; *p*, pubis ; *g*, sciatic foramen ; *k*, ischium.

The tail bones are short and compressed, forming a ploughshare-like process ; the pelvic bones are long, and stretch along the spine fore and aft to an extent proportionally unmatched in the rest of the sub-kingdom (fig. 23). The two pubic bones do not unite in the middle line in front of the pelvis except in the ostrich, but always remain separate and open. The thigh bones are short. The leg-bone consists of two parts, which in adult birds are indistinguishably united. Of these the largest part is the tibia, or leg-bone proper, the lower end consists of the astragalus, or first bone of the tarsus or ankle. The lower part of the shank of a bird consists of the remaining tarsal and metatarsal bones elongated into a single shaft, and below this are the toes, of which usually four are developed. The innermost of these or the hind toe consists in general of two joints or phalanges, the second (inner) toe is made up of three, the middle or longest toe, of four, and the outermost toe of five phalanges. The shapes and dispositions of the toes vary with the habits of the birds ; thus, birds of prey have stout, grasping feet, with sharply hooked claws. Climbers, like woodpeckers and parrots, have the outer and inner toes turned backwards and the other two forwards. In swimmers, all the forward toes are webbed, while in the scraping birds the toes are short, stout, and armed with blunt nails. Many of the bones in the body of a bird are hollow, and instead of containing marrow they are lined by a delicate membrane and contain air, which is conducted into them from the respiratory organs by thin walled canals. This condition is specially exhibited in the

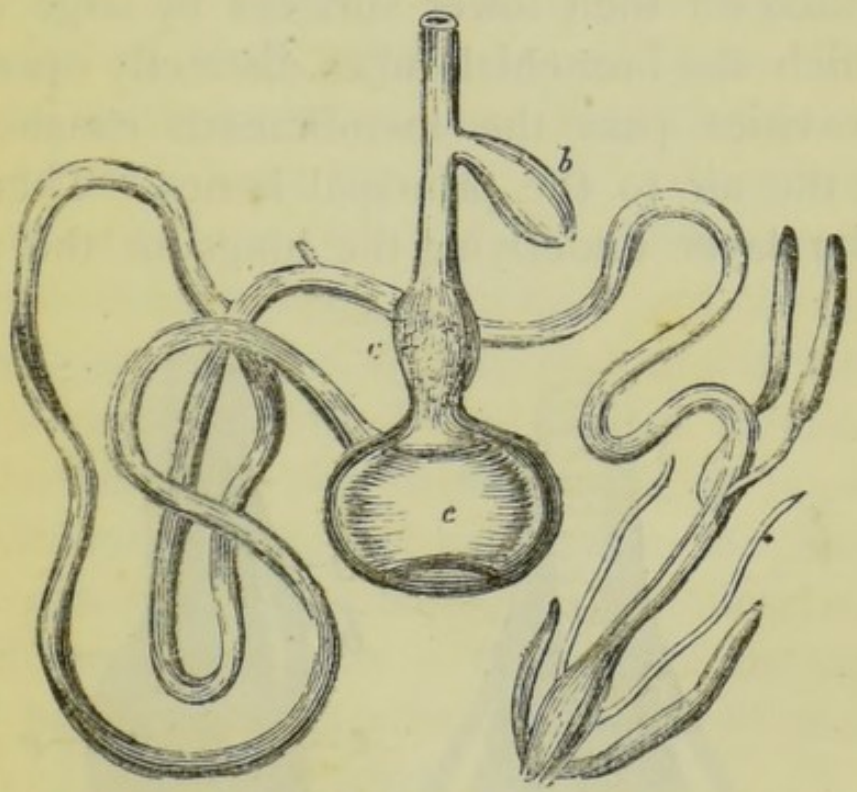
birds of most powerful flight, but the bones of very young birds contain marrow.

32. **Muscles and Viscera.**—The muscle or flesh of birds consists of very close fibres, and the sinews or tendons are often converted into bone. There is an enormous muscle on the front of the breast, the great pectoral, whose action is to depress the wing; beneath this is a smaller, or second pectoral muscle with oblique fibres, arranged like the barbs of a feather, and converging to a tendon which, winding round a pulley at the top of the coracoid, is inserted into the top of the humerus and raises the wing; this is the second pectoral. In the legs of many birds there is to be found superficially on the front of the thigh a slender little muscle, which, starting from the front of the pelvis, passes down the upper or front surface of the thigh, winds round to the back of the knee and runs by a tendon into the superficial flexor (or bender) muscle, for the longest toe (*plantaris*); a second muscle (the *peroneus*), from the outside of the leg can generally be traced into the same toe-muscle. These muscles are supposed to be of importance in the action of perching, and as their tendons pass over several joints they probably have a complex action.

The digestive system of birds consists of the following parts: first, the bill or prehensile organ, varying in shape and texture according to the nature of, and mode of obtaining, the food upon which the bird subsists; secondly, the tongue, rarely soft, usually hard and horny, often barbed; thirdly, the long food-passage, or œsophagus, which, above the furculum, usually dilates into a crop (fig. 24, *b*), below which is

a glandular stomach (*c*) communicating with the gizzard, or true muscular stomach (*c*). This cavity has a thick muscular wall consisting chiefly of two masses of muscle united by a strong tendon, and lined by a rough horny cuticle ; into this birds frequently introduce small stones which assist in triturating or grinding the food, as this organ is chiefly the place where the material of the food is reduced

FIG. 24.



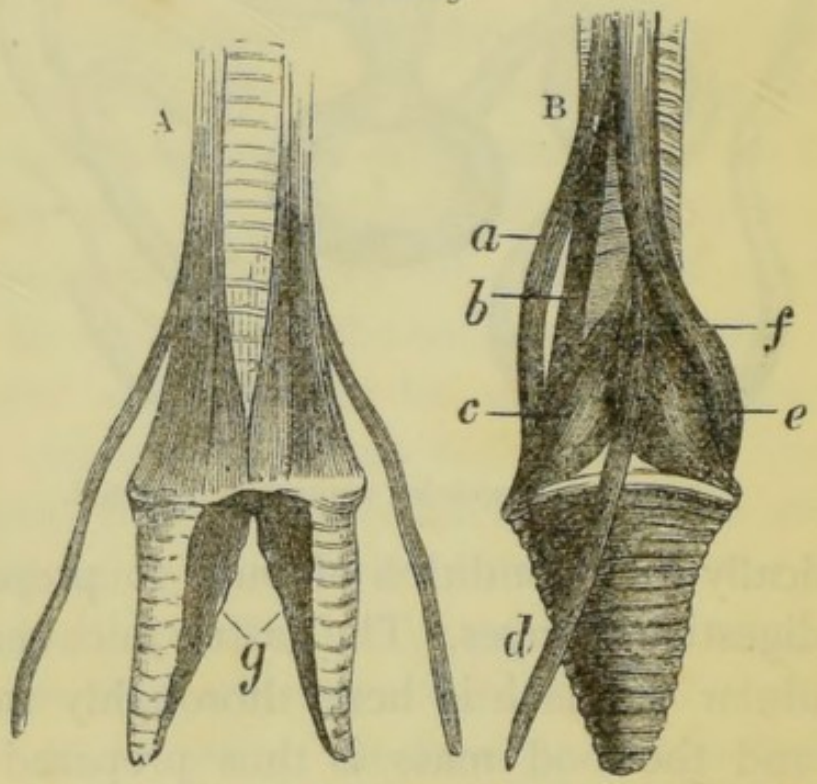
b, crop ; *c*, *c*, glandular stomach and gizzard.

mechanically to a condition of pulp to prepare it for further digestive changes. The gastric juice secreted in the glandular stomach is here thoroughly mixed up with it, and the food mass is thus prepared for the intestinal canal. The gizzard is especially strong in grain, or fruit-eaters, weak or absent in flesh-eaters.

Birds have two separate ventricles in the strong muscular heart ; one on the right side for propelling

the impure or venous blood of the right auricle into the lungs, and the other, or left ventricle, for driving the purified blood after its return from the lungs, through the body; the opening into the right ventricular cavity from the auricle is guarded by a muscular flap. There is only one aortic arch developed in the adult bird, and it arches to the right side, and in many birds there is only one artery developed in the neck for the supply of the head. The lungs are large, and surrounded on their lower surfaces by large air-sacs, into which the bronchial tubes distinctly open; from these cavities pass the membranous canals, which convey the air to the principal bones. There is no muscular layer underlying the lungs for the purpose

FIG. 25.



Organ of voice of the raven.

A, front view; B, side view showing the muscles of vocalisation.

of directly acting on them in respiration, except in the ostrich and apteryx; but as the sternal and vertebral

ribs can move on each other, the bony wall of the thorax or chest cavity is susceptible of a large range of motion for breathing.

As, from the activity of their motion, birds require a more perfect system of nutrition for their ultimate tissues and organs than reptiles, their respiratory apparatus is very highly developed, and hence their temperature is higher than that of any other group of animals.

An organ of voice is usually developed in the air-passages of birds, most commonly at the point where the windpipe or trachea bifurcates to send an air-tube to each lung (fig. 25). At this spot there is a drum-like cavity or syrinx (*g*), in which certain tense membranes can be made to vibrate, and can be acted on by muscles (*a*, *b*, *c*, *d*, *e*), attached to the windpipe. Thus the organ differs from that in mammals, in which the seat of voice is the larynx or upper end of the windpipe. In the wild swan the long and sinuous windpipe is contained in a hollow which is provided for its reception in the keel of the sternum.

The blood of birds contains small elliptical corpuscles which are nucleated.

The eye of birds is remarkable for possessing bony plates in its 'white,' as well as a curious folded vascular projection at the bottom of the eyeball, which projects forwards towards the crystalline lens. There is also a third eyelid, or nictitating membrane, placed below and within the two ordinary lids, and moved by two little muscles on the back of the eyeball, and there is an additional gland whose secretion keeps this accessory lid moist. The senses of smell and

hearing are also largely developed in some birds, notably in vultures and owls, the latter being provided with a distinct external ear.

Most birds have but one oviduct, and that is on the left side; in its lining there are glands which secrete the white of the egg, its membrane, and the shell, during the downward passage of the yolk. The embryonic bird is provided with a rudimental knob on its pre-maxillary bones, which it uses in breaking the egg-shell wherein it is contained.

CHAPTER XII.

CLASSIFICATION OF BIRDS.

33. **Primary Divisions.**—About 8,000 species of birds are known to the naturalist, and these are divided into two primary sub-classes.

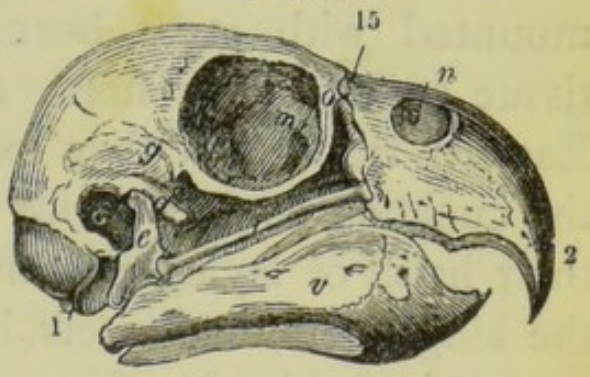
The first sub-class is called *Ratidæ*, and includes all those birds which have a sternum without a keel, a rudimentary furculum and wings, feathers with discontinuous barbs and not distributed in feather tracts, and with no oil gland. They are all natives of warm or temperate climates, and strictly limited in their range. Several gigantic forms which existed until recently, are now extinct, such as the moa of New Zealand and the æpyornis of Madagascar. The ostrich of Africa is a familiar instance, and is provided only with two toes. The American ostrich or rhea is smaller, and inhabits South America.

The cassowary is a native of the East Indian archipelago, and the emu of the Australian continent. The apteryx of New Zealand is the most remarkable of these birds, as it has perfectly rudimentary wings and a long slender bill, and there is a remarkable disproportion between the size of the egg, which is very large, and that of the bird.

The second sub-class of birds is called *Carinatæ* and includes all those birds which have a keel on the breast-bone, a merrythought, usually functional wings, whose feathers are in tracts (except in the penguins) and have the barbs united along their margins. This includes fourteen orders of birds, of many of which there are familiar illustrations easily obtainable.

34. **Order 1, Parrots (Psittaci).**—The most intelligent and most highly organised of birds; easily known by their sharply hooked beaks, both the upper and lower part of which are movable, and by their brightly-coloured feathers. Their feet are prehensile, the outer and inner toes being turned backwards, while the two middle toes are turned forwards, and thus they are enabled to grasp in climbing. The tongue is soft, and the muscles which move it are more distinct than those of most birds, and hence the singular power of mimicking sounds possessed by many of them. They are natives of the

FIG. 26.



Skull of parrot.

n, nostril; *c*, quadrate bone; *v*, lower jaw; *m*, orbit.

tropics, the cockatoos being mostly from the East Indian archipelago, the macaws from South America, the common parrots from Africa and Madagascar. One curious genus, Strigops, the ground parrot of New Zealand, is exceptional in having no keel on its sternum, and some parakeets from Australia have no merrythought. They are vegetable-feeders, principally subsisting on fruits, but often eating honey. Many species live long in confinement, and they are all easily domesticated.

35. **Order 2, Cuckoos, &c. (Coccygomorphæ).**— These are usually long-beaked birds with small flat tongues, having the toes arranged either permanently or temporarily like those of parrots, with the outer and inner turned backwards. The wings have long covering feathers. Some of these birds have enormous beaks thrice as long as the head, like the little toucans of America; in others the beaks are surmounted with great horns, made of spongy bony tissue covered with horn, as in the hornbills of the Eastern tropics. Other examples of this order are the cuckoos, so familiar for their peculiar note and for their habit of laying eggs in the nests of other birds; the kingfishers, bee-eaters, hoopoe, rollers, &c. Some are remarkable for their colours, like the plantain-eaters of Africa. The tongues are hard, often bristled, as in the toucans; few have much vocal power. They are for the most part feeders on insects and animal substances.

36. **Order 3, Woodpeckers (Pici).** — Mostly brightly-coloured birds, with straight, strong, conical beaks, and slender and actively protrusible tongues.

The wings have short coverts. The middle toes are united at the base; the inner toe is small, directed backwards, as is also the outer toe. The tail feathers are short, stiff, and serve as organs of support. These are insect-eating birds like the last group, and they derive their name from their efforts after the capture of their prey. In these the tongue bone is specially elongated, and its lateral processes coiled and disposed to allow of the rapid protrusion of the barbed tongue. Woodpeckers exist everywhere but in Madagascar and Australia.

FIG. 27.

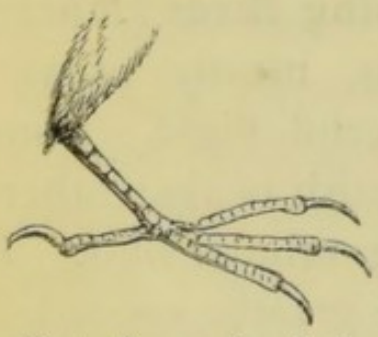
Foot of woodpecker.

37. **Order 4, Swifts and Humming-Birds (Macrochires).**—A small order of birds, mostly of very minute size, and almost all of powerful flight. Some of these, like the swifts, have flattish beaks; others, like the humming-birds, have long tubular bills. In each wing the forearm and hand greatly exceed in length the upper arm, hence the Latin name given to the order. The feet are very weak, scarcely able to support the weight of the body, and the inner toe may in some be turned forwards or backwards. They have a very simple syrinx, and little or no voice. They are mostly tropical birds, and vary much in size, the goatsuckers being the largest, sometimes of comparatively large size; while the swifts are much smaller and somewhat swallow-like. One of these, the Collocalia of the Malay archipelago, secretes, by

means of glands in the throat, a glutinous material of which it constructs its nests, which are the edible birds' nests of Eastern commerce, used as food in China. The humming-birds of Brazil, of which there are very numerous species, are also examples of this order, and include the smallest forms of the entire class of birds; thus *Melisuga minimus*, from the island of San Domingo, only weighs about nine grains, and measures two inches in extreme length; its nest is about the size of a walnut, and it contains two eggs each nearly as large as a pea.

38. **Order 5, Perching birds (Passeres.)**—This large order includes all our small birds, with the exception of those hitherto mentioned. They may be recognised by possessing short wing coverts, a tarsus covered in front with seven large scales, and slender toes, of which the first joints of the two outer are united. They have a well-developed syrinx or organ of voice, and many of them can sing. These birds are very numerous, and make up about twenty-one families. The best known of these are the following:—The thrushes, known by their slightly curved bill, with a notch or tooth on each side near the tip, and with bristles at the angles of the gape of the mouth. They are insect-eaters for the most part. The commonest species are the song thrush; the blackbird, known by its yellow bill and eyelid-edge and its black body; the missel thrush, known by its white-tipped three outer tail feathers; the fieldfare, the redwing.

FIG. 28.



Foot of passerine bird.

To this family belongs the mocking bird of America, which can mimic the song of any other bird. The birds of the wagtail family are recognisable by their slender forms, long legs, long tails, and moderate wings with nine primary feathers. They include the common pied wagtails, the yellow-breasted wagtail; closely allied to which are the hedge-sparrows (*Accentor*) with strong, sub-conical, straight bills, and wings with a very short first quill, the third and fourth primaries being the longest. The warbler family, consisting of small singing birds with awl-shaped beaks flattened at base, are also closely allied; of these the most familiar examples are the nightingales (*Philomela*); the robin red-breasts (*Erythacus*); the red-starts (*Phœnicura*); the sedge and grasshopper warblers (*Salicaria*); white-throats, black-caps (*Curruca*); and willow-wrens (*Sylvia*). The golden-crested wren (*Regulus*) is our smallest British bird, measuring $3\frac{1}{2}$ inches in its greatest length. The pipits (*Anthus*), with awl-shaped bills, keeled at the base above, with two long scapular feathers and long hind claw; the wheatears, whinchats, and titmice are also nearly related to this group.

The crow family (*Corvidæ*) constitute a group of much larger birds; they have strong conical bills with no notch, and robust feet. This family includes the jackdaw, rook, raven, jay, and magpie, and the starling is a nearly related form. These have ten primary feathers, while the birds of the conical-billed finch family possess only nine. This family consists of the house-sparrows, hawfinches, linnets, bullfinches, and nearly related are the larks and buntings.

Among the most remarkable tropical forms are the lyre-birds of Australia, the oven-builders of Brazil; the sun-birds, nuthatch, wax-wings, &c.

39. **Order 6, Birds of Prey (Raptores).**—This order consists of eagles, owls and vultures, which feed on animal food, and are armed with strongly hooked bills (fig. 30), and with strong, sharp and curved claws (fig. 29). At the base of the bill is a

Fig. 29.

Foot of eagle.

Fig. 30.

Head of eagle.

cere or skin, which is pierced by the nostrils. The gizzard is weak, the digestive tract short, the sense organs are acute and powerful. Their strong wings have ten primary feathers, and the tail has twelve rectrices. Owls are mostly nocturnal, round-faced birds, with short beaks, and with eyes directed forwards. They have no crop, and peculiarly soft plumage. Some have tufts of feathers above the ears, such as the horned owls. Vultures are carrion-eaters, most abundant in warm climates, with naked or down-clad head and longer bills. Eagles have feather-clad heads, and short, sharply-hooked bills, and they for the most part feed on prey which they kill for

themselves. To this family belong the hawks, kites, buzzards and harriers, as well as the larger eagles, ospreys, and falcons.

CHAPTER XIII.

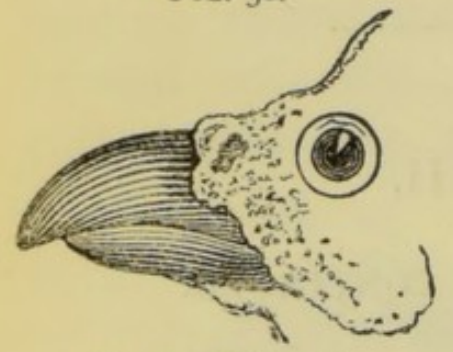
CLASSIFICATION OF BIRDS CONTINUED.

40. **Order 7, Pigeons (Gyrantes).**—This well-marked group consists of the doves and pigeons, characterised by having a gristly plate covering the base of the upper mandible, pierced in front by the nostrils. They are vegetable-feeders, with a large glandular crop which sometimes secretes a milky fluid with which the parents nourish the young birds. They have a strong gizzard, shielded or feathered tarsi, and four usually free toes all on the same level, with short, slightly-hooked claws. They are mostly birds of powerful flight, and have ten primary quill feathers in their long pointed wings, and twelve or rarely sixteen rectrices. They are mostly social birds, often living in great societies. The pigeons, wood-quests, and doves are familiar instances, as also are the passenger pigeons of North America, which migrate in millions, darkening the air by their flocks. Our common pigeons, in all their varieties, are descended from the rock-dove, *Columba livia.* The curious dodo of Mauritius was an aberrant large pigeon incapable of flight, and hence it was easily

captured by the early voyagers, and was extirpated in the seventeenth century.

41. **Order 8, Scraping birds (Rasores).**—This large and economically important order includes the poultry, turkeys, pheasants, grouse, partridge, &c., heavy plump-bodied birds, with comparatively small rounded wings, weak in flight, and with a moderate length of beak and legs; they have stout blunt claws, the hind toe being raised above the level of the others. The name of the order is derived from the habit common to most of them of scraping in searching for their food in or on the ground. The tarsus often bears spurs, especially in the males, and the plumage is close and often brilliantly coloured, as in the peacocks and pheasants. Many of them have naked areas on the head, where the skin is soft and vascular, forming wattles or crests. As they are mostly grain-eaters, they have large muscular gizzards, capacious crops, and long intestines. Our common domestic fowls are natives of India, as also is the peacock and that most gorgeously coloured bird the Impeyan pheasant, whose plumage has a rich metallic lustre. The golden pheasant is a native of China, the turkey of America. In Australia the order is represented by the mound-birds and brush turkeys, which hatch their eggs in 'hot-beds' formed of large masses of decaying vegetable matters which they heap together for the purpose.

Fig. 31.



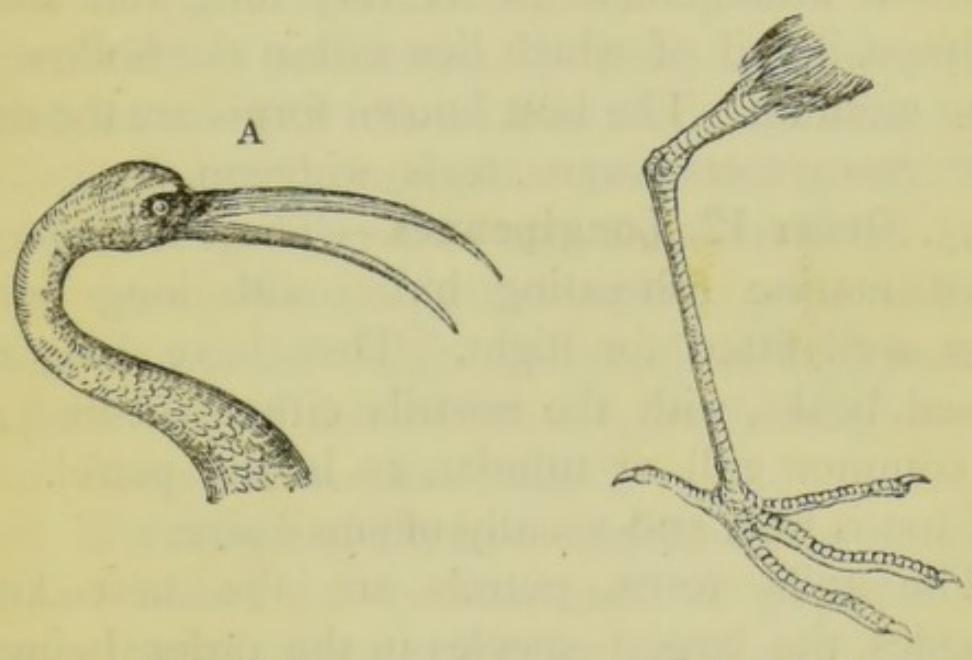
Head of Numida.

42. **Order 9, Grallæ.**—This group consists of long-

legged birds which are often waders in habit, and are characterised by possessing small hind toes and long bills. They feed on worms, molluscs, and fish, rarely on vegetables. The side of the head presents no bare patch between the angle of the mouth and the eye, and the palate exhibits a long cleft between the two lateral halves of the upper jawbones. To this order belong the plovers and peewits, coots and waterhens, corncrakes and snipe, the cranes and bustards, oyster-catchers, herons, and bitterns.

43. **Order 10, Storks (Ciconiæ).**—This group also consists of birds with long legs and bills, which in habit resemble the last, but differ from them essentially in their structure. Thus they have the two

FIG. 32.



Head of ibis. Foot of ibis.

lateral sides of the upper-jaw united along the middle line of the palate; the *lore* or space between the angle of the mouth and the eye is bare, and the hind toe is long and functional. The best known examples

are the ibises, spoonbills, storks, and jabirus, some of which are distinguished for their brilliant colours, like the scarlet ibis, the straw-necked ibis, and the scarlet spoonbill. The loose feathers of the leptoptilus of India are used for ornamenting bonnets, under the name *Marabou* feathers.

44. **Order 11, Ducks and Geese (Lamellirostres).**—The birds belonging to this order make a very natural assemblage characterised by possessing webbed feet and long flattened bills, which on the under surface of the upper mandible exhibit a series of close transverse lamellæ; these act as sensitive prehensile surfaces in feeding, and large nerves are distributed on them. They have large fleshy tongues, and the hind toe is free and small. The wild swan presents a curious arrangement of its very long and sinuous windpipe, a coil of which lies within the hollow keel of the sternum. The best known forms are the ducks, geese, mergansers, swans, teals, widgeon, &c.

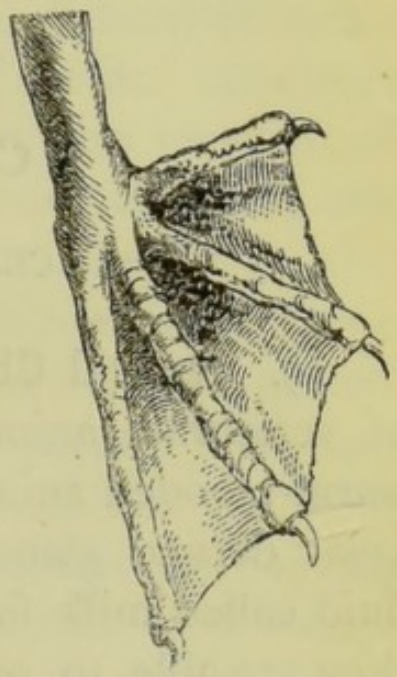
45. **Order 12, Longipennes.**—These are also web-footed marine fish-eating birds, with long pointed wings well fitted for flight. They have long compressed beaks, with the nostrils either slit-like, as in the common gull, or tubular, as in the petrel. The hind toe is free, and usually of small size.

The gulls, terns, petrels are the best known examples, the largest species in the order being the famous albatross, found on the ocean about the equator, which is allied to the small petrels or Mother Cary's chickens.

46. **Order 13, Pelicans (Steganopodes).**—A curious order of water birds which have all the four

toes included in the broad web, hence the feet have a singularly inturned appearance (fig. 33). Many of them have long bills and throat pouches, like the pelicans and frigate birds; other and better known forms are the gannets, cormorants, and long-tailed tropic birds.

FIG. 33.



Foot of pelican.

47. **Order 14, Pygopodes.**—The last order of birds includes a singular assemblage of seabirds, whose wings are small and sickle-shaped, scarcely fitted for flight, and sometimes with scale-like feathers, as the penguins of the Antarctic Ocean. They have the hind limbs even farther back than in the generality of seabirds, and hence the curious erect position assumed by these birds when standing; they have hard pointed compressed bills, and a small hind toe, the three anterior toes are closely webbed. The auks of the northern seas, the puffins, guillemots, and razorbills of our shores, are the most familiar examples. The great auk of the northern seas, is wingless, and like the dodo has become extinct.

48. **Migration of Birds.**—Among birds, as among fishes, we notice the curious habit of periodical migration; the travelling at regular periods into districts wherein suitable food is abundant, and their return on change of season; thus the swallows, swifts, nightingales, and warblers visit this country about the middle of April, breed here, and then return to their winter quarters along the shores of the Mediterranean

on the advent of cold weather, about the first week of October.

CHAPTER XIV.

CLASS 5, MAMMALIA.

49. **General Characters.**—This, the highest class of vertebrate animals, includes all those viviparous, warm-blooded animals which are provided with superficial dermal glands for the purpose of secreting a fluid called milk for the nutrition of the young until they are able to seek out other nutriment for themselves. They are for the most part terrestrial in habit; they are all provided with epidermal covering in the form of hairs; and the lower jaw in them articulates directly with the base of the skull, the quadrate bone being very small and included in the ear cavity, so that it is of use only in conveying sound-waves to the nerves of hearing. Man, all quadrupeds, seals, whales, and bats are examples of this class.

The superficial clothing of hairs characteristic of the class may be only transitory, as in whales and some thick-skinned animals, or the hairs may be thick and spine-like, as in the porcupine and hedgehog, or they may be united into scales, as in the manis and armadillo, or on the tail of a rat. Each hair is the epidermal secretion of a single papilla, and is a solid cylinder composed of long cortical or superficial cells, and rounder central cells. The hairs arise

in pits or follicles, and into these follicles there open sebaceous glands, which secrete an oily material for the lubrication of the hairs.

The neck-region of the vertebral column or backbone in all mammals consists of seven vertebræ, except in three cases;[1] the back region consists of about twenty, but the number is more variable; the shoulder girdle is never connected directly to the spine, but the pelvic girdle always is so, and hence there are always certain vertebræ thickened and united for the purpose of supporting the pelvis; these are known as the *sacrum*, and behind this in most mammals is the tail, which varies extremely in length, sometimes, as in the long-tailed manis of Western Africa, having over forty vertebræ, in others, as in some bats, having only three. In man there are four very small rudimental tail vertebræ, and the same number exists in the gorilla, chimpanzee, and orang-outang. In many mammals, as the South American monkeys, opossums, and kinkajous, the tail is prehensile and is used as an additional hand in climbing.

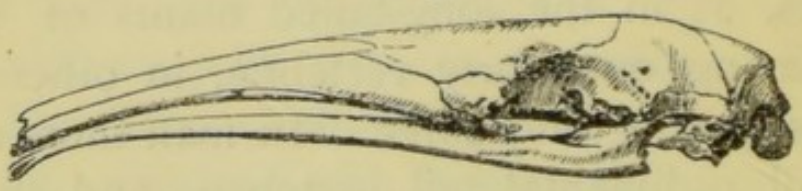
50. **Skeleton.**—The skeleton consists of two classes of bones, some with an interior of spongy cells, others with an internal cavity. In both cases the hollow spaces are filled with marrow. The skull in mammals is a solid box to which the upper jaw is immovably fixed, and it articulates with the first vertebra of the neck by means of two articular knobs or condyles. The lower jaw is composed of two pieces only, one on each side, and it forms a joint directly with the

[1] These are two sloths, one having 9, the other 6 vertebræ, and an aquatic American animal, the manatee, which has 6.

skull, beneath the ear. The shape of the articular surfaces which form this joint is variable, and depends on the nature of the food and the character of the motions which are necessary for mastication. Thus, in flesh-eating animals the lower jaw has a transversely elongated, cylindrical condyle, which can allow only of a vertical motion, while in gnawing animals the lower jaw slides forwards and backwards.

51. **Teeth.**—The jaw arches, and they alone, bear teeth, which are arranged in one row; no accessory teeth are developed on the palate as in reptiles and fishes. The teeth are always in sockets, and are

FIG. 34.

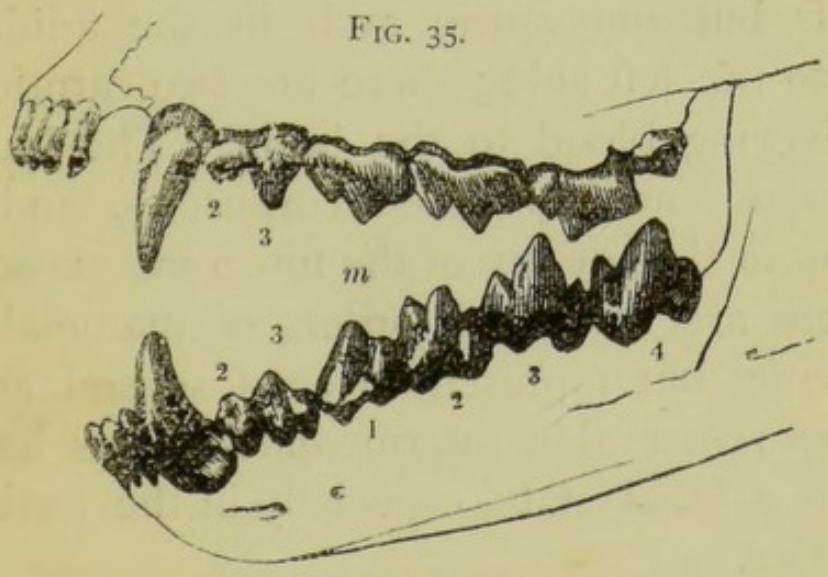


Skull of anteater, a perfectly toothless mammal.

rarely absent, as in the anteaters (fig. 34), though sometimes they are rudimental and disappear early, as in whales. There are usually two sets of teeth; one an early developed or milk set, which soon drop out and are succeeded by a second or permanent set; thus reminding us of what we found in crocodiles, where successively growing teeth follow each other in the one row almost indefinitely as long as growth continues. Those teeth in the upper jaw which are rooted in the foremost bone, or premaxilla, are called incisor teeth, and have usually a cutting edge and a single root. When the first tooth in the maxilla or jaw proper, is placed near the suture or line of contact between that bone and the premaxilla, it is

generally long and pointed and has but one root. To it the name canine is given, while the other maxillary teeth have in general two or more fangs, and are called grinding teeth or molars. The milk teeth are usually fewer than the permanent teeth, and hence some of these grinders have had predecessors while others have not; those which are secondary are called premolars, while those which are primary (the hindermost), are called molars. Similar names are given to the corresponding teeth in the lower jaw. As the teeth vary in number and size in the different orders of mammals, they afford a good and easy system whereby the different forms can be discriminated; and in order to be able briefly to describe the characteristic dentition of any animal, zoologists are in the habit of tabulating the number and arrangement of the teeth of animals in a set formula; thus

FIG. 35.



Teeth of Tasmanian devil.

to write the dental formula of an animal we first put down the initials of the sets of teeth, and follow each initial by the number of teeth of that sort in the two jaws, those of the upper jaw being written like the

numerator of a fraction, while those of the lower are placed as the denominator; thus, in an adult man the dental formula is $I\frac{2-2}{2-2}$, $C\frac{1-1}{1-1}$, $P\frac{2-2}{2-2}$, $M\frac{3-3}{3-3}$; that is, on each side of each jaw there are two incisors, on each side of each jaw one canine, two premolars, and three molars. The jaws are almost always protected by fleshy lips, except in the first order.

52. **Viscera.**—Mammals have well developed brains, and usually acute sense-organs. The lungs and heart are separated from the intestine and other digestive organs by a muscular partition, called the diaphragm, which is an important agent in breathing. The heart consists of four cavities, and the opening between the right auricle and right ventricle is guarded by a membranous valve consisting of three flaps. There is but one aortic arch in the adult, and it arches to the left side; there are two carotid arteries for conveying blood to the brain. The blood contains round, non-nucleated corpuscles, and therein differs from that of any of the foregoing classes.

There are seventeen orders of mammals at present living, but representatives of several additional and most remarkable intermediate orders have been found in a fossil state, especially in the tertiary beds in America.

CHAPTER XV.

CLASSIFICATION OF MAMMALS.

53. **Order 1, Monotremata.**—The first order of mammals is called *Monotremata*, and includes two remarkable Australian forms, the platypus and the spiny anteater. They are both small animals, being about a foot in length. Both have long coracoid bones separate from the shoulder-blade or scapula, which, bird-like, reach as far as the sternum, and the two collar-bones unite into a single T-shaped merry-thought-like bone. In both forms there are two long spur-like bones articulated to the front of the pelvis and embedded in the abdominal muscles, and in both the bones of the skull unite at an early period to form a perfectly continuous braincase. They are also characterised by the intestine and excretory organs opening, as in the birds, into a common cloaca (hence the name of the order). The platypus, or *Ornithorhynchus*, is aquatic, and has a duck-like bill and two small, flat, horny teeth in each jaw. The male has a strong hollow spur on the ankle which communicates with the duct of a poison gland and is a weapon of offence. The spiny anteater, or Echidna (fig. 36), is toothless, and has a long slender horny bill, a worm-like tongue, and a dermal covering of strong stout spines. The young of both these forms are born in a very imperfect state of development.

54. **Order 2, Marsupialia.**—The second order of mammals is named *Marsupialia*, and includes kanga-

roos and opossums, and all those other Australian forms in which the females bear on the under surface

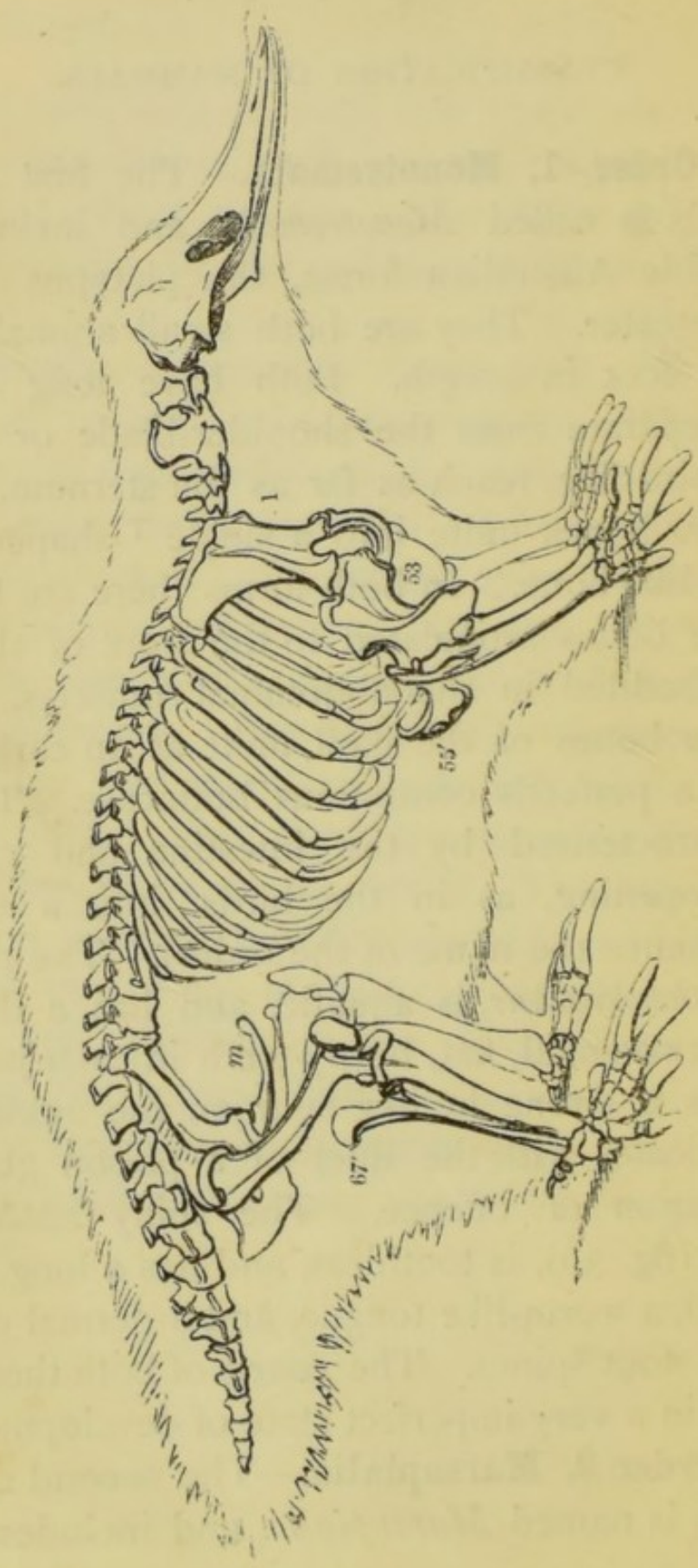


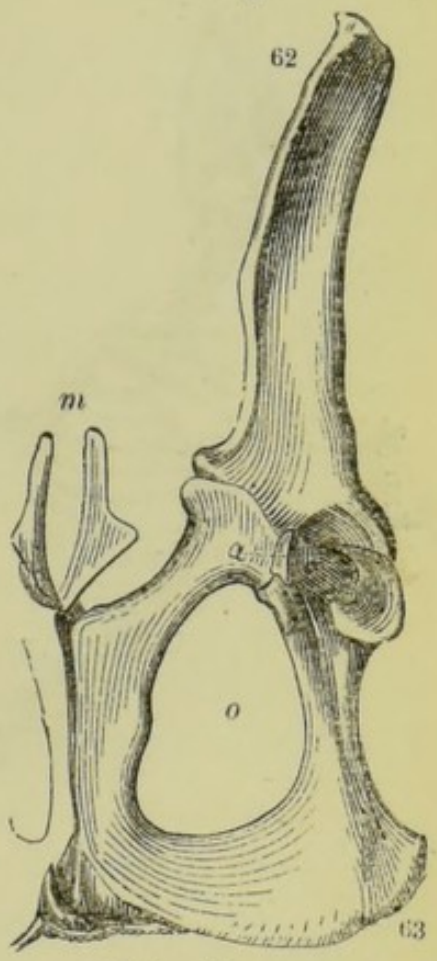
FIG. 36.

Skeleton of the spiny anteater, or *Echidna*.

m, marsupial bones; 53, inter-clavicle; 67, spur on top of fibula'; 51, scapula.

of the body a pouch wherein the young are received and sheltered after their birth. This pouch is supported by two bones (fig. 37, *m*,) similar to those described in connection with the pelvis of the Monotremes; to these bones the name marsupial bones has been given, but they exist in the pouchless males as well as in the pouch-bearing females. All the marsupials are clad with thick fur, and they are armed with claw-bearing toes, two of which on the hind foot tend to become very small and united within a common web of skin. They exhibit many characters of inferiority to the other mammals; thus, the two lateral lobes of the fore-brain are nearly smooth on the surface and are imperfectly united together, and the young are born in an exceedingly rudimental state.

FIG. 37.



Pelvis of kangaroo.
m, marsupial bones; 62, ilium.

The marsupials vary very much in habit, and are modified to suit these habits. Thus, the Tasmanian devil and Tasmanian wolf are flesh-eaters, with sharp claws and sharp strong teeth (fig. 35). The opossums of America are insect-eaters, and have sharp and numerous teeth; they are the only marsupials which live outside the great Australian region, to which all the others are confined, and of which they are almost the sole mammalian inhabitants. Some of

the opossums have the pouch rudimental, and the mother carries her young ones on her back, often

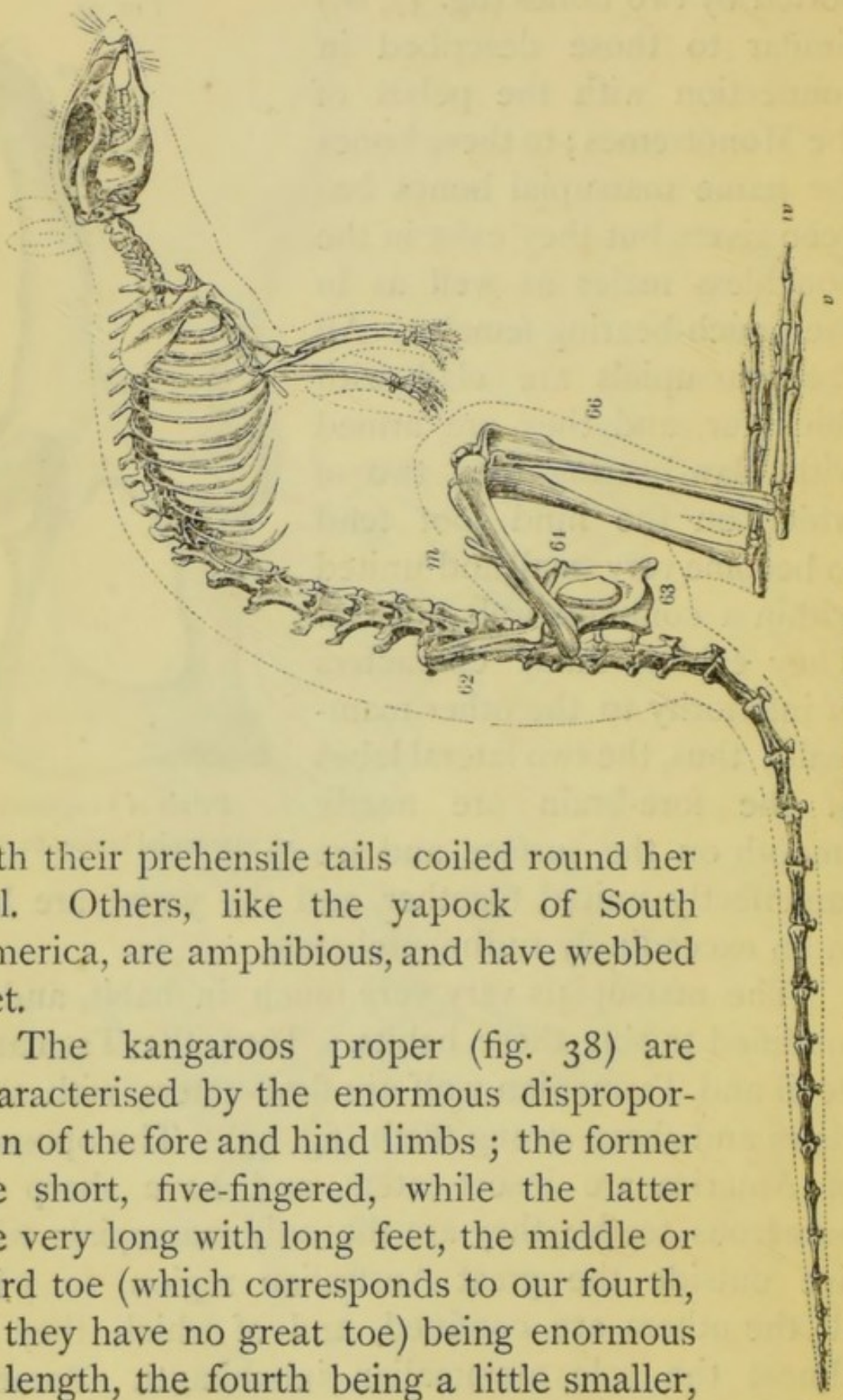


FIG. 38. Skeleton of kangaroo.

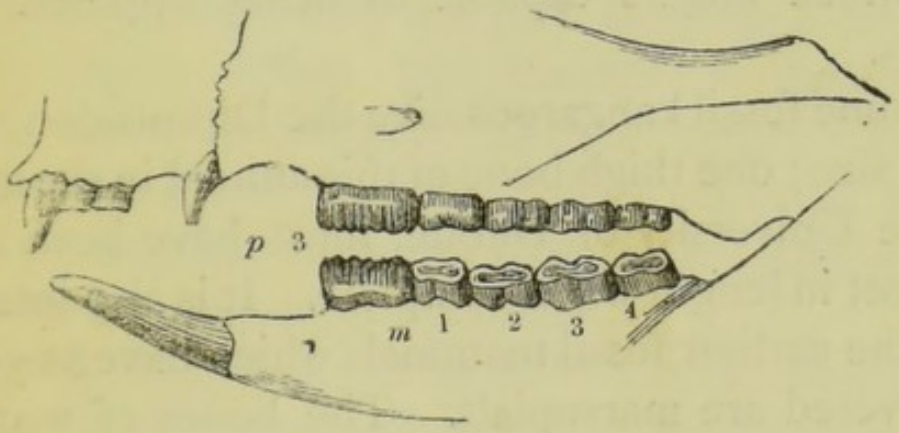
with their prehensile tails coiled round her tail. Others, like the yapock of South America, are amphibious, and have webbed feet.

The kangaroos proper (fig. 38) are characterised by the enormous disproportion of the fore and hind limbs; the former are short, five-fingered, while the latter are very long with long feet, the middle or third toe (which corresponds to our fourth, as they have no great toe) being enormous in length, the fourth being a little smaller, while the first and second are united and excessively

slender. The tail is thick and with the hind legs makes a tripod whereupon the animal rests when standing. In feeding, the animal bends down so as to rest on the short forepaws, and in running it progresses by a series of long leaps or bounds in which it uses only its hind legs.

The largest living kangaroos are about five to six feet high when standing; but the majority of the species are small, some being not larger than a rat.

FIG. 39.



Teeth of kangaroo rat.

These true kangaroos are herbage-feeders, and they have a complexly-pouched stomach to enable them to digest green food. Their teeth generally are:—

$$I\,\frac{3—3}{1—1},\ C\,\frac{0}{0},\ \text{or}\ \frac{1}{0},\ P\,\frac{1—1}{1—1},\ M\,\frac{4—4}{4—4}.$$

The phalangers, or Australian opossums, are fruit-eaters for the most part, and like the opossums of America they have an opposable thumb on the hind foot, which thus is able to act in grasping like a hand. Some of these phalangers have wing-like side folds of skin stretching from the fore to the hind limbs, whereby they are able to take long flying leaps.

The wombat is a burrowing and gnawing marsupial, whose chisel-shaped incisor and other teeth continue permanently to grow, and thus the waste of tooth-tissue which takes place in the process of grinding the roots and twigs which constitute its food, is restored. This animal is about $2\frac{1}{2}$ feet long, and, like the koala or native bear of Australia, has an accessory gland in the stomach, and a long cæcum or pouch, where the large and small intestines unite. They are both also almost tail-less, and the koala has its thumb and index fingers capable of being opposed to the others.

Some fossil kangaroos, like the Diprotodon, were of great size; one thigh bone of this animal in the museum of the University of Dublin, must have been at least two feet in length when complete. It is also interesting that the earliest fossil mammals which have as yet been discovered are marsupials. The bones of marsupials are, in general, easily recognised; thus the lower jaw has an inflexed angle, whereby it can be distinguished from that of any other mammal. The dentitions of marsupials are very variable, as can be seen from the four subjoined examples :—

Kangaroo (fig. 37)	$I\frac{3-3}{1-1}, C\frac{1-1}{0-0}, P\frac{1-1}{1-1}, M\frac{4-4}{4-4}$.
Wombat . .	$I\frac{1-1}{1-1}, C\frac{0-0}{0-0}, P\frac{1-1}{1-1}, M\frac{4-4}{4-4}$.
Myrmecobius or banded anteater	$I\frac{4-4}{3-3}, C\frac{1-1}{1-1}, P\frac{2-2}{3-3}, M\frac{5-5}{6-6}$.
Tasmanian devil (fig. 35)	$I\frac{4-4}{3-3}, C\frac{1-1}{1-1}, P\frac{2-2}{2-2}, M\frac{4-4}{4-4}$.

CHAPTER XVI.

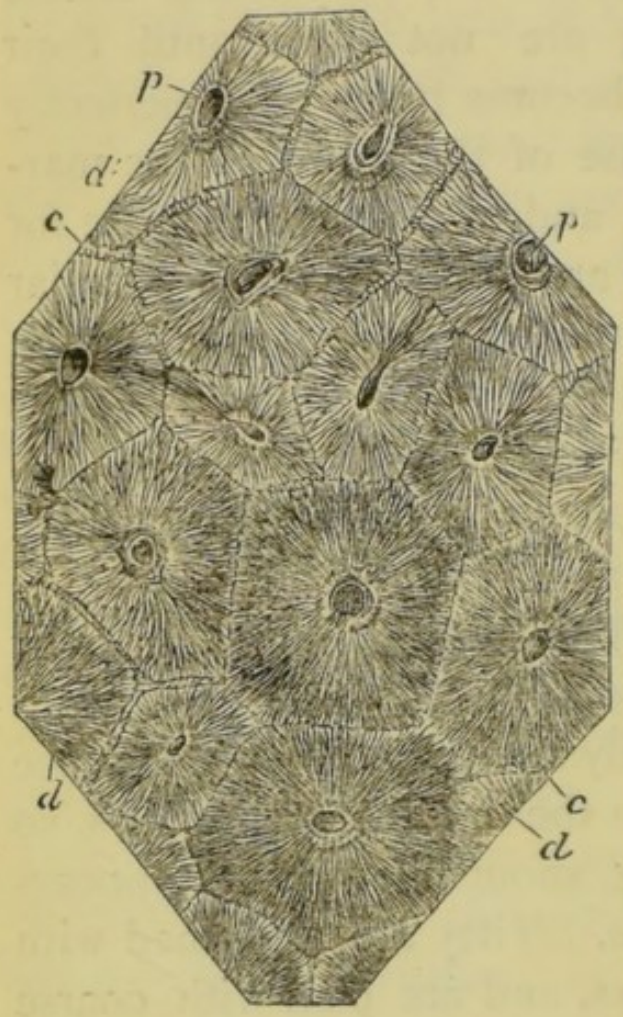
PLACENTAL MAMMALS.

55. **The Placenta.**—In all the succeeding orders of mammals the young are not born until their internal organisation has become much more perfectly developed than in the case of the young of the marsupials and monotremes; and in order to provide for their nutrition while they are thus growing, a peculiar vascular organ, called the *placenta*, is developed, whereby blood is supplied to the embryo for its nourishment; hence they are called placental mammals to distinguish them from the marsupials, which are named non-placental mammals.

Order 3, Edentata.—The third mammalian order is known as *Edentata*, and includes the anteaters and armadillos, which are easily recognised by the absence of incisor teeth, at least in the middle of the jaws, so that the front of the long, snout-like mouth appears toothless, hence the name. They are all armed with strong, usually sharp claws, and are clad with coarse hair, or else with hard scales, and feed on insects, small animals, or carrion. The true anteaters are natives of South America, and are quite toothless (fig 34). They have exceedingly long, worm-like tongues, which they can protrude for the purpose of entrapping the insects whereon they feed; and they have an enormous pair of glands in the neck which secrete a glutinous fluid to render the surface of the tongue sticky. This long tongue they can retract rapidly,

and in order to enable them to accomplish this, the retractor muscle extends back to the hinder end of the breast-bone, which itself is often enormously elongated. Some anteaters are over five feet in length, others are much smaller. The great Cape anteater of South Africa is closely allied, but has a strap-like tongue and grinding teeth, which are peculiar in their structure, as each tooth consists, not of a single papilla like the teeth of most other animals, but of a closely united bundle of separate papillæ (fig. 40). The pangolins of Africa and Asia are covered with overlapping epidermal scales, and are also toothless and insect-eaters. They all have enormous claws on their hands for tearing open the ant-hills so as to reach their prey.

FIG. 40.



Tooth of *Orycterope* or Cape Ant-eater magnified, showing the separate papillæ, *p*, of which each tooth is made up ; *d*, dentine, or tooth-substance ; *c*, cement.

The second family, or the armadillos, are South American, scale-covered burrowing animals, with grinding teeth and a short tongue. They feed chiefly on carrion or small animals, and their dermal armour is arranged in transverse girdles or bands which may be movable on each other.

The Edentates now existing are all of moderate or small size, but from the remains of fossil forms we

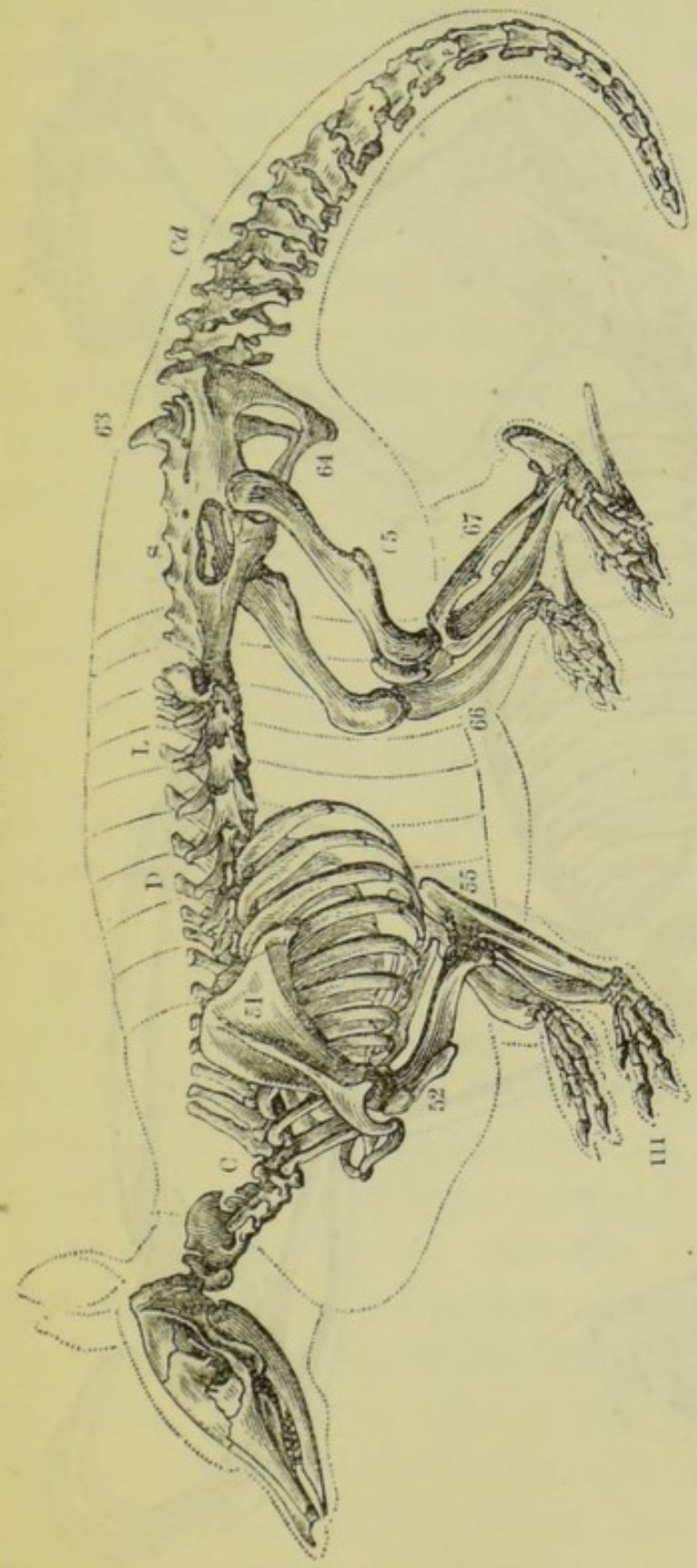


FIG. 41.

Skeleton of Peba armadillo.

C, cervical vertebræ; D, dorsal region, with the outline of the girdles of epidermal scales; L, lumbar region; S, sacrum; *Cd*, caudal or tail region; 65, femur or thigh-bone (the number is opposite the point of the third trochanter); 66, tibia; 67, fibula; 51, scapula; 52, humerus; 55, ulna.

know that some of them must have been of gigantic proportions.

56. **Order 4, Bradypoda, or Sloths.**—These are tail-less animals inhabiting South America. They

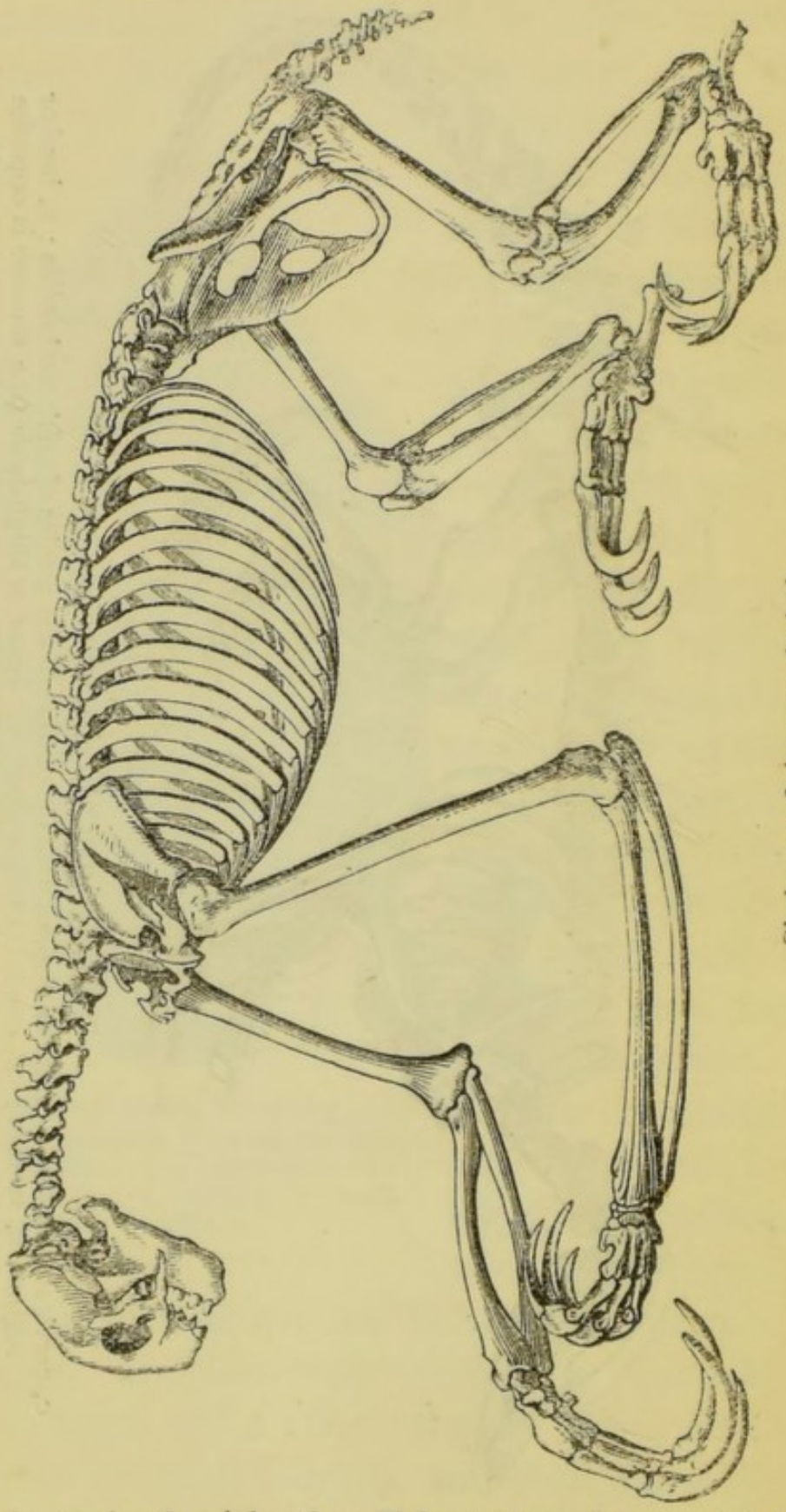


FIG. 42.

Skeleton of three-toed sloth.

are often united with the Edentates, from which they

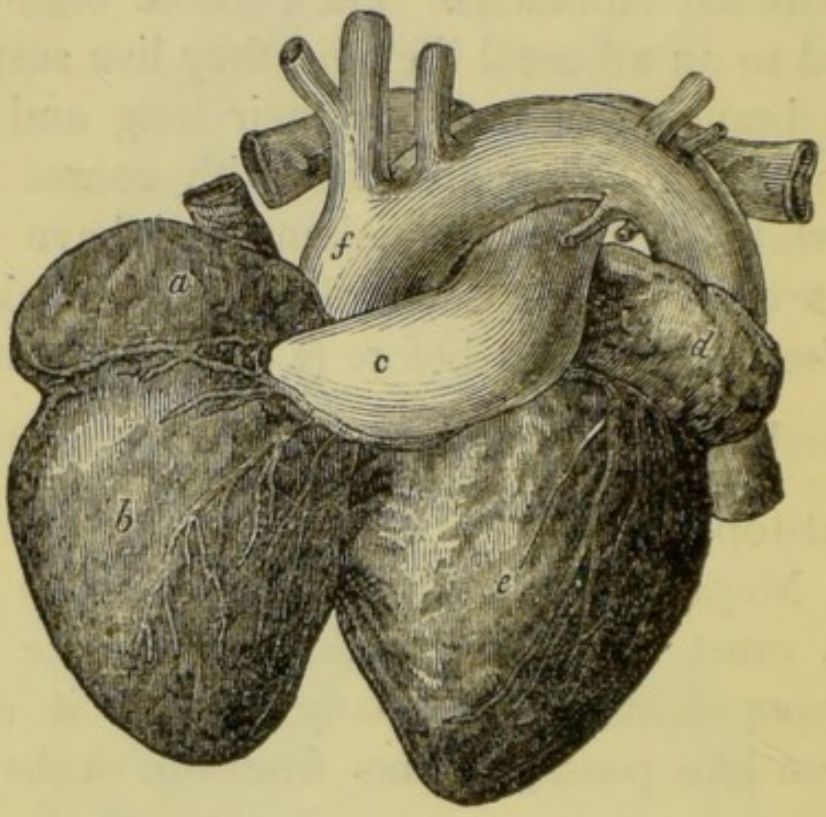
differ in the possession of short round heads, not prolonged into a snout, with a lower jaw of one piece, even from a very early age, and also by having a very remarkable down-directed process of the malar or cheek-bone. They are strictly vegetable-feeders, and have sacculated stomachs. Their whole organisation is adapted to an arboreal life, and they live suspended from the branches of trees by their long and strong hook-like claws. They are clad with coarse hair of a dirty white or brownish colour, and have two or three toes only. The peculiarity of their neck vertebræ has been alluded to before (§ 49). They have no incisor teeth and $\frac{4—5}{5}$ molars, which are simple and nearly flat-topped.

The Megatherium, a fossil sloth from South America, must have been little less in size than a large hippopotamus. In many respects it and its allies seem like passage forms from the sloths to the armadillos.

57. **Order 5, Sirenia or Manatees**, constitute a small group of sea-weed-eating marine animals, of a somewhat fish-like habit and form, usually found near the mouths of rivers. They have a thick skin, sparsely covered with bristles, and flat-crowned grinding teeth. They have no hind limbs, and the fore-limbs are converted into paddles. The heart in some is deeply cleft, the right and left ventricles being nearly separate from each other (fig. 43). One animal of this group, the Rhytina, which inhabited some islands in Behring's Strait, has become extinct within the last century. Another, the dugong, inhabits the Indian Ocean,

while the manatee or mermaid is a native of the opposite shores of the South Atlantic, extending from South America to Africa. These are often confounded with whales, but can be known therefrom by their

FIG. 43.



Heart of dugong, showing the separation of the ventricles.

a, right auricle ; *d*, left auricle ; *b*, right ventricle ; *e*, left ventricle ; *f*, aorta ; *c*, pulmonary artery.

possessing a neck, a movable elbow-joint, a trace of nails, and nostrils far forward and not at the top of the head. They also, except the extinct Rhytina, possess teeth.

58. **Order 6, Ungulata**, includes all those herbivorous mammals whose extremities are used solely as organs of progression, and not of prehension, and in which each toe ends in a hoof or broad case of horny epidermis. They are usually animals of large size, and they have no collar-bones. Their brains, however, are small in proportion to the bulk of the body, and

the intestinal canal is of very great length. There are two chief sub-orders of these hoofed animals, the first consisting of such as have odd toes on their hind feet, and unsymmetrical toes on the fore feet. Of these odd-toed mammals, there are three living types—horses, tapirs, and rhinoceroses. The horse and ass have only a single toe developed on each limb, which corresponds to the third toe of ordinary mammals. They have also a dentition of

$$I\frac{6}{6},\ C\frac{1-1}{1-1},\ P\frac{4-4}{4-4},\ M\frac{3-3}{3-3}.$$

The two best known forms are the horse and the ass ; the former is characterised by its tail, hairy from its base, and by the wart-like callosities on the inner surface of its legs. Remains of horses are found in the bone caves of Britain and of South America, as well as in those of Continental Europe. The striped races of the genus *Equus* are confined to Africa; they are the zebra, the quagga, the dauw, &c., and are scarcely tameable. The wild asses inhabit Western Asia. Fossil horses are known, exhibiting all the intermediate grades of development of feet from the single hoof of the common horse to a perfect tridactylous condition with three functional toes.

The tapirs, natives of Malaya and of South America, are also uneven-toed ungulates, possessing three toes on their hinder, and four (but laterally unsymmetrical) toes on their fore feet. They are characterised by possessing a proboscis-like snout, and rather long legs. In number the teeth are equal to those in a horse.

The rhinoceros (fig. 44) is the third type of this sub-order, and is a native of Africa and the Malay

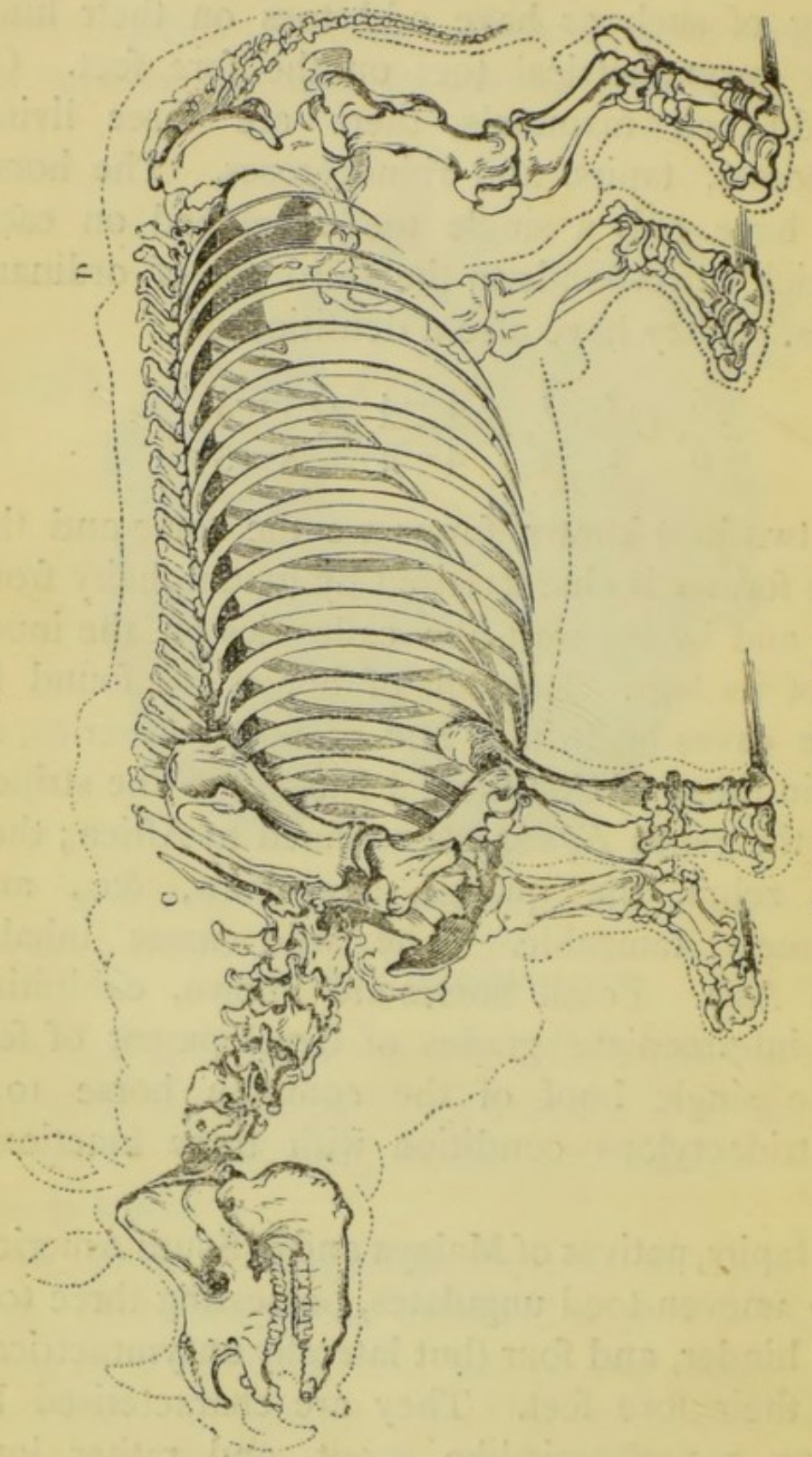


FIG. 44.

Skeleton of the rhinoceros.
The dotted outline shows the position of the horn and of the soft parts; the thigh bone shows the third trochanter.

archipelago; the foot is three-toed, and the skin of

enormous thickness and often folded. The leading characteristic is the long epidermal horn which is rooted in the dermis on the upper surface of the nose. This in structure consists of a tuft of confluent hairs, and sometimes grows to several feet in length, and is of great hardness; the horn is always medial, and usually single, when two exist they are placed one in front of the other. At one time a species of rhinoceros clothed with a woolly coating inhabited Great Britain and the northern parts of Europe and Asia, but it became extinct in prehistoric times.

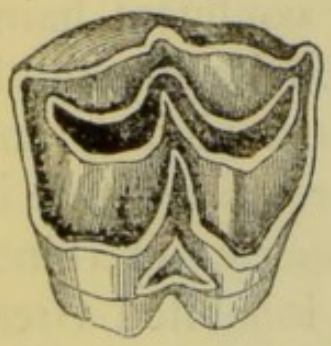
All these odd-toed ungulates have at least twenty-two vertebræ in their trunk, interposed between the neck and the sacrum, and they all have a bony knob or third trochanter on the outside of the shaft of the thigh bone for the attachment of muscles. See fig. 44, also figs. 41, 65.

The second sub-order of hoofed animals includes those whose toes are in even numbers, two or four, and are laterally symmetrical (when there are four, two are in front and two behind). They have for the most part nineteen dorso-lumbar vertebræ, and none of them have the protuberance on the thigh-bone referred to above. Many of them have horns, but these are always on the forehead, and one on each side, never median as in the rhinoceros.

59. **Swine and Hippopotami.**—There are two very well-marked divisions of these even-toed ungulates. In one of these the animals have simple stomachs, and the grinding teeth have little knobs or protuberances on their surfaces, hence these are called *Bunodonts*; in the other group the stomachs are complex,

and the hardest layer of the teeth (the enamel), is arranged in crescents; these are known as *Ruminants.*

FIG. 45.



Crown of the tooth of a deer, showing the enamel crescents.

Of the bunodonts the pigs are the most familiar examples. Our domestic pigs are derived from the wild boars of Southern Europe and Asia, animals which formerly inhabited Great Britain in a wild state. The babyroussa of the Malay Islands is a singular pig whose upper canine teeth grow upwards and arch backwards so as to reach the forehead where they end in a curled point. Most of the pigs have large tusk-like canines, and their teeth are usually represented by the formula

$$I\,\frac{3-3}{3-3},\ C\,\frac{1-1}{1-1},\ P\,\frac{3-3}{3-3},\ M\,\frac{3-3}{3-3}.$$

The hippopotamus of the rivers of Africa is an enormous pig-like creature, with very short legs and a heavy body, and with long tusk-like incisors, two in each jaw ; it sometimes reaches a length of nine feet.

60. **Ruminants.**—The ruminants are so called because they chew the cud, that is, they subject their food to a second chewing after it has been swallowed. They are, for the most part, large soft-fleshed animals, the favourite prey of large carnivores, and as the food which they require for their nourishment is bulky, being green herbage, and only to be obtained in open places of pasturage, where they would be exposed without shelter to the assaults of their enemies, it becomes a matter of vital importance for their well-

being that the process of mastication, a long and tedious one in the case of such food, should be kept over until the animal has laid in its store of provisions

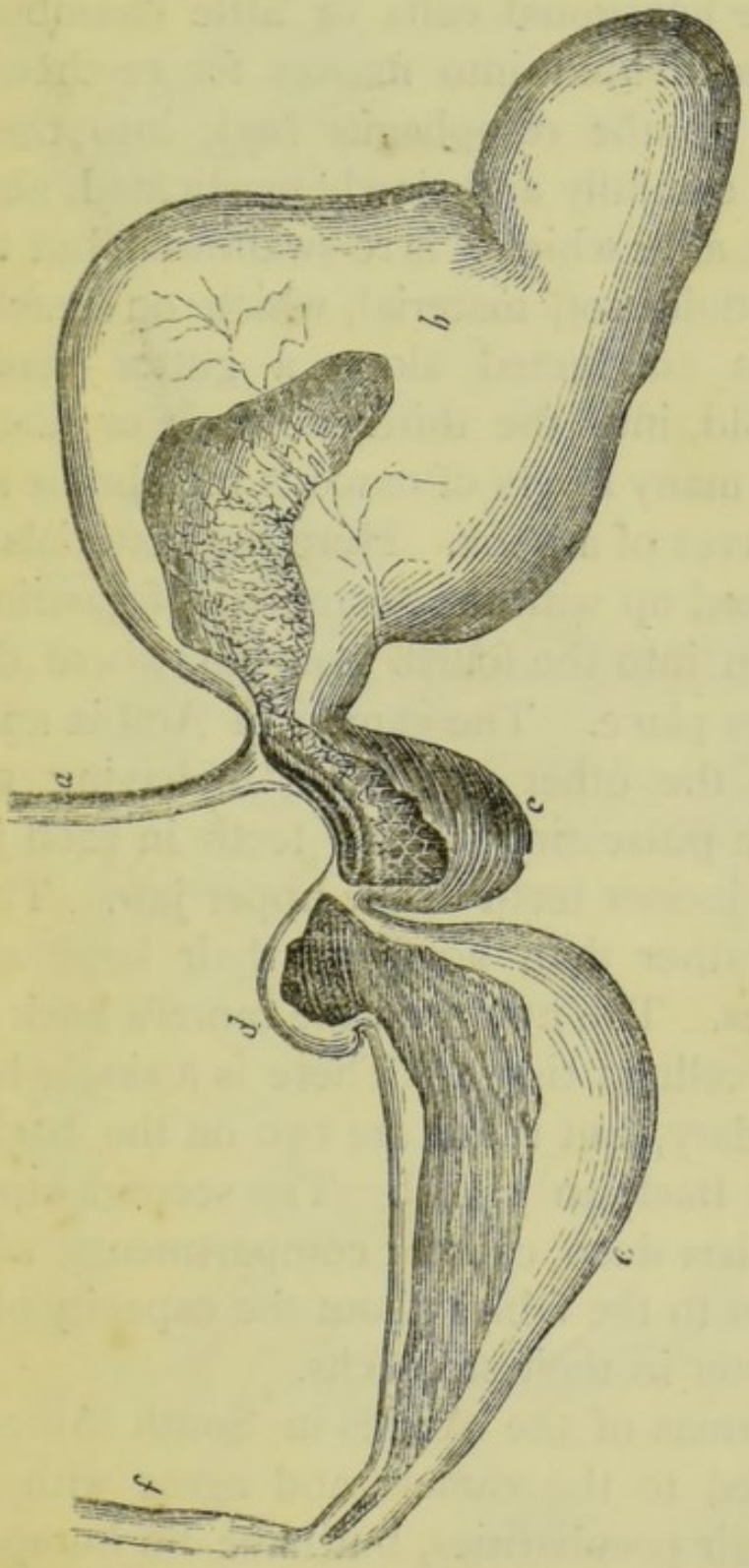


FIG. 46.

Stomach of sheep, showing the four compartments.

a, œsophagus; *b*, paunch; *c*, honey-comb, or reticulum; *d*, liber, or manyplies; *e*, true digestive stomach; *f*, commencement of intestine.

and retired to a sheltered hiding-place. Accordingly the stomach of a ruminant is divided into four com-

partments, and into the first of these (called the *paunch*) the food is taken when first swallowed; then it passes into the second division, which consists of many large hexagonal cells or little chambers; here it becomes divided into masses for re-chewing, and these pass up the œsophagus back into the mouth, where it is carefully and slowly masticated, and mixed with saliva, after which it is re-swallowed, but this time as a semi-fluid soft material, which on reaching the stomach is conducted along a gutter made by a mucous fold, into the third stomach or liber, which consists of many layers of mucous membrane arranged like the leaves of a book. Here the materials are still farther mixed up with the secretions of gastric glands, and pass on into the fourth stomach, where digestion finally takes place. The camels of Arabia and Africa differ from the other ruminants in having no third stomach, in possessing canine teeth in each jaw, and two lateral incisor teeth in the upper jaw. They have also nails rather than hoofs on their large and well-padded toes. The hump on the camel's back consists of fat and cellular tissue. There is a single hump on the dromedary, but there are two on the back of the Arabian or Bactrian camel. The second stomach of the camel has deep cells or compartments, which has given origin to the fables about the capacity of camels to store water in their stomachs.

The llamas of the Andes in South America are closely allied to the camels, and agree with them in most of their peculiarities, but have no humps. The musk-deer, which inhabit the mountainous regions between the Himalaya and the Altai mountains, have

also canine teeth, and are distinguished by the presence of a pair of odour-secreting musk-glands.

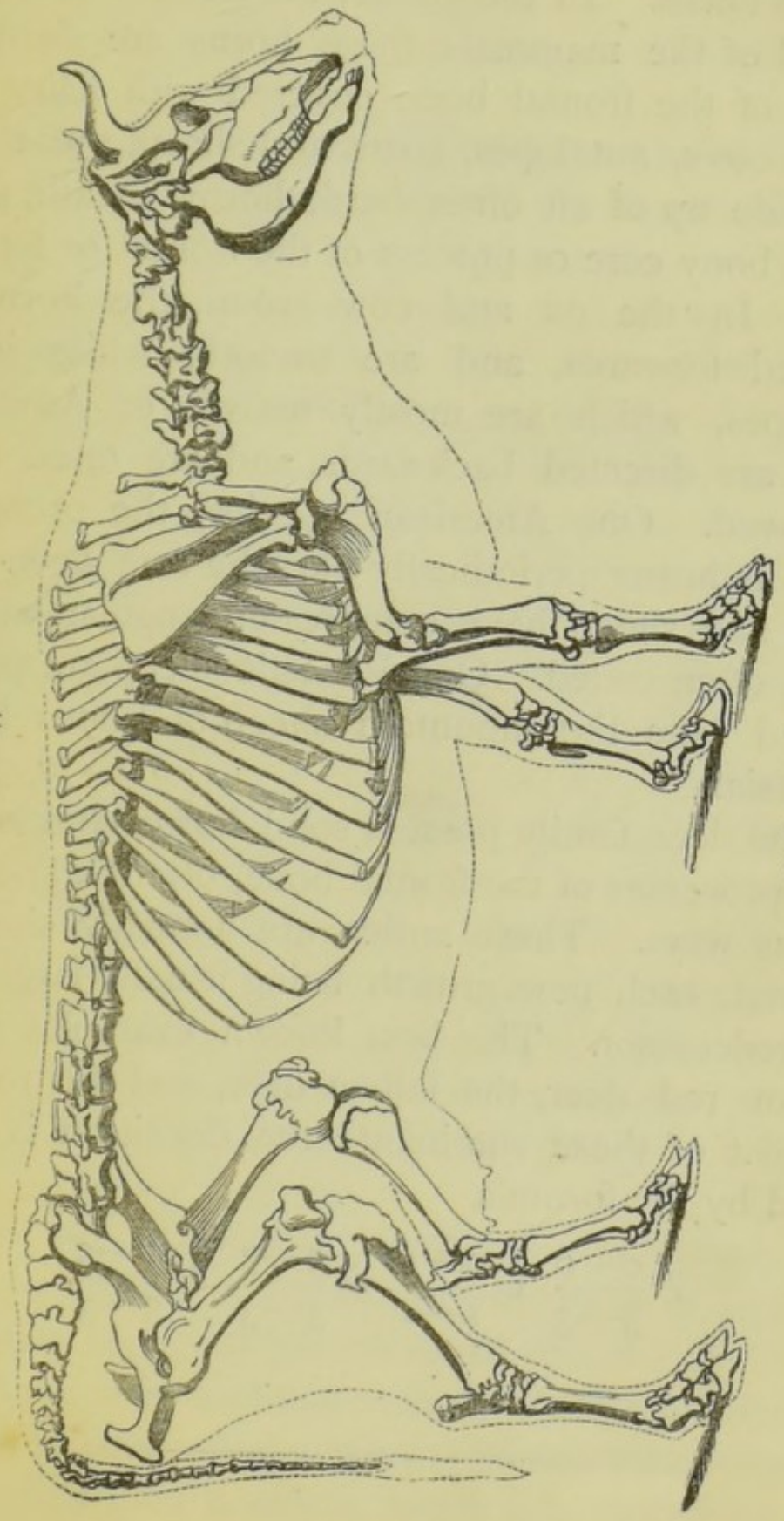


FIG. 47. Skeleton of cow.

The other ruminants have neither canine nor incisor teeth in the upper jaw, and most of them possess horns. In the giraffe, the tallest and longest-necked of the mammals, these horns are short processes of the frontal bone covered with hairy skin. In the cows, antelopes, goats and sheep, these horns are made up of an outer hard, horny sheath, placed over a bony core or process of the frontal or forehead bone. In the ox and cow group, the horns are directed forwards, and are smooth, while in the antelopes, which are mostly natives of Africa, the horns are directed backwards, and are often ringed or waved. One American species, the pronghorn, sheds its horns periodically like the true deer. The goats and sheep have compressed angular wrinkled horns, often coiled. Our domestic sheep are possibly derived from the mountain sheep of South Europe and Asia.

The deer family possess solid horns composed of bony processes of the frontal bone, often branched in various ways. These antlers are annually shed and renewed, each new growth being usually larger than its predecessor. The best known examples are the stag or red deer, the fallow deer, and the roebuck. In most of these ruminants the dentition is represented by the formula

$$I\,\frac{0-0}{3-3},\ C\,\frac{0-0}{1-1},\ P\,\frac{3-3}{3-3},\ M\,\frac{3-3}{3-3}.$$

CHAPTER XVII.

CLASSIFICATION OF MAMMALS—*continued.*

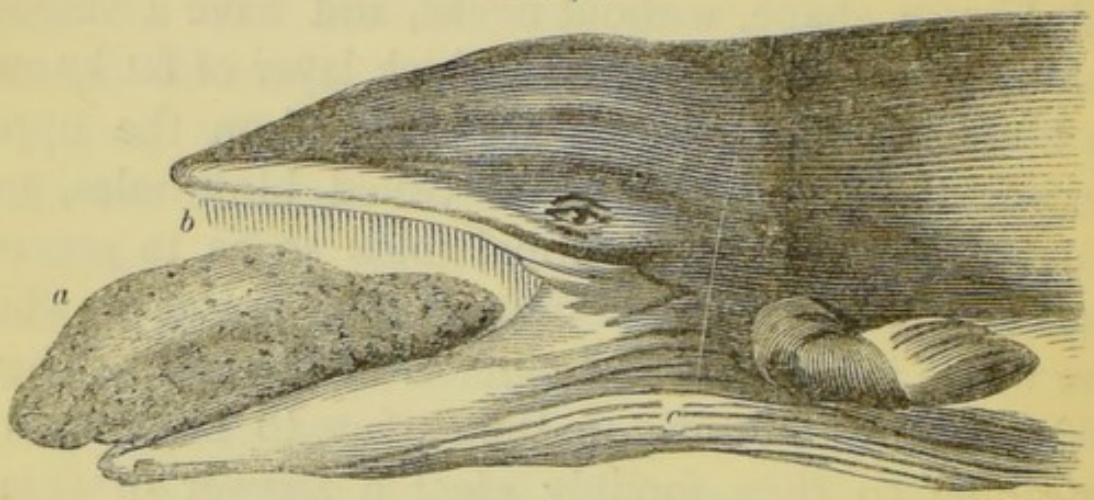
61. **Order 7, Cetacea (Whales).**—These, like the Sirenia, are marine mammals with no hind limbs, and having the fore limbs converted into fins. They are fish-like in shape, without necks, and have a smooth thick skin beneath which is a thick layer of fat known as blubber. The nostrils are situated on the upper surface of the head, and are called blow-holes, and are well protected by dermal folds so as to prevent the entrance of water into the air-passages while the whale is beneath the surface of the sea. These animals require to rise to the surface to breathe, and on doing so they forcibly eject a shower of spray, consisting of the mucus secreted by the membrane of the nasal passages, the vapour of the breath, and whatever sea water lurks in the crevices about the nostril; this process is called blowing, and it is in reality somewhat like a forcible sneeze preparatory to a deep inspiration. The sense of smell is almost or altogether absent. There are seven cervical vertebræ, but they are usually united together so as, in old whales, to form one bone.

The tail in whales consists of two lateral, horizontally-placed lobes consisting of folds of skin and connective tissue appended to the end of the vertebral column; this is the chief instrument of locomotion.

The mouth in true whales is of enormous capacity, and as their food is mostly small fish, cuttlefishes and

molluscs, they require to take in very large quantities of this material for their nourishment, which they do in the following way. The jaw arches are covered all around their edges with horny plates of 'whalebone,' fringed with bristles in place of teeth, and these act as strainers. In feeding, the animal opening its mouth, takes in a mouthful of sea-water and its animal

FIG. 48.



Head and tongue of whale.

a, tongue (represented much too large); *b*, whalebone plates.

contents, and then by closing the jaws and pressing the tongue against the palate, expels the water through the slits between the whalebone plates, which by their opposition and by their bristly margin retain the solid materials to be subsequently swallowed.

In some whales there are exceedingly minute rudiments of the hind limbs, in the form of small ischia or pelvic bones, embedded in the muscles of the abdomen, and not visible on the surface.

Whales have usually complex stomachs, often with four chambers; they have also a moderately long alimentary canal, large and tortuous networks of blood-vessels along the ribs, and a thick fleshy diaphragm.

The large-headed sperm whales are often as much as sixty to eighty feet long. One third of the whole length is formed by the head, whose anterior bones, enormously dilated, are hollowed into a chamber which contains the substance called *spermaceti*, used in making ointments and cosmetics. These whales possess from fifty to sixty large conical teeth in the lower jaw, and therein differ from the baleen whales, which in some cases possess small embryonic teeth that disappear early and are replaced by the whalebone plates. The common porpoises, bottle-noses, and dolphins have numerous simple teeth in both jaws, and the narwhal has one enormous front tooth which sometimes grows to a length of $5\frac{1}{2}$ or 6 feet, forming a horizontal tusk. Whales are the largest of animals, and have been seen over ninety feet in length.

62. **Order 8, Pinnipedia.**—This small order consists of the seals and walruses, and forms a connecting link between the whales on the one hand and the bears on the other. They are aquatic, fish-eating, hair-clad mammals, with four fin-like limbs, each provided with five webbed digits. The hind-limbs are stretched horizontally backwards on the same line as the tail, to which they are very closely united. They have roundish heads provided with numerous sensitive bristles, large eyes, and loosely united facial bones. They have valvular nostrils, no external ears, simple stomachs, and large venous cavities to hold the impure blood while respiration is suspended during diving.

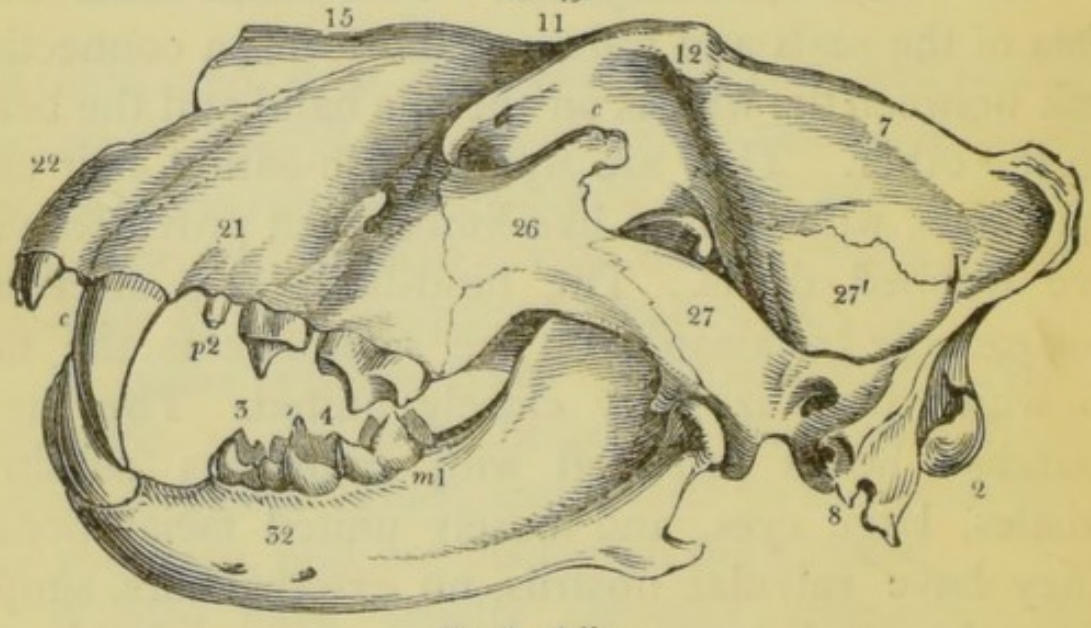
Most seals are marine, but some live in fresh-

water lakes as in Lake Baikal. Our common seal is inoffensive and easily tamed. The walrus, known by its huge tusks or canine teeth, used for digging up the molluscs on which it feeds, sometimes reaches twenty feet in length. The fur seals, whose beautiful skins are of such commercial importance, are natives of the Southern Atlantic and Pacific Oceans. The dentition of the common seal is

$$I\,\frac{3-3}{2-2},\ C\,\frac{1-1}{1-1},\ P\,\frac{3-3}{3-3},\ M\,\frac{3-3}{2-2}.$$

63. **Order 9, Carnivora.**—The flesh-eating mammals are the cats, dogs, weasels and bears, known by possessing sharp claws, long pointed canine teeth, a simple stomach, and a short intestine. The lower jaw is constructed to move only in the vertical plane up and down, having no lateral motion, the condyle

FIG. 49.



Skull of lion.

7, med an temporal crest; 12, post-orbital process; 15, nasal bone.

being transversely lengthened. The molar teeth are ridged and sharp, so as to be fitted for dividing flesh.

They never have collar-bones. The skull of a carnivore can be easily known by the prominent medial crest for the attachment of the powerful muscles which move the lower jaw (fig. 49, 7).

The dog is a typical carnivore, whose teeth are represented by the formula

$$I\,\frac{3-3}{3-3},\ C\,\frac{1-1}{1-1},\ P\,\frac{4-4}{4-4},\ M\,\frac{2-2}{3-3}.$$

In progression dogs are digitigrades, that is they only rest on the last joint of their toes in walking, and their claws are blunt, not capable of being retracted. The numerous races of dogs cannot be sharply marked off from each other, nor can some of the varieties of the dog be sharply differentiated from wolves. The wolf has usually erect ears and larger teeth, but no absolute point of difference can be relied upon. The fox has an oval pupil and a more bushy tail. All the true dogs have comparatively smooth tongues.

The family *Felidæ*, or cats, are also digitigrade carnivores, but they differ from the *Canidæ*, or dogs, in having the claws capable of retraction when not in use, and thus they are preserved from undue friction and are sharp; the retraction is accomplished by means of lateral elastic ligaments. The cats are more purely flesh-eaters than the dogs, and usually hunt and kill their prey; their dentition is

$$I\,\frac{3-3}{3-3},\ C\,\frac{1-1}{1-1},\ P\,\frac{3-3}{2-2},\ M\,\frac{1-1}{1-1}.$$

The lion is a native of Africa and Asia, the tiger, the

strongest of the carnivores, is confined to Asia. Other forms are the panthers and leopards, the ounce, the jaguar or American leopard, the puma or American lion, the tiger-cats, ocelots, lynx, and domestic cats. This last-named is probably the descendant of the wild cat of Abyssinia tamed by the ancient Egyptians. The wild cat of this country is confined to the North of Scotland, and even there is very rare. The cheetah, or hunting leopard of India, has only partially retractile claws. The cats have all rough tongues armed with numerous sharp, recurved papillæ.

The hyænas are intermediate in some respects between the dogs and the cats. They have the dentition and rough tongues of the cats, with a more doglike form and non-retractile claws. They are nocturnal, and can be known by the peculiarly low hind-quarters in comparison with the fore.

Civets and mongooses make another family called *Viverridæ*, which usually possess odorous glands, rough tongues, short legs, and a semi-plantigrade mode of progression. The weasel and otter family, *Mustelidæ*, differ from these in their shorter, rounder heads, smooth tongues, and longer bodies. Many of these are sought for on account of their skins, such as the vison, ermine, sable, mink, &c. Others, like the weasel, skunk and pole-cat, are well-known vermin; the *Mustela foina*, or marten, was the domestic cat of the classic authors.

The plantigrade carnivores are those that bring their whole foot-sole to the ground when walking; they are bears, badgers, and kinkajous. The badgers

have scent glands, whereby they are easily distinguished. The kinkajou, a native of South America,

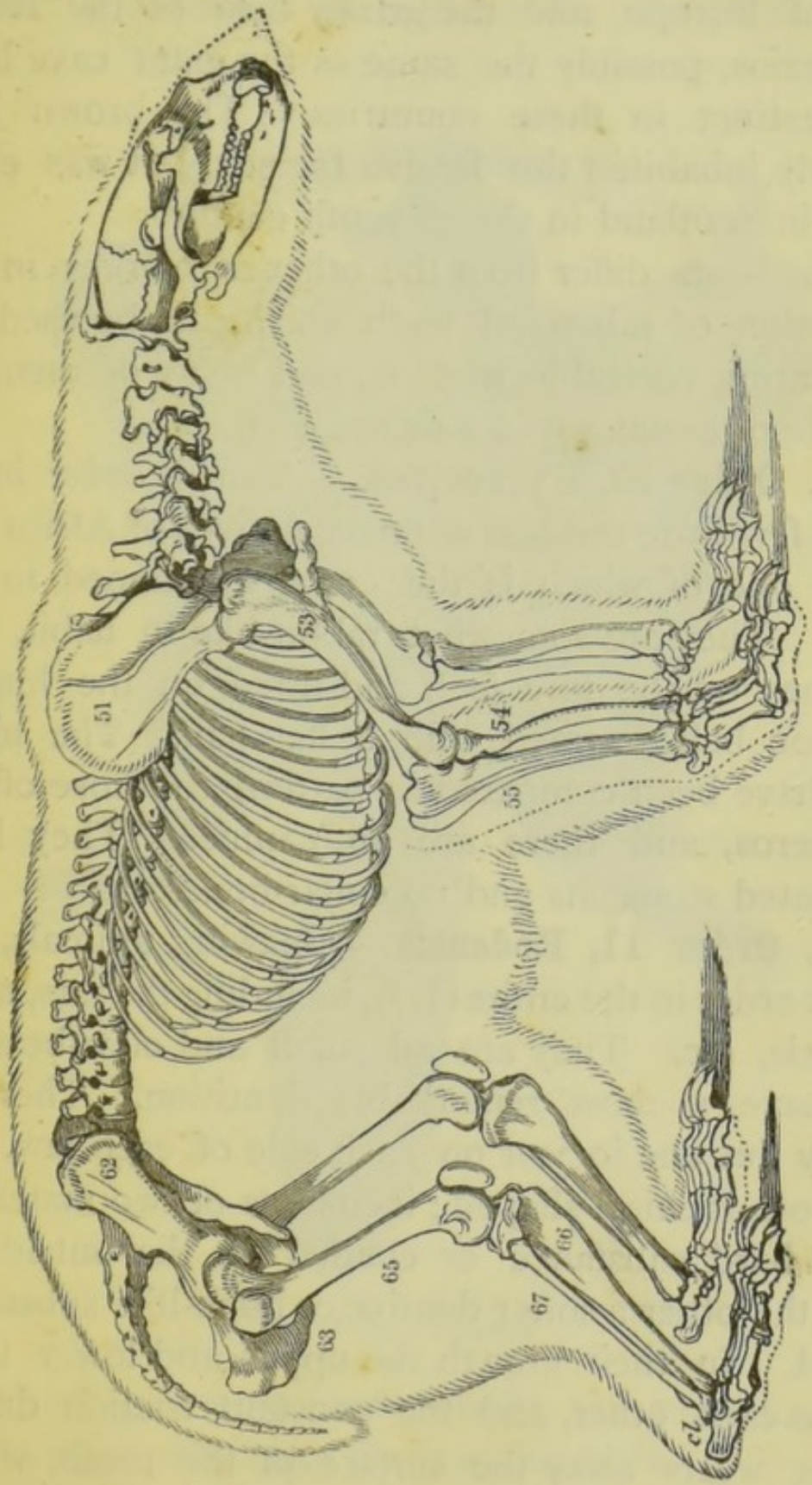


FIG. 50.

Skeleton of polar bear, showing the plantigrade feet.
The bones are numbered as in fig. 41.—53, humerus; 54, radius; 62, ilium; 63, ischium.

has a prehensile tail and retractile claws. The best

known of the bears are the polar or white bear of the Arctic regions, the black bear of America, the brown bear of Europe, and the grizzly bear of the Rocky Mountains, possibly the same as the giant cave bear, now extinct in these countries. The brown bear formerly inhabited the British Islands, but was extirpated in Scotland in the eleventh century.

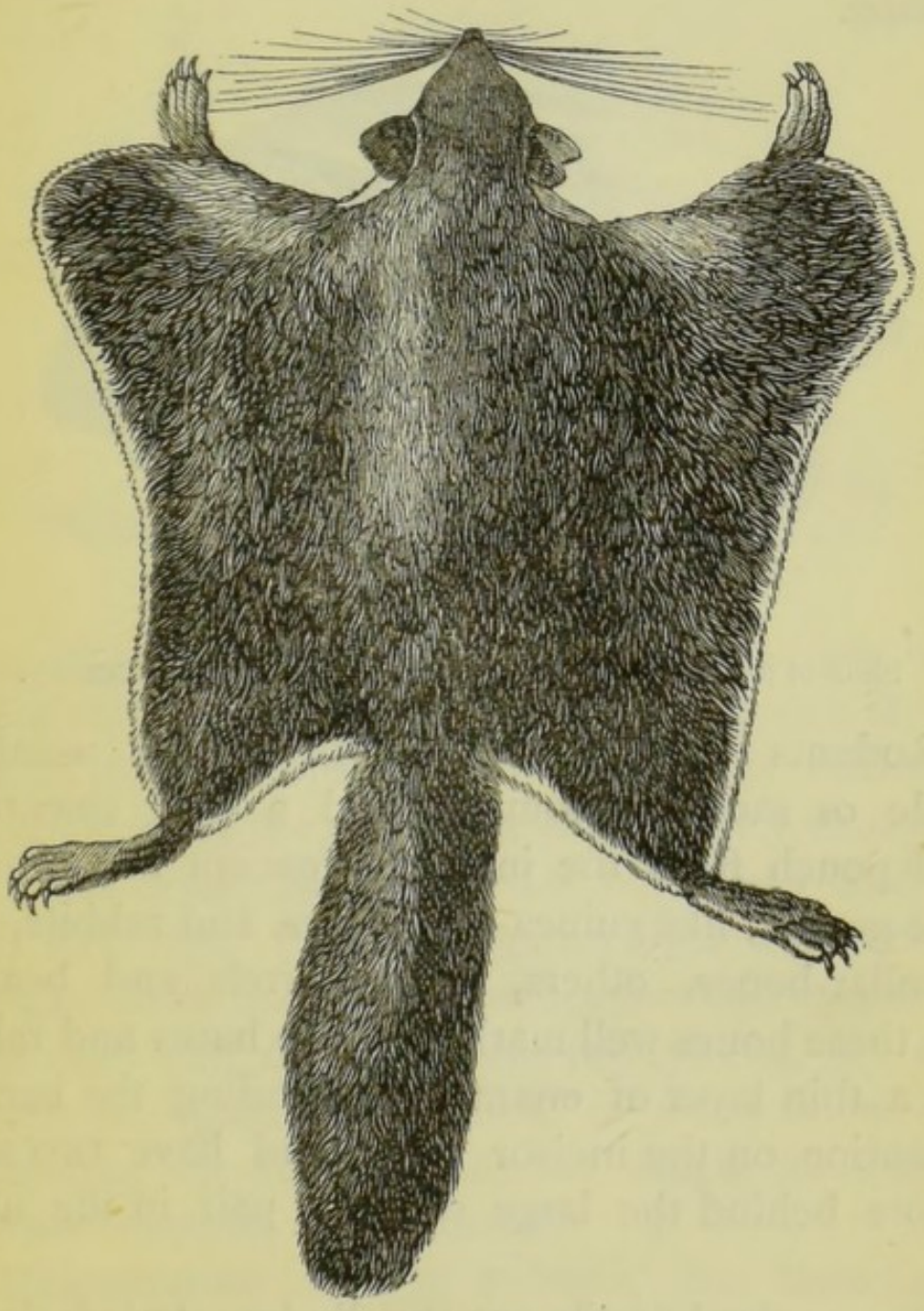
The bears differ from the other carnivores in the possession of tubercled teeth which can be used for masticating vegetable matters, and many of them are capable of partaking of a mixed diet.

64. **Order 10, Hyracoidea.**—A small order including a few little tail-less animals, natives of Africa and Syria, one of which is the cony, mentioned in the Bible. They are somewhat rabbit-like in habit, with four toes on the fore feet, and three on the hinder, each toe being armed with a flat nail. The molar teeth have been compared in pattern to those of the rhinoceros, and there are no canines. They have sacculated stomachs and no collar-bones.

65. **Order 11, Rodentia.**—Gnawing animals, the largest order in the entire class, including the rats, mice, squirrels, &c. They are all small and claw-bearing, and have a most remarkable dentition. There is usually but one incisor on each side of each jaw, and this tooth is chisel-shaped; it consists of two materials, one a hard substance or enamel on the outside or front, the other a softer dentine or bone-like substance behind. In their growth the upper and lower teeth oppose each other, and the constant friction during feeding wears away the surface of the tooth, which however is constantly growing, but as the soft dentine

wears away more quickly than the harder enamel, the tooth is kept constantly sharp; hence when one incisor in a rodent is broken, the one that should

FIG. 51.



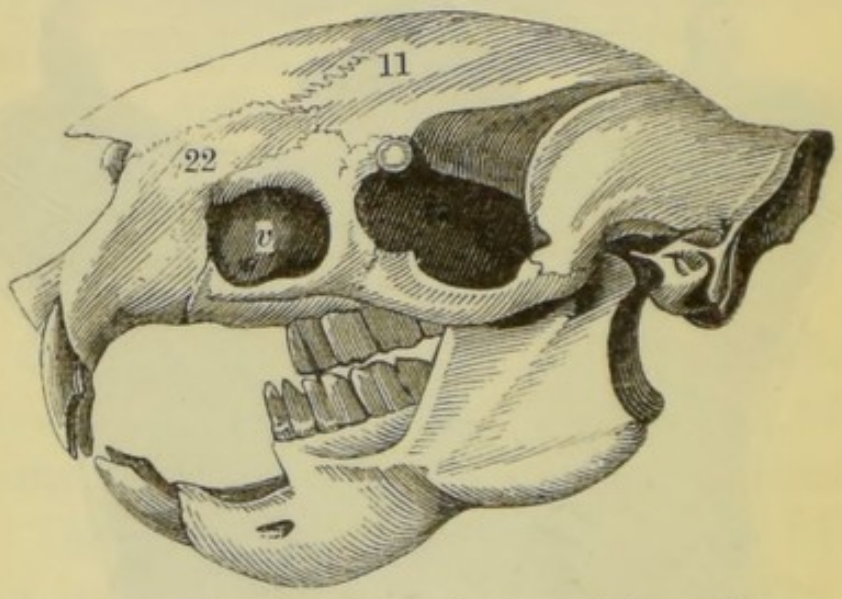
Flying squirrel.

oppose it grows on continuously, and sometimes this mode of growth locks the jaws together.

There are no canine teeth in rodents, and the

molars are separated from the incisors by a long interspace. The lower jaw is large, and its condyle is so articulated as to permit it to slide backwards and forwards in mastication, thus giving the power of gnawing.

FIG. 52.



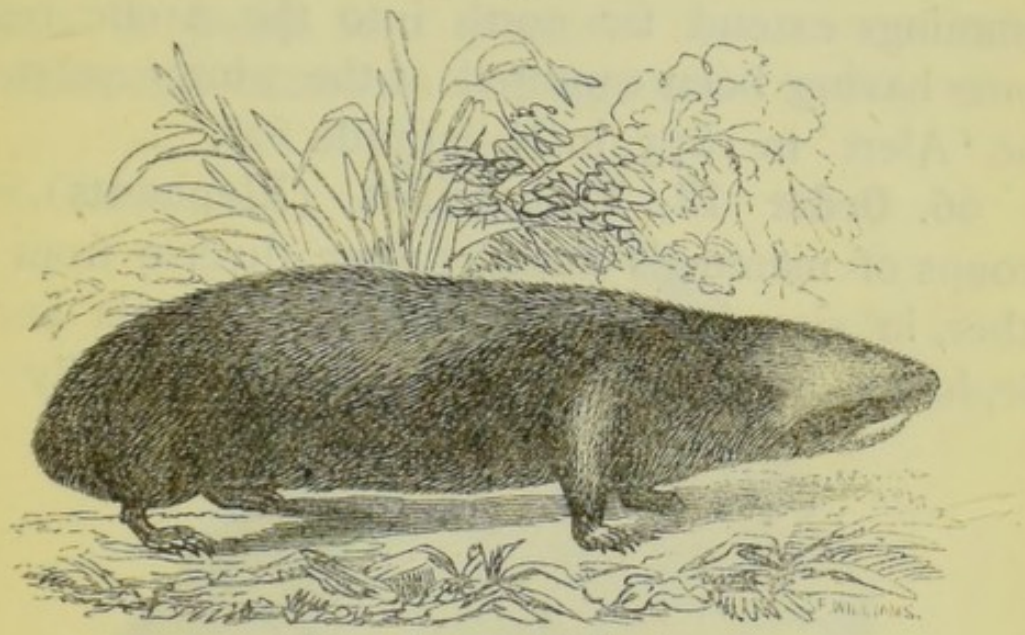
Skull of porcupine, showing *v*, the large infra-orbital cavity.

Rodents have small, smooth brains, usually a simple or saccular stomach, and a long cæcum or blind pouch from the intestine (except in dormice). Some genera, like guinea-pigs, hares, and rabbits, have no collar-bones, others, like squirrels and beavers, have these bones well marked. The hares and rabbits have a thin layer of enamel surrounding the backing of dentine on the incisor teeth, and have two small incisors behind the large ordinary pair in the upper jaw.

The squirrel family are usually long-tailed elegant creatures, and in one genus, the flying squirrel (fig. 51), there is a lateral parachute of skin stretching from the fore to the hind limbs. The beavers have flat scaly tails and webbed hind feet. The rats and mice

are known by their long cylindrical scaly tails, and usually rooted teeth (except in the voles). The common grey rat, introduced from the banks of the

FIG. 53.



The spalax, or blind rat.

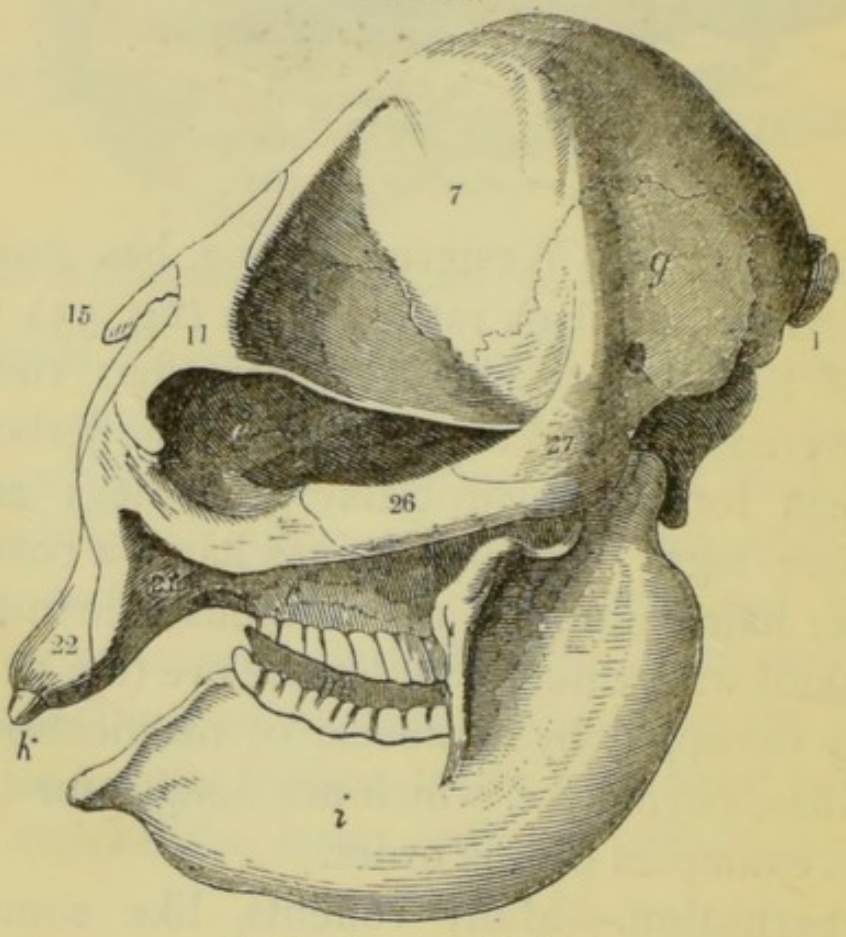
Volga in 1727 into Western Europe, has now nearly exterminated the black rat. Spalax (fig. 53), the rat-mole of SE. Europe and NW. Asia, has rudimental eyes covered by the skin, and Dipus, the jerboa of the East, has long, kangaroo-like hind legs and very small fore legs. The porcupines have a covering of quill-like hairs, and have an enormous hole in the front of the skull wall, directly under the eye (fig. 52), which is partly occupied by a muscle of mastication. The chinchillas, coypu, &c. which are sought for their fur, are also examples of this order.

Hybernation.—Many rodents, like some mammals of other orders, bears, bats, &c., spend their winter in a condition of sleep: this process is called hybernation. Previous to retiring to this rest, these animals store up fat in different regions of the body,

especially in a large gland called the thymus, placed in the thorax, or cavity of the chest, in front of the heart. This fat is absorbed during the winter, and the animal arises next spring lean and hungry. The lemmings extend far north into the Arctic regions, some having been captured at the winter quarters of the 'Alert' in 1875, in N. latitude 82°.

66. **Order 12, Proboscidea (Elephants).** — No groups of mammals appear more diverse from each other, in size at least, than do the rodents and the elephants, and yet the latter are structurally more

FIG. 54.



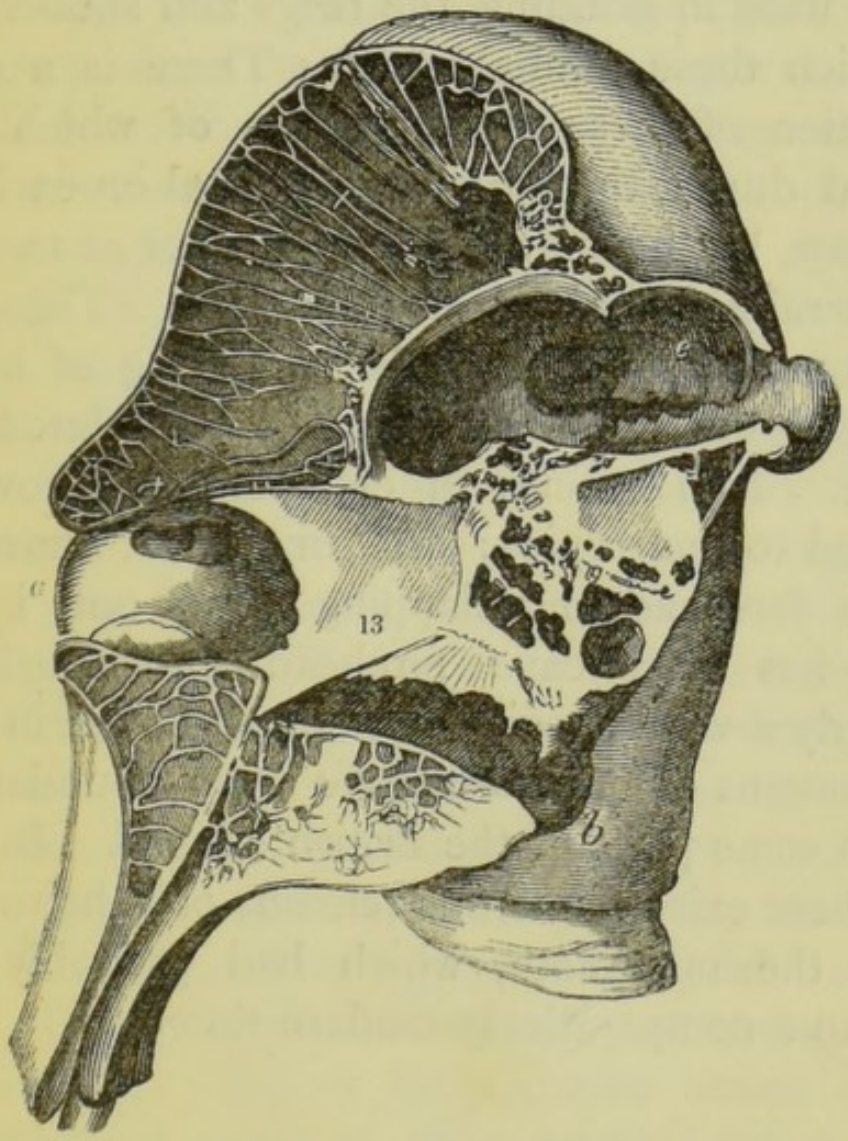
Skull of young elephant.

22, the premaxillary bone, containing the root of the tusk *k*; 15, nasal bone; 7, temporal region; 26, zygomatic arch; *i*, lower jaw; *c*, upper jaw.

closely allied to the former than to any other order of mammals. The elephants are the giants among

living land animals of the tropics, and are covered with a thick naked, or sparsely haired skin. They have five hoof-covered toes on each foot, though sometimes two toes are included in one hoof. The proboscis, or trunk, is a muscular and exceedingly movable double-barrelled tube appended to the nose,

FIG. 55.



Section of the skull of the elephant, showing the small size of the brain case, *e*, and the large size of the air spaces.

b, marks the posterior nostrils; 13, the cavity of the nose; *a*, the front opening of the bony nostrils to the edge of which the trunk is attached.

in fact an extension of that organ, which, by means of a finger-like appendage at the tip, can pick up even

exceedingly small objects. The teeth of an elephant consist of two tusks or incisors in the upper jaw, which grow continuously, sometimes to enormous sizes, and furnish the ivory of commerce. There are no incisors in the lower jaw, but there are on each side of each jaw two large, rough-crowned, quadrate teeth, whose crowns are marked by transverse enamel ridges, used in grinding the twigs and shoots of trees on which these animals feed. There is a constant succession of these molars, seven of which are developed during the life of the animal on each side of each jaw, but never more than two, or at most three, are laterally functional at one time. The skull is enormous, most of its bulk consisting of huge air-cells, and the brain is large and convoluted on the surface. Two species of elephants are now living, confined to the tropics: one in Africa, known by its convex forehead and flapping ears; one in India, which has a concave forehead and smaller ears. Formerly several species of elephants lived in Europe, and remains of one form have been abundantly met with in some parts of the British Islands. In Siberia, also, there exist numerous remains of a hair-clad elephant, the mammoth, which had probably existed down to a comparatively modern time.

CHAPTER XVIII.

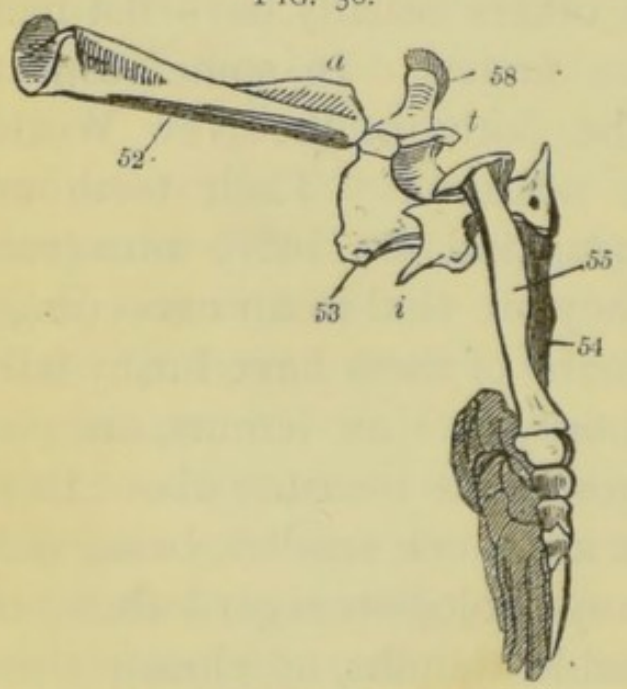
LEMURS, MOLES, AND BATS.

67. **Order 13, Prosimii.**—The lemurs, which constitute this little order, are monkey-like animals, chiefly confined to the Island of Madagascar, and to other islands in the Indian Ocean. They are arboreal, fruit- or insect-eating animals, with an opposable thumb on the fore foot, and sometimes on the hind foot as well, the second toe of which always bears a long claw, while all the others usually have flat-nails like those on the human fingers. In some respects the animals resemble the sloths of the New World, and many of them are nocturnal. Their teeth are always of the four kinds, and are more numerous than those of man. They are clad in an exceedingly soft and thick fur, and many of them have bushy tails, while others, like the Loris, or slow lemurs, are perfectly tailless. The largest forms measure about three feet in length, but some are much smaller, being only a few inches long. Many zoologists regard them, on account of their opposable thumbs, as closely allied to the monkeys; but in their simple brains and in the structure of some of their internal organs, they represent a much lower grade of organisation than that of the monkeys. The aye-aye of Madagascar, a strange little animal, about the size of a rabbit, has nails only on its thumbs, and claws on the other fingers. One singular genus from the Philippine and

Malay Islands, Tarsius, has the tarsus or ankle-bones of the foot exceedingly long, like the corresponding bones in the frog, so that it appears to have two ankle joints.

68. **Order 14, Insectivora.**—This order of mammals consists of the shrews, moles, and hedgehogs, which, as their name implies, feed on insects and worms, and other small animals. They are all of small size, and possess strong claws, long tapering snouts, and numerous sharply pointed teeth, the canines being small or absent. They all possess complete collar bones, a character which distinguishes them from Carnivores, and gives to the fore-limbs a fixity and definiteness of action that would be otherwise wanting. Their brains are usually small and smooth, not unlike those of rodents. In habit they are plantigrade, terrestrial, and usually active. The moles are familiar instances, and present in the highest degree the character of a fossorial or digging animal; the paddle-like hand the square arm-bone or humerus (fig. 56, 53), and the enormous muscularity of the fore-limb enable it to dig with wonderful celerity in pursuit of the worms and insects on which it feeds, while the

FIG. 56.



Bones of fore-limb of mole.

52, scapula; 53, humerus; 54, 55, fore-arm bones.

velvety skin, and the rudimental eyes and outer ears, give it the greatest degree of fitness for its subterranean life. Moles are common in most parts of Great Britain, but are absent from Ireland. The shrew-mouse and the hedgehog are equally common types; the former can be easily distinguished from the true mice by the structure of the teeth. The pigmy shrew of S.E. Europe is the smallest known mammal, being only about two inches long. The flying lemurs of the East Indian archipelago, which form the last family of this order, have a wide parachute-like membrane stretching from the fore-limbs to the hind, and thence to the tail. They form a connecting link between this order and the next.

69. **Order 15, Cheiroptera (Bats).**—This curious group of mammals includes the only forms in the entire class which have any true powers of flight, the so-called flying phalangers, flying squirrels, and flying lemurs having only the power of taking long leaps, In the bats the fore-limbs are very long, the fingers are enormously lengthened, and are united together by an extensive and thin membrane, which stretches from finger-tip to finger-tip, and from thence to the hind limb; the thumb alone is free, and it is always armed with a claw. The outline of this membrane is shown by the dotted line in fig. 57. They are mostly nocturnal, with smooth brains and feeble powers of sight, and are rarely of large size. To move the wings they are provided with powerful pectoral, or breast muscles, and there is often an imperfect keel on the sternum, for muscular attachment. They have also long and strong clavicles. Their hind

limbs are turned outwards in a peculiar manner, so that the knees bend backwards, and the great toes are

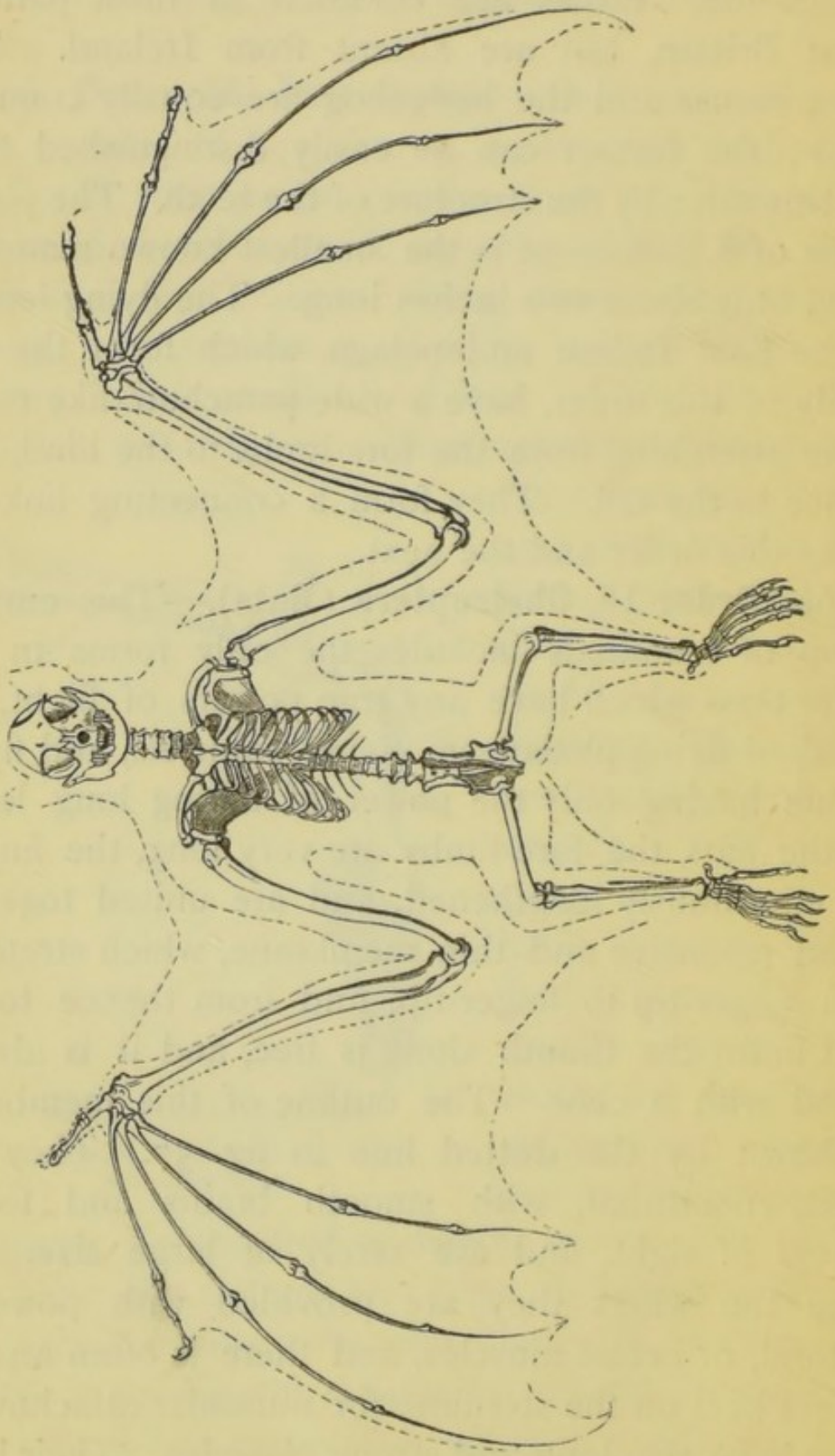


FIG. 57.

Skeleton and outline of bat.

thus twisted to the outer side of the foot, which has five equal claw-bearing toes. Many bats have enormous ears, others, like the vampires of South America, have sensitive leaf-like organs on their noses, made up of complicated folds of skin overlying processes of gristle. The body is covered with soft hairs whose surface presents a peculiar and characteristic scaly appearance under the microscope, and the fronts of the wings are extremely sensitive. They rest by hooking on to branches or ledges by the curved claws of their hind toes, and many of them thus feed with their heads downwards. They are extremely awkward in progression on the ground, and rarely resort to this method of locomotion. Most of the bats of temperate climates hybernate, and these are almost all insectivorous, having sharp-pointed teeth like those of the Insectivora. In warmer regions of the New World there are numerous large species, such as the vampires, which are suctorial in habit, sucking the blood of large animals, for which purpose they have sharp lancet-like teeth, and a long suctorial stomach. In the tropics of the Old World there are the largest individuals of the order, the fruit bats or Pteropi, which inhabit the Asiatic and insular shores of the Indian Ocean. They have blunt teeth, moderate ears, and, in one species, the distance from tip to tip of the wings is often as much as five feet. They are sometimes called flying foxes, from their prevailing colour and the shape of their heads.

CHAPTER XIX.

MONKEYS. MAN.

70. **Order 16, Primates.**—This, the last and highest order of mammals, includes the most highly organised members of the entire animal kingdom—the monkeys, apes, and mankind. They all possess opposable thumbs on some of the extremities, and (except among the marmosets) flat nails in place of claws. The face is mostly naked though fringed with hairs. The teeth are of three kinds and thirty-two in number, the formula being usually

$$I\,\frac{2—2}{2—2},\ C\,\frac{1—1}{1—1},\ P\,\frac{2—2}{2—2},\ M\,\frac{3—3}{3—3}.$$

They have the highest proportional development of brain of all animals, and the fore-limbs are chiefly set apart to wait on the head. There are four sub-orders included:—

1. The marmosets of South America, gregarious small monkeys of a squirrel-like habit, which have sharply tubercled teeth, claw-like nails on all the digits, except the great toe, which alone bears a flat nail. The long fur-clad tail is incapable of grasping, and the thumb is scarcely opposable.

2. The American monkeys, which differ from all others in having an additional premolar tooth on each side of each jaw $\left(P\,\frac{3—3}{3—3}\right)$. They have for the most part prehensile tails, and the thumb of the

hand is not well developed, or is absent as in the spider monkeys : on all their fingers they have thick convex nails. Most of these live in the woods of Brazil, and are found in troops. The howling monkeys have a drum-like enlargement of the tongue bone at the top of the larynx or organ of voice, and with it they can produce a loud booming sound, audible for nearly a mile. In all the American monkeys the nostrils are separated by a very broad partition, their ear-drums or tympanic bones in the skull have also wide oval mouths.

3. The Old World monkeys and apes are characterised by having a narrow nasal septum, and the ear-drums have a long tubular mouth. The dentition is similar to that of man, the premolars being $\frac{2—2}{2—2}$. They have almost always an opposable thumb on the hand as well as on the foot, though it is rarely as perfect, and the muscle which bends it is never separate from the common flexor muscle of the other fingers. The baboon family may be known by possessing cheek pouches, and callous patches whereon they sit, as well as by their elongated jaws. The true baboons have dog-like muzzles and very short tails ; they are confined to Africa and Arabia, and some of them have curiously coloured faces; thus the mandrill, with its blue, deeply-grooved cheeks, its brilliant scarlet lips and nostrils, and its white beard, is a most striking-looking creature. Some, like the Barbary ape, the only species which now lives in Europe, have no visible tails ; others, like the cercopitheci or green monkeys, have long tails, but these organs are

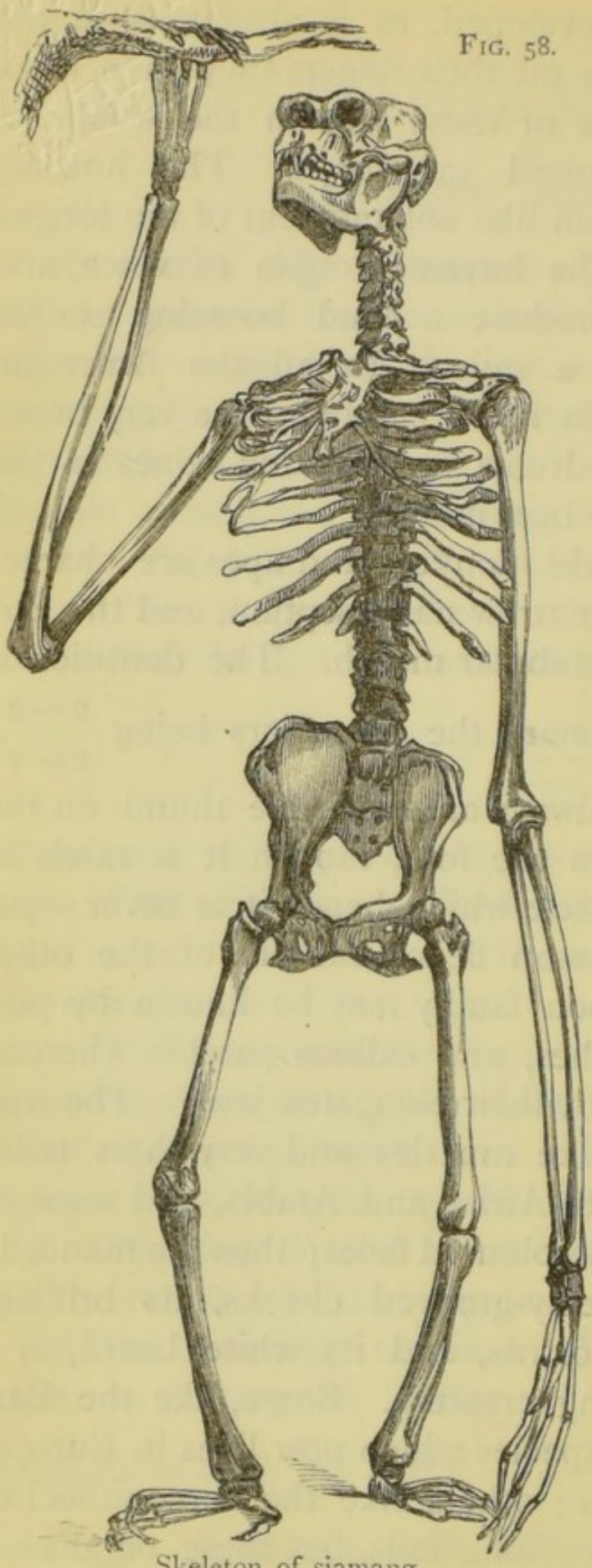


FIG. 58.

Skeleton of siamang.

never prehensile. Many, like the macaques of Eastern Asia, have long and prominent canine teeth, but these are weapons of offence, not indicative of a carnivorous diet. The sacred monkey of India (*Semnopithecus*), and the thumb-less Colobus of Africa, have no cheek-pouches, but possess long tails and callosities, while the highest group of the sub-order, the so-called anthropoids, have no tails, callosities, nor cheek pouches. The chimpanzee is a black-haired ape, a native of Guinea, which sometimes reaches a height of five feet. The

orang-utan, a larger brown-haired species, with longer arms and a larger, rounder head, is found in Borneo and Sumatra. The gorilla, the largest of the anthropoids, is a native of Senegambia, and is nearly as tall as, but much stouter than, a man. The gibbons of Southern Asia differ from the anthropoids in having callosities, and resemble the orangs in the enormous length of their arms (fig. 58).

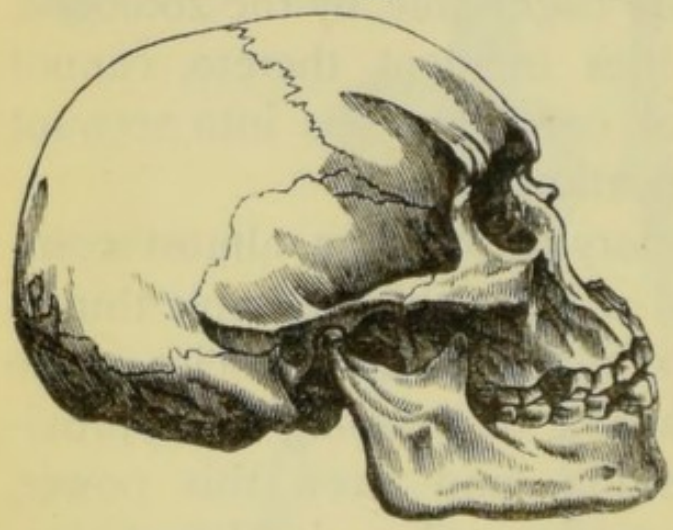
4. Man is the last and highest type included in the order, and though in an anatomical point of view there are not a sufficiently numerous series of differences of kind to lead us to form of him a separate order, yet there are enormous differences of degree, even of such kinds as are cognisable by the zoologist, who, from the difficulties incident thereto, cannot easily take psychological considerations into account in constructing a classification.

Man has a rudimentary (though an almost complete) hair clothing, and a perfectly opposable thumb on the hand, moved by independent muscles, while the great toe is only capable of grasping by approximation, not by opposition, and even this power, though great in some savage tribes, is almost destroyed, in civilised races, by the habit of wearing shoes. The arms in man are shorter, and the hind limbs longer and stronger than in any of the apes. Progression is bipedal, and the feet are plantigrade, while the arms are specially and solely set apart for waiting upon the head. The muscles which keep the body erect, such as those of the back, the extensors of the hip-joint, and the muscles of the calf are enormously greater than are the corresponding

parts of monkeys, while the spinal column exhibits a series of curves so constructed that the centre of gravity falls between the feet. The brain of man is larger in relative size and complexity than that of any other animal, being on an average fifty ounces in weight, while that of the orang-utan weighs only about sixteen ounces. Man is also capable of articulate speech, and, psychologically, man is susceptible of education, which, in kind as well as in degree, is utterly unknown among the lower animals.

Man also is capable of fitting himself for residence in any climate, and having been thus long scattered over the face of the earth, the single human species presents to us numerous varieties, none of which, however, exhibit any approach to true specific distinctness. These varieties may be classed as follows :

FIG. 59.



Skull of negro.

1. Woolly-haired races, such as the Negroes, Andamanese, and the Negritos of the Malay Archipelago.

2. Straight-haired races, which may be,

a. Australioid or dark-skinned, small-headed races, such as the aborigines of Australia, the aboriginal or hill tribes of India and Ceylon, possibly the ancient Egyptians, and the aboriginal races of the stone age.

b. Turanian races, yellow or red-skinned, mostly broad-headed races, like the Mongols, Chinese, the American Indians, &c.

c. Iranian or Indo-Germanic races, pale or olive races, usually bearded, and usually with longer heads and straighter features.

INDEX AND GLOSSARY.

BAD

COB

COC

EEL

EGG

GIL

MER

PEN

ROB

TEA

TEE

ZEB

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