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DUBLIN UNIVERSITY PRESS SERIES.

AN INTRODUCTION

TO

THE SYSTEMATIC ZOOLOGY

AND

MORPHOLOGY

OF

VERTEBRATE ANIMALS.

BY

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PREFACE.

THIS book was originally written as the second volume of my "Introduction to Animal Morphology," of which the first, or Invertebrate part, appeared in 1876. The Board of Trinity College having, with characteristic liberality, offered to publish this volume for me as one of the DUBLIN UNIVERSITY PRESS SERIES, I have re-written it in parts, so as to make it an independent work.

I have to express my sincere thanks to the Board of Trinity College for their kindness in defraying part of the expenses of volume I., as well as for their above-mentioned liberality in connexion with this part.

I have to thank my reviewers for their friendly notices of my former volume, and for their kindly criticisms, by which I have endeavoured to profit in this work.

It is, I conceive, impossible to write a strictly scientific treatise in popular language without

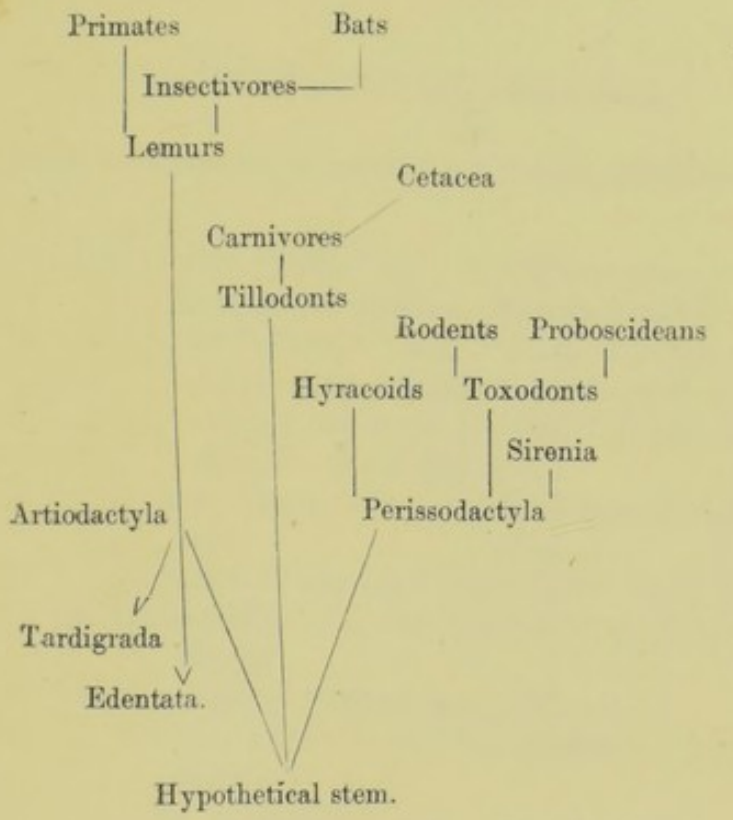
increasing its bulk proportionally; and as I have aimed at conciseness and precision, I have endeavoured, both in this volume and its predecessor, to define every term carefully, and having defined it, to use that term, in place of a periphrasis. As I have, in the Index, referred to the most of these terms, and the places where they are defined, the need of a glossary is obviated.

My calling these volumes "Introduction" has been animadverted on, but I think the word appropriate. I remember, when a student, that I found the gap between most manuals then existing and the monographic literature of zoology to be so great, that passing from the first to the second was practically entering an unknown region; and hence in this work I have tried to make each part sufficiently comprehensive to enable the student, who wishes for additional knowledge of any forms, to pass from a general study of Morphology into the region of detail, without any great intermediate gap.

This work was written in 1874, but I have added to it notices of new discoveries while going through the press as to bring it up to the present-day state of knowledge.

In a descriptive classification it is not easy to give in linear series an adequate idea of relationships: thus among the Mammals, the sequence of the orders adopted in the text affords little idea

of their collateral affinities, but any other linear arrangement would be as faulty. The following diagram gives an approximation to what I believe to be the probable collateral relationships of the Monodelph Mammals :—



The plan of putting the general principles and important characters in larger type, the details in smaller printing, having been found useful, I have adopted it throughout.

To ensure accuracy, I have endeavoured, as far as possible, to check description by dissections, and thus I have been able to verify a very large proportion of the statements made in this volume.

ADDENDA ET CORRIGENDA.

The reader is requested to make the following additions and corrections:—

Page 11, line 4, after "forms" add "by the coalescence of two lateral symmetrical cartilages, the parachordals."

,, 11, ,, 7, after "Rathke," add "which, like the parachordals, may be displaced equivalents of neural arches."

,, 21, ,, 1, "cephalic end of the hypoblast" should read "oral invagination of the epiblast."

,, 23, ,, 17, after "bone," add "segmented from the periotic cartilage."

,, 23, ,, 37, "cranial trabeculæ" should read "cornua trabeculæ."

,, 28, fig. 7, description, "*r*, right ventricle;" should read "*r*, right auricle."

,, 30, line 2, "papillary" should read "follicular."

,, 98, ,, 8, after "splenial," add, "dentigerous in Urodeles, absent in Anura."

,, 132, ,, 25, for "cartilage" read "membrane," and delete the clause following.

,, 132, ,, 28, delete the clause following "turtle," and substitute, "and are likewise developed in membrane."

,, 332, ,, 10, for "a spheno-parietal suture" read "no spheno-parietal suture."

CONTENTS.

INTRODUCTION

TO THE

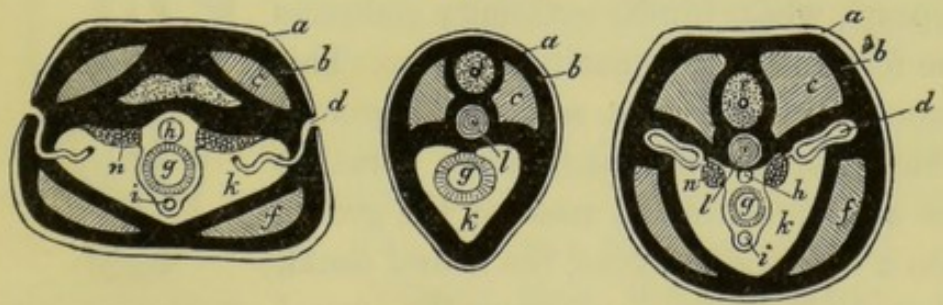
MORPHOLOGY OF VERTEBRATE ANIMALS.

CHAPTER I.

SUB-KINGDOM VIII.—VERTEBRATA (*Cuvier*).

A VERTEBRATE animal is made up of a series of successive externally-unjointed metameres, each consisting of two symmetrical antimeres. There are two parallel longitudinal body-cavities: a dorsal (fig. 1, *e*) containing the central

Fig. 1.



Section through the peristome of a Worm, an Amphioxus, and a Craniote Vertebrate.

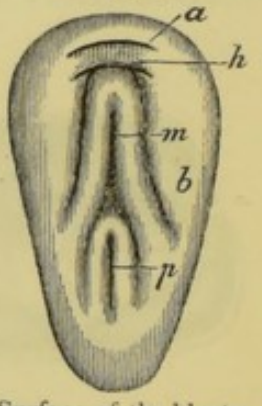
organs of the nervous system, and a ventral (*k*) in which lie the proctuchous digestive tube (*g*), heart, and sympathetic nerves. These cavities are separated from each other by

a longitudinal horizontal partition, in whose middle line is a cartilaginous cellular axis, the notochord (*l*), which either persists or becomes surrounded and replaced by a jointed axis, the vertebral column. The limbs may be none, two, or four; when present, they have an endo-skeleton to which muscles are attached. The vascular system has closed capillaries. The blood is corpusculated, and the impure blood from the intestines is conveyed by a vessel (vena portæ) to the liver.

The ova may be totally or partly cleft in development; in either case a bilaminar blastoderm is formed, between the outer (epiblastic) and the inner (hypoblastic) layers of which, a third, or mesoblastic, layer is developed. The corneal, or surface layer of the epiblast, forms the epidermis, the deeper layer develops into the nervous system, while the hypoblast forms the epithelial lining of the alimentary canal and its diverticula.

On the surface of the blastoderm, in the egg of a bird or mammal, there appears early a primitive longitudinal streak, along which a groove forms (the primitive groove) (fig. 2). A little in front of this, a second longitudinal groove appears, whose hinder extremity embraces the fore-end of the primitive groove. This second furrow is the medullary groove, which deepens; its lips (laminæ dorsales) rise and approximate, making the groove into a longitudinal tube, the neural canal, whose lining epithelium forms the central nervous system. On the floor of this canal the notochord appears, around, or on each side of which the mesoblast becomes segmented into a row of quadrate disks, arranged in a series

Fig. 2.

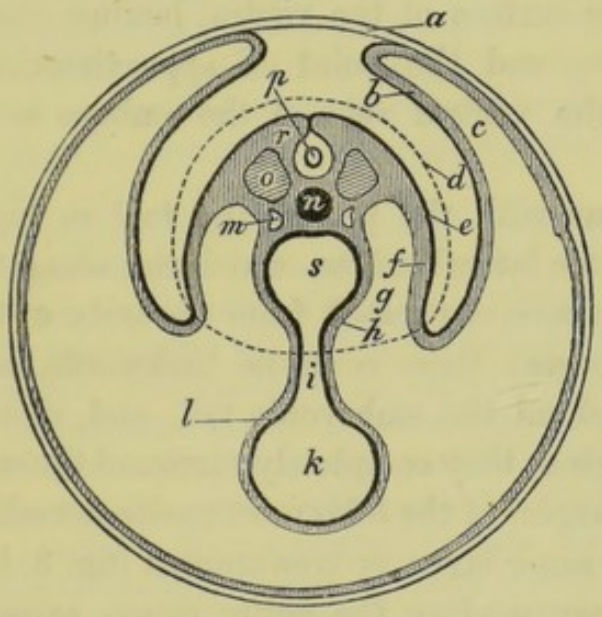


Surface of the blastoderm of a hen's egg: showing *p*, primitive groove; *h*, headfold; *a*, amniotic fold; *m*, medullary groove; *b*, blastodermic area.

from before backwards, which are called the proto-vertebræ. In lower vertebrates the medullary groove alone appears.

In mammals and sauropsids a deep sulcus appears in front of the head of the embryo, and its anterior lip rises as a precephalic fold (fig. 2, *a*). The mesoblast, behind the head and outside the proto-vertebræ, splits into two

Fig. 3.



Transverse vertical section through embryo of a vertebrate animal: *a*, chorion; *b*, lateral fold of amnion; *c*, cavity of amnion; *d*, dotted line limiting embryo; *e*, epiblast; *f*, mesoblast of somatopleure; *g*, cœloma; *h*, mesoblast of splanchnopleure; *i*, duct of umbilical vesicle; *k*, cavity of umbilical vesicle; *l*, hypoblast lining vesicle; *m*, Wolffian duct; *n*, notochord; *o*, protovertebra; *p*, medullary canal; *r*, laminæ dorsales.

layers, the outer of which joins the epiblast and forms the body-wall, or *somatopleure* (fig. 3, *f*), while the inner joins the hypoblast, and with it forms the visceral wall, or *splanchnopleure* (*h*). Between these lies the cœloma, or pleuro-peritoneal cavity (*g*).

Along each side of the epiblast, inferior (ventrad) to the plane of the notochord, a lateral furrow appears, beginning from the head-fold, which, deepening, separates the embryo from the rest of the ovum. The embryonic sides of

this (the laminæ ventrales) bend inwards, approximating below the body, of which they form the lower walls. In so doing they constrict the mesoblast peripherally, shutting out from the body cavity (which they bound) the food-yolk and part of the hypoblast related thereto, which forms a sac (umbilical vesicle), whose communication with the hypoblastic intestinal tube becomes narrow (the umbilical pedicle), and finally shrivels.

The outer surface of the ventral laminæ consists of the somatopleure, and the point of approximation of these layers on the ventral side of the embryo is called the umbilicus.

Continuous with the precephalic fold in higher vertebrates are two lateral ridges, which rise along the sides of the somatopleure, separated from the body of the embryo by deep grooves; these continue backwards, and become confluent behind the embryonic tail, and, rising upwards and converging, they completely surround the embryo, and when the margins of the folds meet medio-dorsally they coalesce. The inner layer, or true amnion (fig. 3, *b*), is thus a membrane surrounding the entire ovum, except the umbilical vesicle, and containing a clear fluid, the liquor amnii. The outer layer, or false amnion, thus shut off from the former, either disappears or unites with the vitelline membrane to form the *chorion*, a membrane smooth within but shaggy with villi outside. The space between these is at first continuous with the pleuro-peritoneal cavity, but eventually the ventral laminæ of the somatopleure close at the umbilicus, shutting off this external cavity from the true cœloma of the fœtus.

Vertebrates are personæ in individuality (see vol. I. p. 11), and are, as a rule, diœcious. The characteristic primitive axis, or notochord, in some sharks appears to be hypoblastic in origin (*Balfour*).

The degree of cleavage of the yolk depends on the amount of nutriment present in the egg for the embryo, as during segmentation that part of the egg which is rich in food-yolk is slower to cleave, and forms larger masses (*Balfour*).

The inner lamella of the blastoderm is formed, in many vertebrates, by invagination; and in those forms in which its origin does not appear clearly to be due to this process, we have reason to believe that it is only because the act occurs simultaneously with or before the completion of cleavage, as suggested by Mr. Balfour.

The primitive groove of the embryo, which is well marked in the bird's egg, rapidly vanishes, and leaves no trace; it is, probably, an heirloom of some lost condition, perhaps a trace of the change in position of the embryonic blastoderm, which in birds and mammals has been shifted inwards.

The cœloma is in parts lined at first by columnar (germinal) epithelium, afterwards replaced by tessellated cells, except over the sex-glands and Wolffian bodies.

Behind the umbilical vesicle, in all but the lowest Ichthyopsids and Acrania, an outgrowth of mesoblast projects between the splanchno- and somato-pleure, towards and often through the umbilicus. This is at first solid, but soon becomes hollow and lined by a diverticulum from the hinder end of the hypoblast. This *allantois*, as it is named, in higher forms extends between the true and false amnion, and at its embryonic end receives the ducts of the Wolffian bodies. In Amphibia the allantoid remains small, as a urinary bladder; in higher vertebrates it is sometimes expanded around the whole embryo external to the true amnion. In higher mammals it applies itself to the deep surface of the chorion, at a space opposite the umbilicus; and here its two arteries (hypogastric branches of the aorta) communicate with the villi of the chorion and through these with the uterine blood-vessels, thus forming a placenta, or medium for the nutrition of the fœtus.

At or before birth or hatching, the pedicle of the umbilical vesicle and its vessels (omphalo-meseraic arteries and veins) waste and disappear, or become faint streaks. The communication between the extra- and intra-somatic part of the allantoid becomes a cord (urachus), while the latter becomes the urinary bladder. The amnion and the chorion are cast off at birth as the membranes of the fœtus.

Vertebrata consist of two primary divisions, Acrania and Craniota. Some zoologists, and with reason, regard the Tunicates as the first division of this sub-kingdom. Lankester thus divides vertebrates into Urochorda (= Tunicata), Cephalochorda (= Acrania) and Craniata.

CHAPTER II.

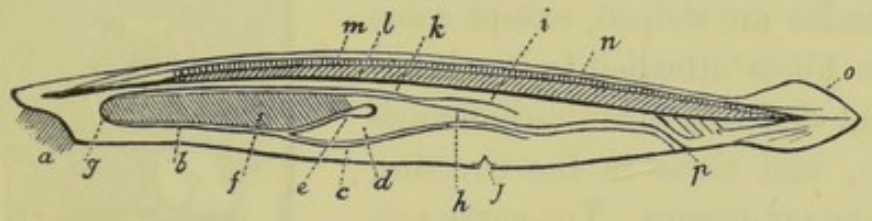
Division I. Acrania* (*Haeckel*).

This includes but one existing form, the Amphioxus lanceolatus, a widely distributed, fish-like, marine animal about 2″ long, ½″ broad, pointed at each end, and laterally compressed, found chiefly in the coralline or intermediate zones. Its tough skin is thin, scaleless, covered by a monoderic columnar epithelium, and having a homogeneous non-nucleated cutis, over a richly canalated hypodermic layer; medio-dorsally behind, it is raised into a low vertical fold or fin, without fin-rays, which extends round the tail and for a little way forward along the under edge, even in front of the anus (fig. 4, *o*). The notochord (*l*) is pointed at each end, and extends forward even anterior to the mouth; it consists of a row of obscurely separate disks, contained in a bilaminar sheath, with lateral perforations, and surrounded by stellate cells, which are most numerous above the disks. There is no heart, skull, brain, ear, kidney, spleen, sympathetic nerve, lymphatic system, mandible nor hyoid arch. The mouth (*a*) is longitudinal, placed below the anterior end, surrounded by a symmetrical labial cartilage of about 12 pieces on each side, each of which usually bears a stiff ciliated cirrus, and is composed of cartilage like that of the chorda. The mouth cavity is a pouch, opening posteriorly into the pharynx by a funnel-shaped canal surrounded by a sphincter; its lining presents a series of rounded ciliated lobes with non-ciliated intervals. The pharynx (*f*) extends for nearly half the length of the body, and is surrounded for the most part by

* Leptocardia (*Müller*), Cephalochorda (*Lankester*).

a cavity, the atrium, which communicates with the outer world by a median aperture, the abdominal pore (*j*), placed two-fifths of the length of the body from the tail, on a papillary elevation of the abdominal muscles; behind this the atrium narrows. The wall of the pharynx is pierced by numerous (60–100) lateral vertical slits, through which the water which enters the mouth escapes into the atrium, from whence it passes through the abdominal pore. The pharyngeal wall is strengthened laterally by a number of stiff (chitinous?) rods between the slits, which are thickened folds of cutis, connected above (dorsally) together, and to the outer notochordal sheath, and ventrally alternately simple

Fig. 4.



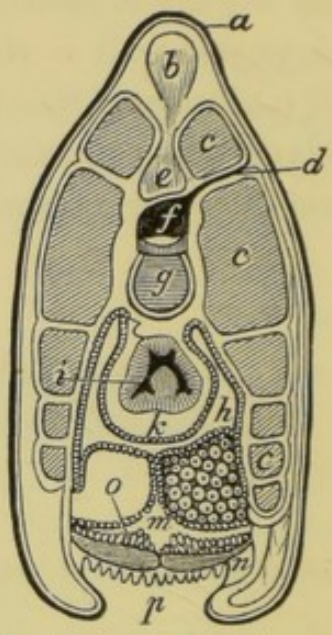
Longitudinal section of Amphioxus lanceolatus, showing the mouth, notochord, liver, branchial clefts, and portal heart.

or forking. A process of the cœloma extends dorsally along each side of the pharynx, and processes stretch into the lateral atrio-pharyngeal folds or arcades (which are half as many as the gill slits), and keep the pharynx suspended in the atrium; one extends along its ventral surface. The pharynx ends posteriorly in a narrow aperture which leads into the alimentary canal (*h*), which is straight, simple, lined with a ciliated, dark, glandular epithelium, and ends in an anus (*p*) which opens a little to the left side. A simple hepatic cæcum, whose apex points forward (*d*), opens into the intestine a very short distance behind the cardiac orifice, and at its opening there is a small glandular follicle (the gland of *Rolph*) of unknown nature. In the floor of the

atrial chamber, in front of the pore, is a long mass of lobulated epithelium consisting of club-like and thread-like cells, which is possibly a renal organ.

The muscle bundles are laterally symmetrical, attached to intermuscular septa which are processes from the external sheath of the chorda. The dorsal series of septa are inclined in a direction upwards and backwards; the ventral septa are longer and point downwards and backwards. A set of abdominal muscles extend in the wall of the atrium from the gills to the abdominal pore. All the muscles are striped, except some fine fibres attached to the branchial skeleton, the intestinal muscles, and those in the covering of the sex-organs. The nerve axis (*m*) lies above the notochord in a neural canal, whose walls are continuous with the outer chordal sheath; it corresponds to the grey axis of the chord of Craniotes, and ends in front in a narrow roundish point, ·06″ from the fore end of the body. The nerves (55–60 pairs) are single-rooted naked bundles of axis cylinders, and they pierce the membranous wall of the neural canal dorso-laterally (fig. 5, *d*). Each nerve gives off a lower (larger) and an upper (smaller) branch; one of the anterior nerves supplies a median ciliated (olfactory) pit at the fore end, over the spinal cord; a second branch near it supplies some pigment specks (eyes?), and a more anterior

Fig. 5.



Vertical section through Amphioxus opposite level of the abdominal pore: *a*, dorsal fin; *b*, elastic apparatus; *c*, muscular masses; *d*, lateral nerve; *e*, elastic body over nerve cord; *f*, spinal cord; *g*, notochord; *h*, atrial cavity; *i*, intestine; *k*, cœloma; *m*, outer division of atrium; *n*, lateral canals; *o*, is placed in the ovary, but the line from it points to the rudimental kidney; *p*, porus abdominalis.

branch supplies the mouth. The rest of the nerves terminate either in the muscles or under the epithelium of the surface.

Over the neural canal, in a longitudinal space formed by the splitting of the outer chordal sheath, is a band of tissue pierced by canals like the material of the hypodermis (5, *e*); over this, in the medio-dorsal fin, is a longitudinal row of spaces, quadrate in horizontal, pyriform in transverse section (5, *b*), filled with elastic endothelium-clad bodies. Similar spaces lie laterally and medio-ventrally, extending between the abdominal pore and the anus; the true fin is that which stretches behind the anus.

Two blind lateral canals stretch in the side-folds from the side of the mouth-cavity to behind the abdominal pore (their existence has been denied, but the careful dissections of Rolph have shown their presence). There is a contractile vessel or *vena portæ* beneath the liver (4, *c*), whose blood enters the hypopharyngeal heart (*e*) with the rest of the systemic venous blood. From the simple cavity which is called the heart, laterally arched branchial arteries spring, each having a contractile swelling at its base, and passing in the wall of the pharynx between the gill slits, to end in branchial veins which terminate in a dorsal aorta. The two most anterior branchial arches (*g*) are large, like aortic arches. In the dorsal trunk (*k*) the blood flows tailwards, in the heart mouthwards. The blood corpuscles are amoeboid, nucleated, colourless.

On each side, under the floor of the atrium in the cœloma, are quadrate or bean-shaped masses, arising probably from the atrial epithelium; these may contain either eggs or spermatozoa, and in both sexes they empty their contents into the atrium by dehiscence, and these escape through the gill slits, or more rarely through the abdominal pore.

The ova are holoblastic, and the blastoderm is a primary vesicle of one layer, which, by invagination, becomes bilaminar, the aperture of invagination or blastopore soon closing. In this spheroidal now bilaminar ciliated embryo a dorsal groove forms, which by closure becomes the neural canal, in whose floor the notochord appears. The invaginated layer or hypoblast adheres in front to the outer layer, and, at the places of meeting, the mouth and pharyngeal clefts form. At the site of the blastopore, or near it, the anus forms. The cavity of invagination remains as the alimentary canal. Two lateral folds, each containing a process of the body cavity, springing above the pharynx and behind the mouth, grow downwards and approximate, uniting except at the atrial pore, thus forming the walls of the atrium.

There is much yet to be known of this "next to man the most important vertebrate;" its fore end is especially interesting as illustrating a stage of vertebrate development in which the front end of the nerve axis and its appendages is composed of segments comparable with those of the rest of the body. When we reach the next division, we find the metameres at the fore end of the skeletal axis confluent, having lost their separate character; and then, as hard tissues originate in them to protect the anterior end of the neural axis, now growing in importance, there is in them no trace of the primary metameric division, and so no trace of the "cranial vertebræ," so often fancied to exist: all such divisions are secondary, depending on the relations of the skull-structures to neighbouring organs. Much of the anatomy of Amphioxus is yet obscure: thus, there is sometimes one eye, sometimes two (*Marcusen*); sometimes accessory pigment spots (*Hasse*).

CHAPTER III.

Division II. Craniota (*Haeckel*).

Vertebrates possessing a skull, a muscular heart, and a brain. The front end of the neural canal formed by the

closure of the dorsal plates dilates into three vesicles (anterior, middle, and posterior cerebral); under the second of these is the end of the notochord, around which a horizontal investing mass or basilar cartilaginous plate forms, below the middle and hinder vesicles. In front of the notochord and basilar plate there are two lateral processes of cartilage arising independently (*Trabeculæ* of *Rathke*), separated by a median space (pituitary fossa), but joining in front to form a flat bifid ethmo-vomerine lamella, on each side of which the dermal ocular sac becomes more or less surrounded by cartilage to form the orbit. Two lateral processes of the basilar plate surround the junction of the posterior vesicle with the spinal canal, bounding on all sides the foramen magnum. Farther forward the side of the basilar plate surrounds the lateral dermal sac which forms the ear labyrinth. In higher forms the sides of the ethmo-vomerine plate expand and cover the nasal sacs, while a central process separates one of these from the other. The internal epithelium of the cerebral vesicles forms the brain, and from it extend processes to these sacs, becoming the auditory, optic, and olfactory nerves, respectively; one also projects through the cartilage behind the periotic capsule, and passing to the lungs and stomach becomes the vagus nerve, and in front of this capsule another extends, called the inferior maxillary (branch of the fifth pair of nerves). The skull may remain in this form, or it may ossify from certain points, which are either single, mesial, or else double or lateral. The mesial are, 1st, around the notochord (basi-occipital); 2nd, in front of the notochord in the floor of the pituitary space (basi-sphenoid); 3rd, in front of the pituitary fossa (presphenoid); 4th, in the middle line of the ethmo-vomerine plate (mesethmoid). The lateral are, 1st, at each side of the

foramen magnum, behind the tenth nerve (exoccipital); 2nd, between the tenth nerve and the posterior vertical semicircular canal of the ear (opisthotic); 3rd, above the posterior vertical canal (epiotic); 4th, between the anterior vertical canal and the inferior maxillary nerve (prootic); 5th, sometimes one external to this (pterotic)—the 2nd, 3rd, 4th, and 5th may unite to form a periotic or petrous bone; 6th, between the inferior maxillary branch of the fifth nerve and the second, a bone may extend outward (alisphenoid); 7th, between the second and first nerves is another process—the orbito-sphenoid; 8th, on each side of the nasal sac and in the lateral part of the ethmo-vomerine plate is the pre-frontal. These may remain separate, or may unite in various ways. Over the foramen magnum, in the cartilage, one, two, or four centres of ossification unite to form one bone, the supra-occipital.

The roof of the skull is rarely completed by cartilage, but the fibrous membrane which surrounds the cartilage closes the cavity by extending above the vesicles. In this membrane the following bones are formed by parostosis; 1st. The parasphenoid, situated medially under the basi-sphenoid. 2nd. The vomer, below the mesethmoid. 3rd. The squamosals, in front of the exoccipital, and outside the periotic. 4th. The parietals, farther forward on each side, over the middle cerebral vesicles. 5th. The frontal, over the anterior vesicles. 6th. The accessory, or post-frontal bones, may be between the 4th and 5th on each side: and 7th. The nasal bones, over the olfactory capsules. There may be thus in the skull five single and eight double cartilage ossifications, and two medial and four pair of lateral membrane ossifications. Occasionally a third, single, inter-parietal bone exists, above the supra-occipital. These bound the brain case, which is easily

divisible into these segments: a posterior, or occipital; a middle, basispheno-parietal; and an anterior, pre-sphenofrontal.

Below the skull on each side, and at right angles to the long axis of the body, are from three to nine bands, meeting symmetrically in the upper mesial line, each containing a cartilage rod (visceral arch), separated from each other by slits (visceral clefts). The membrane in front of the anterior cerebral vesicle forms a median (nasal), and two lateral (pre-orbital) processes, between which, on each side, are the nasal sacs, and external to which are the eyes. Below and in front of the eye on each side, a process named the maxillary lobe extends forwards to the mesial line, beneath the nasal sacs, and separated from the pre-orbital lobe by a groove, which may close or may persist as a duct from the eye to the nasal sac. The pair of maxillary lobes usually unite in the middle line, leaving behind them openings into the nasal cavities (*choanæ*). Below the united maxillary lobes is a deep cleft, the mouth, or first visceral slit leading into the digestive canal, and bounded below by the first post-oral visceral arch, whose cartilage rod is called *Meckel's* cartilage. The proximal end of this cartilage, touching the periotic, often ossifies; and around its distant end is developed a group of membrane-bones, forming the lower jaw, or mandible. The second visceral arch also touches the periotic proximally, and its distal part, below this bone, is frequently segmented from above downwards, into tympano-, stylo-, epi-, and cerato-hyal; the last joins mesially a vertical bone, the basi-hyal. The other visceral arches are very variable.

In the maxillary lobe is a rod of cartilage (pterygo-palatine), whose anterior part, below the presphenoid, ossifies as the palatine, and its hinder part, below the

alisphenoid, as the pterygoid bone; this part generally touches the proximal end of Meckel's cartilage. In the membrane of the face, over the cartilage, are found on each side: 1st, a pre-maxillary splint bone, in the fronto-nasal process; 2nd, a maxillary bone, in the surface of the maxillary lobe; 3rd, a lachrymal bone, around the preorbito-maxillary groove; 4th, a jugal or malar bone, in the base of the maxillary process, behind the orbit; 5th, the quadrato-jugal bone, farther back, and touching the outside of the proximal end of Meckel's cartilage. Some of these bones may be absent.

The epithelium of the neural canal, as in Acrania, forms the spinal marrow; that on the sides and floor of the hinder cerebral vesicle thickens into a pear-shaped mass, the *medulla oblongata*, or myelencephalon (fig. 6, *b*), whose central cavity is called the fourth ventricle. Its roof behind thickens, and forms a special lobe, or *cerebellum* (*c*); but the part in front remains thin and membranous (the valve of *Vieussens*). In the front of its floor transverse fibres pass from one side of the cerebellum to the other, forming the *pons Varolii*. The cavity (*a*) of the middle cerebral vesicle narrows into a canal (*Sylvian aqueduct*), on whose floor are two lateral rounded masses of longitudinal fibres, continued up from the medulla oblongata (the *crura cerebri*), which are joined by a thin intercrural lamina. The roof of the vesicle becomes divided into two or four bodies, the optic lobes, or corpora bi-, quadri-gemina (*m*).

The cavity of the anterior vesicle (3) becomes the third ventricle, and its sides thicken, forming the optic thalami (*p*). Anteriorly it sends off on each side a pouch (*h*) which dilates into a space (lateral ventricle) that may become larger than the original middle cavity.

The walls of these lateral ventricles form the cerebral hemispheres, of which an internal thickening forms the grey mass, or corpus striatum (*s*). The front wall, or lamina terminalis, of the third ventricle (*t*) often develops not only a transverse band (anterior commissure), but two longitudinal vertical bands (pillars of the fornix), which form prominent upper lips for the opening from the third into the lateral ventricles (foramen of *Monro*). A flat band (*taenia semicircularis*), passing from the optic thalamus forward, forms a lower lip for the opening, and ends by joining with the anterior pillar of the fornix to form a central white knob in the middle of the base of the brain, the *corpus mammillare*, which lies close to its fellow in the mesial line. A funnel-like elongation of the third ventricle, downwards to the pituitary space, expands therein over the hypophysis, or pituitary body. At the upper part of the third ventricle, and in front of the optic lobes, lies a rounded mass, the epiphysis, or pineal gland (*e*). The rest of the roof of the cavity remains as a thin vascular membrane (the *velum interpositum*), over which the fornix may stretch backward. In mammals, a layer of transverse fibres lies above the fornix, from one hemisphere to its neighbour, forming the corpus callosum; beneath it the inner walls of the hemisphere are thin, forming a vertical partition (septum lucidum) between the lateral ventricles, which isolates a small part of the median fissure of the brain, the fifth ventricle.

The brain thus consists of five sets of ganglionic masses, which from before backwards are—1st. Corpora striata. 2nd. Optic thalami. 3rd. The grey nuclei of the crura cerebri and bi- or quadri-geminal bodies. 4th. The central ganglia of the cerebellum: and 5th. Those of the medulla oblongata. The peripheric grey matter of the central hemispheres forms the organ of consciousness, to which communications are brought from without. The other grey ganglia interposed between this perceptive centre and the sources of the impressions serve as means whereby the diverging fibres may be reduced in number, and thus are known as interruption masses.—*Meynert.*

Fig. 6.

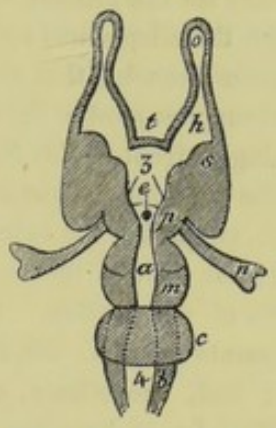


Diagram of the brain of a Craniote: *a*, cavity of middle cerebral vesicle, or *aqueductus Sylvii*; 3, cavity of anterior vesicle, or 3rd ventricle; 4, cavity of hinder vesicle, or 4th ventricle; *b*, wall of medulla oblongata; *c*, cerebellum or roof of 4th ventricle; *m*, mesencephalon; *e*, pineal gland; *n*, optic nerve; *p*, optic thalamus; *s*, corpus striatum; *h*, lateral ventricle, or cavity of cerebral hemisphere; *o*, olfactory nerve; *t*, lamina terminalis.

The spinal cord consists of two lateral columns joined by a median commissure, each column being grey within and white outside. On transverse section,

the grey nerve matter looks somewhat like the letter H, the crossbar being the commissure.

The medulla oblongata exhibits: 1st. Two anterior longitudinal elevations, the pyramids; 2nd. Two lateral eminences, the olivary bodies, or, in place of these, a thick transverse band, *corpus trapezoides*, which rarely coexists with olivary bodies (as in monkeys), but usually supersedes them (Lemurs); 3rd. Two posterior peduncles of the cerebellum. The corpus trapezoides is only a continuation of the transverse fibres of the pons Varolii; hence, when that part of the brain is large, as in man, the transverse fibres are entirely included in it, and no separate *c. trapezoides* appears, while, when the pons is small, these fibres being uncovered appear as a part of the medulla oblongata.

A hollow process from the front of the lateral ventricle forms the olfactory nerve (*o*) (1st pair, the bulb of which corresponds to the retina, *Luys*); one from the third ventricle, originally separate from the optic lobes, forms the optic nerve (2nd (*n*)); one from the posterior vesicle, the auditory (8th); at the side of the medulla oblongata arise the remaining pairs of nerves, including the great trigeminal (5th), which divides into three branches, an ophthalmic supplying the space between the trabeculæ and the maxillary process, a superior maxillary for this process, and an inferior maxillary for the mandible, emitted between the alisphenoid and prootic bones. Parallel with each sensory nerve is a motor branch; that along with the ophthalmic (3rd pair) from the crus cerebri supplies most of the orbital muscles, and a detached thread (4th) beside it arising in front of the Sylvian aqueduct, though emerging behind it, supplies the superior oblique muscle of the eye. The second motor nerve is the 6th, supplying the external rectus, choanoid, and the muscles of the third eyelid; the third is the motor root of the mandibular nerve supplying the muscles of mastication. In connexion with this 5th pair there may be six separate ganglia: 1st, Casserian, at its root, formed of its sensitive part alone; 2nd, the ciliary, on the ophthalmic, supplying parts of the eye; 3rd, *Meckel's*, on branches of the maxillary; 4th, *Arnold's*, on branches of the mandibular; 5th, *Cloquet's*, on the Jacobsonian organ, formed by branches from *Meckel's;* 6th, the lingual, on branches of the mandibular, seventh and sympathetic. The 7th nerve or facial arises in front of the 8th, supplies the superficial muscles of the face and over the hyoidean arch; the 9th or glossopharyngeal supplies the lining of the second visceral cleft; the 10th is a long nerve (vagus or pneumogastric), passing to the lungs, stomach, &c.; the 11th or spinal accessory has a spinal origin, but joins the 10th, and supplies the superficial protractor muscles of the shoulder-girdle; the 12th or hypoglossal is the motor nerve of the muscles of the tongue, and is often a true spinal nerve.

The eye develops from two sources, the percipient part being an outgrowth from the brain, the refractive from the skin. A sac of integument becomes involuted behind the maxillary lobe, and, as it sinks in, its mouth closes, forming the *outer eye vesicle*, whose lining epithelium thickens to form the crystalline lens. The cavity of the sac is at first in the centre of the lens, but as the epithelium grows it is pushed backwards, and finally is obliterated. The lining of this sac is thus rendered discontinuous with the surface epiblast, which closes over it and forms the cornea. While the outer eye vesicle is forming, an inner one grows from the anterior cerebral vesicle, and extends outward and forward obliquely until it meets with the outer vesicle; when the dermis of the deep surface of the outer sac, impinging on the convexity of the inner, drives in its fundus towards its pedicle, so that its cavity becomes finally obliterated, and its solidified pedicle becomes the optic nerve. The cup thus formed is not complete, as a temporary fissure extends into it from below,* notching it deeply, allowing the dermis of the vitreous humour to communicate with the mesoblast outside. The outer wall of this cup-like cavity produced by the inversion of the fundus of he inner vesicle becomes the pigmentary layer of the choroid; the inner wall becomes the retina; the edge of the cup narrows, and its inner surface becomes radially folded as "ciliary processes," and uniting with the mesoblast forms a vertical curtain (iris), which grows inward in front of the lens, and has its anterior margin narrowed to a central hole, the pupil, which is thus the mouth of the optic cup. The dermis of the outer vesicle,† or else a layer of mesoblast, intruded through the choroid fissure, dilates between the back of the lens and the front of the retina, becomes attenuated and liquefied, and forms the vitreous humour. Another layer of mesoblast sinks into the corneal epiblast, but carries a thin layer of it on its inner side which becomes the epithelial lining of the anterior chamber, within which the aqueous humour is secreted.

The mesoblastic sheath of the inner eye-vesicle, continuous with the connective sheath of the nerve centre or dura mater, becomes the sclerotic; and anteriorly this fuses with the forward growth of the mesoblastic dermis in front of the lens (*cornea*), which sends a marginal projection backwards between the sclerotic and pigmentary layers, becoming the vascular layer of the choroid.

In the larval lamprey the eye is not much more complex than in Amphioxus, but in the adult lamprey it becomes more highly developed. The

* Along this fissure the pigment is deficient; hence, when it closes, it appears as a clear line.

† The dermis may make only the capsule of the lens, not the whole vitreous humour.

sclerotic (white of the eye) is cartilaginous in sharks, but is in others fibrous or fibrocartilaginous, having bony plates in birds and reptiles. Where the sclerotic joins the cornea, its rounded interlaced bundles of connective tissue become flattened and ribbon-like, and the corpuscles arrange themselves in layers. The cornea consists of—1st, polyderic, often differentiated, epithelium, derived from the epiblast; 2nd, a foundation lamina, the anterior elastic lamina, present in the sheep, pig, and man, doubtful or absent in the horse, dog, goat, or calf; 3rd, the proper mesoblastic cornea of dense laminated connective tissue, with ramifying corpuscles and soft gelatinous tissue between its layers. In these, wandering white corpuscles are often found, and through the layers wide anastomotic canals pass, lined only on their deep surface by epithelium (*Schweigger Seidel*); 4th, a deep elastic layer, separated in the seal from the last by a layer of nucleated fibrillar tissue.

While the eye sac is thus being modified, the skin on the surface sinks in around the margin of the eyeball, and an upper and lower fold of skin become eyelids, whose lining dermis is called conjunctiva; and its altered dermal glands are called *Meibomian* along the lid edges, lachrymal at the outer angle, or Harderian (internally), while the outer part of the fissure between the fronto-nasal process and the maxillary becomes the nasal duct. The crystalline lens consists of a structureless capsule and an interior of elongated often serrulated epithelial cells. The lens is globular in fishes, flattened in mammals. The iris or colored part of the eye is perforated by the central pupil,* and hangs in contact with the front of the lens.† The choroid consists of a vascular lamina with vorticose veins and looped arteries. The outer lamina in most fishes is white and glistening (*lamina argentea*); in mammals it is loose, dark and connective (*lamina fusca*). The inner layer is made up of pigment cells, to which is added either a delicate layer of clear cells, or a bluish or green metallic-looking lamina, the tapetum, whose finely-ribbed surface produces the coloration as an interference phenomenon. There are two forms of tapetum—1st, cellular, found in fishes, and carnivora, whose cells contain lime-crystals in the former, seldom in the latter; 2nd, fibrous, found in many other mammals (*Brücke*).

The retina or percipient element consists of—1st, an outer or bacillary layer of rods and cones, like the crystal cones of invertebrate eyes. The

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* The pupil may be round, vertically or transversely elliptical, linear, triangular (some Amphibia), square (Galeus), &c.

† The iris consists of an epithelial surface-layer, a vascular parenchyma, and two sets of muscle fibres, a radial set of fibres (*dilatores pupillæ*), and a circular sphincter (supplied by the sympathetic, independently of the ciliary ganglion, *Hensen* and *Völckers*). These fibres, like those of the ciliary muscle, are smooth in most animals, striped in birds.

cones consist of two elements—an outer conical (reflecting apparatus, very long in nocturnal animals), and an inner ventricose composed of axis-cylinder material (this same division is seen in the rods of many arthropods). Cones predominate in birds' retina (except owls), and in the macula of the human eye. Between the two elements of the cones are often highly refracting "lenticular bodies" (*Schultze*). No cones exist in eels, bats, moles, and hedgehogs; no rods in most reptiles, Elasmobranchs, Ganoid and Marsipobranchs. The bacillary layer is undeveloped at birth in rabbits and kittens; but rods appear in four days, followed by the other elements; 2nd, an external limiting membrane, followed by a series of layers of nuclei and granules, with a middle connective intergranular lamina, separating them into inner and outer series; 3rd, a molecular layer; 4th, a layer of multipolar nerve cells; 5th, fibres of the optic nerve. The whole is supported by a net-work of radiating connective bands, which superficially expand, forming outside the bacilli an external, and inside the nerve fibres an internal, limiting membrane. The retina ends behind the iris in a margin (*ora serrata*). The front of the choroid behind the iris is plicated into sixty or seventy vascular folds (ciliary processes). The outer layer of the connective tissue forming the vitreous humour is called the hyaloid membrane, and it sends a process in front of the lens, which bounds around it a space, the canal of *Petit*. From the junction of the sclerotic and cornea to the ciliary processes, a *ciliary* muscle passes, which can draw forward these processes, and alter the convexity of the lens, thus altering the focus of the eye; a separate part of it is called the *tensor choroideæ*, and a circular band is described as "*compressor lentis*" (*H. Müller*).

In the eye of fishes the pedicle of the mesoblast projecting in through the choroid fissure remains as a fold (*processus falciformis*), from the lower and outer part of the eyeball to the back of the lens. This in birds consists of two parts, one membranous and one vascular, which becomes a folded projection—the *pecten*, pouch-like in the ostrich, and hence named *marsupium*.

In all Craniota, except Myxinoids, several sets of muscles exist for the eye. From the bottom of the orbit arise four recti—superior, inferior, external, and internal—which move the eye in the four cardinal directions. Two others, arising from the upper and lower parts of the inner and anterior edge of the orbit (or connected thereto by a pulley), pass to the outside of the eye and move it obliquely. These are the superior and inferior obliques. Still deeper is a four-cleft muscular sheath round the optic nerve (*choanoid*), and occasionally, in addition, there is a *levator palpebræ superioris*. An inner cutaneous fold, or third eyelid, may exist between and within the other two; for it, two muscles are often developed. These last, the choanoid and the outer rectus, are supplied by the sixth pair of nerves, the superior oblique by the fourth, and the rest by the third.

CHAPTER IV.

Craniota (*continued*).

The olfactory organ is median and azygos in Marsipobranchs, double in others, opening externally between the middle and lateral processes of the naso-frontal lobe, and lined with a plaited membrane. In fishes it is a groove, usually crossed by a transverse bridge of skin.

Sometimes the membrane is stretched over a papillary eminence (*Balistes*). In *Chimæra* one opening extends to the angle of the mouth. In *Dipnoi* and *Amphibia* the groove lies deeper, between the maxillary arch and the frontal process, and opens into the mouth through the upper lip. In caducibranchs the hinder opening is bounded by bone. As this canal grows, the true olfactory region becomes by degrees differentiated from it as a diverticulum from its upper and hinder wall, and in front it becomes complicated by the development of cartilaginous supports, developed either from cartilages of the ethmoidal region or from the dermis. A horizontal plate extends backwards from the maxillary arch, which becomes the palate, and separates the nasal canals from the mouth. When this extends to the mesethmoid septum it separates one nostril from the other, often leaving long fissures in the nasal floor. The extension of the palate separates the mouth and the nose, leaving the latter to open by choanæ into the post-oral cavity (pharynx), and on the face. Palatine openings may remain permanently between the maxillæ and palatine, as in marsupials, or between the maxillæ and premaxillæ, as in the incisive canal of *Stenson*. An anterior mucous diverticulum from these, which may be lamellated or saccular (and which is supplied by the olfactory, the nasal branch of the fifth, and the naso-palatine and anterior palatine branches of *Meckel's* ganglion), is called the organ of *Jacobson*. It is an accessory smelling organ, as if to discern the odour of food when in process of mastication.

In the nasal folds of mucous membrane there are formed turbinal bones (or cartilages, as in tortoises and birds); of these, two are connected to the ethmoid (superior and inferior ethmo-turbinals), one is independent, but articulating with the maxilla (maxillo-turbinal, or inferior spongy bone). This is most largely developed among mammals in the otter and seal, very small in Sirenia, Cetacea, and some marsupials. There is also a sphenoidal turbinal (the bone of *Bertin*) really connected to the base of the vomer.

Air-holding diverticula are developed from the nasal canals in certain directions: 1st, in the frontal bones (frontal sinuses) in some birds (as in ducks), and in mammals, very large in ruminants; 2nd, in the maxilla (*antrum maxillare*), absent in carnivores, edentates, and rodents; very large in solipedes; 3rd, in the body of the sphenoid (sphenoidal sinuses); continuous in the elephant through the temporal, parietal and exoccipital bones.

The lining membrane of the nasal passages is thickly covered with mucous glands, some of which are occasionally displaced and enlarged, and may communicate with the nose only by their elongated ducts. These glands may lie on the maxilla (snakes), in a pit in the maxilla (crocodiles), on the frontal or nasal bones (birds), or included in the posterior ethmoidal cells or antrum in mammals.

The mucous membrane of the nose differs in the upper or olfactory tract from that in the lower or respiratory tract. The former consists of three layers, an epithelial with spheroidal cells, covered with non-vibratile processes, and also containing cells with a narrow, rod-like, distal process (smelling cells of *Schultze*); both these are continued inwards to a basement network of nervous matter, whose interspaces contain nucleated protoplasm (*Exner*). Beneath this is a connective tissue basement, like that of ordinary mucous membrane; in this the olfactory nerve breaks up, and sends branches to the nervous net-work on its surface.

All Craniotes have an organ of hearing arising in the embryo as an involuted dermal sac, on each side of the hinder cerebral vesicle, above the cerebral end of the second visceral arch. This sac becomes closed on the surface, and outside the dermis of the cavity thus formed (the membranous labyrinth) a bony or cartilaginous peri-otic capsule develops. A thin offshooting pouch passes upwards, and soon opens only at its two ends, forming a superior semicircular canal. (This constitutes the whole ear in Myxinoids, where the fibres of the auditory nerve end on the* ciliated surface of these cavities without otoliths.) In lampreys, two such canals, anterior and posterior, form. In others, a third external or horizontal also is developed, with an ampullated inner end. The periotic capsule in fishes has no deficiency towards the second visceral cleft; but in amphibia, between its fore and hinder segments (pro- and opisth-otic) there is a fenestra ovalis, closed by a membrane. In Anura, sauropsids and mammalia, there is a second opening (fenestra rotunda) in the opisthotic alone. Within the vestibule are otoliths—in fishes either numerous and small, as in sharks, sometimes very minute, as in higher vertebrates, or more usually two, as in teleosts, an anterior larger or *sagitta*, a posterior discoidal or *asteriscus*. The neck of the primary dermal sac may remain as a tube leading from the

* Each cell has a single cilium in Petromyzon.

surface to the vestibule, as in some fishes, or it may close externally (lizards), or remain as a pouch of the vestibule (*recessus labyrinthi* of birds), or it may be utilized for the passage of a vein, as the *aqueductus vestibuli* of mammals. The membranous vestibule early divides into two parts: an upper, connected to the semicircular canals (utriculus*), and a lower, or sacculus. In some fishes the sacculus is lengthened downwards and forwards. This process, in sauropsida and mammals, becomes slightly club-shaped, or coiled, forming the *scala media cochleæ*. The periotic capsule does not lie close to these structures, as the liquefied hypodermis of the tegumental sac (perilymph, or *liquor Cotunnii*) intervenes; but, outside this, the ossified capsule is moulded to these structures, forming bony semicircular canals, a bony vestibule with two foveæ (foveæ hemispherica and semielliptica) for the sacculus and utricle, and a bony tube for the scala media cochleæ. In the straight or lageniform cochlea of the bird the membranous tube runs along one side of the bony space for it, and a partition stretches from it to the opposite wall of the space, dividing the bony cochlea into two parallel tubes, an upper opening into the bony vestibule (scala vestibuli), and a lower (scala tympani) opening into the visceral slit by the fenestra rotunda. In higher mammals the cochlea elongates and coils on itself,† making a whorl and a half in Cetacea and hedgehogs, 2 in the seal, 2¼ in ruminants, horse, and elephant, and 2½ in kangaroos, bats, and Primates; 3 in carnivores; nearly 4 in pigs; 4 in the cavy, opossum, and agouti; 5 in the paca. The central axis (*modiolus*) around which it coils transmits the acoustic nerve, and the two scalæ, tympani and vestibuli, are separated by a bony layer, *lamina spiralis*, projecting for ⅔rds across the tube of the cochlea.‡ The scala media completes the division, and consists of an upper wall (membrane of Reissner) and a lower (lamina basilaris). These unite externally with the endosteal lining of the bony labyrinth, internally with the free edge of the spiral lamina. Nerves pass through this lamina to the upper surface of the membrana basilaris, and end in two sorts of cells, conical cells of *Corti*, with elongated apices, continuous with the nerves, their bases free under the superficial connective *lamina reticularis*. These are arranged on central ascending and descending rod-like supports;

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* On the utriculus is an opaque spot, *macula acustica*, with three kinds of epithelium: 1st, cylinder; 2nd, basal cells; 3rd, spindle cells; like those of *Deiters* in the cochlea. The ends of these cells project as short stiff lines on the surface. In these the vestibular nerves terminate (*Odenius*). *Reich* showed a similar nerve-ending in spindle cells in the ear of Petromyzon.

† Spirally, the result of growth under pressure.

‡ The two scalæ communicate at the top of the cochlea by an opening (*helicotrema*).

between these cells are narrower hair-like cells of *Deiters* with dilatations, like the nasal cells of *Schultze*. Lying on the reticular lamina is the *membrana tectoria*. The scala media is continued out of the bony cochlea into the vestibule by a rounded cæcal or cochlear duct, into which the delicate *canalis reuniens* of Hensen opens from the sacculus. Within the membranous labyrinth is a fluid (*Liquor Scarpæ*, or endolymph).

The organ hitherto described is the internal ear. As an appendage to this, the upper end of the first post-oral visceral slit in higher vertebrates is modified; its outer end narrows, becomes bounded by fibrocartilage, forming the external auditory meatus, and a fibrocartilaginous flap becomes the external ear, with a reflected rim or *helix*, and an anterior free projection, *tragus*. The inner end of the slit becomes tubular (Eustachian tube). The walls internal to the meatus close, by the ingrowth of the membrana tympani, cutting off the passage from within outwards, leaving as traces of the original passage the minute *foramen Rivinii*, and, perhaps, the pouch of *Tröltsch*.* The central part of the canal thus cut off from without dilates into the cavity of the tympanum, into which the two fenestræ open; a disk of bone, to which a rod (Columella) or arch (Stapes) is attached, blocks up the fenestra ovalis, and its outer end either joins the membrana tympani, the base of the hyoid arch, or is embedded in muscles.

As an organ of taste the tongue is developed in vertebrates, attached to the basihyal, and often with sensory papillæ of four types on its surface—1st. Filiform, simple or branched, epithelium-clad, recurved, for prehension. 2nd. Fungiform, conical, beset with points, sensitive, supplied by the gustatory branch of the fifth nerve. 3rd. Circumvallate papillæ, a few in a row, posteriorly supplied by the glossopharyngeal nerve, flat-topped, and surrounded by a shallow groove. 4th. Foliated, or lateral lamellar organs as in the tongues of many mammals. In these papillæ, nerves end in spindle cells (*Axel Key*). There is sometimes a central *foramen cæcum* in the tongue, often communicating with a branched gland. In mammals the tongue is beset with glands at the tip (*Nuhn's*) and in front of the insertion of the styloglossus muscle (*Blandin's*); postero-laterally are the absorbent or lymphatic follicles of *Salter* and *Henle*. In the middle of the tongue there may be a bony or cartilaginous axis (entoglossal bone).

In connexion with the visceral arch system there may be other arches which are only present in rudiment; thus, the labial cartilages of selachians, and even the cranial trabeculae, may be pre-oral visceral arches.†

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* A little pocket seen from within the tympanum, bounded by the ligaments of the handle of the malleus.

† Possibly the maxilla and premaxilla may be the splints replacing the arches, of which the selachian labial cartilages are the rudiments, as the

From the cephalic end of the hypoblast a saccular process projects upward, between the trabeculæ, into the pituitary space, becoming the hypophysis or pituitary body, which afterwards becomes connected to the anterior cerebral vesicle. This process limits the anterior extension of the notochord.

Behind the skull the notochord has a mesoblastic sheath, of three layers, an inner structureless, a middle elastic, and an outer or skeleton-building. At first, axial masses of mesoblast on each side of the notochord divide from before backwards into a chain of successive segments or protovertebræ, marked from each other by clear lines. These first detach from their dorsal and outer surface a double layer of cells, which forms the muscle plates;* then the remainder or connective cells formed on their inner side sends an epaxial process upwards over the neural canal, and a hypaxial process under the notochord, uniting the corresponding parts of the proto-vertebræ of each segment. Thus the neural canal and the notochord become surrounded by mesoblastic processes. Then internal to the proto-vertebral body there arises the spinal nerve and its root ganglion, as offshoots from the back of the spinal cord, while the sympathetic ganglion arises from a segmentation of the protovertebra. The boundary lines between the proper vertebral segments vanish, and they appear continuous; a secondary segmentation then takes place in the mass, the cleavage lines being each situated in what before was the middle of a protovertebra. Hence these secondary cleavage lines are alternate between the separations of the muscular lamina, and each muscle plate is attached to the back of the anterior and to the front of the posterior vertebra in contact with it. From the proto-vertebræ there were also paraxial mesoblastic processes, growing into the somatopleure, in which ribs are afterwards developed; and these, as well as the neural arches, formed in the epaxial processes, are related to the intervertebral spaces. The neural arches and ribs are cartilaginous processes, formed respectively in the epaxial and paraxial processes. In the chick, ossification begins in the second or third cervical vertebræ, on the twelfth day. The chorda itself never segments, and in the higher vertebrates disappears in the intervertebral spaces; and its inner sheath forms the ligmentum suspensorium, or *nucleus pulposus;* while in the vertebræ it chondrifies, and is lost by fusing with its surroundings.

Thus, most Craniotes have a segmented bony axis, each of whose vertebræ consists of a solid *body* of bone, and a *neural arch*, of two coalescing,

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vomer may be the splint of the trabecular arches. Parker regards the labial cartilages as extra-visceral cartilages, not branchial arches.

* These muscle plates are derived from the lining of an upward extension of the pleuro-peritoneal cavity, and exhibit a contractile character very early. —(*Balfour*).

autogenous,* lateral *laminæ* (neurapophyses), joined to the body on each side by a neuro-central suture. Over the medio-dorsal union of these laminæ is an autogenous *neural spine*. A process, usually exogenous,† jutting from each lamina is the *upper transverse process* (diapophysis); a spur, generally autogenous, from each side of the body is the *inferior transverse* process (parapophysis). The front of each lamina sends forward a little exogenous spur (pre-zygapophysis), articulating with a corresponding pair of spurs on the back of the preceding laminæ (post-zygapophysis). Some vertebræ have additional exogenous mammillary processes (metapophyses), behind each pre-zygapophysis, and another between the transverse process and pre-zygapophysis (anapophysis).

The single or bifid ends of the separately ossified ribs, which surround the visceral cavity, are attached to the ends of the upper and lower transverse processes. The central region of the body where they are developed is the *dorsal* region; the vertebræ between the dorsal and head, corresponding to the region where the mesoblast does not divide into splanchno- and somato-pleure, are called *cervical*. Where a hind limb exists, its basal girdle abuts on one or more vertebræ, which are called *sacral;* those between the sacral and dorsal are called *lumbar*, and the post-sacral are *caudals*, or, if few, *coccygeal*. The part of the rib joined to the upper transverse process is the *tuberculum;* that to the lower, *capitulum*. A single vertebral segment has thus a body mesially, a neural arch (bounded by the laminæ) behind, and a hæmal arch (bounded by the ribs) in front; while two lateral canals are formed by the junction of the bifid rib-end and the two transverse processes. In any animal the number of vertebræ is expressed by a vertebral formula, the initial of each group preceding its number; thus, in men, the vertebral formula is C, 7; D, 12; L, 5; S, 5; C, 4. The first cervical (*atlas*) articulates with the basi- or ex-occipitals, by particular processes called condyles; the second vertebra is called *axis*.

Within the neural canal the epithelium of the dorsal groove forms the spinal cord, as a hollow tube, whose sides thicken to form the lateral column, while its cavity remains, and becomes divided into a ventral and a dorsal part. The former remains as the central canal of *Stilling*, while the latter becomes slit-like, and by absorption loses its epithelial roof, hence forming the posterior fissure of the cord. The anterior fissure is morphologically different, being only an infolding of the surface from rapid growth.

Between each pair of vertebræ the spinal cord emits lateral nerves, each with two roots, an upper sensitive, and a lower motor. Below each ver-

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* Ossified from a separate centre.

† Ossified as an outgrowth from a pre-existing centre.

tebral body the sympathetic ganglia form, and are connected by commissures into a chain supplying the viscera, and communicating with all the cerebrospinal nerves.

CHAPTER V.

Viscera of Craniota.

In the visceral cavity the hypoblast forms a cylindrical tube, at first blind at each end, but soon a mouth forms in front, as a dermal involution, between the maxillary lobe and Meckel's cartilage. A somewhat similar opening forms behind as the anus. The mouth is bordered by dermal folds, or lips, within which are usually calcified papillæ (teeth), and below, the tongue, which is often fleshy and protrusible, attached to the basihyal.

The region of the visceral clefts (pharynx) has a wall of striped muscles, which are the muscles of the visceral arches, or their modification. The thoracic extension of the hypoblast is a muscular tube, the œsophagus; the abdominal part is differentiated into a stomach and intestine; the former may be tubular, saccular, siphonal, double, or complex; it has two openings: one œsophageal or cardiac, and one intestinal or pyloric. The splanchnopleure forms several (usually three) layers of muscle in the wall of the canal—longitudinal, circular, and oblique. The mucous epithelium is cylindrical, and its surface is covered with glands, which often at the pylorus form glandular lamellæ (*plicæ villosæ*). The glands of the stomach have cæcal or branched ends, lined with epithelial cells, which may be either large "invest-

ing" cells, or small, pale, gastric cells. A layer of unstriped muscle (*muscularis mucosæ*) underlies the mucous layer, and is joined to the proper muscular layer by connective tissue. The stomach receives branches from the vagus and from the sympathetic nerves.

The intestine may be straight or coiled, 2–20 times the length of the body; its first part, or duodenum, is separated from the stomach by a sphincter muscle (pyloric valve), and receives the ducts of the liver and pancreas, often looping round the latter. It has racemose (*Brünner's*) glands in its wall, and has no oblique muscular stratum; some of the longitudinal fibres often stretch into the suspensory fold of the peritoneum, and are attached to the hinder part of the somatopleure, forming a *suspensorius duodeni* muscle (*Treitz*). The succeeding part of the intestine is cylindroid, with no large appended glands, lined by a single layer of sub-conical or cylindrical epithelium, and possessing mucous glands, villi, and absorbents. The mucous membrane may form a continuous spiral valve, or numerous projecting folds (*valvulæ conniventes*, or *Kerckringii*). In the muscular layer, between the longitudinal and transverse fibres, the sympathetic nerve forms a gangliated *plexus myentericus* (*Auerbach*), and another plexus (*Meissner's*) lies in the sub-mucous tissue. This part often ends by a valvular opening, in a dilated portion of the canal, the large intestine or colon, which may begin by a blind dilatation (*cæcum*), from which a narrow blind tube, the vermiform appendix, in a few cases projects. The colon may be $\frac{1}{10}$ or $1\frac{1}{2}$ the length of the small intestine, and is often sacculated; when long it is curved, and arches over the origin of the small intestines, which thus appears to pierce the root of its peritoneal investment. The descending part of the large intestine (rectum) ends in a common cloaca, or a separate anus. Lymphatic follicles are abundantly distributed under the mucous membrane of the small intestine, forming *Peyer's* glands.

At an early embryonic stage, a longitudinal shallow groove appears within the hypoblastic tube, on its ventral side. This becomes divided into anterior and posterior parts by a wide transverse ridge; the hinder of these deepens, closes preaxially by the union of its lateral lips, thus forming a cæcal pouch like the liver in Acrania; its fundus bifurcates, or as the groove may be double from its beginning, each branch lengthens, becomes solid by cell growth, and again divides, forming a tree-like arrangement of solid branches, united by a connective parenchyma. Ultimately the union of the intercellular passages forms a single or multiple bile duct, opening into the intestine below the pylorus. The epithelium increases within, and distends the branching

cæca, forming a solid organ, the liver, whose ultimate follicles have no connective wall, being simple excavations between the gland cells (*Hering*).

In its growth the liver extends to the vena cava inferior, below its dilated sinus venosus (see p. 32); it also surrounds the root of the omphalo-meseraic vein (Fig. 7, *o*), which returns the blood from the intestine (here called the vena portæ), where it joins the allantoic vein (*al*). These vessels here break up into a venous net-work, whose meshes interlace with the tubular system of the gland, and make an important component of the organ. The liver may be simple, or the allantoic vein and its serous sheath (falciform ligament) may divide it into two lobes, right and left (Fig. 8, *u*); each of these may be again divided into two lobes, a lateral and a central (*rc* and *lc*, *rl* and *ll*). Postaxially between the right lateral and right central lobes a part of the primitive tubular system often dilates into a gall bladder (*g*), which is either imbedded in the gland or pendent from it, or may appear remote from it by the obsolescence of the right lateral lobe. This bladder is usually at the end of a primary branch of a primordial hepatic cæcum; hence it communicates with the hepatic duct only, by its neck being united thereto; rarely it is a dilatation of the middle of a duct whose gland radicles form a lobe beyond it, communicating with it by hepato-cystic ducts. The two central lobes often unite, forming a tri-lobed liver, with right, central, and left lobes; postaxially, two accessory lobes may be formed, a right and a left; behind these, the liver substance between the vena cava and the right branch of the v. portæ forms a lobe inclining to the right (*lobulus caudatus*) (*c*); and another lobe (*s*) connected to this intervenes between the vena cava and the ductus venosus (*l. Spigelii*). There may be eight lobes in the liver; but sometimes the organ is still further broken up into lobules, as in Capromys, camel, and seal, or some of them are absent.

Fig. 7.

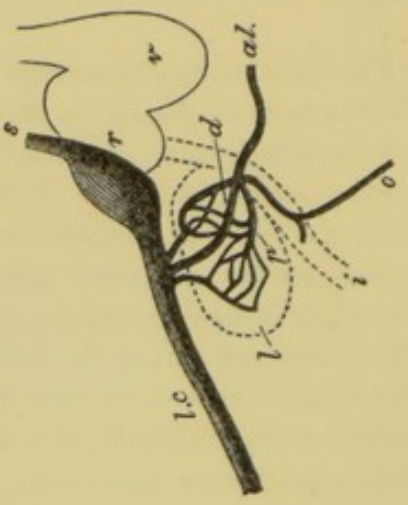


Diagram of the Vessels in the Liver: *al*, allantoic vein, or umbilical vein; *o*, omphalo-meseraic vein, or vein from the hypoblast; *p*, portal-plexus of veins in *l*, the liver; *lc*, inferior vena cava; *s*, superior vena cava; *d*, ductus venosus, or continued trunk of the allantoic vein to join the vena cava close to its dilatation or sinus venosus; *r*, right ventricle; *i*, intestine, on which will be seen the vena portæ as a small stem, joining the omphalo-meseraic vein.

The pancreas is a follicular or racemose gland, beginning as a diverticulum from the intestine, and remaining in this form wholly or partly, as in fishes;

its duct (*Wirsungian*) is generally the remains of the original tubular outgrowth.

Fig. 8.

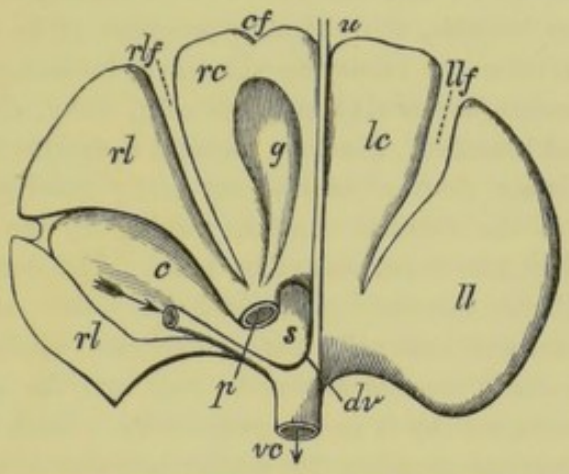


Diagram of the lobes of the Liver: *rl*, right lateral lobe; *ll*, left lateral lobe; *lc*, lef central; *rc*, right central; *u*, umbilical vein; *dv*, ductus venosus; *vc*, vena cava; *rlf*, right lateral fissure; *llf*, left lateral fissure; *cf*, cystic fissure; *g*, gall bladder; *c*, lobulus candatus; *s*, lobulus Spigelii; *p*, vena portæ.

Teeth may be of two kinds—First, epidermal, secreted by separate dermal papillæ, as in Myxine, Petromyzon, and amphibia. The horny sheaths of the jaw arches in tortoises, birds, true whales, &c., are of a different nature, being a general hardening of the whole epithelium, a supplemental contrivance following the vanishing of true teeth, as shown by the embryonic appearing and vanishing of teeth, in cases where ultimately such sheaths appear (Trionyx, Psittacus, Ara, some whales). Probably of this nature are the concentric heaps of epithelium, like minute points of horn, found by *Kölliker* and *Serres* in the human gums, and by myself in many other mammals.

The second kind of teeth are calcified papillæ, and may form on the surface of the membrane, or in pits. In mammals the papillæ are often seated each at the bottom of a compartment of a primary dental groove, whose sides rise into ridges, and finally unite above, to inclose each in a

separate sac. In other vertebrates there is neither a primary dental groove nor a papillary stage in growth.

As the papilla grows, and the matrix of its connective tissue calcifies from the surface inwards, the outgoing processes of its central cells (or odontoblasts) traverse the calcifying substance, becoming *dentine fibres*, which are numerous (five or six from each cell), wavy, closely set, somewhat parallel, and branched. These are included in dentine tubuli, or canals, lined by a resisting *dentinal sheath*, not easily acted on by reagents. Around them is the calcified matrix, making up the *dentine*, which exhibits wavy lines due to flexures of its tubes. The central mass of the papilla (in which lies mucous tissue, plexiform vessels, silky non-medullated nerve fibres, and externally the odontoblasts, whose processes project into the dentine) remains soft as the *pulp*, and the space within the calcified body occupied by it is the *pulp-cavity*. Each odontoblast not only sends off dentinal processes, but shorter processes to the deeper cells, and lateral processes to its neighbour cells. Dentine (ivory) makes up the body of most teeth, but it is usually coated with enamel. The primitive dental groove, or the tooth papilla, is clad with a thickened epithelium, and when the tooth sac closes, the space around the papilla is filled with this material (the enamel organ). The epithelial cells on the surface of the dentine lengthen into rods, calcify, and are called enamel fibres. Calcification takes place in laminæ often with layers of pigment spots (*Hertz*), producing brown parallel striæ (*Retzius*). Transverse markings in these enamel prisms may be due to intermittent calcification. The rest of the material over the enamel changes into stellate gelatinous tissue (stratum intermedium of *Hannover*), which, as the tooth in growth passes upward, is absorbed, as also is the roof of the sac; then the tooth becomes "cut," or projects on the surface. Over the enamel is a membrane described by *Huxley*, with minutely processed cells. Sometimes the dentine tubuli project into the enamel surface, as in some rodent and marsupial mammals. The horny cuticle over the enamel in young teeth is called the persistent capsule of *Nasmyth*.

The basal connective tissue of the surface of the tooth papilla below its neck is changed into true bone (cement); it rarely covers the crown (as in some ungulates); its outer layer is sometimes non-lacunar, but between the cement and the dentine lies a lacunated layer (the interglobular substance of *Czermak*); the cement often exhibits *Sharpey's* perforating fibres, as in the dog, and its osteoblasts are in clusters, surrounded by dense connective capsules (*Gerber*).

Teeth may be simple, with a simple pulp cavity, compound, or folded;

compound teeth may be of two kinds, either with a single pulp stem, giving off many branches, produced by the dentinization of a branched papilla (Galeopithecus), or numerous separate pulp cavities may exist in the one tooth, formed of a number of contiguous small papillæ (Orycteropus). In a folded tooth there is a single irregular pulp cavity, and the materials of the tooth may be variously plicated. Teeth usually sink through the mucous membrane to the bone, and may be attached to it by ligament, or be ankylosed by a special development of bone by their side (pleurodont) or base (acrodont), or may be sunk into sockets (thecodont), and then the pulps may be large and permanent with permanently growing teeth; or the neck of the pulp cavity in the root of the tooth may narrow, and the tooth reach a definite limit of size. The bones to which the teeth are attached are usually the maxillæ, pre-maxillæ, and mandibles; often the vomers, palatines, pterygoids; and in fishes, parts of the hyoid and branchial arches, rarely the parasphenoid (Plethodontidæ), basi-occipital (carp), or cervical vertebræ (Rachiodon). All the teeth may be similar (homodont), or some may be altered in shape, and arranged in sets (heterodont). In some animals the first-formed teeth are shed, and replaced by a second growth, formed in offshoots from the original tooth sacs (these animals have been called diphyodonts); in others, the first set have no successors (monophyodonts). In the former case, when the tooth sac closes, a small diverticulum projects from it, and is shut off beneath the primary sac, as a secondary sac, in which a secondary papilla grows for the permanent tooth; on its development the growth is attended with absorption of the root of the first, or milk tooth, which falls out, to be replaced by the second. The top or free part of a tooth is its crown, the middle is its body, and the inserted part its fang. The crown may be marked with pointed eminences (cusps) or ridges.

A longitudinal vertical double layer of the lining* of the cœloma (the mesogastric fold) fixes the intestine to the spine, extending from one end to the other, partly attached to the front wall of the abdomen, anterior to the allantoic veins, partly to the posterior, or it may disappear in part by absorption, the intestine hanging free, as in the lamprey. In the anterior layer, passing to the stomach, the liver is developed. The elongation of the small intestine stretches the fold going thereto, which becomes plaited (the mesentery). When the large intestine is short, its serous envelope is also short, but on elongation and extension it carries upward and forward with it a fold of the serous membrane, which crosses over the root of the mesentery, and descends on the right side; this fold is the transverse mesocolon,

* This consists of a monoderic epithelium (sometimes called endothelium) and a connective basement; between the epithelial cells are lymph-spaces or pores communicating with the lymphatic vessels.

and it crosses the medio-dorsal line between the mesentery (behind) and the duodenum (in front). In mammals, from the convexity of the stomach, two layers of serous membrane descend, and then turn up behind the organ to return to the spine, separating finally into an ascending and descending layer, the latter of which is continuous with the mesocolon—often inseparably adherent to its surface, as in man. In the mesentery of lizards, amphibia, and tortoises, muscular fibres from the splanchnopleure are continued to the somatopleure.

The blood contains red as well as white corpuscles,* and may be as hot as, or hotter than, the external medium, the heat varying with the activity of respiration and the degree of separation of the arterial and venous blood. The heart has a striped muscular wall, and is developed below the middle cerebral vesicle in the mesoblastic space, whose lining serous membrane closing round it generally forms a shut pericardium. The heart appears first as a solid cellular mass of the splanchnopleural mesoblast; below the anterior end of the hypoblast it becomes tubular, loops on itself, then a partial septum divides it into a hinder thin-walled receptive cavity or auricle, and anterior thicker ventricle, hanging freely in the pericardium, and by its contraction driving the blood through the body. The veins generally unite, and form a *sinus venosus* before entering the auricle, and the tube leaving the ventricle likewise often dilates into a *bulbus aortæ*, usually with a striped muscular coat.

On the development of the lungs the auricle divides into right or venous, and left or arterial chambers, by the growth of a septum. The ventricle may also become divided into a right *cavum venosum*, communicating with the right auricle and pulmonary artery, and a left *cavum arteriosum*, opening from the left auricle and into the aorta. The interauricular septum may be slow in being completed, and the two sides communicate permanently in some reptiles, and until birth in mammals and birds, by a foramen ovale.

* In adults. Leptocephalus, the larva of the conger, has no red corpuscles.

The heart may be thus bi-, tri-, or quadri-locular. In higher Craniotes, as growth advances, the heart moves backwards as far as the middle of the thorax.

Fig. 9.

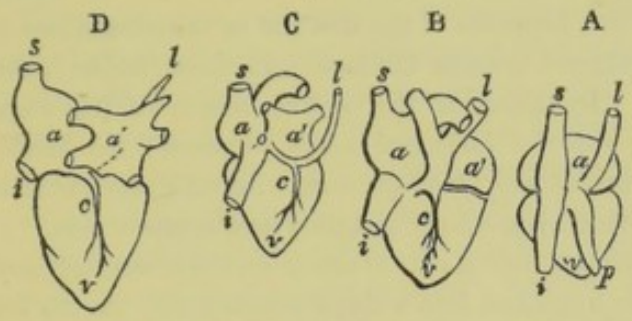


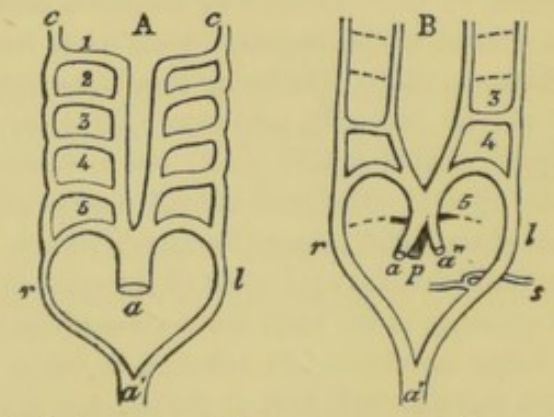
Diagram of hearts: A, of Reptile; B, of Bird; C, of Didelphian; D, of Mammal; *a*, auricle, right; *a'*, auricle, left; *v*, ventricle; *c*, coronary vein; *i*, inferior vena cava; *s*, superior right vena cava; *l*, superior left vena cava.

The muscle of the heart wall is poor in kreatin, and its fibres are made of united cells. The bundles of fibres are partly common to several cavities, partly proper to each. Some of the former project into the cavity of the ventricle as bundles (carneæ columnæ), and may be arranged as pilasters or trabeculæ, or attached by their free ends by tendinous cords to the auriculo-ventricular valve. Some of the largest of these *cordæ tendineæ* have fleshy fibres in their substance (*Œhl*). The lining membrane of the cavities (endocardium) consists of—1st, internally polygonal epithelium; 2nd, close elastic fibres, with scattered smooth muscle cells; 3rd, connective tissue, outside which is a double layer of gelatinous striped muscle fibres, broader and shorter than those of the heart proper (*Purkinje's* fibres). Thus the endocardium is, in the ventricles, the equivalent of the coats of the blood vessels. Around the chief openings in the heart fibrous, sometimes bony, zones form, and parts of the lining membrane are inflected as valves at each of these. In the right auricle valvular folds form at the opening of the sinus venosus, or at those of the inferior (*Eustachian* valve) and left superior vena cava (*Thebesian* valve). At the right auriculo-ventricular opening there is a valve of 1–4 flaps; at the left, one of two laminæ—the mitral valve. At the openings of the arteries from the ventricles there are semilunar valves, at first developed as thickenings of the wall (*Tonge*), then becoming hollow. The auriculo-ventricular valves have the tendons of the columnar muscles inserted into them; the valves at the mouths of the arteries are passive, each moved by the current of the blood alone. Each consists of an epithelial, a fibrous (from the zona tendinosa), and an elastic layer (from the endocardium). The

heart is the best nourished muscle in the body, and is permeated with vessels from the root of the aorta, or intermuscular spaces from the cavity of the ventricle. Through the muscle are fine lymphatic interspaces (fissures of *Henle*). The distention of the heart wall with blood in the higher vertebrates is an important cause of ventricular diastole (*Garrod*). The heart has a double nervous supply: one inhibitory, from the vagus; and the other excitory, from the sympathetic; filaments of the first end in the spiral fibres of bipolar ganglion cells, scattered through the heart-substance (*Bidder*); the latter, in the nerve tissue. Irritation of the cardiac branch of the vagus, below the origin of the superior laryngeal nerve, depresses the heart's action, and lowers the intravascular blood-pressure. Stimulation of the cardiac branch of the last cervical sympathetic ganglion accelerates action.

From the primary bulb a pair of aortic arches arises, left and right, which unite above the hypoblast into a single dorsal aorta. As the heart recedes in development, second, third, fourth, fifth, and rarely sixth and seventh, even to a ninth pair of arches, arise parallel to the visceral arches, all passing to the dorsal trunk. These may become modified by obliteration, by the breaking up of the middle of an arch into a rete mirabile, or by the sending off of branches. The first arch supplies the head; often the fourth supplies the fore-limbs. The dorsal trunk gives off intercostal, omphalo-meseraic,

Fig. 10.



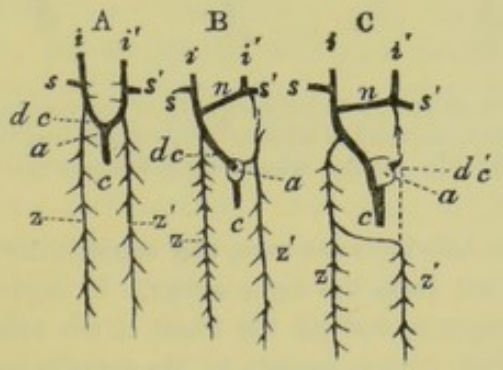
A. Diagram of Aortic Arches: *a*, cardiac aorta; 1, 1st arch supplying the head, 2-5 arches; *r*, right arch; *l*, left arch; *a'*, dorsal aorta; B, modification of arches.

gastric, hepatic, mesenteric, and after giving off renals, usually divides into two allantoic and one middle caudal artery. These arteries are tubes with five coats—1st, an inner, of flat fusiform lining cells; 2nd, a fenestrated network of fine elastic fibres; 3rd, a layer of longitudinal and transverse fibres in a granular matrix (rarely with muscle cells, as in man's popliteal artery—*Eberth*); 4th, muscular fibre cells in a connective basis with elastic fibrils, or merely the connective tissue with no muscle, as in the ascending aorta of

primates (in general the elastic element increases with the calibre of the vessel). The muscle cells are circularly placed, with some interrupted longitudinal bands, strongest in movable arteries like the mesenteric and gastric. 5th, an outer elastic and connective tunica adventitia, containing minute nutrient arteries (*vasa vasorum*), which do not pierce the deeper coats. Arteries end in minute capillaries, with homogeneous contractile walls, or fusiform cellular lining, and sometimes a tunica adventitia (*Chrzonszczewsky*), sometimes black dots on the wall, like stomata (*Cohnheim*). The nutrient elements transude these vessels to the tissues, and the capillaries end in veins which return the blood to the heart. Veins are rarely rhythmically contractile, usually possess valves (of finely fibrillated connective tissue with stellate cells, and occasionally smooth muscle cells—*Wahlgren*). The tunica adventitia in the vein is stronger than that in the arteries; the muscular coat is also well marked (except in the right superior v. cava of primates and carnivora). Most veins have circular fibres alone; some few have an inner and outer longitudinal set as well (iliac, femoral, mesenteric in man); some only an outer of longitudinal fibres (inferior v. cava and azygos, &c.)

The primitive venous system of Craniotes consists of symmetrical hypaxial longitudinal trunks in the mesoblast, one from each side of the head passing backward (jugulars), and one from each post-axial part of the trunk passing forwards (cardinals). These meet and unite, forming short trunks on each side (ducts of *Cuvier*), which pass inwards to the sinus venosus. When the fore-limbs develop, their veins, the subclavians, join the jugulars, and the two symmetrical brachio-cephalics thus formed pass to the Cuvierian ducts, and form with them the right and left superior venæ cavæ. In higher

Fig. 11.



A. Generalized diagram of the Venous system of Vertebrates: *i i'*, right and left jugular veins; *s s'*, subclavian veins, or veins from the fore-limbs; *d c*, ducts of Cuvier; *a*, auricle; *c*, inferior vena cava; *z' z*, cardinal veins or venæ azyga; B. Specialized form, with a communicating branch from one cardinal vein to the other (*vena innominata*); C. Arrangement found in man.

animals a transverse branch of communication (Fig. 11, *n*) forms between these trunks opposite the junction of the left jugular vein and the left subclavian vessel (the left vena innominata); the left trunk below it diminishes, so that the main part of the blood of both sides flows through the right superior vena cava). The left may even be quite obliterated, leaving as its only rudiments a crescentic vestigial fold of pericardium (*Marshall*) (C, *d'c*), and the muscular coronary sinus of *Reid*, which now serves only to admit the blood of the coronary vein into the right auricle. The cardinal veins, passing the primordial kidneys, send some branches thereto (Fig. 12, C, *r*), which form a capillary reno-portal plexus. These branches reuniting form renal veins, which pass inwards, join their fellows of the opposite side medially, and form an ascending trunk, the inferior vena cava passing to the sinus venosus (Fig. 11, *c*; Fig. 11, *j*). The veins of the lower limbs (Fig. 12, *f*) may either pass into the reno-portal system

Fig. 12.

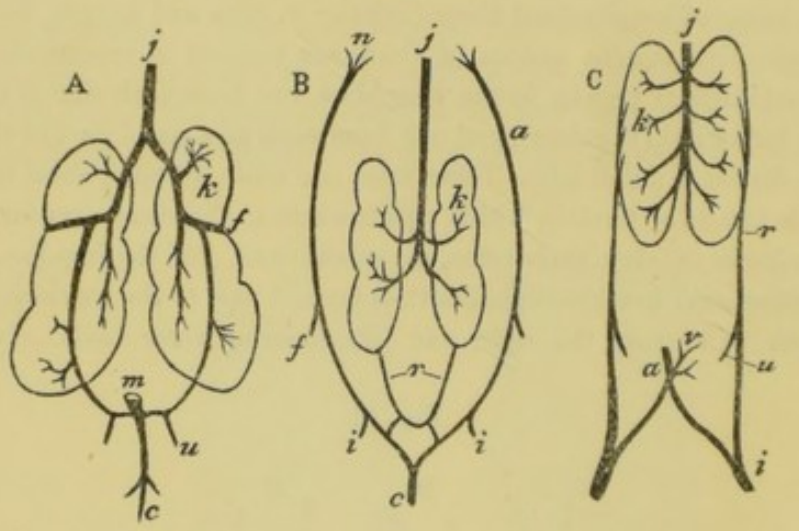


Diagram of the veins of the posterior extremity of the vertebrate body: A, venous arrangement in a bird; B, veins of alligator; C, veins of frog; *c*, caudal vein; *i*, iliac vein; *r*, renal advehens; *j*, inferior vena cava; *k*, kidney; *u*, *i*, hypogastric veins; *f*, crural vein.

or directly into the inferior vena cava, and coincidently the cardinal veins diminish in size, and form the venæ azyga. In higher forms the reno-portal system disappears, and all the blood of the kidneys, lower limbs, and hinder vertebral region ascends to the inferior vena cava directly. The veins from the hypoblast (intestinal, and in the fœtus omphalo-meseraic from the umbilical vesicle) unite in a trunk, the vena portæ, which ascends to the liver, and there breaks up into a hepato-portal plexus, which, re-consolidating, ends in the sinus venosus (see Fig. 7). The

veins from the allantois in the embryo (umbilical veins) ascend on the abdominal wall, and unite with the vena portæ before its division, often sending a branch directly onward to the inferior vena cava (*ductus venosus*). An epigastric vein, a branch of the caudo-ischiatic vein, ascending on each side of the wall of the abdomen, dips in near the liver to join the allantoic vein.

Lymphatic vessels exist in Craniota, to return into the circulation the superfluous plasma exuded in the process of tissue-nutrition; these begin as wall-less lacunæ. On serous membranes inter-epithelial spaces exist, leading directly into the lymphatics (*Dybkowsky*, &c.) Lymph vessels are either loose connective spaces around the blood vessels, with a wall of flattish endothelium (perivascular canals as in the brain or liver—*His. Macgillavry*), or as vessels with valves and coats, like veins. These unite into large trunks, and pour their fluid into the jugular and caudal veins, or, forming a lymph sheath around the aorta, may end in the superior vena cava. This aortic sheath may divide into two lateral *thoracic ducts*, or one of these alone may persist (on the right side). These at their endings may have dilatations with striped muscular coats (lymph hearts). The lymphatics from the intestines carry chyle (and are called lacteals).

Here and there in lymph sheaths or vessels, stellate connective corpuscles collect, interrupting the flow of the fluid, which then passes in the intervals between the branched processes of the connective cells, and in these nets lymph corpuscles are entangled. Such little swellings are called lymphatic follicles, and around each is a network of fine lymphatic vessels. Of this nature are the follicles of the pharyngeal and faucial tonsils, or of Peyer's patches in the small intestines. When placed at the confluence of large lymphatics, they are called lymphatic glands, and have an outer connective wall sending in trabeculæ, and fine fibres crossing the lymph path (where the lymph corpuscles are delayed and multiply), which unite centrally to form a mass of club-shaped processes. Such glands may form a mass at the root of the mesentery (the pancreas of *Aselli*, as in seals and whales). Another mesoblastic lymphatic organ is the spleen, developed in the meso- or diaphragmato-gastric peritoneal fold. Here in the embryo formative cells accumulate in intercellular meshes, and blood vessels shoot thereinto. In reptiles the spleen is a lymphatic gland, whose trabeculæ are blood capillaries. In higher vertebrates this organ has a connective capsule covered fœtally with columnar, in the adult with scaly, epithelium, sending in processes containing smooth muscle cells. These sheathe the veins closely, the arteries loosely. The small arteries have no companion veins, and their adventitious coats, entangling lymph cells here and there in connective meshes, form solid rounded minute outgrowths, called Malpighian bodies. The spleen pulp consists of cells in a lacunary intercellular tissue;

the walls of the capillaries, becoming finely granular, and diminishing into mere threads with attached cells, allow the blood to escape into the lacunæ, wherein the veins begin by cribriform canals, whose walls are lymph cells and intercellular tissue (*Peremeschko*). Thus the lymph and blood spaces are continuous.

In front of the pericardium in Craniotes lies a vascular lobate body, the thymus, made of a loose capsule and fibrillar trabeculæ entangling solid lymphatic follicles and coarsely granular polynuclear cells, and spheroidal, often compound, concentrically striated bodies (*Hassall's* concentric corpuscles). In hybernating animals this organ becomes distended with fat before the period of sleep; in others it disappears as development proceeds.

The thyroid body is a similar vascular body in the neck, single or double, and inclosed in a capsule which divides it into primary and secondary segments, each made of vesicular acini, which consist of a hyaline membrane and a layer of gland-epithelium. Between these vessels are networks of lymphatics; it originates as a process from the neck end of the hypoblast (*W. Müller*).

In Craniota the respiratory organs are connected to the preaxial end of the digestive tube, and consist of vascular networks exposed to water (gills) or air (lungs). Gills may be filamentous or lamellar, attached to the visceral arches, receiving blood from the aortic arches, and carrying it to the dorsal aorta. The gills may be external, their vessels being networks on loops from the arches, or else internal, with the aortic arches themselves breaking into retia. They are bathed by water entering by the mouth, and escaping through the visceral clefts, and are often covered by a dermal fold (operculum) from the second gill arch.

Lungs are air sacs, with smooth or sacculated walls formed as lateral offshoots from the preaxial end of the hypoblastic groove (before mentioned in connexion with the liver). They open into the pharynx by a tube, the trachea, composed of a ciliated epithelial lining, a glandular basement strengthened by an elastic and muscular layer, and a connective sheath containing cartilage rings. At its top is a cartilaginous box or larynx, suspended below the basi-hyal, and containing folds of mucous membranes whose vibrations produce voice. In its simplest form the larynx consists of two lateral cartilaginous strips, united above and below by connective tissue. These may be segmented into an upper free part (arytenoid), and a lower ring-like section (cricoid), with a shield-like cartilage in front (thyroid).*

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* From the thyroid to the arytenoid cartilage stretch horizontal antero-posterior folds of fibrillar tissue and mucous membrane, the vocal chords, an

The lungs lie one on either side of the heart, and receive blood from the branchial arch, which is returned aerated, entirely or partly (Proteus) to the left auricle. The trachea divides into two bronchial tubes, which pass, one into each lung, and break up into fine air passages. In pulmonary breathing the air enters the lungs either by being forced in from the mouth (as in frogs), or it rushes in to fill the vacuum produced by the dilatation of the cavity wherein they are placed. Expiration is produced by the contraction of the cavity wall and the elasticity and muscularity of the lung.

CHAPTER VI.

Reproduction, etc., of Craniota.

The urinary and reproductive organs are closely united in Craniotes. Very early in the embryo a cellular tube, the Wolffian duct, forms in the post-axial intermediate cell mass of mesoblast external to the protovertebra, passing backwards into the two horns, prolonged at the upper and back part of the cloaca (*infra*). Internal to its origin, a lateral glandular mass appears on each side, the Wolffian body, consisting of small transverse tubuli, whose cæcal dilated ends contain vascular tufts. In ichthyopsids this remains through life as the functional kidney, but in others there is formed a secondary duct, the ureter (arising as an outgrowth from the lowest part of the Wolffian duct, and growing forwards —*Kupffer*), followed by asecondary glandular formation, the kidney, of the same type as the Wolffian body (of which it is a later developed portion).

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upper, false, and a lower true; between these on each side is the ventricle of the larynx. Between the two true vocal chords is a chink, the *rima glottidis*. At the top of the larynx in mammals is a trigonal opening, the glottis, with a leaf-like elastic cartilage in front of it (epiglottis), and a mucous lip on either side, passing from it to the apex of the arytenoid—the aryteno-epiglottidean fold.

Internal to the Wolffian body the sexual glands form, having at first no connected ducts; they are primarily indifferent, then become either male or female, but are never functionally hermaphrodite, except as an anomaly. A tube, the Müllerian duct, forms parallel to the Wolffian duct (of an involution of the germinal epithelium of the pleuro-peritoneal cavity—*Bornhaupt*). This, growing from before backward, passes from behind this gland to the cloaca. In the female these ducts dilate, become the oviducts or Fallopian tubes, their fore-end remaining open as the *ostium abdominale*, while their hinder ends may thicken and form uteri, or may unite. The Wolffian body in the female wastes, forming a rudimentary organ, the Epoophoron (organ of *Rosenmüller*), beside the ovary. Its duct may remain below as the canal of *Gärtner;* above, as the hydatid of *Morgagni*. In the male the Wolffian body becomes partly appended to the testis, its tubes shooting into the sex-gland, as the *vasa efferentia*, while its upper part may remain separate above as the organ of *Giraldés;* and below, a separate tubule forms the *vas aberrans* of *Haller*. Its duct becomes coiled, as the epididymis and vas deferens, or excretory seminal duct. The Müllerian duct aborts in the male, leaving only its lower end, which forms the *vesicula prostatica*.

The primitive vertebrate type seems to have been the possessor of a hermaphrodite gland, with a double derivative apparatus, one half of which thus becomes aborted in either sex. The Wolffian tubuli correspond one to each protovertebra, and represent the segmental tubes of worms (Fig. 1, *dd*). They arise from the deepest part of the side of the band of fusion of the epi- and meso-blast (axis band of *His*), and its lining may be directly related to the epiblast. According to *Waldeyer* and others, the Wolffian tubuli arise as diverticula from the Wolffian duct. The primitive duct (segmental duct of *Balfour*) divides longitudinally into the ducts of *Müller* and *Leydig* (or Wolffian). *Balfour* suggests that it is the most anterior segmental duct modified. The vas deferens is a muscular tube, the male modification of the

Wolffian duct, with glandular ampullæ in its walls in its lower part in mammals; none in Sauropsids (*Leydig*).

The kidney is surrounded by a fibrous or connective capsule; its outer layer consists of tortuous uriniferous tubes, each beginning in a flask-like dilatation, into which passes an artery which within forms a glomerulus, out of which passes a slightly smaller vein. The tortuous tubes unite into straighter ones, ending in the ureter, often arranged in one or more pyramids.

The ovary is generally loose in texture, pedunculated, often attached to the spine by a single or folded serous *mesovarium;* it discharges its ova by dehiscence. This organ is covered by germinal epithelium, which lines its primary involutions; within this is a connective mesoblastic mass of fusiform cells, forming the stroma, whose centre may be vascular, the bulb of *Rouget*. In the stroma are imbedded small sacs, formed from the surface pits, the Graafian vesicles, each of which is lined by glandular yelk-secreting cells, some of which are larger, more specialized, passing into ova. The mouth of the oviduct is open, plain, or fringed; the tube is narrow at first, then widens as it approaches its fellow, with which it may coalesce in different degrees, or they may remain separate.

The testis consists of convoluted tubuli (except in marsipobranchs), whose epithelium becomes modified into spermathecæ, within which spermatozoa form. The head of the spermatozoon may be the altered nucleus of the sperm-cell, whose contained protoplasm forms the second part or intermediate piece, from which the flagellum is the outgrowth (*Grohe* describes the investment of each spermatozoon as structureless, and its contents as contractile). The tubuli of the Wolffian body extending into the testis form a tubular system of *coni vasculosi* and *vasa recta*, opening into the Wolffian duct or vas deferens. An outgrowth from the end of the Wolffian duct forms the *vesicula seminalis*. The glandular epithelium of the testis may be derived from the lining of the Wolffian tubules, and, according to *Sernoff*, has nothing to do with the germinal epithelium.

Early in the embryo a post-axial involution of dermis (**primary cloaca**) communicates with the cavities of the allantois and hypoblast; into this open the ureters, the Wolffian, and the Müllerian ducts. In many animals this arrangement is permanent; in others the cloaca divides into two parts, genito-urinary and anal, each surrounded by its own muscular sphincter, often separated by a bridge of skin, the perineum. Into the former, behind the Müllerian duct, there open frequently the ducts of small accessory glands (*Cowper's* glands in the male: *Huguier's* and *Bartholin's*, in the female). The sides of the cloaca in males from the perineum forwards tend to close medially and to elongate, the sphincter becoming a muscular envelope. Vascular connective tissue develops as an erectile sheath on the

ventral side, or around the urogenital canal (corpus spongiosum). Antero-laterally in the cloaca two processes of the same material (corpora cavernosa) form and approximate, and these three uniting make up the intromittent organ or penis. These are at first only thickenings of the cloacal dermis, but they often become attached to the ischium.

Post-penially the cloaca may remain open, as in birds and monotremes, the penial groove not being continuous with the allantoic bladder; but in other mammals the upper part of the genito-urinary sinus, into which the ureters open, becomes continuous with the bladder, and below this the tube narrows as a neck of the bladder. The muscular tissue around the end of the aborted Müllerian duct, imbedding some racemose glands, surrounds the

Fig. 13.

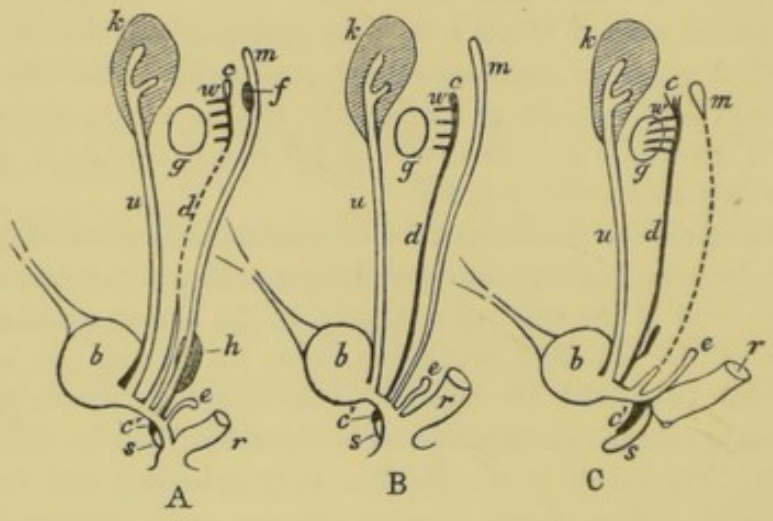


Diagram of the constituents of the urinogenital apparatus in both sexes. B represents the generalized embryonic type, which becomes either female (A) or male (C); *b*, bladder; *c*, cæcal end of the Wolffian duct becoming the pedunculated hydatid of the epoophoron; *d*, Wolffian duct becoming the canal of Gaertner in the female; *e*, glandular pouches of prostate; *f*, opening (in the female) into the Müllerian duct (Fallopian tube); *g*, sex gland, ovary in A, testis in C; *h*, uterine muscular wall; *k*, kidney; *m*, Müllerian duct becoming rudimental in the male, or developed as the Fallopian tube in the female, with the hydatid of Morgagni at its cæcal end; *r*, rectum; *s*, corpus spongiosum; *u*, ureter; *w*, Wolffian body, whose tubes form the epoophoron in the female, the epididymis in the male; *c'*, corpus spongiosum.

next part of the tube and the ends of the Wolffian ducts, thus forming the prostate gland. This organ thus represents the uterus, and contains, like it, ganglionic plexuses of nerves and Pacinian corpuscles. There is nothing in birds analogous to the prostate, but in tailed amphibians the anal glands may be homologous; of similar nature are the acinous glands opening into the vas deferens.

When the cloaca closes post-penially, the corpus spongiosum posteriorly develops into a *bulbus urethræ*. The testes may remain in their original place, or (as in the higher mammals) they descend. From the fundus of each in this case a cord, with a muscular wall and lax tissue (*gubernaculum testis*), passes downwards to an area of loose skin on each side of the closed post-penial cloacal outlet (*scrotum*); by this cord as a guide the testis descends, pulling along with it a serous fold (*mesorchium*), which forms a coat for the gland (*tunica vaginalis*). The testes then may either lie sub-abdominally, or enter the scrotum, traversing completely the abdominal wall by an inguinal canal. In its course the testis carries with it its vessels and nerves forming the spermatic cord, the Wolffian body and duct, and the gubernaculum, which last, with some reflected fibres from the second muscular layer of the abdominal wall (the internal oblique), makes a muscular investment or cremaster for the organ. An anterior skin fold around the end of the penis is called the *præputium*.

In the female the urogenital cloaca remains open; the scrotal folds form outer, the præputial form inner, marginal processes (*labia majora* and *minora*); the precloacal erectile tissue forms a rarely perforate papilla (*clitoris*); and the urogenital openings remain patent posteriorly, the genital canal being named vagina.

The supra-renal capsules are vascular and nervous mesoblastic organs above the Wolffian bodies, consisting of cortical and medullary layers. The first of these is of three strata—1st, one of connective vascular tissue; 2nd, one of connective fascicles; and 3rd, one of netted capillaries and stellate cells. The medullary matter is loose, soft, possibly a highly vascular sympathetic ganglion (*Leydig* and *Kölliker*).

In most Craniota a longitudinal lateral ridge rises along the sides of the embryo, on which two pair (rarely by abortion one pair) of symmetrical processes bud from the epiblast as limbs. Each limb has a cartilaginous axis, on which it is built, consisting of a basal girdle imbedded in the side of the embryo, and a projecting ray. The first pair of limbs spring behind the visceral clefts; the second generally still more post-axially. As the two pair are formed under similar conditions, and have more or less community of function, they exhibit a parallelism of structure even in minute particulars, but this can only be homonomy, as there are no true homoplastic relations between them. The fore limb- or shoulder-girdle consists of a single or double cartilage, whose dorsal (scapular) and ventral (coracoid) parts are primarily rod-like. Where they meet laterally, the limb ray projects. Over the coracoid rod the integument behind the last visceral slit is often attached, and its deep layer ossifies as a splint bone, the clavicle. The scapula may remain single or may divide; the coracoid usually divides

into two rods: an anterior, precoracoid (*c*), and a posterior, coracoid (*d*). The scapula rarely joins the vertebral axis; the coracoid, when developed, always joins the sternum. Internal and superior to the scapula an area remains cartilaginous, or ossifies by endostosis the supra-scapula (*a*). The pre-axial portion of the scapula is called *pre-scapula*, the post-axial *post-scapula;* between the two rises a dorsal portion, often as a ridge (spine of the scapula), and sometimes a separate element (meso-scapula), to which the clavicle becomes attached. The cleft between the meso- and post-scapula is shown at its lower end in Amphibia, its upper in Sauria, and medially in Manis. The coracoid may likewise have a median meso-coracoid process, and in front (pre-axially) it has often an epiphysary cartilage, or epi-coracoid (*e*), between which and its fellow may be a single mesial cartilage, the omosternum. When the clavicles approximate medially they may have a central dermal bone between them (inter-clavicle), which, if they co-exist, overlies the omosternum.

Fig. 14.

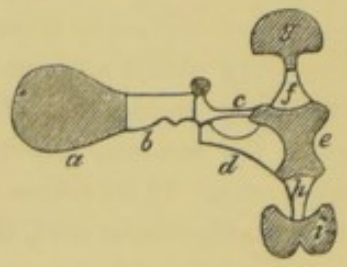


Diagram of shoulder girdle of frog: *a*, suprascapula; *b*, scapula; *c*, procoracoid, bearing the clavicle; *d*, coracoid; *e*, epicoracoid; *f*, omosternum; *g*, anterior end of omosternum; *h*, sternum; *i*, xiphisternum.

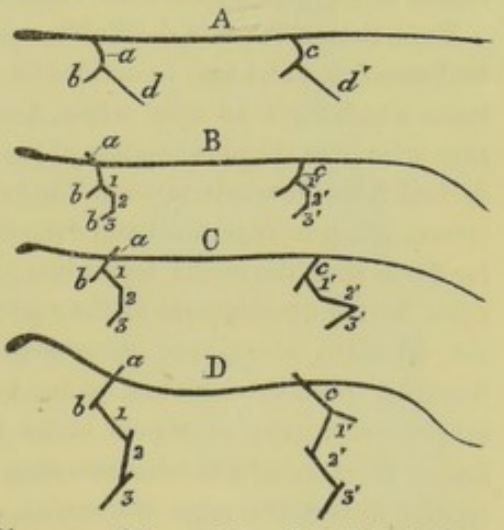
The pelvic girdle is simpler, and consists of a similar single or double rod, from which the ray passes as in the fore-limb. The dorsal element is the ilium, presenting a pre- and post-iliac surface and an intervening crest, as in the scapula; the ventral cartilage, which meets its companion mesially, segments also into a pubis (resembling the pro-coracoid), and an ischium (resembling the coracoid). There is no ossified splint, but a fibrous band (*Poupart's* ligament) usually takes the place of a clavicle. An azygous, pre-cloacal cartilage, resembling the omosternum, may exist. The ilium abuts on the consolidated ribs of the sacral vertebræ.

The limb-ray in its simplest form consists of a jointed gristly axis projecting laterally at right angles to the axis of the body. It consists primarily of a central cartilaginous rod, to which are appended an external or lateral, and an internal or medial accessory rod. This primary condition rarely remains; the two accessory rods often slip upwards, and all three articulate with the shoulder-girdle, forming three basal rods side by side, then named respectively the pro-, meso-, and meta-pterygium (Fig. 16 : 1, 2, and 3). To the ends of these articulate more numerous radial bones, beyond which are still more numerous cartilage nodules, to which dermal bones are often appended. One or two of the basipterygial bones may abort, but the metapterygial (3) is constant, and in most, forms the single basal bone of the limb (femur in the hind limb, humerus in

the fore). To it articulate two radial bones (4 and 5)—a pre-axial (radius in the fore limb, tibia in the hind) and a post-axial (ulna in the fore limb, fibula in the hind), between which at the lower end may be intercalated a short bone, the os intermedium (6) (os lunare in the fore, head of astragalus in the hind limb), usually displaced downwards to the level of the next row. A series of three cartilage bones follows—one (scaphoid in the fore, astragalus in the hind limb) below the pre-axial radius or tibia; one (cuneiform in the fore, calcaneum in the hind limb) below the post-axial ulna or fibula; and a third (centrale in the fore, scaphoid in the hind limb) below the intermedium. A series of five cartilaginous or bony nodules succeeds these, numbered from the pre- to the post-axial side. The first is called in the fore limb trapezium, in the hind entocuneiform; the second in the fore limb is the trapezoid, in the hind mesocuneiform; the third is the os magnum in the fore limb, the ectocuneiform in the hind; the fourth and fifth often coalesce, forming the unciform bone in the fore limb, the cuboid in the hind limb. These two rows of bones, taken together, make up the carpus in the manus, or tarsus in the pes or hind foot, and are usually arranged in two rows—the scaphoid, intermedium and cuneiform, forming the first in the manus; the centrale, lying in the middle, and the five others, forming a second series. To these succeed five longer cartilage rods—the metacarpals in the manus, the metatarsals in the pes, each of which bears a series of one to five, rarely more, phalanges. The number of parallel rows rarely exceeds five; rarely, as in ichthyosaurus, the number gradually increases downwards.

The limb-ray is at first horizontal; then the pterygio-radial joint bends downwards, in the transversely vertical plane; then the whole ray becomes rotated through the arc of a circle, of which its girdle joint is the centre. In higher forms the fore limb is usually rotated backwards, the hind limb forwards.

Fig. 15.



Diagrams of the position of the limbs in Vertebrata: A. Outline of fish: *a*, shoulder girdle; *b*, coracoid region; *c*, pelvic girdle; *d*, limb ray; B. outline of Amphibian, showing the subdivision of arm, forearm, and hand, and their relations: C. Reptile: D. Mammal.

Craniota possess two muscular systems, both mesoblastic in origin, an exo- and an endo-skeletal. The first, best marked in the higher forms, consists of the erector muscles of the hair and feathers, and the panniculus, or hypodermal layer, chiefly composed of fibres radiating from each limb-ray, or a longitudinal medio-dorsal, or medio-ventral band, and sphincters for the orifices. These are formed from the superficial mesoblast of the somatopleure.

The endoskeletal system is formed principally from the surface of the protovertebræ; and at first it consists of two longitudinal lateral segmented masses, stretching from head to tail, each made up of as many segments as there are protovertebræ. The myotomes or segments are separated by intermuscular laminae. The development of transverse processes divides this mass into a dorsal and a ventrolateral part, and in this form the muscular system exists in the tail of a fish. The dilation of some regions, the contractions of others, and the formation of more complex vertebral processes, disturb the straight course of the fibres, and incline them to divide into parts which differ in obliquity. The development of the limb-girdles introduces another element of variety, the superficial layers being attached to these, while the deeper remain purely axial. The parts of the dorso-lateral mass retaining its normal simplicity in higher animals becomes divided into *ilio-costalis* (from ilium to rib, and from rib to rib), *longissimus dorsi* (from the transverse processes of the lower to the transverse processes and ribs of the anterior vertebræ), *spinalis dorsi* (from the hinder to the fore dorsal spines), *multifidus spinæ* (from transverse processes to spines), *interspinales*, *intertransversales*, *rotatores spinæ* (spines to laminæ), *levatores caudæ*. The extension of this series to the head forms the *splenius* (spinous processes to head), *complexus* (transverse processes to head), *recti capitis major* and *minor*, and *obliqui capitis*. The muscles of this group are the least variable throughout the whole division.

From the mesoblast of the Wolffian ridge, or from the protovertebræ, arise the limb muscles, which may be divided into intrinsic and extrinsic, the latter being those which have an axial origin, but an appendicular insertion (this group may arise from the muscle-plate of the protovertebræ, but seems rather to be derived from the somatopleure). The extrinsic muscles consist of—1st, a dorso-lateral group in superficial and deep strata; the former consisting of muscular fibres from the medio-dorsal line to the metapterygium, divided into two parts by the development of the scapular spine and clavicle; its parts are—1st, adaxially *cleido-* and *sterno-mastoid*, and *cleido-* and *sterno-occipital*, *trapezius* (from the vertebral spines to the scapular spine); 2nd, abaxially *deltoid* (from spine of scapula to the metapterygium), and *teres minor;* the deeper sheet consists of *latissimus dorsi* (spines to the pterygium), *rhomboideus* (spines to vertebral edge of scapula), and *dorsi-epitrochlearis*, *occipito-scapularis*, and *trachelo-acromialis*. Around the pelvic girdle the same group is simpler, forming the *gluteus externus*, *caudo-femoralis*, *coccygeus*, *tensor vaginae femoris*, and *sartorius*. 2nd, The ventro-lateral muscles consist of two sets: one derived from ventral extensions of the protovertebral muscle plates (Kölliker); its middle part retains its longitudinal direction and tendinous intersections (*rectus abdominis*, *sterno-hyoid*, *sterno-thyroid*, *genio-hyoid*, *depressor caudæ*); its lateral part forms the outer and inner oblique muscles of the abdomen, and the intercostals. Superficially, the mesoblast of the

Wolffian ridge forms two laminæ: a superficial, consisting in the fore limb of the *costal*, *sternal* and *clavicular pectorals*, *subclavius*, and *sterno-scapularis* muscles, and a deeper, the *omohyoid*, *levator scapulæ* and *serratus magnus*. Corresponding parts posteriorly are the *adductors*, *pectineus*, and *obturators*. A series of ventro-lateral muscles lie beneath the vertebral column—the hypo-skeletal muscles of *Huxley* (hypaxial of *Stannius*). These may be derived from separate muscle-plates (*Kölliker*), or from the intermediate cell-masses, and the group consists of the following parts: *psoas*, *quadratus lumborum*, *longus colli pyriformis* (*?*), *femori-caudalis*, and laterally the *infra-costales*, *triangularis sterni*, and *transversus abdominis*.

The intrinsic limb-muscles are, primarily, continued bands from the body muscles on each side of the axial cartilage. The zono-pterygial joint is usually capable of moving in all directions, and the muscular lamina which surrounds it becomes segmented into four sets of muscles, protractors (*supra-spinatus*, in the fore limb, *iliacus* in the hind, from the pre-scapula and pre-ilium), retractors (*infraspinatus* in the fore limb, from the post-scapula; *gluteus medius* in the hind limb, from the back of the ilium), adductors (*coraco-brachialis* in the fore limb, *quadratus femoris* and *pectineus* in the hind limb, and others attached to the ventrolateral series); and abductors (fused with the dorso-lateral series). The relations of these parts in the two limbs is an indefinite homonomy, *i. e.*, they are segmentations of similar muscle-sheets and may or may not correspond. The pterygio-radial joint is movable only in one plane (flexion and extension), and the muscles are disposed accordingly. There are usually three extensors: one scapular or iliac (*anconeus longus* in the fore limb, *rectus femoris* in the hind), one from the pre-axial side of the pterygium (*anconeus externus* in the fore, *vastus internus* in the hind limb), and one from the post-axial side (*anconeus internus*, *vastus externus*). The flexors are also three or four (coraco-radial, or ischio-fibular; gleno-radio-ulnar, or ischio-tibial; humero-ulnar, or femoro-fibular: there may be an additional flexor in either limb).

Fig. 16.

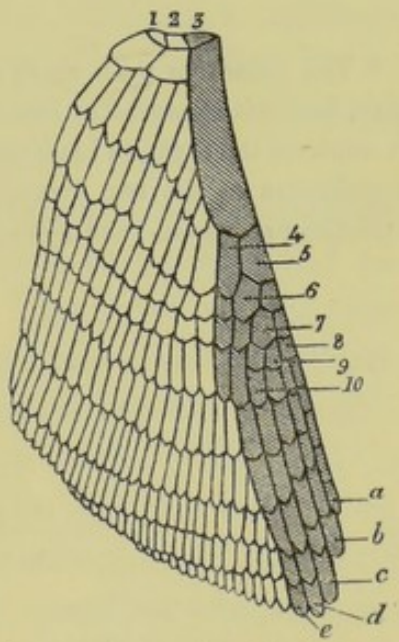


Diagram of pterygium of Selachian: 1, propterygium; 2, mesopterygium; 3, metapterygium; 4, 5, radial bones (developed into radius and ulna in higher forms); 6, os intermedium; 7, os centrale; 8, carpalia; 9, metacarpal; 10, phalanges; *a*, *b*, *c*, *d*, *e*, digits which are developed in other vertebrates.

The digital muscles vary with the function of the limbs; when most per-

fectly developed there is for each finger or toe a superficial and deep long pterygial extensor, and one or two long pterygial flexors; there may be also pterygial flexors for the 2nd and 5th metacarpals or metatarsals, and extensors for the 1st, 2nd, 3rd, and 5th metacarpals or metatarsals ; also there may be pterygio-radial muscles to move the pre-, or the post-axial bone; these may be pre-axial (supinators) or post-axial (pronators). Sometimes there are shorter transverse radio-ulnar or fibulo-tibial muscles on the fore and hinder aspects of the limb.

Craniota are divisible into three provinces—Ichthyopsida, Sauropsida, and Mammalia.*

Limbs may have (A) an inconstant, or (B) a constant number of radii. The first may have (*a*) the shaft and ray similarly (Ichthyosaurus) or (*b*) dissimilarly differentiated, the rays then being (*a*) unaltered (Dipnoi), (*b*) altered by fusion (hind limbs of Chimæra), (*c*) or by detachment and connexion of some rays to the limb-girdle (Sharks), (*d*) or by peripheral reduction of radii (Teleosts and Ganoids). The second form B may have a hexameric (Plesiosaurus), or a decameric division of the carpus and tarsus (*Gegenbaur*).

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* The primitive limb shaft (archipterygium) consists of an axial rod, with, beside it, a medial or inner, and a lateral or outer, diverging rod. In Protopterus the inner, in Lepidosiren both, diverging rods are suppressed. The transference of the two diverging rods to the shoulder-girdle makes the tripartite pro-, meso-, and meta-pterygium.

CHAPTER VII.

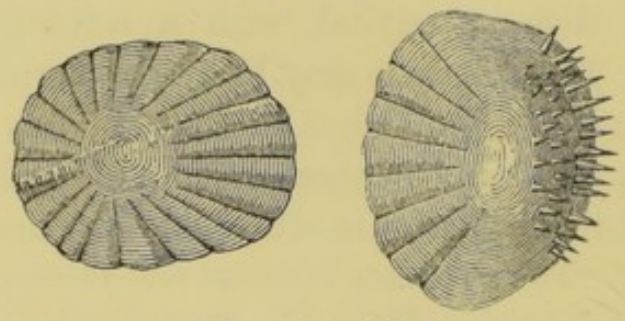
Province I.—Ichthyopsida (*Huxley*).

Craniota with no amnion and a rudimental allantoid, a thin epidermis or none, breathing by gills at some period of life, having not less than two aortic arches, cold blood, with some of its corpuscles red, nucleated, and a bi- or tri-locular heart. The notochord often persists, and when bony vertebræ form, their bodies have no epiphyses. The skull has usually a large para-, and a small basi-sphenoid, and the occipital condyles may be none, one, or two (which are then exoccipital, with a cartilaginous basi-occipital). The mandible may be absent, cartilaginous, or of membrane bones, attached to the skull by a cartilage plate, or by a suspensory apparatus. The Wolffian bodies persist, and their ducts open either into a cloaca or behind the rectum. This province includes two classes.

Class I. Pisces, Fishes. Permanently branchiate aquatic ichthyopsids, with oval blood corpuscles, and no distinct ventral allantoic bladder. The limbs are fins; the fore limbs forming pectoral fins, the hinder, ventral. There is a median single post-anal fin supported on fin rays, and a medio-dorsal fin sometimes in two parts. The tail is margined by a fin supported on rays, and this may be an equally distributed fringe with the straight vertebral axis in the centre (diphycercal), or the vertebral axis may be bent up and prolonged into the upper lobe of the bilobed tail, and margined by shorter rays, while the lower lobe consists of long fin rays (heterocercal tail), or the axis may be bent up and may end abruptly, while the arch-bones on the hæmal side (hypural bones) being widely

dilated may support two equal lobes, one above and one below (homocercal). The shape of a fish is that best suited for aquatic locomotion; there is no neck, and to allow of free motion of the tail (the propelling organ), all the viscera are pressed forwards. The epidermis is thin. The surface of the cutis is generally raised and ossified into scales of various forms, of which the chief varieties are—1st. *Placoid*, dentine-like ossifications of dermal papillæ, as granules, tubercles, or spiny scales (Elasmobranchii). 2nd. *Ganoid*, laminated, rarely imbricating scales or shields, having a bony basis covered with a layer of enamel-like, hard, polished ganoine. 3rd. *Cycloid*, thin, easily detached,

Fig. 17.



Cycloid and Ctenoid Scales.

flexible, imbricating scales, with a smooth hinder edge, and marked with concentric striæ. 4th. *Ctenoid*, with a spiny or pectinated edge, imbricating, and having their striæ angulated posteriorly.

Fin rays are also dermal ossifications, in united symmetrical pairs. Along the side of most fishes exists a series of sense organs, at the bottom of a row of pores forming a lateral line from head to tail. There is no dermal muscular system. The brain is small, often less than $\frac{1}{900}$th the weight of the body, larger proportionally in the young, only filling the cranial cavity in embryonic life.

The blood corpuscles are round in lampreys, largest in sharks. No

sternum nor sternal ribs are present in fishes. The cells of the epidermis are easily detached along with the slimy coating of the surface. Single secreting cells in eels and other fishes resemble the unicellular glands of Vermes. In Marsipobranchs the cuticle is continuous, and is traversed by pore-canals. The remarkable spiral mucous cells described by Leydig in Myxinoids probably belong to the system of the lateral line. The cutis may be very thick (four inches on the head of Orthagoriscus (*Leydig*)), and is often traversed by slime canals, which frequently sink into the subjacent bones. The cutis may be ossified into a continuous bony case of united shields (pipe fishes, &c.). These, in some places, touch the cartilaginous skeleton, and form splint-bones, which are instructive as they often represent the deeper splints in forms where, from the larger development of the dermis, these membrane bones appear as deeper formations. According to the researches of Hertwig, the various forms of dermal ossification in fishes can be reduced to one type, all being modifications of teeth, with osseous plates around their bases.

Intermediate forms often exist between the typical forms of scales. Thus, scales with striæ like those of ctenoid scales may possess an entire hinder edge; they are then called sparoid (*Troschel*). Some fin rays in Chimæra are concentrically laminated chitinous threads. Fins without rays, like the hinder dorsal of the trout, are called adipose fins.

Each pore of the lateral line series leads into a simple or branched tube (filled with a gelatinous matter), whose cæcal, ampullated, or rosette-like end contains a nerve bulb. When the tube is branched the nerve runs along its side, and sends twigs into every branch of the canal. In sharks there are bundles of unbranched tubes on the surface of the head, and branched canals along the side of the body. The forms of these canals are characteristic in many genera. The head tubes, supra and infra-ocular, receive their nervous supply from the lateral branch of the fifth nerve; those of the lateral line, from the lateral branch of the vagus. It is probable that these are generalized sense organs, capable of appreciating to some extent all forms of vibration. Sometimes *closed* follicles of similar structure exist, and in Cyprinoids there are allied beaker-like organs, consisting of a peripheric layer of long cylindrical cells, around a central, softer, cellular mass, and between these are papillary nerve endings.

In Orthagoriscus there is a dermal orbicular sphincter for the eyelids, and a similar muscle is present in some Selachians.

In the adult fish, between the outer connective membrane of the brain (*dura mater*) and the inner vascular membrane (*pia mater*), there is a thick gelatinous connective tissue and fat, in place of the *arachnoid* of higher animals. The lobes of the brain are arranged nearly in a line in the hori-

zontal plane. The olfactory lobes are large in lampreys, separated and stalked in sharks—the stalks arising from the middle of the side of the cerebrum, whose lobes are united (separate in some sharks). The cerebrum, for the most part, corresponds to the lamina terminalis of the third ventricle. The lobes are solid and distinct in teleosts, united to the olfactory nerves in the Dipnoi. The *thalamencephalon* around the third ventricle is hidden by the optic lobes in teleosts, large and distinct in sharks, small in lampreys. At the sides of the median process from its floor (infundibulum) are often two lateral *lobi inferiores*, which are united into one in lampreys. The optic lobes are nearly confluent in sturgeons, rudimental in Amblyopsis, large in lampreys, hollow in most teleosts. The hinder wall is thin, and a deep fold (the fornix of *Gottsche*) extends forwards, separating the ventricle of the optic lobes from the cavity of the middle cerebral vesicle below, on each side of which the floor of the optic ventricle is raised into gangliform swellings.

The cerebellum is small in Myxinoids, larger and lamellar in others (by some considered to be a double organ, a small part only being truly cerebellar). The fourth ventricle has smaller margins in Chimæra, or a lateral trigeminal lobe for the origin of the fifth nerve, convoluted in Scymnus. In some electric fishes there is a lobe on the hinder peduncle of the cerebellum for the origin of the vagus. The spinal cord in Trigla and the sunfish is dilated at the root of each nerve, contracted between each pair.

The nasal sac is single, central, opening behind into the pharynx in Myxinoids, cæcal behind in the lamprey. In other fishes the smell-organs are double, symmetrical, in the form of a pair of grooves lined by radially (sturgeon) or biserially folded ciliated mucous membrane, sometimes with secondary plicæ. The nerves end in cells with hair-like processes. The organ is stalked in Antennarius, bell-shaped in Lophius; in some it is open, in others crossed by a bridge separating an anterior from a posterior opening, to which in sharks there may be an upper (lateral) and a lower (alar) marginal cartilaginous strip. The two openings may be widely separated. In Symbranchus the hinder opening is over the eye; in some eels one opening is in the border of the lip; in Polypterus there are in each nasal sac five radiating canals, with a folded lining. In Dipnoi one opening traverses the thickness of the lip, the other is external.

The optic nerves may cross each other with no uniting fibres, as in teleosts, or with a few such fibres, as in Cyclostomata. Rarely one nerve pierces the other (some Clupeoids), or a commissure and decussation may exist (Elasmobranchs). The eye is flattened* in front, with a small anterior

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* In Apterichthys cæcus it is under the skin; in Amblyopsis, reduced to a ragmentary rudiment; in Lepidosiren it is also under the transparent skin.

chamber, a thin flat cornea forming a large part of the surface of the eyeball. The sclerotic consists of cartilage (sharks, &c.), bone (Xiphias), cartilage with a bony ray (sturgeon), or fibrous tissue with two cartilages (Teleostei), rarely fibrous alone. Within it is a shining, connective *tunica argentea*. The choroid is vascular, with (in Ganoidei) or without ciliary processes. In it, around the entrance of the optic nerve, in all fishes with an opercular gill the ophthalmic artery forms a plexus (the choroid gland). The pupil is oval, round, or quadrate, and the crystalline lens is spheroidal; a falciform process of the choroid projects from the fundus of the eyeball, to be attached to the capsule of the back of the lens, where its end is sometimes dilated and covered by a layer of smooth muscle (*campanula Halleri*). The lining layer of the choroid is a *tapetum cellulosum*, with calcareous bodies in its cells (Chimæra and many teleosts). In sharks a pillar-like stalk of cartilage springing from the bottom of the orbit articulates with the back of the sclerotic. This is represented in teleosts by a fibrous band. There is no lachrymal apparatus nor choanoid muscle, and the eyelids may be none, or one circular fold, or more commonly two immoveable vertical folds (one anterior and one posterior). Some sharks have horizontal lids and a moveable third eyelid. Crystal cones and nerves of a gelatinous consistence, enveloped in pigment, exist between the gill-rays, on the head, or in four rows on the belly in some Scopelidæ, Chauliodes, and Stomias. Some of these are in series with the lateral line organs, of which they seem to be modifications.

The inferior maxillary is the largest branch of the fifth nerve, and sends a lateral branch to the surface sense-organs; and this in Cyprinoids joins the first spinal and the vagus nerves. The superior maxillary emits a large buccal branch; the seventh gives off opercular, hyomandibular, mandibular, and hyoid motor branches. The vagus early divides into—1st, a branchio-intestinal, which gives off a superior laryngeal branch to the gills and their muscles; then gastric filaments, which supply the swimming bladder; 2nd, ramus lateralis, which runs under the lateral line in the inter-muscular space, supplying the sensory organs; this gives off a supra-opercular branch over the shoulder-girdle, and within the cranium may join the fifth. In Myxine there is a lateral nerve, and the branches of the vagus stretch to the anus. Into the beard-feelers of some fishes (cod, &c.) branches of the inferior maxillary or superior maxillary (sturgeon) nerves may be continued, which end in bulbous extremities. Some fish have detached fin rays (pectorals of Polynemus, &c.), which may be similarly sensory.

The tongue in fishes consists of mucous membrane spread over the basi-hyal, and is scarcely gustatory but; the soft palatine folds, somewhat erectile in Cyprinoids, with their branches from the vagus, and with an epithelium of

beaker cells, are sensitive. The taste organs are minute cup-shaped bodies, each consisting of investing and gustatory cells. Similar organs exist in the mouth of the tadpole. The ear in Myxinoids consists of one semicircular canal, in lampreys of a vestibule and two canals, each with a separate ampullated and a united undilated end, but no otoliths. In other fishes there are three canals, not completely surrounded by cartilage in Chimæra, but inclosed in the periotic in other fishes. In rays the anterior and posterior canals are circular, opening by distinct tubes into the vestibule, whose upper part communicates with the surface by a fine tube, opening valvularly. In Cyprinoids a transverse canal (*sinus impar*) unites the posterior processes of the vestibule of each side, from which a central mucous atrium extends backwards in the basi-occipital to an opening into two canals on the body of the first vertebra. Behind this a chain of three bones extends to the swimming bladder. From the fore part of the sinus a forked canal extends forwards into the alisphenoid. The front end of the bifid swimming bladder of Clupeoids is directly related to the vestibule; in Siluroids, Sparoids, and Percoids the vestibule and the swimming bladder are also connected. In the pike, a membranous sac opens into the vestibule behind the semicircular canals. In the embryo of the lamprey the labyrinth begins as a single vesicle containing a rounded otolith, which is lost at a later stage.

The peritoneal cavity of fishes is ciliated, and has often a single (Cyclostomes, some Ganoids), or double (sharks, eels, sturgeons, &c.), *porus abdominalis*, postaxial in Ceratodus. Its pericardiac segment is not shut off in lampreys, sturgeons, nor sharks. The mouth never has a sphincter; the lips may be thick (wrasses), transversely folded (Mugil, Labrus), or conical (Mormyrus). There are no salivary glands, but sometimes sublingual follicles (lampreys) or papillary glandular folds exist.

Teeth* exist in most fishes, epidermal in the oral disc of the lamprey, dermal, but with no enamel, in others. These may be enlargements of the dermal placoid scales (sharks, &c.), where sometimes the series can be traced from without inwards, gradually becoming more tooth-like and less scale-like. As no individual tooth grows beyond a definite size, there is generally a succession in rows from within outwards. In bony fishes the teeth may be villiform (perch), isolated, ankylosed to the bone, or moveable and fastened only by ligament (Lophius, Anableps, Poecilia), rarely in sockets, and replaced vertically (Sargus and hypopharyngeal teeth of wrasse), or deeply embedded in bone (hypopharyngeal of Scarus). Coalescing teeth, developed from separate papillæ, form a beak in the last genus,

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* Owen enumerates six forms of tissue in fish-teeth, called *osteo-dentine*, *vaso-dentine*, *vitro-dentine*, *plici-dentine*, *labyrintho-dentine*, and *dendro-dentine*.

not to be confounded with the calcified horizontal dentine laminæ in Gymnodonts secreted by a continuous pulp. Teeth are placed on the premaxilla and dentary bone of the mandible, rarely on the maxillæ (Clupeidæ and Salmonidæ), commonly on the vomer, &c.: one broad, thick, basi-occipital tooth exists in carps and tench. The opening into the œsophagus has often a sphincter, and in Lepidosiren a valvular fold at its commencement. The œsophagus is short, longitudinally folded. In Caesio, sturgeon, &c., its mucous lining is covered with papillæ (jagged processes in Spinax). In the torpedo there is a grey submucous layer. In Cottus scorpius it is suspended to the spine by a muscular band. The stomach has a wide cardiac and a narrow pyloric opening; it may be a cæcal or siphonal pouch (Pleuronectes and sharks), globular in Mormyrus, in two sacs suddenly bending forwards in Lophius. It is sometimes gizzard-like (Mugil, Johnius, Gillaroo trout), with an envelope of striped muscle (tench), and often with a reticulated mucous membrane (Gymnotus). At the narrow pylorus in sharks is a small sac, (*bursa Entiana*), receiving the bile and pancreatic ducts, and fœtally the vitelline duct. In sturgeons it is marked outside by many folds, and is saccular within. In Lepidosiren its segments are more sharply defined as cæcal pouches which, in teleosts, are developed as *pyloric appendages*, absent in the carp, gobies, wrasses, Chromidæ, Muræenoids, Cyprinodonts, sole, some Siluroids, Lophobranchs, Plectognaths: 1 in Polypterus and Ammodytes; 2 in Anabas, turbot, Lophius; 3 in perch and Diploprion ; 4–9 in Cottus; 5–9, Trigla; 6, Scorpæna; 9, Clupea; most numerous in Salmonoids, Ganoids and Scomberoids. Each tube may be single or branched; thus there may be 50 appendages with 30 openings (pilchard), or 50 with 6 (Cyclopterus), or 120 with 4 (whiting or sword-fish), or with one duct (Spatularia); in the latter cases the cæca are united by connective tissue into a gland. In some genera they are variable, present in one species, and absent in its allies, &c.: when numerous, they may be in a longitudinal, transverse, or annular series, or in several fascicles.

In Hemitripterus the large stomach can be filled with air, and may act as a swimming bladder. The intestine is straight (Exocœtus, Myxinoids) or slightly coiled, with a spiral fold in Cyclostomes and Chimæra (which, in the former, contains an intestinal vein). This in Elasmobranchs becomes a spiral valve,* extending from below the bursa Entiana to near the anus. It exists also in Dipnoi and Ganoids (except Lepidosteus).† There is rarely a sepa-

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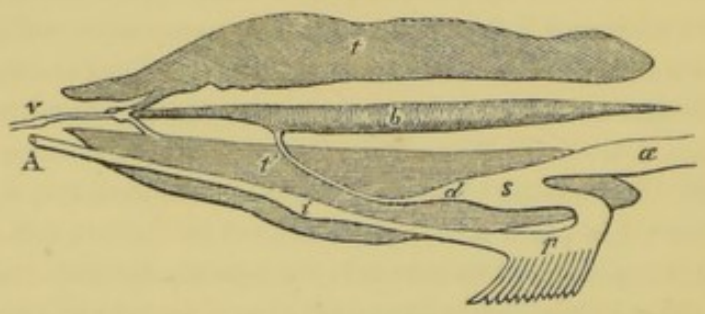
* As in the extinct reptile Ichthyosaurus and the larvæ of some exotic amphibia.

† In some sharks a small blind cæcal tube, with glandular walls, opens into the lowest part of the intestine. In Chimæra a small gland exists in the intestinal wall, at the same spot, but no pouch.

rate large intestine, never a cæcum,* but sometimes a valvular fold, marking off the lower intestine. Teleosts may have transverse mucous folds in the intestine and few villi, but never possess a spiral valve. The anus opens in front of the genital opening, and a cloaca exists in Dipnoi and Elasmobranchs, not in teleosts nor Ganoids. An anal gland is present in Squatina, Læmargus, and other sharks (the digitiform appendix of *Duvernoy*). In Lepidosiren only, a rudimental allantois exists, as a fine tube of the anterior cloacal wall. The liver is fatty, and possesses a gall-bladder† (except in Cyclopterus, Barracouda, Lates, Pristis, Cyclostomata, Echeneis, Labrus, and a few others), with or without hepatocystic ducts. There may be one (lamprey, salmon, pike, &c.), two, separate (Myxine) or united lobes (Elasmobranchii and some teleosts); three (Cyprinoids), or nine (Ammodytes, &c.), lobes. Its colour may be red (bream, Atherina), orange (Holocentrum), green (lamprey), or black (Spatularia). In some sharks (Selache), there is a *diverticulum*

Fig. 18.



Viscera of Herring: *œ*, œsophagus; *s*, stomach; *p*, pyloric appendages; *i*, intestine; A, anus; *b*, swimming bladder; *t*, testes; *v*, vas deferens; *d*, opening of duct of swimming bladder.

Vateri in the wall of the duodenum. There is a well-developed pancreas in the sturgeon and swordfish (*Allesandrini*), as well as in Læmargus and other sharks. In other fishes this organ is rudimental, represented by a tubular organ, which opens into the duodenum (the duct of *Weber*), and by the cæcal tubuli appended thereto (*Legouis*). The spleen is rarely absent (Cyclostomi, Dipnoi; but a small glandular mass in Lepidosiren, between the muscular and serous layers of the stomach, may be splenic), single, double (Squatina) or multiple (Lamna, Carcharias). There is a single longitudinal mesentery, which may disappear in parts by absorption, leaving the intestine free, as in the valvular part of the intestine in many sharks.

The swimming bladder (fig. 18, *b*) is an air sac placed between the vertebral

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* In Alopias there are 39 folds in 7 inches.

† Petromyzon has no gall-bladder, while Ammocætes has one.

column and the intestine, in front of the kidney, covered below by peritoneum,* and usually single, consisting of an outer contractile layer and an inner venous, often with vascular plexuses (air glands, as in the eel, cod, &c.); it often communicates with the back (rarely with the ventral side, as in Polypterus Lepidosiren) of the œsophagus (Physostomi), or with the fundus of the siphonal stomach (Clupea), by a pneumatic duct, which may have a sphincter muscle round it. It may have no duct (Physoklisti), or it may be divided by trabeculæ (Lepidosteus), or by an incomplete (Characinidæ, Cyprinidæ), rarely by a complete transverse partition (Bagrus), or by a longitudinal one (Arius, Gagora, Lepidosiren). It rarely extends to the end of the tail in the muscles (Ophiocephalus, Squamipinnes), in a special part of the hæmal canal (Gymnotus), and may have four compartments, with three transverse septa. Rarely it is complexly sacculated (Sciænidæ, Sphyræna, Pimelodus, Trigla, Lethrinus, Dules). Corvina trispinosa has four symmetrical cæca, Johnius and Pogonias have branched cæca. The wall is alveolated in Amia, Bagrus, and Gymnarchus (in which it may be a functional lung, *Hyrtl*), Lepidosteus, Ceratodus and Lepidosiren. The air contained in it may have 19–25 per cent. of oxygen, or in marine fishes even up to 80 per cent. Branches of the vagus and sympathetic are distributed on its walls. Its function is hydrostatic, but fish can alter their bathymetric position even without its aid, after puncture or ablation (*Gouriet*). Voice, present in few fishes, may be produced in trigloids by the susurrus of the muscles of the air bladder.† The swimming bladder never receives direct vessels from the heart in teleosts nor Ganoids.

The gills in Cyclostomata are usually seven or six (right side of Bdellostoma heterotrema, or both of B. hexatrema) lateral dilated pouches or tubes, with a vascular, often folded, lining; each opens internally either into the pharynx (Myxine, Bdellostoma), or into a pharyngo-branchial tube, lying ventrad of the intestine (lamprey), blind behind, but opening into the pharynx in front. Their separate outer openings in lampreys are in a lateral longitudinal line. In Myxine they unite externally, and open by one *porus branchialis*, on the level of the heart, behind the hinder gill; there are seven gills on the right, but on the left the hindmost tube has no gill folds, and remains as a wide œsophago-cutaneous duct, dipping into the œsophagus from the branchial pore. In other fishes the gills fringe the visceral arches, and are bathed by water admitted by the mouth, and emitted through the visceral slits. Even the first arch may have a degenerated gill as an arterial

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* Absent in Cyclostomes, rudimental or absent in Elasmobranchs, Pleuronects, Blennioids, Lophius, Gymnetrus, Symbranchus, Loricaria, &c.

† Irregular sounds are produced also by flapping of the opercula (*Müller*), or regular friction of the pharyngeal bones (*Dufosse*).

plexus (accessory branchia, or opercular gills of Elasmobranchs and some Ganoids). In Elasmobranchs there are usually five gill pouches, whose slit-like outer openings are only separated by septa, to which the vascular gill folds do not extend. In Chimæra these folds extend even to the edge of the septa, and in sturgeons the gill fringes outstretch the septa by $\frac{1}{3}$rd; in teleosts by $\frac{2}{3}$rds. The relation of the walls of these pouches to the bilaminar

Fig. 19.

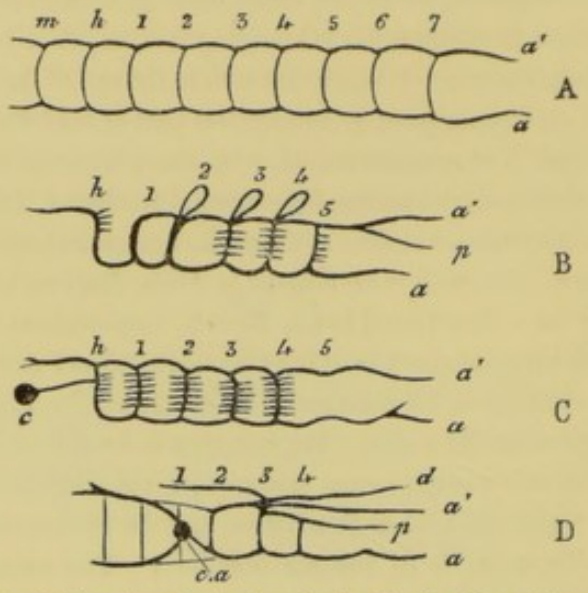


Diagram of the Specialization of the Aortic Arches in Branchiate Vertebrates: A, ideal system of symmetrical lateral arches—*m*, mandibular, *h*, hyoid arteries; 1—7, branchial arches; *a*, cardiac aorta; a^1, dorsal aorta. B, Aortic Arches of Lepidosiren—2, 3, 4, external gills on the fourth, fifth, and sixth arches; *h*, internal gill on the hyoidean artery; others are marked by cross lines on the fifth, sixth, and seventh arches, the last being marked by No. 5; *a* and *a'*, aortæ; *p*, pulmonary artery. C, Aortic Arches of Teleost, showing internal gills on the third to sixth arches—an opercular gill on *h*, the hyoid arch sending off the ophthalmic artery to the choroid gland *c* opposite 5, and below it two arches exist in the embryo, which vanish in the adult. D, arrangement of arterial arches in the frog.

gills of Ganoids, and to the united gill pairs in teleosts, is shown in the annexed table:—

Selachians	β^1	B^1	B^2	B^3	B^4	B^5
Ganoids	β^1	b-b	b-b	b-b	b-b	b-
Teleosts	—	β^2	B^1	B^2	B^3	B^4

In Lophius and Diodon three pairs of branchial arches and gills only exist. Labroids, Cottus, Sebaste, Scorpæna, Polypterus, &c., have one uniserial and three biserial gills; Malthæa and Lepidosiren have one uniserial (anterior half of 3rd order), and two biserial gills. Amphipnous has only one biserial gill (2nd

branchial arch). The sub-opercular gill of teleosts* (β^2) is distinct from the accessory gill of selachians (β^1), and is connected with the hyo-opercular artery. To both β^1 and β^2 the name *pseudo-branchia* has been given, but it is generally confined to the latter.

Accessory respiratory organs are often present, such as the spiral appendage to the 4th arch in Heterotis, the tree-like appendages of the upper end of some of the branchial arches in Synodontis, Heterobranchus, Clarias, &c.; or an accessory gill may form in a curved cæcal pouch or pouches, from the branchial chamber (Meletta, Lutodeira). In Saccobranchus, processes of the gill cavity extend among the lateral muscles, in Amphipnous, behind the head, and these receive branches from the cardiac, and return them to the dorsal aorta. The gills are overlapped in most fishes (except Elasmobranchs and Marsipobranchs) by dermal flaps from the 2nd post-oral visceral arch (opercula), leaving large lateral openings; these slits are close together in Sphagebranchus, confluent as a median fissure in Symbranchus. External gills exist in Lepidosiren, young Polypteri, and embryonic sharks.

The heart is behind the gills, in front of the pectoral fins, within a pericardium (to which it is tied by bands in the wolf-fish, &c.) It consists of a thin auricle and a ventricle; the first receives the blood from the venous sinus, which may have two valves at its mouth (Lophius, Selache), and is larger proportionally than in any other class of vertebrates. In Scorpæna and Myxine it is behind, in the sturgeon in front, and in the eel, perch, and carp above and to the left of the ventricle. There are two (4 in sturgeon, and globe-fish) semilunar auriculo-ventricular valves, with (sturgeon) or without *cordæ tendineæ* attached. In the sunfish two smaller valves are intercalated between the larger. The ventricle is pyramidal, cavernous within, ending in a muscular conus arteriosus, the valves at whose mouth may be in two rows of three in each (Galeus, Carcharias, Scyllium, Chimæra, Mustelus), three rows of four (Amia), three rows (Lamna, Zygæna), three rows of four valves and one of five (sturgeon), four rows (Acanthias, Hexanchus, Raia, Trygon, &c.; *Stöhr* describes five), five rows (Rhinobatus, Scymnus, Squatina; *Stöhr* describes six), six rows (Pristis, Myliobatis), three rows of nine or ten, alternately large and small (Polypterus), or eight rows of subequal valves (Lepidosteus). Of these valves, those of the anterior row alone are large, the others are often mere tongues, often rudimentary. The foremost row represent the single row of valves at the mouth of the aorta in Teleostei. Albula (a Clupeoid) exhibits an intermediate condition, having two rows, each of two valves (*Stannius*). Xiphias and the sunfish possess one row of four valves at the mouth of the aorta. The *bulbus aortæ* of bony fishes is the

* This may have cartilage rods in it, and sometimes it appears as a vascular lobate gland, as in Esox. In Antennarius the gill cavity is prolonged into a pore above the pectoral fin.

commencement of the aortic stem, quite separate from the conus, which is part of the heart (*Gegenbaur*). There is generally one common artery to nourish the heart (from the 2nd branchial vein in Teleostei), and a row of anastomosing inter-muscular lacunæ. The aorta in Myxine extends forwards as an *arteria vertebralis impar*, giving off two lateral symmetrical arches, which divide into inner and outer branches. In the lamprey the central trunk fails. The aorta gives off five branches in Ganoids, four in teleosts (the hinder having aborted), which form fine networks on the gill filaments, from which arise the branchial veins. The foremost of these arches gives off a hyo-opercular artery, which ascends along the hyoid arch and bifurcates, one branch forming the gill-like network or subopercular gill on the inside of the hyomandibular bone, from whence it is continued as the ophthalmic artery, to form the choroid gland; the other returns to the continued trunk of the first arch, which is called carotid, and ascends under the base of the skull, giving off a transverse branch to join its fellow, forming the *circulus cephalicus*, and supplying the brain and head. The other branchial veins unite to form the systemic aorta, which descends in the hæmal canal, giving off the subclavius before (teleosts) or after (Selachia) the junction of the branchial veins. The aorta gives off branches to the myotomes, to the air bladder, and generally one cæliaco-mesenteric to the digestive organs. The cæliac and mesenteric may come off separately, and may have muscular bulbs at their origins. In Lamna the two cæliacs form a plexus between the pericardium and the liver, whose branches again unite. The aorta passes between or through the kidneys (Engraulias), giving off renal and ovarian or spermatic vessels; its continued trunk (caudal artery) enters the hæmal canal in the caudal vertebræ and passes to the end of the tail.

There are two jugular and two cardinal veins (the latter unite in Myxine and join in the left jugular), usually entering the sinus venosus by symmetrical Cuvierian ducts. A single caudal vein (with a caudal pulsating heart in eels) lies beside the caudal continuation of the aorta, and divides into two equal (Cyclostomes, Selachia, and some teleosts) or unequal branches (the right being the larger—sometimes there is no left), which join one or both cardinal veins. From these, branches enter the kidneys, therein form a reno-portal capillary plexus, whose branches form the inferior vena cava, which receives the blood of the hepatic vena portæ, and ascends to the sinus venosus (when there is one cardinal vein its blood may all ascend by this channel). A bilobed thyroid gland (absent in Myxinoids) lies in advance of the first branchial arch. The thymus (absent in Ganoids) lies under the dorsal muscle, behind the branchial sac. The lymphatics are numerous, forming capillary plexuses and lymph sheaths and sinuses. A long lymphatic trunk runs between the ventro-lateral muscle masses, receiving branches from each myotome; two trunks accompany the lateral nerves, one on each side, and

two lie in the spinal canal. Where these join the caudal vein there is a small pulsating lymph heart. The vena portæ in Myxine is also contractile. The heart in fishes beats 20-30 times per minute. Beside the choroid gland there may be other retia, such as the red body of the eel's swimming bladder, or that on the liver of the tunny.

Myxinoids have lateral Wolffian ducts with rows of short transverse cæcal branches, each containing an arterial tuft. These canals either end separately at the ventral pore, or, as in the lamprey, they unite mesially for a short distance. The duct is developed separately from the gland. In other fishes the branches are more complex, and the gland more compact. Sometimes it stretches along the whole spine, or only a small part; sometimes it extends into the caudal canal, as in some Gadoids. In many this gland is lobate (Salmonoids). Both ducts may unite in teleosts, opening behind the genital orifice, or with it behind the anus. Each ureter may have a dilatation at its end (sharks), or at their union; rarely there is a post-rectal sac, apart from the ureters. The suprarenal capsules are yellow streaks in front of and within the edges of the Wolffian bodies (Elasmobranchs), or whitish yellow masses above the kidneys (Teleostei); they consist of rounded heaps of irregular or stellate cells, in one or many rows, often around a central cavity.

The reproductive organs of Cyclostomata are solid, subvertebral masses, lying in a free serous fold, or close to the dorsal wall, shedding their contents into the abdominal cavity, from which they escape by the *porus genitalis*. In Elasmobranchs the ovaries are round, symmetrical, usually two, rarely one central (Spinax, Notidanus); the oviducts have trumpet-shaped inner openings, and dilate into a uterus before they open into the cloaca; within this duct is either a compact heart-shaped gland (Elasmobranchii) or scattered follicles (Dipnoi). The males have small paired testes with an epididymis and vas deferens which, after many windings, dilates gradually, forming a vesicula seminalis in Squatina, and ends in the cloaca. A long gland may accompany it in some. In Ganoids and some teleosts there is no union between the oviduct or vas and the sex gland, in others there are ducts leading definitely from the glands to the surface. In some Serrani a crescentic testis frequently receives an ovary within it; in carp and eels hermaphroditism has also been more rarely found (*Ercolani*). Sometimes only one sex gland, right or left, may be present. When the sex organs are functionally active the colour may change, or wart-like growths may project. In the female of Rhodeus amarus a long tube projects from the genital duct whereby the eggs are laid. In many teleosts the ovaries and testes can only be distinguished when full of their sexual products. In teleosts and Cyclostomes the ovary is not apparently covered with germinal epithelium. In most fishes the ova are impregnated in the water, after emission, but in Plagiostomi the ventral fins in the males are modified into copulatory claspers.

CHAPTER VIII.

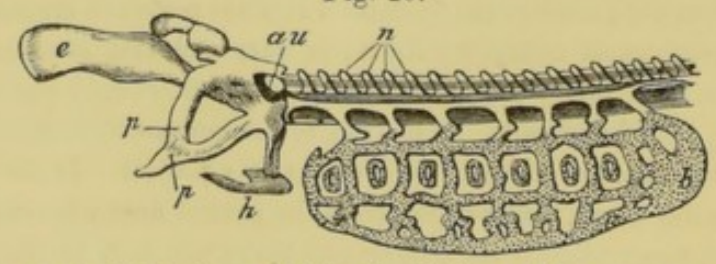
MARSIPOBRANCHII, ETC.

ABOUT 13,000 species of fish are known, divided into five sub-classes.

SUB-CLASS I. MARSIPOBRANCHII (*Huxley*).—(Cyclostomata), worm-like, limb-less fishes, having a persistent notochord, whose sheath is not homologous with the segmented cartilage layer of higher vertebrates; the only trace of segmentation being the neural arches (fig. 20 *n*) which are present in lampreys. These cartilages contain fat, have little intercellular substance, and yield no chondrin on boiling. The hypoblast is formed distinctly by invagination, as in Amphioxus. The gills are pouch-like, without arches, but with an *outer gill framework* (fig. 20 *b*) of cartilage strips between the gill openings, and dorsal and ventral pieces appended to each. In the lamprey the last of the ventral pieces bears a median cartilage, which supports the pericardium. The sex glands are azygos and ductless, the *porus genitalis* post-anal, the skin scaleless, the teeth epidermal on the palate and tongue.

The skull is immoveable on the spinal column, and consists of a small cartilaginous brain case, deficient above; posteriorly there are two lateral ear

Fig. 20.



Skull, Gill-basket, and Vertebral Column of Lamprey.

capsules (*au*) projecting outwards, below and external to which jut out two stylo-hyal processes (*h*). In front of these are lateral looped metapterygoid

processes(*p*), which anteriorly are continued into the palato-pterygoid cartilage. In the middle of the roof of the skull, anterior to the fontanelle, is the single nasal sac, whose fundus is continued downwards and backwards, in front of and below the brain cavity. Anterior to this is a cartilaginous roof-plate for the mouth (*e*), overlapping by its front edge a second roof-plate still further forward, under whose edge lies a crescentic cartilage, with lateral rib-like appendages. There is no mandible, but under the first roof-plate is a palato-pterygoid cartilage. The mouth is circular or crescentic, suctorial, and a cartilaginous style lies in the axis of the tongue. There is a median fin around the tail. Two Orders are included, each containing one family.

Order I. *Hyperotreta* (*Müller*), including the family Myxinidæ, which consists of ecto-parasitic fishes, boring into the bodies of other fishes, characterized by having rudimental facial cartilages, no air bladder, one long jagged epidermal tooth on the palate, and two series of lingual teeth. The nasal tube opens into the palate by a valve-protected orifice, and its tube is encircled by cartilage rings. The functionless eyes are covered with skin. The bulbus aortæ has two valves and no muscular layer. Myxine has six pair of gill pouches, with a common lateral opening far back, so as not to be covered when the head is immersed in the body of its prey. Bdellostoma has 6–7 outer gill openings.

Order II. *Hyperoartia* (*Müller*), including one family, Petromyzonidæ, lampreys, with a cæcal nasal pouch; mouth beardless, with fleshy lip; teeth many, larger on the labial cartilage, a palatine row of two-pointed teeth, and a crescentic, many-pointed, lower-jaw-like plate; gill framework moveable by muscles; gill pouches, seven on each side; marginal fin divided, vertebral axis with rudimental arches, of which the hæmal bound a tail-canal. Immature forms (Ammocœtes) differ from the adult in having small covered eyes, fine beard-filaments, a crescentic toothless mouth, no genital pore, a continuous marginal fin, and the gills opening in a longitudinal lateral furrow.

Sub-Class II. Elasmobranchii (*Huxley*).—Sharks and rays, with a cartilaginous skeleton, no swimming bladder, naked skin or a surface of placoid scales, an intestine with a bursa Entiana, and an elongated membranous valve, attached either spirally or longitudinally* within its canal.

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* In this case, as in Carcharias and Galeocerdo, the fold is rolled into a cylindrical spiral.

The conus arteriosus is contractile, with many rows of valves* and a coat of striped muscle. The first post-oral visceral cleft usually remains as a spiracle, opening in front of the suspensorium, and from the visceral arches in the embryo deciduous external gills project. In the adult, the gills are 5–7, with plaited walls placed on the opposed surfaces of the septa between the visceral clefts. The first gill sac is between the hyoid and the succeeding arch (fig. 19, B).

The pectoral fins are large, attached to a simple cartilaginous shoulder-girdle, which has no splint bones, is united medio-ventrally to its fellow, and is not attached to the skull. The superscapula, when distinctly segmented, as in the rays, is united medio-dorsally to the cervical spines. The pelvic girdle is similar, abdominal, with a smaller pair of fins appended.

The skull consists of a cartilaginous brain case, with several deficiencies above, sometimes with a calcified surface, but with no true membrane bones. The mandible consists of Meckel's cartilage calcified, and there is no maxilla nor premaxilla. Teeth always exist. The ethmoidal part of the skull-cartilage has two lateral nasal cavities, between which is a rostral process, and behind them are the orbital fossæ. The eggs are few, large, often laid within a leathery tendrilled case, secreted by a large gland in the oviduct. The hypoblast has a series of cells connecting it to the surface, like those of Ecker's yolk-

* The conus of sharks, &c., differs from the bulbus aortæ of teleosts, and is represented by the mouth of the ventricle with its single (double in Albula) row of valves. These valves are the homologues of the front or largest row in Elasmobranchs. These structures in the conus of sharks may be perfect, or retrograded into tongue-shaped valves; sometimes two sets can be discriminated, *serial* or perfect valves, and *intermediate* or rudimental (*Gegenbaur, Stöhr*).

plug in amphibians (which see), evidently a trace of ancestral derivation by invagination. The notochord is derived from the hypoblast. The embryology of selachians has been lately studied by Mr. Balfour, whose papers on the subject are among the most valuable recent contributions to morphological literature.

Two orders are included.

Order I. *Holocephali*, Chimæras.—These fishes have a membranous operculum over the four gill clefts, a persistent notochord, in whose sheath are numerous fine calcified rings, four or five of which belong to each vertebral segment, as indicated by the cartilaginous neural and hæmal arches, of which the most anterior are united into a continuous mass. The skull has an anterior triangular process stretching from each side of its base, representing the palato-quadrate and suspensorial cartilages, but showing no trace of segmentation (transition forms between this and the arrangement found in other sharks have been met with). There are four teeth in the upper and two in the lower jaw, which are not replaced. The ear is not completely inclosed in the skull-cartilage. The naked skin has well-marked mucous canals. The single family Chimæridæ contains two genera, one boreal (*Chimæra*), one austral (*Callorhynchus*), both with large heads, small sub-terminal mouth, large lidless eyes, no spiracles, pectoral fins one-third the length of the body, elongated filiform tails, and the anterior dorsal fin having its first ray as a strong serrated spine.*

Order II. *Plagiostomi* (*Müller*), or *Selachia*.—Sharks and rays proper, having wide mouths on the under side of the head, dermal placoid scales, notochord with intervertebral

* On account of their cranial and appendicular peculiarities Prof. Huxley raises the Holocephali to the rank of a sub-class.

dilatations, surrounded by cartilaginous or bony rings, or with concave vertebral bodies, frequently calcified; sometimes, as in rays, the anterior vertebræ may calcify continuously, and there may be twice as many neural arches as bodies, owing to the development of intercalary or intercrural arches of cartilage. The tail end of the notochord is bent upwards, and its sheath is not continuously calcified. The tail fin is usually heterocercal, rarely diphycercal.* The ribs are small or none. The skull bears a single anterior labial cartilage on each side, behind which is a posterior labial cartilage, with an inferior limb appended (see p. 32); behind this is the palato-quadrate cartilage, forming the functional upper jaw, articulating with which on each side is the ossified *Meckel's* cartilage forming the lower jaw; both of these bear numerous teeth, which succeed each other, growing from behind forwards as they are worn out. The skull is attached to the vertebral column by a vertebral joint, with a double articulation (Squatina), or the basilar region becomes continuous with the vertebral column (dogfish). The hyoid arch is attached by a cartilaginous suspensorium, or hyomandibular segment, to the cranium, beside the ear-capsule; and this supports at its lower end the posterior and outer end of the palato-quadrate, as it articulates with *Meckel's* cartilage, behind which the stylo-cerato-hyal element is attached, which medio-ventrally unites with a basi-hyal copula (absent in Torpedo, small in the ray). The 5–7 hinder

* Kölliker has shown that there is a considerable variety in the histology of the selachian vertebral column, depending on the degree of development and calcification of the outer skeleton-building layer of the sheath of the notochord, the strength of the underlying *tunica elastica externa*, the thickness of the inner chord-sheath, and the presence of an *elastica interna*.

visceral arches consist of two elements, which are attached together medio-ventrally by their copulæ, or as in Torpedo, each is attached to its predecessor directly. The copula of the hyoid arch is prolonged into the basis of the tongue. To the hyoid are attached gristly filaments, the rudiments of an operculum, or in some the homologues of the outer gill supports of lampreys. The anterior teeth are usually sharp, the hinder blunt. In Cestracion the median teeth are broad, flattened, and ridged on the crown. In some rays (Myliobatis, Ætobatis) the teeth are pavement-like. The nasal sacs open under the snout, and, like the brain and the other sense-organs, are more highly developed than in other fishes. Some are viviparous, and in Mustelus laevis and Carcharias the plicated vascular wall of the umbilical vesicle becomes interlocked with rough vascular processes of the continuous lining of the uterus, forming a sort of placenta, for the nutrition of the embryo. The males of some have a protrusible penis. The egg-shell in the oviparous forms is quadrate, with filiform, often coiled, processes at its angles. Like the Chimæras, these are marine, with the exceptions of Pristis Perottetii, in the Senegal River, and some South American and Indian species of Torpedo, Narcine and Tæniura. Sharks also ascend the Amazon to considerable distances.

There are two sub-orders.

Sub-order I. Raiadæa, body flattened, discoidal, from the great development in width of the pectoral fins; and the branchial clefts are on the ventral surface. There is no anal fin and no nictitating membrane. The shoulder-girdle is joined to the skull, which is either ossified to the first vertebra, or with two lateral and no median articular facets. Tail often with large spines; spiracles always large. This includes five families:—1. Myliobatidæ, eagle rays: tail narrow, long; eyelids none; pectoral fins rayless beside the head, a dermal head fin or process, and pavement-like teeth. 2. Trygonidæ: tail filiform, usually finless; pectoral fins united in front of the head. 3. Raiidæ, skates: tail slender; pectoral fins rayed from the snout to the ventral fin, dor-

sal fin on the tail; oviparous (the preceding families are viviparous). 4. Torpedinidæ, electric rays:* tail fleshy with a terminal fin, body discoidal, skin naked, teeth conical. 5. Rhinobatidæ: body flattened, spindle-shaped; pectorals separate from the head and from the ventral fins; dorsal fins two, skin rough, teeth flat. Pristis, the saw-fish, has the calcified mesethmoid prolonged into a snout, in which are 20–30 teeth in sockets along the margin on each side.

Sub-order II. Squalidæ, sharks: body elongated, with more or less pointed snout, shoulder-girdle free from the head, teeth trigonal, sharp; gill-slits lateral, basi-occipital with a median articular surface. Of these carnivorous predaceous fishes there are ten families—1. Pristiophoridæ, sawfish-like sharks, with gill-openings in front of the pectoral fins. 2. Squatinidæ (angel fishes); body flat; dorsal fins two, anal none, pectoral large; mouth terminal. 3. Spinacidæ (spiny dogfishes), having a strong spine in front of each of the two dorsal fins, anal none; the five gill-slits are in front of the pectoral fin, and a deep groove extends on each side of the mouth. 4. Scymnidæ, like the last, but with no dorsal spines. Læmargus, the Greenland shark, has no oviduct (*Turner*). 5. Notidanidæ have one dorsal and one anal fin, 6–7 gill-openings, and small spiracles. 6. Lamnidæ (porbeagles) have two dorsal and one anal fin, the first dorsal being between the pectoral and ventral fins; nostrils do not communicate with the mouth, spiracles small; gill-openings large, prepectoral. Carcharodon reaches 40 feet in length, as sometimes does Selache; Rhinodon, even larger, has its first dorsal almost over the ventral fin. 7. Galeidæ (topes) have the last gill-opening over the pectoral fin, a nictitating membrane, a small (Galeus) or large (Mustelus) spiracle. 8. Carcharidæ (blue sharks): anterior dorsal fin between the pectoral and ventral fins, eyes with a nictitating membrane, whose muscle is post-orbital, spiracle absent, the last gill-opening over the pectoral fin; closely allied is Zygæna, with its broad hammer-like head with lateral eyes. 9. Scylliidæ (dogfishes): anterior pectoral over or behind the ventral fin, spiracles present, but no nictitating membrane. 10. Cestraciontidæ (the Port Jackson shark), an ancient form, with pavement-like central teeth, no nictitating membrane, but with spiracles, two dorsal fins, with spines, united mouth and nostrils. The mesozoic Hybodonts were closely allied.

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* The intimate structure of electric organs, too long a subject to take up here, will be found very well and minutely described by Prof. Babuchin, in Reichert's "Archiv. für Anat. ü Phys.," 1876, p. 501; in Stricker's "Histology," and in Leydig's "Gewebelehre."

CHAPTER IX.

Ganoidei.

Sub-class III. Ganoidei (*Müller*).—This order, like the last, was numerously represented in the Palæozoic period. Now it consists of about thirty species. They are for the most part fresh-water fishes, with an exoskeleton of enamelled,* overlapping scales, or of dermal osseous plates (sturgeon, Scaphirhynchus), or absent (Spatularia). They resemble the last group in the structure of the conus arteriosus, the intestinal valve (rudimental in Lepidosteus), and the optic commissure, but they have no connective layer in the sheath of the notochord, and no cloaca. The sex-glands have continuous ducts in Lepidosteus, opening into the ureters, or they may be single Müllerian tubes opening from the peritoneal cavity into the ureters, and thus on the surface; or the ureters may open into these, as in Polypterus. They have an air-bladder with a pneumatic duct. The ventral fins are abdominal, and the tail diphycercal or heterocercal. The structure of the skull varies in the seven orders, but in all there are membrane ossifications, a double vomer, and usually a tooth-bearing maxilla. The tail in all contains the unsegmented notochord.

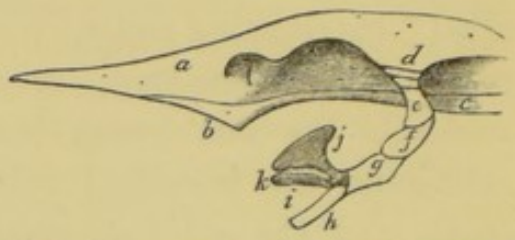
Three of the orders include palæozoic forms and have no living representatives:—I. *Cephalaspidea:* scales mostly enamelled, forming acomplete armour-plating; head covered by a continuous shield, possibly with no jaws; skeleton cartilaginous. II. *Placodermi:* pectoral region shielded, head with several separate plates, shield with enamel joints; skeleton partly bony. III. *Acanthodidæ:* scales small, shagreen-like; lateral line between two rows of scales; tail heterocercal; some of the fins with spines in front of them; shoulder-girdle a bony hoop; skull cartilaginous; operculum absent. These united the Ganoids and the sharks.

* The enamel-layer or ganoin is structureless.

The orders which have living representatives are as follows:—

Order IV. *Chondrostea* (*sturgeons*): naked, or with dermal bony plates, and with heterocercal tails; notochord persistent, with an epithelial, often differentiated, lamina around it, forming a tube, whose vertebral segments are only shown by the presence of arches; the skull is cartilaginous, continuous behind with the cartilages of the spine, and in front prolonged into a mesethmoidal beak; inferiorly, membrane splint bones (parasphenoid and vomer) are developed; superiorly in the skin dermal bones, representing the interparietal, parietals, frontals, post-frontals, squamosals, &c., and smaller intercalary shields. In Spatularia there is a partly ossified upper and a cartilaginous lower part in the suspensorium, to which is attached the hyoidean arch, and also the jaws, which consist of an ossified dentary bone overlapping *Meckel's* cartilage below, and a palato-quadrate cartilage above, which is covered anteriorly by an ossified maxilla. A bony operculum is attached to the back of the cartilaginous end of the upper suspensorium, and a branchiostegal ray is articulated to the hyoid. In Acipenser the suspensorium consists of three parts, and the palato-quadrate is closely attached to *Meckel's* cartilage, and loosely to the skull, so that the mouth can be protruded. The pectoral arch has three superficial membrane bones, no post-temporal, a post-clavicle, clavicle, and inter-clavicle, and under these is a cartilaginous supra-scapula and a continuous coraco-scapular cartilage. The paired fins are not lobate. The gills are not fully covered by the operculum; the preoperculum, when present, stretches forward on the cheek. Branchiostegal rays may exist, but there are never large jugular plates, and there is an opercular gill attached to the hyoid arch. Spiracles are also present, except in Scaphirhynchus. The front edge of the tail and dorsal fin bears a row of large scales (*fulcra*). This order includes two families with living representatives, and several others entirely extinct—one Sturionidæ (sturgeons), with five longitudinal rows of keeled bony plates on the body and a toothless mouth. Acipenser sturio, the sturgeon, ascends many of the larger European rivers. A. huso, ruthenus, and stellatus yield isinglass from the swimming bladder (other forms of isinglass are extracted from species of Silurus and Polynemus in India). The notochord and its sheath is eaten in Russia under the name *wesiga*, and the roe constitutes the caviare of commerce. Scaphi-

Fig. 21.



Skull of Sturgeon: *a*, mesethmoid rostrum; *b*, vomerine splint; *c*, parasphenoid; *d*, periotic region; *e*, *f*, hyomandibular or suspensorium; *g*, symplectic; *h*, Meckel's cartilage; *i*, mouth; *j*, pterygoid process; *k*, palato-quadrate cartilage.

rhynchus has no true pseudobranchia, only an opercular gill. Fam. 2. Spatularidæ (N. America and China), with a naked skin; long, flat, spatulate beak; no opercular gill; no ribs; small teeth in the young, which are lost as age advances.*

Order V. *Crossopterygia.*—Pectoral fins (and often the ventrals) rounded or long, lobate, with the fin rays all nearly equal, and connected with the rounded edge of the often discoidal pterygium, which is thus fringed by the rays; one pterygial bone is generally aborted, and some rays join the shoulder-girdle; dorsal fins one, two, or more; the rays of the dorsal and anal fins exceed in number the interspinous bones; branchiostegal rays none, but there are two large jugular plates†; tail diphy- or hetero-cercal; scales cycloid or rhomboid, often enamelled, and chamfered; vertebræ in the recent species amphicœlian; cranium with ossified basi-occipital, ex-occipital, and pro-otic cartilage bones, doubled vomers, the hyomandibular and symplectic both ossified. There are separate palatine, pterygoid, meta-, and ecto-pterygoid, and quadrate ossifications in the palato-quadrate arch, to the last-named of which the symplectic (absent in Polypterus) is closely attached. The preoperculum extends forward on the cheek. They have spiracula and diphycercal tails, and a sacculated, longitudinally-divided air bladder, whose duct opens ventrally into the œsophagus. The shoulder-girdle consists of a supra-clavicle attached to the post-temporal, one or two post-clavicles, clavicle, and inter-clavicle, of which the post-temporal and interclavicle are the only ones with a distinct surface of ganoine; behind there are two post-clavicles, upper and lower, deeper seated on the small scapula and coracoid, ossified from separate centres (Polypterus), or unossified (Calamoichthys). There are two living genera, both African: Calamoichthys, a long snake-like form from Calabar, and Polypterus, from the Nile and Senegal, with rhomboid scales in oblique rows, and many dorsal fins, each with a strong front spine. The extinct palæozoic allied families are Dipteridæ, Monosticha, Cœlacanthidæ, &c. Holoptychius and Glyptolepis unite the Ganoids to the Dipnoi.

Order VI. *Lepidostea.*—Tail abbreviately heterocercal, scales rhombic, enamelled; a pre-operculum, branchiostegal ray, with a median jugular plate in front, and limbs not fringed with rays; bodies of the vertebræ opisthocœlous, ossified; aortic bulb, with five rows, each of eight valves; opercular gill present; spiracle absent; teeth many, of two sets, long

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* Sturgeons have no teeth on the jaws, but have rows of small teeth on the gill arches (*Hertwig*).

† These are not confined to Ganoids, but occur in Megalops, Elops (Clupeidæ), and in Lophobranchii, among teleosts.

and short; skull with cartilage bones and double vomers, as in Polypterus; the symplectic loosely joined to the quadrate; the maxilla of separate ossifications. The proximal end of the mandibular cartilage ossifies, and becomes a separate *os articulare;* a *dentary* splint forms antero-externally, and a *splenial* postero-internally; to these are superadded *angular*, supra-angular, and coronoid pieces. The sexual ducts are continuous with the glands; the shoulder-girdle has no interclavicle between the approximating clavicles, no specialized post-clavicle, and a single ossific centre in the cartilaginous girdle; the rays of the median fins equal the interspinous bones in number, and the fins have fulcra for the most part. There is one living genus, Lepidosteus, or bony pike, from the N. American rivers, and many fossil forms are allied.

Order VII. *Amiada.*—Tail abbreviately heterocercal, with no fulcra; scales concentrically marked, thin, cycloid, with a very thin ganoine layer. The head-bones are covered by a thin enamel layer; there is a preoperculum, and branchiostegal rays, a single median jugular plate, and a spiral intestinal valve; air-bladder double, cellular; limbs not lobate; no inter-clavicle; a post-frontal and a sphenotic co-existing; aortic bulb with two rows of valves; the cartilage arches and centre of the vertebræ are surrounded by a bony layer, so as to form a continuous arch and central ring, leaving an inner residue of cartilage. Amia calva, the only living representative, lives in Lake Champlain.

CHAPTER X.

Teleostei.

Sub-class IV. Teleostei (*Müller*).—Fishes with a bony skeleton, showing a marked reduction in the development of the primary cartilage as compared with Ganoids, and a dermal clothing of ctenoid or cycloid scales, rarely of bony or calcified plates (Ostracion), or scaleless (Galaxias, &c.)* The vertebral bodies are bicon-

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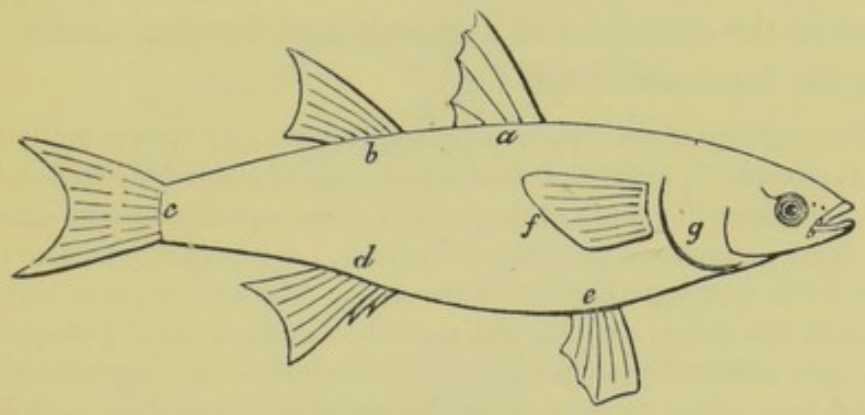
* If shagreen-like, or beset with bony points, they are not dentinal (Balistes)

cave, bony, with intervertebral thickenings of the notochord. In many (Physostomi, &c.) there is in each vertebral body an X-like arrangement of cartilage, each peripheric end being at the prolonged base of the pedicles of the hæmal or neural arches; and in some (Siluroids, &c.) the anterior vertebræ unite into a continuous mass. The body consists of trunk and tail. In the former the vertebræ bear ribs below on each side, but have no sternum. (In some Clupeoids a medio-ventral dermal ossification may be a functional analogue of the sternum). The ribs

Fig. 22.



Outline of a Teleostean fish (Mugil):—*a*, anterior or spiny dorsal fin; *b*, posterior, usually soft-rayed, dorsal fin; *c*, caudal fin (homocercal); *d*, anal fin; *e*, ventral fin or hind-limb; *f*, pectoral fin or fore-limb; *g*, operculum.

never articulate with the tips, usually with the bases of the transverse processes, or rarely with the bodies of the vertebræ, as in Ganoids. Posteriorly sometimes the ribs ankylose, forming a wide hæmal canal; or the ribs may be absent or rudimental (Lophobranchii, Plectognathi). Tendinous ossification between the myotomes often exists, as in the herring, which are called epipleural ribs, Artedian

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* In Symbranchus the trunk vertebræ are plano-concave, the anterior even opisthocœlous.

bones, &c. The vertebral bodies have articular facets on their lower edges, and there are oblique articular processes above the centres. The vertebræ are never as numerous as in some Elasmobranchs (366) or sturgeons; eels have up to 230, but usually they are fewer, even as low as 15 (Ostracion). The tail vertebræ have complete hæmal arches. Those of the terminal part widen, flatten vertically, and consolidate with the interspinous bones of the caudal fin, becoming the *hypural* bones.* The end of the notochord is almost always bent up, and either persists in its cartilaginous sheath, or that sheath calcifies, and forms a *urostyle*, coalescing with the dorsal edge of the upper part of the consolidated hypurals, and forming a solid basis for the homocercal tail fin.

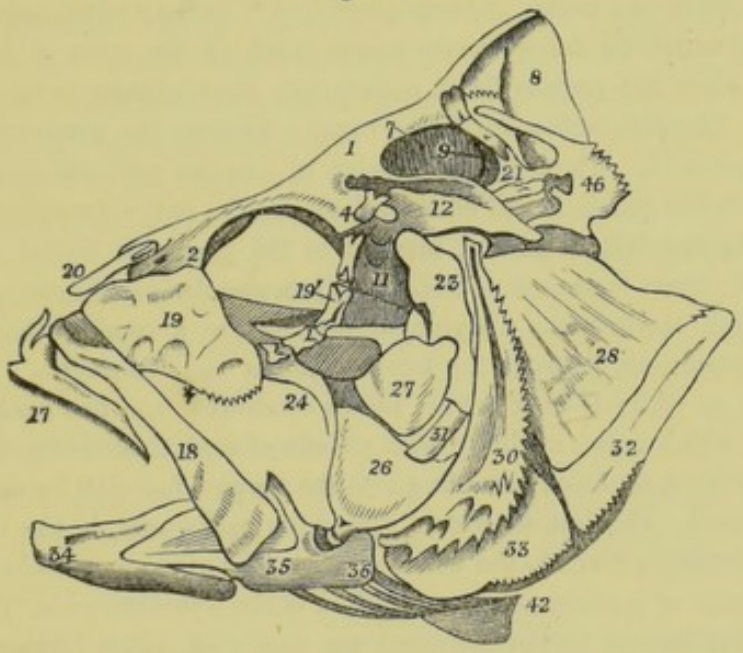
The cartilage of the cranium in young teleosts may become partly (pike, &c.) or completely ossified. Behind, a basi-occipital and two occipitals develop, the latter bounding much of the *foramen magnum*, and sometimes excluding the former completely therefrom (Cyprinus). A supra-occipital above completes this post-vagal segment of the skull. The next segment surrounds on each side the ear capsule, and medially exhibits a small Y-shaped basi-sphenoid ossification (often absent), below which is the large parasphenoid splint bone, united by suture to the basi-occipital. The alisphenoid may or may not be ossified, or to it may be consolidated the orbitosphenoid, which otherwise may either exist as separate small bones or may remain cartilaginous. The ear capsule consists of its five parts (Parker). The opisthotic lies in front of the ex-occipital, and may be small (pike), large (cod), or unossified. Above is the epi-otic.† The pro-otic in the salmon is large, and projects mesially between the basi-sphenoid and basi-occipitals, and has been confounded with the alisphenoid. Postero-externally is a cartilage bone (pterotic), which takes the place of the membrane squamosal of other vertebrates, with which it is sometimes confounded; and antero-externally is an additional element, sphenotic, which is sometimes called post-frontal, but

* Generally the hypurals are the interspinous bones alone, the arches being here obsolete.

† Teleosts show the first trace of a ductus cochlearis in the form of a cysticula (*Breschet*) or process of the sacculus.

which is a cartilage bone, not parostotic. There is no presphenoid. The ethmoidal region is represented by a thin interorbital septum, above which is a narrow extension of the cranial cavity. This anterior region remains as cartilage medially, but laterally may have a prefrontal, or more properly ecto-ethmoid (Parker), pair of ossific centres. The vomer forms a splint-like sheath for the medial cartilage, and there are lateral splints over the nasal sacs (nasal bones), sometimes a meso-nasal, and rarely a septo-maxillary (herring). Other membrane bones are the parietals forming lateral roof-bones, generally placed at each side of the median juncture of the frontal and

Fig. 23.



Bones of head of Perch: 1, frontal; 2, pre-frontal; 4, sphenotic; 7, parietal; 8, supra-occipital; 9, epi-otic; 11, pro-otic; 12, pterotic; 17, premaxilla; 18, maxilla; 19, lacrymal; 19′, sub-orbital; 20, nasal; 21, post-temporal ossicle; 23, hyomandibular; 24, ecto-pterygoid; 26, quadrate; 27, meta-pterygoid; 28, opercular; 30, pre-operculum; 31, symplectic; 32, sub-operculum; 33, inter-operculum; 34, mandible; 35, articular; 36, angular; 42, copula; 46, post-temporal.

the supra-occipital, joining occasionally with each other in the median line. A supra-orbital bone may lie in front of the orbit behind the prefrontal. Jugal bones exist in some Ganoids and Physostomi, as well as in pipe-fishes and Clupeoids.

Two points must be borne in mind regarding the morphological bearing of these divisions:—1st. That the so-called separate cartilage bones are really only separate ossific centres in a primarily more or less continuous cartilage; and 2nd. That these cartilage bones are, for the most part, replaced in the course of development by a secondary ectosteal deposit, so

that their adult representatives are really, for the most of their bulk, membrane developments.

Outside the ear capsule, in the upper part of the suspensorium, is an ossification (hyomandibular), segmented from the cranial end of the hyoidean arch, which supports at its distal end a rod-like bone (symplectic), whose lower end fits into a hollow in the quadrate bone, to which *Meckel's* cartilage articulates. The palato-quadrate cartilage ossifies in several pieces: the distal end is the quadrate above mentioned; the anterior proximal end below the basi-cranial axis in the palatine, and the intermediate pterygoid portion, may divide into three, which from without inwards are meta-, meso-, and ecto-pterygoid.* In front of the palatine is the maxilla, which in fishes rarely forms much of the gape of the mouth, except when the premaxilla is rudimental, or ankylosed to the vomer or nasals. The premaxillæ are large, usually forming the greater part of the upper jaw-arch. The mandible consists of—1st, an articular bone, an ossification in the proximal end of *Meckel's* cartilage; 2nd, a dentary splint bone external; and 3rd, a splenial internal to the persistent mesial part of the cartilage; there is sometimes added (4th) an angular membrane bone. The hyoid arch consists of—a stylohyal attached to a small cartilage intercalated posteriorly between the hyomandibular and symplectic. This ends below in an epihyal, after which follow ceratohyal and two basihyals, the inner of which unites medially with a chain of central elements, the first of which is the entoglossal extending into the tongue, followed by one, two, or three copulæ; the last of which, stretching backwards, is the urohyal, a name sometimes given to the whole series. The gills are stretched on bony arches, each of four segments, a repetition of the hyoidean arch. The uppermost joints (except in the foremost) are expanded, often dentigerous (epipharyngeal or pharyngo-branchial bones); the second joint, or epi-branchial, is generally short; the third, or cerato-branchials, elongated, bearing often spinose anterior processes (gill rakers), which are dermal splints of the same nature as the branchiostegal rays on the hyoid arch, and the lowest segment or basibranchial unites directly or indirectly with the copulæ. The 6th arch is only represented by its broad and dentigerous pharyngeal bone (hypopharyngeal) ankylosed to its fellow of the opposite side in Wrasses, &c.

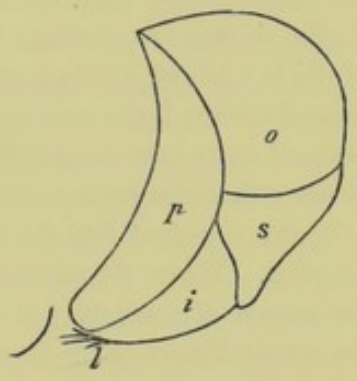
Covering over the gills, and articulated to the back of the hyomandibular, is the operculum (figs. 23 and 24), in front of which and over the intercalary cartilage lies the preoper-

* In Gasterosteus the palatine at once articulates with the quadrate.

culum, behind which lies the interoperculum, while below the operculum proper is the suboperculum. These together make the skeleton of the gill cover. Below and in front of the margin of the preoperculum and hyoid arch, lie bony rays, in the lower edge of the opercular membrane, nearly parallel to the edge of the opercular fold, and articulating in front to the epi- and cerato-hyals, free at their under edge. These are called branchiostegal rays.

In the Labyrinthobranchs the second joint of the fifth gill arch is folded into much divided and mazy lamellæ, which form the labyrinthic organ for respiration. The organ appended to the fourth arch in some Clupeoids is a modification of this arch.

Fig. 24.



Operculum, consisting of *o*, operculum proper; *p*, pre-operculum; *s*, sub-operculum; *i*, inter-operculum.

The unpaired fins in embryonic teleosts form a continuous membranous border. Their rays may be spinose or soft, made up of transverse joints and dichotomous. They are never preformed in cartilage, but are single-paired dermal ossifications, and are supported on remarkable dagger-like bones, arranged in a row medio-dorsally, each one placed in the interval between two neural spines, to which it is joined by membrane. These interspinous bones are membrane ossifications around a pre-existing cartilage interspinous rod (which condition persists in Elasmobranchs). The rays and their interspinous bones may articulate by a shackle-joint, the former ending in a ring, which is linked in a corresponding ring of the latter. Small depressor and elevator muscles for these fin-rays may be parts of the otherwise unrepresented dermal system of muscle. The interspinous bones for the anal

fin are similar to those of the dorsal, and those of the caudal are flattened and widened, forming the hypural bones, either by themselves or by fusing with the flattened hæmal arches of the terminal vertebræ.

The shoulder-girdle consists of a coraco-scapular cartilage, ossifying generally in two pieces. The clavicles are large, and join together mesially by ligament or by suture (Siluroids). There is often one or two post-clavicles, and dorsally a supra-clavicle, joined to the skull by a forked post-temporal (absent in eels), one limb of which touches the epi-, the other the pter-otic. The coracoid is never fenestrated. There is generally a meso- and a metapterygial *basale*, between which three radial bones reach the shoulder-girdle, so that five cartilage bones usually articulate therewith. The pelvic girdle is a lateral cartilage rod, joined by suture or ligament to its fellow. Sometimes the limbs may abort or remain filamentary (Murænophis), or one pectoral alone may remain (Monochir). The branchial arches have muscles to move them forwards and backwards.

In the unpaired fins the lateral halves may be symmetrical or unsymmetrical. When the rays are spinous, then the fin-rays, if symmetrical are named *Homacanthi;* if unsymmetrical, *Heteracanthi.* When the rays are simply fibrous bands they are named *Tilopteri* (*Kner*).

Teleostei have terminal or subterminal mouths ; each has a non-muscular aortic bulb, with only two valves (see p. 81), no spiracle, and the optic nerves cross, but form no commissure. They lay many small eggs, which are usually fertilized after extrusion. Few are viviparous. Over 9000 species are known, grouped into six orders.

CHAPTER XI.

Orders of Teleostean Fishes.

Order I. *Physostomi* (*Müller*).—Fishes whose air-bladder, when present, has a duct opening anteriorly into the digestive tract, whose fin-rays are soft, dichotomous, transversely

jointed, except perhaps the first, which may be spiny. The skin is naked, or clothed with cycloid scales, rarely with bony plates; the hypo-pharyngeal bones are distinct.

The 3000 species of Physostome fishes are grouped in the following families, which may be divided into two groups, according as the ventral fins are abdominal or absent (*abdominalia* and *apoda*).

Physostomi abdominales include 23 families:—

1. *Siluridæ.*—An enormous group of freshwater fishes, with naked bodies; heads often clothed with ganoid or bony plates, mouths terminal, armed with many small bristle-like or two-pointed teeth. The premaxillæ are large, forming the upper edge of the mouth; the reduced maxillæ often carrying sensory feelers. There is no sub-operculum, and the swimming bladder is connected with the vestibule of the ear by means of a duct. There is often an anal fin, and the first ray of the pectoral is spiny, often toothed, and it articulates with the shoulder-girdle by means of a complex joint. Silurus glanis is one of the largest freshwater fishes of Europe, and reaches a weight of over 100 lbs. Many of these have accessory tubular respiratory organs appended to the gills, as, for example, Clarias, Saccobranchus, and Heterobranchus. One toothless S. American form, Hypophthalmus, has no swimming bladder. In Arius the males receive into their mouths the eggs, when freshly laid, and hatch them in the spaces above the gill arches. Malapterurus, the Rasch found in the Nile, has an electric organ running for the whole length along each side.

2. *Goniodonta.*—Closely allied freshwater fishes, mostly from South America, with no swimming bladders, but with pseudobranchia. The heads and bodies are clad with large, rough, bony plates, and the first ray of each fin is a strong spine. The head is lengthened into a snout in some, beneath which is the mouth; the teeth are angularly bent in most, and the maxillæ are large, ex. Loricaria. Pseudecheneis has a sucking disk between the pectoral fins.

3. *Characinidæ.*—Regularly-scaled S. American or African river fishes, with one (Erythrinus) or two dorsal fins, the posterior being an adipose fin. The head is naked, and with no barbules. The upper jaw is formed of both premaxillæ and maxillæ. There are neither lingual teeth nor pseudobranchiæ, and the swimming bladder is divided into two parts, anterior and posterior, the former reaching to the vestibule of the ear. Curimatus, a Guiana genus, has no teeth of any kind. Other genera are Serrasalmo, Myletes.

4. *Scopelidæ.*—Naked or scale-clad, with short intestine, and, like the

last, with an oviduct, and no swimming bladder; upper edge of the mouth of the premaxilla alone, and there are no barbules. An adipose fin lies behind the dorsal, and pseudobranchiæ are always present. The pyloric cœca are few or none. The genera are Saurus, and Scopelus, whose phosphorescent lateral eye-specks have been above alluded to.

5. *Sternoptychidæ.*—Naked or sparsely scaled; the mouth-edge is formed of both the premaxilla and maxilla, and there are phosphorescent spots along the lower edge, ex. Chauliodes, which has no pseudobranchia; Sternoptyx, &c.

6. *Stomiadæ.*—Naked or finely scaled, with a hyoid barbule; mouth-edge as in the last, operculum small, and no pseudobranchia.

7. *Salmonidæ.*—Scale-clad, naked-headed fishes, without barbules, but with an adipose fin; the upper mouth-edge consists of premaxilla and maxilla. An air-bladder, pectinated pseudobranchiæ, and many pyloric cœca are always present; but there is no oviduct, in which respect it differs from the four preceding families. The flesh is often coloured, and well flavoured. The salmon and trout, Osmerus, the smelt, Thymallus, the grayling and Coregonus, the pollan are familiar illustrations.

8. *Galaxiidæ.*—Salmon-like, but naked-skinned freshwater fishes from the southern hemisphere. They possess an oviduct, and no pseudobranchia nor adipose fin, ex. Galaxias.

9. *Haplochitonidæ.*—A small intermediate group, also from the southern hemisphere, with an adipose fin, and no pyloric appendages, ex. Haplochiton.

10. *Percopsidæ.*—A small *ctenoid*-scaled group of fishes, with an adipose fin, and no pyloric appendages.

11. *Umbridæ.*—A small group of cycloid-scaled fishes, with the upper mouth-edge consisting of both premaxilla and maxilla, with no adipose fin; pyloric appendages, and a glandular pseudobranchia, like that of the pike, ex. Umbra, from S. Europe and N. America.

12. *Amblyopsidæ.*—Viviparous, small, freshwater fishes from N. America, with the anus under the throat, in front of the pectoral and ventral fins, head naked, pseudobranchia none, stomach with a cæcum and pyloric appendages. The swimming-bladder is notched in front. Amblyopsis spelæus, the blind fish of the Great Cave of Kentucky, has rudimentary eyes. Chologaster has well-developed eyes.

13. *Cyprinodontidæ.*—Carp-like fishes, with maxillary and pharyngeal teeth, no barbules, an air-bladder, with no ossicles and no pseudobranchia, pyloric appendages, nor adipose fin. The sexes are often dimorphic. Rivulus, from Central America, has no swimming-bladder. Jenynsia has in the male a clasping organ, made of the modified anal fin, as has Pœcilia. Anableps,

of Surinam, has a transverse opaque bar crossing the cornea and iris, dividing each eye into an upper and lower half. Some are viviparous, and others lay their eggs when nearly hatched.

14. *Cyprinoidei.*—Carp: freshwater fishes of temperate climates, with naked head and scaly body; the premaxilla alone forms the upper edge of the gape, and the hypo-pharyngeal and basi-occipital are alone dentigerous. The swimming-bladder is united to the ear by ossicles, and there are no pyloric appendages. An oviduct is present. Many have barbules like the carp (Cyprinus), and Barbus, the barbel. Carassius, the goldfish, has no barbules. Other forms are Leuciscus, the roach and rudd; Tinca, the tench; Phoxinus, the minnow. Rhodeus has, in the females, a long tube for depositing the eggs within the shells of Unios. One genus, Homaloptera, has no swimming-bladder. Kneria is quite toothless and beardless.

15. *Acanthopsidæ.*—Carp-like fishes, with scaleless head, weak pharyngeal teeth, and with the swimming-bladder in a bony case; the sub-orbital bones often bear moveable spines; mouth always with six or more barbules, ex. Cobitis, the loach.

16. *Esocidæ.*—Pike: scale-clad, beardless, voracious freshwater fish, with abundant teeth on all bones of the jaws and throat, except the maxillæ (which laterally enter into the gape). Pyloric appendages none; swimming-bladder simple, and pseudobranchiæ glandular.

17. *Mormyridæ.*—African river fishes, with compressed body; head and operculum covered with a naked skin, leaving only a small, spiracle-like, vertical, free gill-slit. There is no adipose fin, nor barbule, and two pyloric appendages. The premaxillæ are mesially united into a single bone. In Mormyrus there is a lateral caudal pseud-electric organ, and there is a post-auricular opening leading into the labyrinth. Gymnarchus uses its swimming-bladder as a lung; and an allied form, Gonorhynchus, from the southern hemisphere, has no swimming-bladder, and spiny scales; it is made by Günther the type of a separate family.

18. *Hyodontidæ*, consisting of N. American freshwater fishes, differ from the foregoing families in having a fully developed operculum, a wide gill-opening, and one pyloric appendage.

19. *Osteoglossidæ* have hard mosaic-like scales and a lateral line of wide openings. One of these, Heterotis, has a spiral, accessory, respiratory organ on the fourth gill arch.

20. *Clupeidæ.*—Herrings: marine fishes, with compressed bodies covered with large flexible scales, and with hard, serrated, dermal plates, often along the ventral line. Some have transparent eye-lids, and all have pyloric appendages, wide gill-openings, a pseudobranchia, and a perfect operculum. This includes Clupea, the herring, of which several species are sought as

food. C. harengus is the common herring, C. Caspia the Caspian herring, C. Pontica the Black Sea herring, C. elongata the American herring. C. pilchardus is the pilchard, C. sprattus the sprat, C. sardinia the sardine. The whitebait (Rogenia alba) has pterygoid teeth, but is thought by some to be a young stage of the herring. Alosa, the shad, is nearly toothless. Engraulis, the anchovy, has a wide gape, with a long maxilla and toothless jaws. Albula has two rows of aortic valves.

21. *Chirocentridæ.*—Scaly clupeoid fishes, with spirally folded mucous membrane in the intestine, and no pyloric appendages, nor pseudobranchiæ.

22. *Alepocephalidæ.*—Mediterranean clupeoid fishes, with numerous pyloric appendages.

23. *Notopteridæ.*—Tropical fishes, with a pointed tail, and the anal fin running along the lower end of the body as far as its tip. There is no pseudobranchia, and an internally sacculated swimming-bladder, and two pyloric appendages.

24. *Halisauroidei.*—Atlantic fishes, with numerous pyloric appendages, no pseudobranchia, and a simple swimming-bladder; tail exceedingly long, and pointed.

Physostomi apodes consist of three families of eel-like fishes, usually with small scales embedded in the soft skin, which covers the head, and usually leaves very narrow gill-slits. The ventral fins are absent, and the other fins are weak or none.

25. *Gymnotidæ.*—South American electric eels, with pointed tail, and anus very far forward; mouth-edge formed only of the premaxillæ, doubled swimming-bladder, and numerous pyloric appendages. Gymnotus is the electric eel, which sometimes reaches a large size.

26. *Symbranchidæ.*—Tropical mud-eels, with no pectoral fins, anus far back, one median ventral gill-slit, no swimming-bladder nor pyloric appendages. In Amphipnous there is an air-sac communicating with the branchial chamber.

27. *Muræniдæ.*—Eels, with the anus remote from the head, a tooth-bearing maxilla, and the premaxilla united to the vomer; the shoulder-girdle, like that of Amphipnous, is not connected to the skull, and there are no pyloric appendages. The eels, congers, &c., belong to this family. The larval form of the scaleless conger eel is a semi-transparent worm-like fish, with pointed minute head and no red blood-corpuscles nor swimming-bladder. This is known as Leptocephalus or Helmichthys, and is supposed by Günther to be an abnormal condition of anomalously retarded development in the embryonic conger.

Among the physostome fishes there are almost always more than five jointed rays in the ventral fins.

Order II. *Anacanthini* (*Müller*).—Physoklistous fishes with soft fin-rays; with no spiny rays in the median fins, except in Gadopsis; and with separate hypo-pharyngeal bones. The ventral fins are not on the abdomen, as in the Physostomi, but are under the throat or thoracic.

These fishes may be divided into two groups, like the last, viz., Apodes and Sub-brachiati. The Apodous families are:—

1. *Ophidiidæ.*—Eel-like fishes, with wide gill-openings, and few or no pyloric appendages. In Ophidium the ventral fins are represented by a pair of forked filaments attached to the hyoid. Fierasfer is parasitic in Culcitæ and Holothuriæ. Ammodytes, the sand-lance, has no swimming-bladder, and one pyloric appendage.

2. *Ateleopidæ.*—Japan fishes, with the ventral fin consisting of simple threads attached to the shoulder-girdle. Body with a long compressed tail.

The Sub-brachiate families are:—

3. *Brotulidæ.*—Ventral fins reduced to one filament, body elongated, swimming-bladder bifurcate, ex. Brotula. Lucifuga is an inhabitant of subterranean waters in Cuba.

4. *Macruridæ.*—Ventral fin of several rays; pseudobranchia none, but pyloric appendages numerous; the long dorsal and anal fins reach to the pointed tail, ex. Macrura.

5. *Lycodidæ.*—Ventral fins attached to the shoulder-girdle (absent in Gymnelis), gill-opening small, swimming-bladder none, pseudobranchia present.

6. *Gadidæ.*—Long-bodied sea-fishes, with small smooth scales and 1–3 dorsal fins. The gill-openings are wide; there are pyloric appendages, a swimming-bladder, and usually a glandular pseudobranchia. Gadus includes the cod, haddock, pollock, saith, lithe; Merluccius is the hake; Lota, the ling and eel-pout; Motella, the rockling, &c.

7. *Gadopsidæ.*—Australian fishes, with a few spiny rays.

8. *Pleuronectidæ.*—A singular group of asymmetrical fishes, with *ctenoid* scales, and flattened, laterally compressed, often discoidal bodies, swimming on one side, so that the dorsal and ventral edges lie horizontally in the one plane; the upturned side is usually coloured, the under side is white; the two eyes are placed in the adult on the upper or coloured side. The dorsal and anal fins are long, marginal, and undivided; the swimming-bladder is absent, and the visceral cavity is small. The embryos begin life with symmetrical eyes, and the displaced one gradually moves round the front of the head to its anomalous site. The other head-organs, nose, olfactory nerves, &c., participate in the peculiarity of unilateral development, whose

stages have been so carefully described by Professor Traquair (" Trans. Linn. Soc., vol. xxiv.) The eyes are on the right side in Hippoglossus, the halibut, the largest of the family, as in the flounder and plaice; they are on the left in the turbot (Rhombus). The soles, dabs, top-knots, &c., are also examples.

Order III. *Plectognathi* (*Cuvier*).—Usually short, stout fishes, with plated or spiny body; no ventral fins, or these replaced by spines; hypopharyngeal bones separate; premaxillæ and hyomandibulars immoveably articulated to the skull; mouth small, with its upper jaw edge formed by the premaxilla. Outer gill-slit small, in front of the pectoral fins, the operculum being covered by muscles and skin. The dorsal fin is soft; the inner skeleton is reduced, often cartilaginous; the vertebral column consists of twenty, or even fifteen vertebræ, with rudimental ribs or none, and with a symmetrical terminal tail vertebra. The air-bladder has no duct, and the intestine has no pyloric cæca. They are for the most part marine.

The families are :

1. *Ostracionidæ.*—Trunk-fishes, body 3–4 angled, often with spines, inclosed in a fixed case of calcified hexagonal plates forming a box, from which the moveable soft-based tail projects. The vertebræ are 14, ankylosed; the ribs and ventral fins are absent; the jaws have 10–12 teeth, in sockets.

2. *Balistidæ.*—File fishes, laterally compressed, with shagreen-like skin (the rough points not dentinal), or with hard shields; teeth clavate, 8, above and below. The vertebræ 7, 10, or 7, 11–14 (Monacanthus). Anterior dorsal fin, with one or more long, erectile, spiny rays. Ventral none, or spinose, but the pelvic bones are united into an arch abutting in front on the pectoral arch, and behind on the base of the anal fin.

3. *Triacanthidæ.*—East Indian fishes. Skin with small scale-like shields; dorsal fin with 4–6 spines, and ventral replaced by a pair of strong spines.

4. *Gymnodonta.*—Skin leathery, with numerous spines, no ventral fins, and a soft dorsal, capable of erection. Ribs none. The jaws are beak-like, projecting, and each jaw bears a single enamel-covered tooth (Diodon), or two above and one below (Triodon), or two above and two below (Tetrodon). These fishes, by swallowing air, can inflate a sub-œsophageal sac

(which has a muscular sphincter, and extends beneath the skin of the abdomen), rendering themselves balloon-like. Tetrodon fahaca, which, like the Malay Xenopterus, is a freshwater form, is often left inflated on the fields after the inundations of the Nile. Orthagoriscus, the sunfish, has no pharyngeal sac nor swimming-bladder; its jaw is edged with enamel, showing no median suture, and behind this investment are several rounded teeth; the skin is shagreen-like; the body short, strongly compressed, often exceeding 100 lbs. in weight. Triodon has rudimentary ribs, a suture in the upper jaw investment of enamel, but none in the lower.

Order IV. *Lophobranchii* (*Cuvier*).—Body prismatic, protected by dermal, quadrate, bony plates. Ventral fins absent; the pectoral fins are small, and the dorsal fin is short; the anal and caudal often rudimental. Pharyngeal bones distinct; snout tubular, toothless; skeleton partly cartilaginous, ribless; gill-slit narrow, from the union of the simple opercula to the shoulder-girdle. The air-bladder, when present, has no pneumatic duct, and the gill filaments are few, often paired, tufted, clavate; branchiostegal rays none. The males in Syngnathidæ bear ventral pouches, in which the ova, when extruded by the females, are received and incubated. In some forms the pouch is represented by two dermal folds, one on each side of the tail, and in others (Nerophis) the eggs are borne on the abdomen or tail in rows. They are chiefly found in the shallow shore-waters of Palæotropical seas.

There are two families:—

1. *Syngnathidæ.*—Small pectoral fins, with narrow gill-openings; one soft dorsal fin, and no ventral fin. This includes Syngnathus, the pipe-fish, which has a straight tail, and often a caudal fin; and Hippocampus, the sea-horse, which has a prehensile tail, without a caudal fin.

2. *Solenostomidæ.*—Gill-opening wider; dorsal fins two, the rays of the first, which is long being unjointed, and all other fins being developed. Swimming-bladder and pseudobranchia are absent. This includes one genus from the Indian Ocean—Solenostoma, an odd-shaped fish, in which the dermal skeleton, which consists of stellate bony plates, is covered with a soft thin skin. The males have a ventral egg-pouch.

Order V. *Acanthopteri* (*Müller*).—Physoklistous fishes, usually with ctenoid scales, more rarely with sparoid or cycloid, or with bony plates, or naked and scaleless. The hypopharyngeal bones are usually separate, and the fin-rays of the anterior dorsal and of most of the other fins are spiny. The ventral fins also are usually placed far forward, either under or in front of the pectorals. This order includes about 4000 known species, most of which are marine, which are arranged in forty families. The swimming bladder is absent in some, and when present is sometimes prolonged into the cavity bordered by the hæmal arches of the hindmost trunk vertebræ.

1. *Aulostomidæ.*—Elongated fishes, with naked skin or ctenoid scales; in Amphisile, with thin bony shields, forming a regular dorsal *shell;* the facial bones are prolonged into a pipe-fish-like tubular snout, at whose extremity is the narrow mouth, which is toothless (Centriscus), or armed with weak teeth. Centriscus and Amphisile have no pyloric appendages, and the anterior vertebræ are fused together; the azygous fins are weak or absent. Ex. Centriscus, the sea snipe; Fistularia, the tobacco-pipe fish; and Aulostoma, the trumpet-fish.

2. *Gobiesocidæ.*—Elongated, flattened anteriorly, naked; ventral fins far apart, with a sucking disc between them, supported on a broad coracoid. The swimming-bladder is absent, and there are only 3 or $3\frac{1}{2}$ gill-pairs. Ex. Lepadogaster, Gobiesox.

3. *Ophiocephalidæ.*—Indian freshwater fishes. Elongated, with shielded head, no spiny fin-rays, and an accessory hollow space above the gill-cavity. The abdominal cavity is prolonged into the tail.

4. *Labyrinthici.*—Air-breathing, palæotropical fishes, with interrupted or no lateral line, a narrow gill-opening, and over the gill there is a labyrinthine supra-branchial organ in a space above the pharyngo-branchials. In this space water is retained, and moistens the gills. Anabas, the climbing perch of India, travels on land by means of the spines of the operculum and pre-operculum; it can remain for six days on land. Osphromenus olfax of China is said to be in flavour the most delicious of fishes. In Luciocephalus there are two dilated membranous organs in a supra-branchial, post-ocular sac.

5. *Trachypteridæ.*—Elongated, ribbon-like, scaleless fishes, with narrow mouths, with a divided and elongated dorsal fin, the forepart of flexible

unjointed rays; anal fin absent; the tail is unsymmetrical or absent; pyloric appendages numerous. Ex. Regalecus.

6. *Cepolidæ.*—Ribbon-like, with small cycloid scales, an undivided dorsal fin, and a long anal. Ex. Cepola, the band-fish.

7. *Chiroideæ.*—A small family of small-scaled fishes, in which the sub-orbital bones articulate with the pre-operculum.

8. *Blenniidæ.*—Usually elongated or cylindrical, slimy fishes, naked or with small scales, with long dorsal or anal fins, and with the ventrals far forward. The swimming-bladder and the pyloric appendages are absent in many, the former being present in Petroscirtes. The males have often a genital papilla, and the females are often viviparous, as in Zoarces. The wolf-fish, Anarrhichas, is one of the most voracious of fishes. The commonest forms are the blennies, abundant on our shores, and the gunnel (Centronotus), common in the rock-pools around our shores. Salarias scandens is said to climb out of the water.

9. *Notacanthidæ.*—Eel-like fishes, with small cycloid scales, with many free spines in place of a dorsal fin; the pectoral fins are far back, the shoulder-girdle being disconnected from the head. The jaws are beak-like, and the gape is but little extensile, and a swimming-bladder is present. Ex. Mastacembelus, from the rivers of India.

10. *Sphyrænidæ.*—Sub-cylindrical pike-like fishes, with small cycloid scales and an uninterrupted lateral line, a wide gape, and formidable teeth. The dorsals are two, far apart, and the ventrals far back. Sphyræna, the barracouda, is an exceedingly fierce American fish.

11. *Atherinidæ.*—Sub-cylindrical, with moderate scales and an obscure lateral line; teeth weak; ventral fin far back. Ex. Atherina, the sand-smelt. Tetragonurus has no swimming-bladder.

12. *Mugilidæ.*—Oblong fishes, with moderate cycloid scales, no lateral line, and a narrow mouth; ventral fins are appended to the elongated coracoid. The foremost dorsal fin has four spines, and the lower jaw exhibits a medial swelling, which sinks into a pit in the upper. There is a gizzard-like stomach and a long convoluted intestine. The grey mullet, Mugil Capito, is a familiar example.

13. *Gasterosteidæ.*—Small fishes, with free dorsal spines in front of the dorsal fin, united pelvic and shoulder-girdles, and sub-orbital bones articulated to the pre-operculum. In the embryo the ligament joining the swimming-bladder and the digestive canal is perforated. Gasterosteus pungitius and aculeatus are the common sticklebacks.

14. *Gobiidæ.*—Usually small fishes, with a weak spiny and a longer soft portion in the dorsal fin; ventral fins united, and forming a disk-like surface: pyloric appendages none, but there is an anal papilla and pseudo-

branchiæ. The gobies have a rudimental or no swimming-bladder. Licydium has moveable teeth, embedded in a gum. Periophthalmus has closely set and very prominent eyes. Amblyopus, from India, has exceedingly small eyes. Trypauchen has a deep cavity above the operculum, but not communicating with the gill-chamber. Callionymus, the dragonet, has united pharyngeal bones and a spiny pre-operculum.

15. *Cyclopteridæ.*—Thick oblong fishes, with bony tubercles on the skin, or naked. The ventral fins have rudimental rays, and their bases form a large sucking disk; the swimming-bladder is absent. Cyclopterus is the ungainly-looking lump-fish of our seas.

16. *Cataphracti.*—Large-headed, and usually rough or spinose fishes, many of them of eccentric forms. Sub-orbital bones broad, united by bone to the pre-operculum, and covering the cheeks. The spiny dorsal fin is weaker than the soft, and the body is often clothed with bony plates (Agonus, Peristedion), or with small ctenoid scales (Trigla, gurnards), or naked (Cottus, the bull-heads). In Trigla, Prionotus, and Dactylopterus the swimming-bladder is divided into two parts, and possesses lateral muscles. Most of the other forms have no swimming-bladder, as Agonus, Cottus, &c. Dactylopterus has wing-like pectoral fins, which are used like those of the flying fish. Pegasus is also winged, and from its seahorse-like shape it has been referred to Lophobranchii by some.

17. *Pediculati.*—Fishes of extraordinary shapes, with a thick fore part of their bodies, and no scales. The base of the pectoral fin is elongated into an arm or peduncle for the fin-rays, and the gill-pairs are diminished in numbers, with no pseudobranchia. The gill-opening is small, and placed beneath the base of the pectoral pedicle, but the gill-chamber is wide. The skin is generally warty, and the ventral fins are jugular. Lophius, the fishing frog or angler, of our own seas, has an enormous gape, and a mouth armed with pointed moveable teeth. The head-bones are spinose, and the three foremost rays of the dorsal are free, elongated into "fishing-rods," whose tips are said to act as baits, and whose bases articulate with the interspinous bones and skull by shackle-joints. Antennarius has tentacle-like processes of its dorsal fin. Malthe, the bat-fish, has a snout-like prominence, and a tentacle retractile into a cavity. Halieutæa is also flattened, disk-like.

18. *Batrachidæ* differ from the last in the reduction of the spines of the dorsal fins, in the well-developed slime canals, and in the absence of the peduncles of the pectoral fins. They also possess swimming-bladders. Thalassophryne has a poison-gland on its operculum, whose duct traverses a strong marginal opercular spine (*Günther*).

19. *Trachinidæ.*—Elongated fishes, with a short spiny portion of the dorsal fin. Most of them have no swimming-bladder, except Pinguipes

and Sillago, and numerous caudal vertebræ. Cichlops has closely united pharyngeal bones. Many of them have the eyes close together, and directed upwards. Ex. Uranoscopus, the star-gazer, and Notothenia. The ventral fins are in front of the pectoral. Trachinus, the weaver, is commonly thought to inflict poisonous wounds.

20. *Scomberidæ.*—Smooth, elongated, mostly with widely-forked tails, naked or with small cycloid scales, and a weak spiny portion of the dorsal fin. The ventrals, when present, are thoracic. There are often false fins behind the true dorsal, as in Scomber, the mackerel, and Thynnus, the tunny, whose caudal vertebræ are flattened and thickened laterally. Echeneis, the remora or sucking fish, has a dorsal elliptical sucking disk on the head and neck, with two rows of transverse folds in it, looking like the bars of a Venetian blind; it has no swimming-bladder, like Stromateus, Comephorus, &c. In Nomeus the ventral fin is fixed by a skin-fold to the under surface, and can be folded into a groove. Zeus, the Johndory, has a high, compressed, disk-like body, with a row of bony plates at the bases of their dorsal and anal fins. Lampris luna, the opah or kingfish, is also compressed and gorgeously coloured, but has no bony tubercles. Coryphæna, the "dolphin," has a long, flexible, rayed dorsal fin and a jugular anus. Stromateus has tooth-like processes in its œsophagus.

21. *Xiphiidæ.*—Mackerel-like fishes, with the premaxillary bones and vomer elongated into a sword-like process, and with pseudobranchiæ, a swimming-bladder, and many pyloric appendages. Xiphias is the sword-fish, whose weapon sometimes is thirty inches long, or even more. The branchial lamellæ of each arch are inseparably united.

22. *Carangidæ.*—Mackerel-like fishes, with high, compressed bodies. The hinder rays of the dorsal and anal are often half free. Caranx is the horse mackerel, which has prominent bony scales at the hinder end of the lateral line. Naucrates, the pilot-fish, supposed to guide the sharks, hence the name. When young this genus possesses pre-opercular spines and a continuous dorsal, but when mature the dorsal fin-rays become isolated, and the spines unite.

23. *Acanthuridæ.*—Compressed, high fishes, with small or no (Acronurus) scales. The tail is adorned with spines or bony plates (Prionurus). The forehead is horned in Naseus; and in all, the swimming-bladder is forked behind.

24. *Trichiuridæ.*—Elongated; naked, or with small scales; teeth strong; median fins elongated, often with false fins on the tail; vertebræ numerous, 168 to 242. The ventrals are rudimentary or absent.

25. *Sciænidæ.*—Oblong, compressed, with ctenoid scales, which often cover the toothed operculum and the cheeks. Some of the head-bones are inflated, with large slime canals. The pectoral fin-rays are all branched,

and the swimming-bladder is usually bordered by cæcal appendages, forming a marginal fringe (except in Larimus, which has a simple air-bladder). In Ancylodon these appendages are branched, and cover the entire abdomen. Pogonias has united pharyngeal bones, as also has Umbrina.

26. *Polynemidæ.*—Small, oblong, palæotropical fishes, with large pectoral fins, some of whose rays are extremely elongated, and free. The median fins are scale-clad.

27. *Kurtidæ.*—Elongated, compressed fishes from the Indian and Pacific Oceans, with very small scales, and one very short dorsal fin. Ex. Kurtus, Pempheris.

28. *Teuthiidæ.*—Small-scaled Indian and Pacific fishes, with large swimming-bladders, forked fore and aft. The ventral fins have a spine at each extremity, and the sides of the narrow-based tail are spine-armed. The clavicle joins the first interspinous bone of the anal fin. Ex. Teuthis.

29. *Berycoideæ.*—Compressed, high fishes, with large lateral eyes, a spiny operculum, ctenoid scales; ventral fins have more than five soft rays, except in Monocentris, in which each consists of a strong spine and a few rudimental soft rays. Ex. Beryx, Hoplostethus.

30. *Polycentridæ.*—High, compressed S. American river and estuary fishes, with no lateral line and long median fins, whose spiny parts are long. Ex. Polycentrus.

31. *Scorpænidæ.*—Long, slightly compressed, often with spiny heads, and often tasseled; the sub-orbital bones are united to the pre-operculum. Some have elongated pectoral rays, and many of them are of remarkable shapes. Ex. Scorpæna, Apistus, Sebastes.

32. *Cirrhitidæ.*—Compressed, elongated, with cycloid scales. The ventral fin is thoracic, but behind the pectoral, some of whose under-rays are spinous and undivided. Cirrhites has no swimming-bladder, while Chilodactylus has one, with appendages.

33. *Sparidæ.*—Compressed, oval fishes, with sparoid scales and an unarmed operculum. On the neck from the supra-scapula to the middle of the head, there is a row of large scales; these are covered by skin and pierced by fine slime-canals. Aphareus has a small cavity, internal to the base of the pectoral fin, which communicates with the gill-chamber, and possesses small glands. The teeth vary considerably; some have rounded crushing teeth; others have sharp cutting teeth. In Lethrinus the hypopharyngeals are united. In Hoplognathus the teeth are united, so that the jaw-margins form a sharp, cutting, tooth-like edge.

34. *Gerridæ.*—Tropical sparoid fishes, whose dorsal fins have a basal row of scales separated from the rest of the scales by a groove; pseudobranchia

glandular; stomach with no cæcum; hypo-pharyngeal bones united; pyloric appendages rudimentary. Ex. Gerres.

35. *Embiotocidæ* or *Holconoti.*—Viviparous, compressed, oblong fishes, with cycloid scales, a dorsal row being differentiated as in the last. There is a conical genital papilla behind the anus, upon which the sex-organ opens. This acts as a copulatory organ in the male. There is at the hinder end of the ovary a brood-pouch, within which the young are retained and nourished until they become one-third the size of the parent. Ex. Ditrema.

36. *Squamipinnes.*—High, compressed fishes, whose median fins are scale-clad with finely ctenulated scales, a simple swimming-bladder, and a pseudobranchia. Chelmo has a long protrusible mouth. Toxotes is said to eject water so as to strike insects.

37. *Mullidæ.*—Elongated fishes, with large scales and unarmed opercula, two hyoidean barbules, and pseudobranchia. They have four branchiostegal rays. Ex. Mullus, the mullet.

38. *Nandidæ.*—Oblong, compressed, palæotropical fishes, with an interrupted lateral line, five or six branchiostegal rays, a swimming-bladder, and pseudobranchia.

39. *Etheostomata.*—N. American river fishes, with no swimming-bladder, with only the anterior sub-orbital bone, no pseudobranchia, and with the opercular membrane often united at the ventral edge.

40. *Pristipomatidæ.*—Elongated, compressed fishes, with the gill-membrane cleft to the middle of the inter-operculum; teeth weak, none in Macquaria; a swimming-bladder and pseudobranchia are present.

41. *Percoideæ.*—Highly specialized bony fishes, with ctenoid scales, a spiny or toothed pre-operculum and operculum. The swimming-bladder is simple, the stomach has a cæcum, the infra-orbital bones are free and small, and the branchiostegal rays are seven. Serranus has a large swimming-bladder and many pyloric appendages. S. scriba and cabrilla are hermaphrodites. Perca is the common perch. Labrax, the basse of our seas, has teeth on its tongue. Acerina has deep cephalic slime-canals. Pomotes has united pharyngeal bones.

Order VI. *Pharyngognathi.*—The most highly specialized of the Physoklistous fishes, with the hypo-pharyngeals coalescent, either with or without a median suture, and with short teeth. This is a small order, and includes four families.

1. *Scomberesocidæ.*—Cycloid-scaled, pike-like fishes, with soft fin-rays only, a glandular pseudobranchia, and an obscurely marked pylorus, with

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no appendages. There is a row of keeled scales along the ventral aspect, and the dorsal fin is far back. The maxilla laterally forms part of the upper jaw-margin. This includes Exocœtus, the flying fish, whose large pectoral fins enable it to take long leaps out of the water. Belone is the gar-pike or green-bone. Hemirhamphus is the under swordfish, so called from its long sword-like lower jaw. Scomberesox is the Saury pike.

2. *Chromidæ.*—Spiny-finned, ctenoid-scaled fishes, with interrupted lateral line, a median suture in the hypo-pharyngeal, ventral fins placed on the thorax, no pseudobranchia, few or no pyloric appendages, and a cæcal sac appended to the stomach. The fourth gill is bilaminar, but short, and the fourth slit is very small. Chætobranchus forms nests for its eggs. Geophagus has a labyrinthiform organ, richly supplied with nerves, and which acts as a brood-pouch for the eggs.

3. *Labridæ.*—Wrasses: oblong, spiny-finned fishes, with cycloid scales; strong jaw teeth, but none on the palate; pseudobranchia and swimming-bladder both developed. These are the common rock fishes of our shores, which are known by their fleshy lips and long spinose dorsal fins. The teeth of both jaws are united into a broad cutting plate in Scarus. The teeth on the pharyngeal plate are flat and grinding. There are no gastric cæca, and the fourth gill-arch has but a single branchial lamina, the slit between this and the hypo-pharyngeal being closed. Ex. Labrus, Crenilabrus, Novacula.

4. *Pomacentridæ.*—Wrasse-like fishes, with ctenoid scales, weak teeth, a toothless palate, pseudobranchiæ and a swimming-bladder. The lips are not fleshy, and the stomach has a cæcum and pyloric appendages. The fourth gill-arch bears unequal laminæ. Ex. Amphiprion, Pomacentrus.

Sub-class V. Dipnoi (*Müller*).—Tropical fishes of an extremely generalized type living in mud, with broad heads, wide gape, small eyes, no spiracle, and long compressed bodies, clad with imbricated cycloid scales, and provided with many lateral and cephalic slime-canals. The tail is pointed, diphycercal, and the limbs are four, filiform, whose many-jointed gristly axis supports numerous lateral cartilaginous rays, and exhibits an interesting archaic type of limb-ray.* The median fin-rays are unjointed; the notochord is thick.

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* I append to this chapter some notes on the nature of limbs, and on the structural relations of fishes from Professor Huxley's Paper on Ceratodus.

and its cartilaginous sheath shows no vertebral subdivisions, and embeds the proximal ends of the ribs, of the hæmal and neural arches. The shoulder-girdle (at least in Protopterus) consists of a small post-temporal and no interclavicle; the large epicoracoids are separate from the coracoids, and the cartilage elements are unossified. The intestine has a spiral valve, and ends in a cloaca. The swimming-bladder forms a symmetrical pair of lung-sacs, with rigid walls, and the common pneumatic duct opens ventrally into the œsophagus. The heart has a small left auricle, which receives the blood from the capillaries in the alveoli of the wall of the swimming-bladder by a single pulmonary vein. The posterior nares open into the cavity of the mouth, while the anterior open externally.

The arrangement of the nostrils is comparable with that of Cestracion, if we imagine the middle portion of the groove to be occluded, and the hinder end removed farther into the mouth. The bulbus aortæ has transverse rows of valves in Ceratodus, but has two longitudinal folds, spirally attached to the wall in the other forms; the first aortic arch vanishes; the second supplies the opercular gill; the third gives off carotids; and the fourth, which sends a branch to the outer gills, unites with the continued dorsal trunk, forming the aorta; the fifth and sixth supply the outer and inner gills; the seventh passes to the inner gill alone. In Protopterus the single pulmonary artery going to the swimming-bladder arises from the left of an eighth arch, whose right member is absent; in Ceratodus the bladder is supplied from the cæliac artery. The gill-arches are five in Lepidosiren, six in Protopterus, and the gill-slits are four in the former, five in the latter, in which the outer or embryonic gills persist for a long time.

There is a urinary bladder behind the rectum, and the ovaries are closed sacs in Lepidosiren, but are convoluted in Ceratodus.

The chondrocranium is continuous; in Protopterus and Ceratodus there are ossified ex-occipitals; of membrane bones there is a well-developed parasphenoid, a median anterior, and a posterior roof-bone, which probably represent coalescent frontal and parietal bones respectively. The vomers are rudimentary. The squamosals, or pre-opercular bones, are large, and the operculum and sub-operculum are developed. The latter in Ceratodus is a

rod-like bone, joined at its ventral end to the angle of the jaw by a band of fibres conterminous with the hyomandibular ligament (*Huxley*). There are two labial cartilages, and a persistent Meckel's cartilage, which is invested by membrane bones in the lower jaw, forming angular, dentary, and splenial bones, the last-named of which in Ceratodus bears the teeth, as in Siren and Polypterus. The hyomandibular is absent in Lepidosiren, but is present as a small four-sided cartilage in Ceratodus, with a symplectic spur. There are the usual hyosuspensorial and mandibulo-hyoid ligaments. There are five developed branchial arches in Ceratodus, with the rudiment of a sixth, and two copulæ; the branchiostegal rays are cartilage nodules, and there is no true quadrate. The mandibular arch is joined directly to the base of the chondrocranium. The brain is comparatively large, with a small cerebellum, small optic lobes, a large pineal gland, and a narrow thalamencephalon; the cerebrum is imperfectly divided, as in sharks. In Lepidosiren there is a slight asymmetry of the brain (*Hyrtl*).

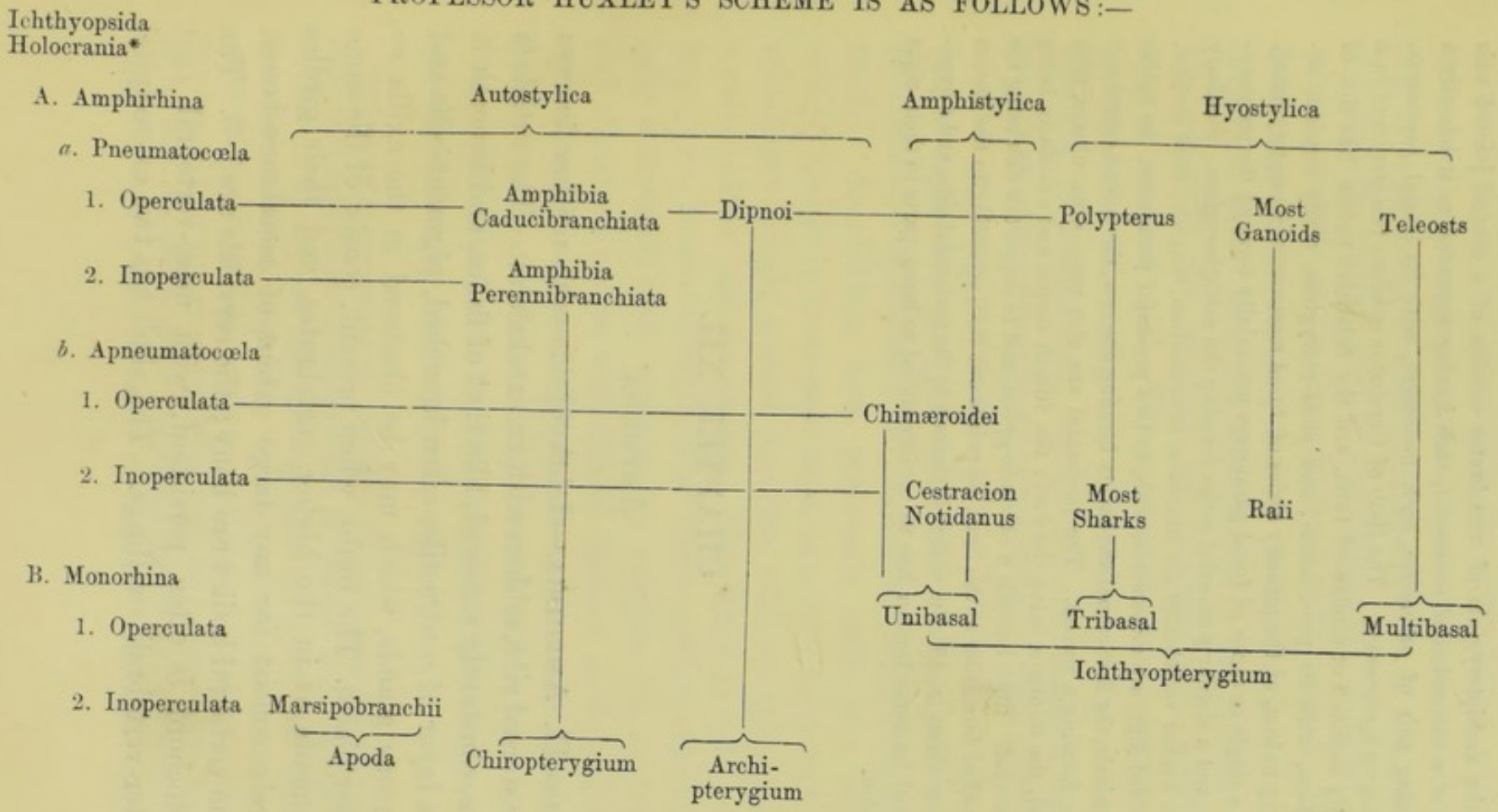
There are three genera, each containing one species—Ceratodus, the largest, is from Queensland, and has valves in its conus arteriosus. Lepidosiren, from S. America, early loses its embryonic external gills, and has two conical premaxillary teeth. Protopterus, from Africa, has three dendriform outer gills persistent.

There are several points wherein the classification of fishes given above is possibly capable of improvement, notably in the separation of the Chimæras and the Sharks. Professor Huxley has pointed out that there are many points wherein these differ essentially, and has proposed to elevate the Holocephali into an order equivalent to Selachia.

Professor Huxley has proposed, "as a mode of stating the facts of Morphology in a condensed and comprehensible form, which shall be purely objective," the following schematic arrangement of the orders of fishes, depending on the structural characters of the skull and limbs. The points specially to which he pays attention in the skull are the modes of attachment of the jaw-arches; sometimes the palato-quadrate arch is attached by its own substance, *i. e.*, by a suspensorium, consisting of a part of the mandibular arch itself—this is called *autostylic* attachment; or the mandibular arch may be quite free, or only joined by ligament to the chondrocranium, and suspended by the large dorsal element of the hyoid arch—this mode of attachment is called *hyostylic*. Other forms have the palato-quadrate separate, and slung by its own ligaments, and a small hyomandibular, which, however, only partly supports the jaw: these are called amphistylic.

In the limbs the points of Professor Huxley's scheme are, the relations of the pterygia to the limbs of the higher vertebrates. He regards Gegenbaur's mesopterygium (p. 48) as that which becomes the humerus, and considers

PROFESSOR HUXLEY'S SCHEME IS AS FOLLOWS:—



* Professor Huxley makes a subdivision Entomocrania for Amphioxus, which he regards as a fish.

that the archipterygium of vertebrates consists of a central jointed axis made of a succession of *mesomeres*, each having appended to it laterally a diverging pair of *parameres*, each mesomere, with its lateral *parameres*, making up a *pteromere*. The limb of Ceratodus exhibits this structure in a slightly modified or condensed form, and the Selachian paddle, like that of Scyllium, with its pro-, meso-, and meta-pterygium, really consists, according to him, of the primary series of fused mesomeres (mesopterygium), with a single or series of fused parameres pre-axially forming the propterygium, and a similar post-axial series forming the metapterygium. Similarly in the higher vertebrates the humerus, intermedium, centrale, third carpale, and third digit are mesomeres, with, as two pre-axial parameres, the radius and radiale, the first carpal and pollex forming one row, the second carpal and index forming a second. The post-axial are also two—ulna, ulnare, fifth carpal, the minimus being the first; the fourth carpal and annularis being the second. Such he calls a *chiropterygium*, and in support of this being the method of formation of the limb, he points out that, according to the system of Gegenbaur (p. 48), the radius is thrown to the post-axial side, and a hypothetical humeral torsion has to be introduced to bring parts to their right position.

CHAPTER XII.

Amphibia.

Class II. Amphibia.—Ichthyopsids with neither fin-rays nor sternal ribs, seldom with an exoskeleton. The cuticle is thin, constantly renewed, like that of fishes, and beneath it is a layer of contractile, often branched, pigment-cells and mucous glands, which may be clustered in the axilla or other places. The limbs, when present, consist of the same elements as in the higher vertebrates, and their girdles rarely consist for any large extent of membrane-bones. The vertebral bodies are bony; the cervicals are 1–3. The notochord is often persistent, with meso-vertebral (not inter-vertebral) swellings. The skull has two ex-occipital

bones, each bearing a condyle, for articulating with the first vertebra; an immovable suspensorium is attached to the fixed palato-pterygoid cartilage, which is attached to the periotic behind and to the ethmoidal in front, and whose quadrate end is the most constantly ossified. There is no inter-orbital septum, and no ossified supra- nor basi-occipitals, basi-, pre-, nor ali-sphenoids; the pro-otic and the columella are constant, but the epi- and opisth-otic may or may not exist. The ear capsule, which completely includes the labyrinth, has a fenestra ovalis, rarely a rotunda. Parasphenoid, double vomers, parietal, nasal, maxillary, and premaxillary bones usually exist, and there is often a temporo-mastoid splint, T-shaped in Anura, which represents the pre-operculum (squamosal). The proximal end of Meckel's cartilage never ossifies, the distal rarely. Amphibians have prehensile teeth (not masticatory) always in more rows than one; they have oral, but no salivary glands, a short intestine, with no spiral valve, a gall-bladder, and no cæcum. The blood is cold, with large, oval, nucleated corpuscles. The heart has a rhythmically contractile sinus venosus, two auricles, one ventricle, and a bulbous aortæ, with striped muscles in its wall and an incomplete septum. There are never fewer than two pairs of aortic arches, and both reno- and hepato-portal veins exist. The larvæ breathe by gills, which may persist or vanish, but the adults possess lungs.

Rudimental fin-rays exist in the feet-webs of some salamandroids (Leydig); claws only exist in one salamander and in Xenopus Boiei, and an exoskeleton in Cæcilia and Labyrinthodonts, in the dorsal bony plate of Ceratophrys and Brachycephalus. There is usually one sacral vertebra, to which the ilium is attached; rarely the right and left ilia abut on different vertebræ. In the development of the vertebræ the formation of the body is for the most part perichordal, but in Pipa, Pelobates, &c., it is epichordal. The pubis, when present, is usually cartilaginous. The caudal vertebræ

have a hypaxial arterial canal, beginning at the second (Derotremata), third (Caducibranchiata), or fourth vertebra (Perennibranchiata). The cranial axis exhibits no flexure. The vomer is single in Pipa, Dactylethra, and Pelobates; absent in Cæcilia. The primordial cranium has, above, one anterior and two posterior fontanelles filled with connective tissue; in Pipa alone is the entire lateral cranial wall ossified. There are lateral ethmoids, often ossified, and quadrato-jugals bony or ligamentous (Urodela). The mandible consists of dentary, splenial, sometimes angular, rarely articular (Ceratophrys) pieces. The basihyal is ossified. The first vertebra has an odontoid prominence, which touches the basi-occipital cartilage. The humerus has a ligamentum teres in some, as well as the femur.

Smooth muscular fibres often exist in the mesentery. The cardiac ventricle is spongy within. There is usually a single coronary artery from the right carotid; the left auricle is small, and receives one pulmonary vein. The veins have striped muscles in their coats, and are rhythmically contractile; two semilunar valves guard the auriculo-ventricular opening. The conus arteriosus has at its mouth a constriction (*fretum Halleri*), and has rows of valves within (Urodela). There are no lymphatic glands, but four lymph-hearts exist, as well as spleen, thymus (behind the mandible-angle), thyroids, and supra-renal bodies. There are abdominal fat masses connected with the last-named glands, and somewhat resembling hybernating glands in structure. The trunk muscles present a strong tendency to myotomic division. The cerebellum is small, the spinal cord fills almost the entire extent of the spinal canal; the optic lobes are large, ventricular, and the optic nerves form a commissure. The cerebral hemispheres are ventricle-bearing, and have begun to encroach on the thalamencephalon or third ventricle, which tends to be continuous with the optic lobe region. The sixth nerve appears in some Urodeles fused with the fifth, as is the facial nerve in Anura. The tenth, or glosso-pharyngeal, and the spinal accessory, are only branches of the vagus, which also sends a lateral branch, like that to the lateral line organs of fishes, but here it is chiefly distributed to the side muscles. The hypo-glossal is the first spinal nerve.

The allantois is small, included, persistent, and saccular, forming a pre-cloacal urinary bladder, but not receiving the ureters. The oviducts open into the peritoneal cavity, and, like the vasa deferentia in the male, communicate with the ureter. The vasa deferentia frequently open into the uriniferous tubes of the persistent Wolffian bodies. The paired testes are often lobed; the ovary is fixed to the spine by a peritoneal mesovarium.

The tongue is usually soft and large; the glottis lies on the ventral wall of the pharynx, is bounded by lateral cartilages, and opens into a laryngeal sac, with which the (seldom deeply sacculated) lungs communicate directly,

or by a trachea (Siren), or bronchi (Pipa). In aerial breathing the air enters the mouth through the symmetrically paired nostrils, and is swallowed by the elevation of the hyoid driving the air into the glottis. The abdominal muscles act in expiration. The soft vascular skin may act as an accessory breathing organ.

The eggs are soft-shelled, and have not much food yolk.

Cleavage commences in the yolk of the frog's egg by the formation of two vertical fissures at right angles to each other in its upper third, and a horizontal cleft parallel to its equator at the junction of the upper and middle thirds. The lower two-thirds of the sphere remains as yet uncleft, and above it the segmentation cavity, or cavity of *von Baer*, forms. The cleaved portion above this cavity becomes divided into numerous small cells, forming a roof-layer or epiblast of two strata, a superficial, corneous, from which is developed the epithelium, and a deeper layer of white cells forming the nerve-centres; while the thick portion below gradually divides, its surface becoming for the most part cleft into small cells, while its interior and its surface at its lower pole remains as large polygonal whitish cleavage masses. Between this white surface-patch below, and the outer mantle zone of finer cells, a crescentic fissure forms, soon becoming a complete circular groove (the fissure of *Rusconi*), which renders defined the mass of large white cells on the surface (the yelk-plug of *Ecker*). The fissure of *Rusconi* deepens, becoming extended upwards above the cavity of *von Baer*, and it expands into a semilunar cavity, which displaces the primary segmentation hollow. The roof of this cavity of Rusconi consists of germ cells continued from the margin of the outer lip of the fissure, showing that the cavity is thus an invagination, as *Remak* originally surmised. The Rusconian cavity becomes the primitive digestive canal, and the invaginated layer of cells forming its roofs and lateral walls is the hypoblast.

It is right to add that *Golubew*, *Stricker* and others explain the formation of the hypoblast as a delamination of the primary cell layer, but certainly the balance of evidence, direct as well as analogical, is in favour of the invagination theory.

Of other interesting developmental points it is worth mentioning, that in some salamandroid larvæ cranial myotomes appear beside the notochord on each side of the third cerebral vesicle. Also that the cranial notochord is persistent to some extent in Proteus. Proteus also, like Cæcilia, often shows an imperfect interauricular septum.

CHAPTER XIII.

Classification of Amphibia.

There are about 450 known living Amphibians, which are divisible into four Orders.

Order I. *Urodela* (*Dumeril* and *Bibron*).—Permanently-tailed Amphibians, with amphicœlous or opisthocœlous vertebræ, and often a scarcely constricted notochord; always with fore-limbs, and usually with hinder; with no exoskeleton; a short astragalus and os calcis. The dorsal muscles consist of symmetrical myotomes; the biceps and brachialis anticus are united; there are femoro-caudals, but no lumbrical muscles. The quadrate bone is unossified; the tympanic cavity absent; the fenestral plate of the columella auris is attached to the quadrate by a ligament, or has a bony style. Each iliac vein receives a branch of the caudal, and forms in the kidney a reno-portal plexus. There is often a separated prefrontal bone (except in Menobranchus, Siren, Amphiuma, and Proteus); there is no super-scapula. The second and third digits of the manus have two, and the fourth has three phalanges; the fifth, when present, has one (Amphiuma) or two. The eggs are usually elliptical, and separately deposited. External gills are present in the larvæ. There are no eyelids in the larvæ, nor in perennibranchiate forms, the transparent skin being continued over the cornea. The palate bones are not medially united, and the palatine teeth are in clusters, and are sometimes supplemented by teeth on the parasphenoid.

There are three sub-orders.

Sub-order I. *Perennibranchiata.*—Urodeles whose larval three pairs of external gills persist. The truncus aortæ bears two series of paired valves (Professor *Huxley* names the part of the truncus containing the valves *Pylangium*, and the bulb-like end of the arterial trunk *Synangium*). The hyoid arch is attached to the distal end of the suspensorium, and the basi-hyal bears entoglossal and uro-hyal bones. The carpals and tarsals are unossified. Each branchial-arch-cartilage consists of an upper and lower segment; the nasal sac is lined by a plaited membrane, and the inter-auricular septum is incomplete. All but the first and the few hindmost of the vertebræ are amphi-cœlous, and the rudimental ribs are attached to single or bifid transverse processes; the fore-arm and fore-leg bones are unankylosed. Five genera are included—Proteus, a blanched, lizard-like form, with rudimental eyes, from the Maddalena and other Dalmatian and Carniolan caves. It has no sternum, orbital muscles, maxillary teeth, nor nasal bones. The nasal openings perforate only the lip. There are 29 trunk-, 1 sacral-, and 28 caudal-vertebræ; the sacral plexus consists of two nerves; the hind-limb has two toes, three tarsal cartilages, and a single cartilage in the pelvic girdle, joining the sacrum directly. The weak fore-limb has three digits, and a fissure in the glenoidal region of the shoulder-girdle. The thyroid body is single; the stomach is a slight dilatation of the cylindrical alimentary canal; the kidneys are united behind; the slit-like glottis has two simple lateral cartilages; the truncus arteriosus gives off two branches, which bifurcate, the posterior branches again dividing, thus forming three pairs of arches; the two foremost give off branchial loops to the outer gills, whose returning blood enters the same vessel, and then they form the dorsal aorta, the third arch supplies the lowest gill, and its blood is returned into the root of the dorsal aorta. The pulmonary vein only carries part of the blood from the lungs back to the heart, the rest enters the systemic veins.

Siren, the mud-eel of S. Carolina, is two-limbed, with a lateral line of dermal mucous follicles, with 64 trunk- and 36 caudal-vertebræ; and palatine teeth, in numerous transverse rows, close behind each other; the premaxilla and dentary bone of the mandible bear horny teeth, but the splenial is also dentigerous; the tongue is small, arrow-shaped. The inner nostril is outside the pterygovomerine teeth. The manus bears four fingers, the scapula and coracoid are ossified, but the sternum is absent, as is the pelvis; the auricles are scarcely separate; the allantois very small; the liver has a large right, a small left lobe, and has hepato-cystic ducts. There are three pairs of ciliated gills and three gill-slits; four pairs of branchial arches, the first and fourth of which are fixed.

Pseudobranchus, also bipedal, has a tridactylous manus, larger eyes, one

gill-slit, non-ciliated gills, and a wide opercular flap, free to the end of the chin.

Menobranchus, according to *Cope*, is the larvæ of a salamandroid; Batrachoseps, and Siredon, the Axolotl of Mexico, according to *Marsh* and *Peters*, is also the tadpole of a higher form. Possibly the foregoing may be arrested larvæ, which, without metamorphoses, become sexually mature, a condition which has been noticed, though rarely, in other undoubted tadpoles; thus a branchiate tadpole of Triton punctatus has been seen to spawn.

Sub-order II. *Derotremata* (*J. Müller*).—Amphibians with no external gills in their adult condition, the adherent operculum only having one pair of gill-clefts. The first visceral arch is unjointed, and loosely attached to the hyoid copula, and there is no uro-hyal. The sternum is unossified, and the *pylangium* has two rows of four valves. There is often a prepubic bone attached to the pelvic girdle. The genera included are:—

Amphiuma, from N. America; eel-like, with long quadrate head, one gill-opening on each side; palatine teeth in two rows, diverging behind. There are 5–6 pairs of ribs, and a rudimental or no sternum; there are 62 trunk-, 1 sacral-, and 30 caudal-vertebræ; the nearly functionless limbs have 2–2 (in one form 3–3 digits). The external nares are close, minute, the choanæ surrounded by bone; there are separate stylo- and cerato-hyals, and an indistinct tongue. The gall-bladder is not in contact with the liver. The atlas has a tooth-like spur on its cranial side, as in Menobranchus, and there is no supra-occipital cartilage; the lungs are far back in the abdominal cavity; the visceral arches are 4; the hindmost aortic arch sends off pulmonary, œsophageal, and cardiac branches.

Menopoma, also American, has 19 trunk-, 1 sacral-, and 25 caudal-vertebræ; a smooth skin; a fringed body and legs; a large head, with closely-set marginal nostrils; 4–5 webbed digits; a wide short liver, carrying a gall-bladder in a hinder notch. The columella has a cartilaginous style, and the pterygoid bone joins the maxilla. The gill-slit has a constrictor muscle; the myloyhoid is enormous, and the internal oblique muscle of the abdomen is of large size. The lumbar plexus has two roots, and the sacral has three. The cloaca opens behind the pelvic limbs, and the sternum is developed.

Sieboldia, of Japan, has no gill-slits in the adult, and only two visceral arches; the sacral vertebræ is opisthocœlous, as in Menopoma; the pylangium has five fleshy semilunar valves at its base; three, also fleshy, at the base of its right, and one, membranous, at the base of the left division. The cerato-hyal is a single bone on each side attached to a median copula. The pterygoid and temporal muscles are fused (separate in Menopoma); there is a cartilaginous supra-occipital and a small ex-occipital at each side, as well as two small orbito-sphenoids. The hypo-vertebral muscles are

continued into the hind limb by four bands, which are caudo-ischial, caudo-crural, caudo-femoral, and caudo-pedal; the sixth nerve, as in Menopoma, is a branch of the trigeminus. The glenoid cavity is fenestrated, and the sternum is developed. This is the largest living Urodele, exceeding four feet in length. The fossil Andrias, from Œningen, is closely related.

Sub-order III. *Caducibranchiata* (*Latreille*).—Large-eyed Urodeles, with deciduous gills, closed visceral slits in the adult, opisthocœlous vertebræ, eyelids in the adult condition, ossified carpals and tarsals (except in Plethodon, &c.), double vertebral transverse processes and fibrous quadrato-jugals. The prepubic bone may exist, and the large ex-occipitals join the opisthotics; the tooth-bearing palatines coalesce with the vomers; there is a choanoid muscle; a great ventral pubo-hyoid; atlanto- and occipito-mandibulars for depressing the lower jaw; one adductor and one gluteus muscle. Palatine teeth, a nonplicated olfactory sac, and a posterior pair of lymph-hearts exist. The tongue is broad, rarely free laterally and behind. The spermatozoa may have an undulating membrane instead of a flagellum.

The larvæ have a transitory lateral line, with rudimental sense-organs; four pairs of aortic arches, of which the fourth becomes pulmonary; its continued trunk, returning from the lungs, joining the aorta, which is formed of the second and third; the first closes for its upper half; its base dilates and breaks up into a network of dense branches (the carotid gland), from which the carotid and hyoidean arteries arise. There is sometimes a papillary penis and a bilobed prostate. The abdominal veins are surrounded by lacunar lymph spaces. Elongated fat masses lie beside the lobulated supra-renal capsules. The larvæ may have sphenoidal teeth, which sometimes, as in Amblystoma, vanish in the adult.

This sub-order includes about thirty species from the eastern and about sixty from the western hemisphere, mostly S. European and N. E. American. They constitute two families:—

1. *Mecodontia.*—Palatine teeth in two long rows, diverging behind on the inner edge of two processes of the palatine; no sphenoidal teeth. This includes Salamandra, mostly terrestrial, with a row of dorsal and large parotid glands (dermal glands behind the ear); immovable ribs; 14–16 trunk, 1 sacral, and 25–40 caudal vertebræ, some of which are opisthocœlian; they have vomerine teeth in the larvæ. Pleurodeles is described as having fourteen pairs of ribs piercing the skin, and capped by horny tubercles (denied by *Leydig*). Triton is mostly aquatic, with flattened tail, lateral pores, and an oblong tongue, with free sides. The fronto-temporal arch may be ligamentous or bony. Desmognathus has a ligament passing from the spine of the atlas to the mandible, which limits the motion of the latter, and the occipital condyles are cylindroidal.

2. *Lechriodonta.*—Palatine teeth along the hinder edge of the united palatines, in rows, which converge posteriorly. Sphenoidal teeth exist in Plethodon, Spelerpes and Batrachoseps, and the tongue may be peltate (Spelerpes), entirely adherent (Onychodactylus), or free behind and attached in front. Amblystoma has amphicœlous vertebræ, ossified carpals, tarsals, and premaxillæ; their larvæ are the Axolotls (Siredon), which possess three external gills, cartilaginous carpus and tarsus, sphenoidal teeth, and no eyelids. Both adult and larvæ have sphen-ethmoid bones, and cartilaginous pedicles, ending in an ossified quadrate. In the adult form there is a rudimental septo-maxillary, and the internasal cartilage is covered by the nasal process of the premaxillary.

S. lichenoides has been seen changing into A. mavortium. S. mexicanus has very recently been described as metamorphosing.

Batrachoseps is an American form like Spelerpes, and its larva, according to *Cope*, is the Necturus, or Menobranchus lateralis; but the transformation has not been seen. This remarkable larval form has a broad flat head, three visceral arches, small eyes, many rows of vomerine teeth, a skull like that of Proteus, with no nasals, jugals, rudimental maxillæ; prominent epiotics fused with the opisthotics; the vomers touch in front, but diverge behind; the parietals have three processes—an external, touching the suspensorium, a middle, and an inner. The squamosal is rod-like; the splenial tooth-bearing, as well as the dentary, and the quadrate ossified. It has 18 trunk-, 1 sacral-, and 22 caudal-vertebræ; four 4-toed limbs; a lobulated pancreas; an enormous internal oblique muscle in the abdomen; the pterygoid and temporal muscles are united, but are exceeded in size by the masseter. The cerato-hyal is large, the genio-hyoid is attached to the uro-hyal; there is a dorsal, exoskeletal, longitudinal muscle, and the omo-hyoid springs from the pre-coracoid cartilage. There is no glenoidal fissure in the shoulder-girdle.

Onychodactylus, from Japan, is a salamander which bears claws on its 4–5 toes. Plethodon has no pterygoid, a free tongue, and amphicœlous vertebræ.

Order II.—*Gymnophiona* (*Müller*).—Limbless, nearly tailless, worm-like, burrowing Amphibians, inhabitants of tropical climates, with no limb-girdle, and with muscles in myotomes, as in fishes, with a dermal skeleton of small, round, concentric, and radiated scutes, embedded in the soft glandular annulated dermis. The vertebræ are many (reaching in C. lumbricoides to 230),

amphicœlian, traversed by the persistent notochord, which is divided by a transverse septum in each vertebra, and with no spinous processes. The first and the last alone have no ribs. In all but Rhinatrema there is a tentacle lying in a canal between the eye and the point of the snout. The larvæ has five cartilaginous visceral arches and one pair of gill-slits, which, with the gills, vanish in the adult.

There is no tympanic cavity, and the columella has a bony style and operculum. There is no supra-occipital bone, two frontals and parietals forming a complete bony roof, covering an unpaired ethmoid. The opisthotics unite with the ex-occipitals; the nasals join the premaxillæ, except in Epicrium, in which there are also prenasals. The choanæ perforate the hard palate, their outer side being formed by the vomers, which, as well as the jaws, bear sharp recurved teeth usually (especially on the mandible), in two rows. The two dentary bones form a median chin-suture. There are two hyoidean ⌙-shaped cornua, united together medially and to the front of the middle of the first visceral arch. In Cæcilia the temporal fossa is covered by an expansion of the quadrato-jugal and sometimes a post-orbital, and the eye is also covered by an outgrowth from the upper jaw and a supra-orbital bone, pierced by a small hole. The eye is hypodermal, except in Rhinatrema. There is a trachea, and the right lung is smaller than the left, or *vice versa*. The short digestive canal ends in a round sub-terminal anus. The liver consists of successive flattened lobes, with the gall-bladder to its left side. The tongue is fixed, fleshy, with two round bosses corresponding with the inner nostrils. Cæcilia compressicauda, according to *Gervais*, produces living young, with no traces of gill-openings. Siphonops (Brazil) has no embedded scales, and 80–100 broad tegumental rings. One species of Epicrium has a copulatory organ, consisting of four bilobed protrusible prominences acted on by a tape-like muscle.

These animals are regarded by *Günther* as amongst the highest of living Amphibians, and the closest to the Sauropsida. The carboniferous form Ophiderpeton possibly links these to the next order.

Order III. *Labyrinthodonta.*—Palæozoic and Mesozoic, tailed, limb-bearing, rarely limbless, Amphibians, with clavicles and inter-clavicle, forming a sculptured plastron, together with oval, ventral, dermal plates (and gular scales in Micropholis). The vertebræ are not numerous (thirty in some), amphicœlous or opisthocœlous. The skull-roof is bony, sculptured externally, with grooves, probably for slime-canals, but smooth within. The palatine bounds the choanæ posteriorly and externally; the teeth are

vertically and complexly folded with a much involuted pulp cavity. The epiotics are pointed, prominent; the parasphenoid small, the post-frontals large; there are also pre-frontal and frontal scutes, as well as post-ocular, temporal, and jugal shields. There is one coraco-scapular bone; feeble pentadactylous limbs, with separate radius and ulna; an unossified carpus and tarsus; two of the mostly one-rowed mandibular teeth may be tusk-like, and an articular ossification may exist in the mandible. Some, like Archegosaurus, had apparently no ossified ex-occipital, divided tooth-bearing vomers, the temporal fossa roofed by bone, short free ribs, an unossified vertebral column, gill-arches, and few cement folds in the teeth these form the sub-order Archegosauria. Others, like Ceraterpeton, have bony vertebræ, no gill-arches, two occipital condyles, pleurodont teeth, with few cement folds; these are the Microsauria of *Dawson*. The remaining and most numerous forms have labyrinthic foldings in their ankylosed teeth, no gill-arches, two occipital condyles, and bony vertebræ.

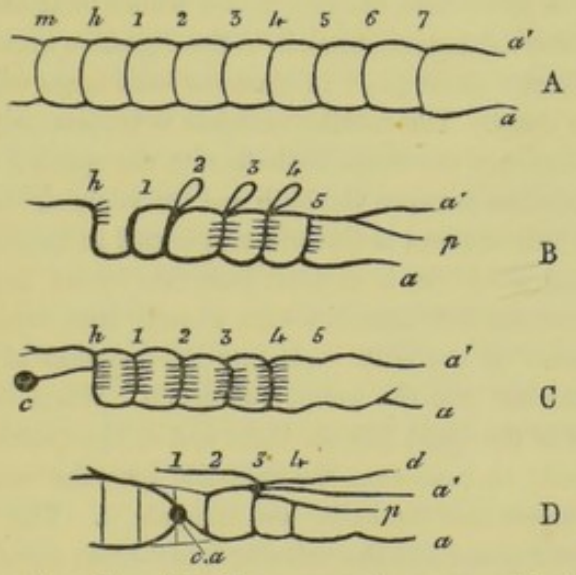
These were at the same time the most generalised and the highest in organization among the Amphibians.

Order IV. *Anura.*—Four-limbed Amphibians, whose adult forms lose gills, gill-slits, and tails. Their bodies are short, broad, flattened; the pro-, rarely opisthocœlian vertebræ not over eleven in number, with small spines, long transverse processes, and distinct articular processes; eight are pre-sacral, one sacral, and two caudal. The digits are four or five; the mandible is mostly toothless (except in Hemiphractus and Grypiscus); the parietal and frontal bones are united. The calcaneum and astragalus of the tarsus are lengthened, united above and below, forming a second segment in the crus, which has thus two ankle-joints, one above and the other below. There is a single hour-glass-like sphen-ethmoid or girdle-bone in the fore-part of the skull, whose anterior part is divided by a longitudinal vertical partition, and whose anterior third is pierced by the nasal branch of the ophthalmic nerve. The radius and ulna are ankylosed, as are the tibia and fibula. The allantoic bladder is bifid, and its veins end in the hypogastric vein; each iliac vein bifurcates, one branch

passing to the reno-portal plexus (fig. 12), the other to the anterior wall of the abdomen (epigastric vein), there to join its fellow of the opposite side, to receive the allantoic vein, and entering the liver to unite with the vena portæ.

The young have at first neither gills nor limbs, and consist of a large head and a flattened tail; the mouth is bordered by two cartilages, *rostral* and *adrostral*, possibly homologous with the labial cartilages of sharks, disappearing at maturity. The outer gills then develop, and a

Fig. 25.



D. Diagram of aortic arches of the frog:—*a*, aorta; *c.a*, carotid gland; *d*, cutaneous artery; *p*, pulmonary artery; 1, 2, 3, 4, branchial arches

heart of one auricle and one ventricle. The jaws have horny sheaths, which are afterwards shed. An operculum grows from before backwards, covering the gill-arches, except at one part, generally on the left side, thus inclosing a cavity wherein the fore-limbs bud, beginning before the hinder, but not coming to the surface as soon. The outer gills then disappear, and short gill-filaments form on the second gill-arches. The intestine is long, spiral, in this larval or tadpole stage.

The larvæ have four pairs of aortic arches, which at first pass directly from the heart to the sub-ventral aorta, giving off looped branches opposite the external gills, which pass thereto, and whose branchial veins return into the same trunks. The internal gills are formed by the middle of the aortic arch breaking up into an exposed capillary network, bathed by water. When gill-breathing is abolished the anastomoses re-dilate, the foremost arches become the carotids, form a carotid gland, or rete mirabile (fig. D, *c.a*), which presents a mechanical obstacle to the flow of blood through it, while its dorsal continuation vanishes. The second pair of arches become the aortæ, each of which gives off subclavian and vertebral branches, and has a semilunar valve at the base, with its free border towards the heart. The third and fourth arches coalesce at their bases in the adults, the former becoming the long cutaneous (*d*), while the fourth forms the pulmonary artery (*p*). The right aorta is wider than the left, which before their dorsal union gives off a large caeliaco-mesenteric branch to the digestive organs. The blood corpuscles are large—about $\frac{1}{800}''$ in diameter—the large veins have striped muscles in their coats. The cardiac ventricle is transversely elongate, and its right end opens into the aortic bulb close to the opening of the right auricle, the constriction between the bulb and the ventricle being the *fretum Halleri*. This bulb inclines to the left, and is tied in its place by the *fraenulum bulbi* of *Brücke*. It is divided into two by an imperfect septum, attached above to the left side, but with a lower free border to the right. The right chamber of the bulb leads into the openings of the carotid and aortic arches, the left into the pulmo-cutaneous. When the auricles contract, the blood of the right fills the right end of the ventricle, that of the left, the left end; so that when the ventricle acts, the venous blood of its right end first passes into the bulb, and distends it. The capillary resistance of the carotid gland and the valvular folds in the aorta offer a primary obstacle to the entrance of the blood, which rushes unopposed into the patulous mouth of the pulmo-cutaneous arches; soon the resistance from tension in these arteries equals and exceeds that of the aortic valve, and the mixed blood of the ventricle rushes into the aorta to supply the body; and when the intravascular tension in these vessels exceeds the resistance in the carotid glands, the last and purest blood enters and supplies the head (*Brücke*).

Lymphatics are numerous, beginning in lacunæ, and at first having only an epithelial coat. Those from the extremities end in four pulsating lymph hearts with striped muscular walls (*Leydig*)—two placed behind the hip-joint and communicating with the iliac veins, and two prescapular, placed on the transverse processes of the third vertebræ, and communicating with the subclavian vein.

The skull in the tadpole has the palatopterygoid process fused with the antorbital process. In the adult frog the quadrato-jugal is comma-shaped; bony; the premaxillæ and maxillæ often carry teeth—the vomers mostly, the palatine never, are dentigerous. There is an λ-shaped pterygoid bone partly growing by ectostosis, partly by endostosis; nasal bones rarely exist, and the pterygoid muscle is single. In Dactylethra the nasal bone is single.

Behind the sacrum the sheath of the notochord ossifies into a urostyle, to which the arches of the two caudal vertebræ, which have no centra, become ankylosed. (These vertebræ have centra, and are separate in the tertiary Palæobatrachus.) The sacrum is generally procœlian, with a double convexity for the urostyle behind, which has two corresponding anterior concavities (one in Bombinator).

The shoulder-girdle (fig. 14) has in some (Acrodytes, Calamites, Megalophrys, Rana, &c.) a perfect omosternum medio-ventrally. This is rudimental in Pipa and Pseudis; absent in others. Behind it the epicoracoids meet in the middle line, and still farther back are the usually ossified meso- and the cartilaginous xiphi-sternum. In some, like toads, there is very little ossification in the sternum; others (Acrodytes) have no ectosteal bone, while Rana, Pleuroderma, Plectropus, have an ectosteal sheath for the mesosternum. The coracoid is separated by a fontanelle from the precoracoid, on which a membrane splint or clavicle is developed: rarely is the coracoid uncleft, as in Hylædactylus. In Dactylethra the precoracoid is as large as the coracoid; in most others they are unequal. Above the shoulder-joint is a scapula and a superscapula, rarely, as in Microps, uncleft, or, as in Hylædactylus, partly cleft. The scapula may itself be divided: the suprascapula is largest in Pipa and Bombinator.

The pelvic girdle consists of a sacral rib, usually ankylosed; an ilium and an ischio-pubis, united mesially to its fellow: a central prepubic bone exists in Dactylethra. There are nine carpal bones, the first very small; the scaphoid and cuboid unite in the tarsus, but the cuneiforms are separate.

The dermis is soft, pigmentary, glandular, often warty with clusters of glands on the arms (Pelobates), on the back (Kalophrynus, Hylarana), or legs (Bufo); sometimes flat bony scutes exist, as on the back of Ceratophrys, where they are separate from the vertebræ, or Brachycephalus, where a wide scute is attached to the spines of the 4–8 vertebræ, and two smaller ones to the 3rd and to the 1st and 2nd.

The mouth is lined by ciliated and goblet epithelium, and the tongue, absent in Pipa and Dactylethra, is usually attached in front and free behind, or peltate (Heteroglossus). The œsophagus is dilatable, longitudinally plicated, sheathed at its lower end by muscle-bundles (a rudimental diaphragm),

and opening, with scarcely a cardiac constriction, into the siphonal stomach, whose mucous lining is rugous with simple tubular glands, and often a pyloric valvular fold. The intestine, long in the tadpole, becomes short, ending in the short, wide colon above the cloaca. The bi- or tri-lobed liver has the gall-bladder embedded in the right lobe, and with hepatocystic ducts. The pancreas is flat and narrow; the glottis is narrow, with an annular crico-thyroid cartilage, large arytenoid cartilages, and in the male there are two distensible air-sacs opening into the larynx (by one opening in Hyla). There are at least two vocal cords on each side, and a hyo-arytenoid muscle (absent in Pipa); the trachea is short or none, and the bronchus enters the saccular lung abruptly. The eyes (hidden in Pipa) have, in most, eyelids and a nictitating membrane, usually a choanoid muscle, but no lachrymal apparatus. The tympanum may or may not remain as a cavity, and the Eustachian tubes may be absent, minute, wide, or with a single mesial opening (Pipa, Dactylethra). The columella may have its style attached to the soft parts, or to the membrana tympani, or it may widen into a plate; there is a tensor tympani attached to it, and in the toad a second or stapedius muscle. The primary ear vesicle did not arise from the surface, but is formed by an involution of the deeper layer only of the epidermis. The kidneys are flat and compact, with white oval testes in front. There is a spleen and a saccular ovary. In some, a common duct carries the urine and the sexual products; in others the ureter, opening near the cloacal end of the genito-urinary canal, receives the vasa deferentia, and the upper part of the genito-urinary canal either atrophies, as in frogs, or becomes a seminal vesicle, as in toads. In Pipa, the eggs are spread by the male, after impregnation, on the back of the female, and the skin thickening around them into ridges, bounds pits in which they are hatched. In Opisthodelphys the gill-sacs become changed into egg-pouches, and two bands pass from the visceral arches, which expand into bell-shaped skin-appendages. Nototrema has also dorsal pouches. Others lay their eggs in chains. In Alytes these are carried around the legs of the male. There is no intromittent organ. In *coitû* the male is attached by means of his thumb, which becomes hypertrophied and spasmodically inflexed.

The spinal cord has well-marked brachio- and lumbo-rachidian bulbs and few spinal nerves. The exoskeletal system of muscles so feebly represented in Urodela consists here of several series of fibres. In the tadpole the hyoid and visceral arch system consists of a central basi-hyal and five pairs of arches; four hindmost of these at first coalesce at their pharyngeal ends, then atrophy, having only in the frog a rudimental thyro-hyal cornu, and two small cartilaginous spurs to represent them; the first arch becomes the stylo-cerato-hyal.

A rudimental ovary has been found coexisting with a testis in Bufo variabilis and cinereus; large fatty bodies lie in the abdomen anterior to the testis and behind the lungs.

There are many species of tailless Amphibians arranged in two sub-orders:

Sub-order I. *Aglossa.*—Tongueless; Meckel's cartilage is completely covered by splints, with a bony cavum tympani, a single mesial opening of the Eustachian tube, and no parotids. This includes two families: 1. Dactylethridæ, African, with premaxillary and maxillary teeth; atlas and axis separate; a confluent sacrum and urostyle; a moderate xiphoid; a long scapula; no arciform epicoracoid; back with a dorsal shield; the three outer toes of the pes clawed. Silurana is probably its larva, and has two maxillary cirri, ex. Dactylethra (Xenopus). 2. Pipidæ, American; atlas and axis confluent; no premaxillary teeth; sacrum and urostyle separate; a wide xiphoid and a long arciform cartilage; styloid cornua and palate bones absent in the adult; a small Eustachian opening, and covered eyes.

Sub-order II. *Phaneroglossa.*—Tongue-bearing, with separate or no Eustachian tubes. This order includes four sections:—

§ 1. *Raniformia.*—Digits simple, with no suckers; upper jaw with teeth; pupil transverse or round. This includes four families: 1. Ranidæ, with no parotids, and undilated sacral vertebræ, except in Crinia, ex. Rana, frogs, Ceratophrys, with horn-like elongations of the upper eyelids. Pleuroderma has a large lumbar gland; the other genera differ chiefly in the shapes of the tongue and the disposal of the vomerine teeth. 2. Discoglossidæ.—No parotids, and sacral vertebræ dilated. Discoglossus has opisthocœlian vertebræ. Megalophrys has eyelid horns, like Ceratophrys. 3. Alytidæ.—Several transverse processes dilated; parotids present. Alytes has arciform cartilages and opisthocœlous vertebræ. 4. Bombinatoridæ.—Sacrum expanded; parotids absent; no tympanum nor distinct Eustachian tube. Pelobates has a knife-like prominence on the second row of the tarsus, and a rudimental tube; the tongue is fixed in Bombinator, which has no tube. Cacotus has a rudimental Eustachian tube and an undulated sacrum.

§ 2. *Bufoniformia.*—Maxillary teeth none; digits simple, without suckers. This includes four families: 1. Phryniscidæ.—No tympanum nor Eustachian tube, nor parotids; sacrum slightly expanded; tongue fixed in front. Brachycephalus has a dorsal bony shield. Hemisus has a retractile tongue and an oval metatarsal spur. 2. Rhinophrynidæ.—Ear as in last; parotids present; tongue free in front. 3. Engystomidæ.—Ear perfect; sacrum expanded; parotids none. Clavicle absent in Cacopus and Engystoma. 4. Bufonidæ.—Ear perfect; sacrum expanded; parotids present; arciform cartilages large. Ex. Bufo, toads.

§ 3. *Hylæformia.*—Digits with sucking disks; maxillæ with teeth. This includes five families: 1. Polypedatidæ.—Sacrum not expanded; parotids absent. Hylarana has two lateral groups of dermal glands. The episternum is bony in Polypedates, &c.; cartilaginous in Phyllobates and Hylodes, which have T-shaped end-phalanges. Hemiphractus has a bony shield on the head. 2. Plectromantidæ, similar to last, but with large parotids, and no sucking disks in the manus. 3. Hylidæ, tree-frogs, with expanded sacral vertebræ, no parotids, webbed toes, and perfect ears. Nototrema has a posterior dorsal sac in the females. 4. Phyllomedusidæ, with parotids, expanded sacrum, and large sucking disks. 5. Micrhylidæ, with no parotids, expanded sacrum, and no tympanum nor Eustachian tube, nor vomerine teeth. Ex. Microhyla.

§. 4. *Hylaplesiformia.*—Maxilla toothless; fingers and toes with sucking disks. This includes three families: 1. Hylædactylidæ, with no parotids, dilated sacral vertebræ, and a perfect ear apparatus, ex. Callula. 2. Hylaplesidæ, with no parotids, cylindrical undilated sacrum, and T-shaped last phalanges, ex. Hylaplesia. 3. Dendrophryniscidæ.—No parotids, rudimental tympanum, and unexpanded sacrum.

CHAPTER XIV.

Province II.—Sauropsida (*Huxley*).

Oviparous, or ovo-viviparous craniota having an amnion, a respiratory allantois, and an epidermis developed into scales or feathers.* The visceral arches never bear gills, and dermal glands are never set apart to nourish the young.

The skull articulates with the atlas by one convex condyle on the ossified basi- and exoccipitals. The basisphe-

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* These may be periodically shed and renewed. This process in Reptiles is called ecdysis; in birds, moulting.

noid is large, with no separate parasphenoid in the adult. The pro-otic is ossified, often distinct, and the mandible consists of 8–12 pieces, jointing to the skull by means of a quadrate bone. The vertebræ have ossified centres, but no surface epiphyses. The ankle-joint is meso-tarsal. The heart has two auricles; the red blood-corpuscles are oval, nucleated. The aortic arches are rarely more than two, often single (on the right side). The bronchial tubes

Fig. 26.

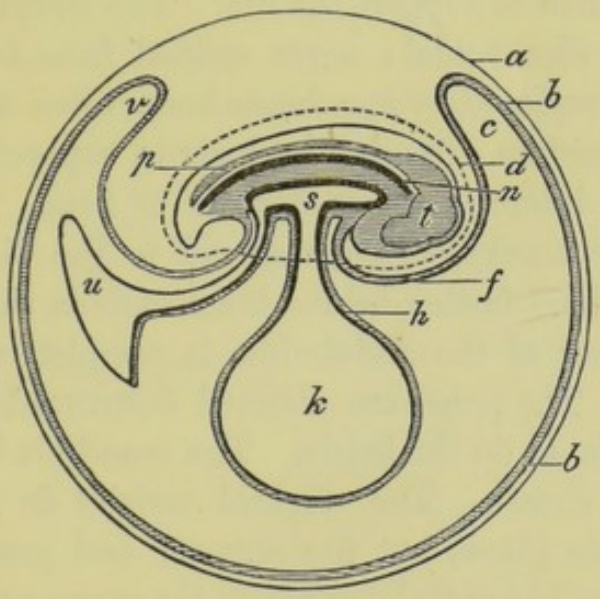


Diagram of the formation of the Allantois in Allantoic Vertebrates. The dotted line shows the position of the body of the embryo.—*a*, vitelline membrane inclosing the egg; *b*, amnios; *c*, the cavity of the anterior amniotic fold rising in front of the head end of the embryo; *d*, dotted line surrounding the embryo; *f*, fold or depression limiting the head fold of the embryo; *h*, hypoblast; *k*, umbilical vesicle; *n*, notochord; *p*, nerve chord; *s*, digestive canal; *t*, head vesicle; *u*, allantois; *v*, cavity of the hinder amniotic fold.

branch irregularly in the lungs, and there is never a functional diaphragm nor a bulbus aortæ. The Wolffian bodies are replaced by secondary kidneys, whose ducts open into a cloaca, which also receives the intestine and sexual ducts. The eggs have much food-yolk. The cor-

pus callosum in the brain is rudimental or absent. Two classes are included :—

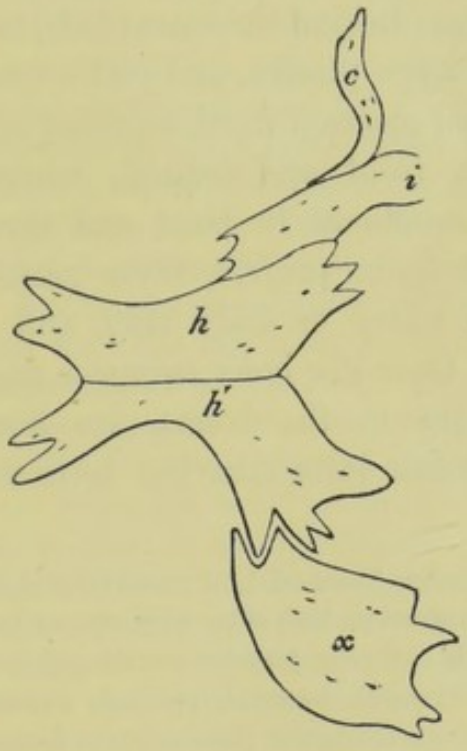
1. Reptilia (*Cuvier*).—Cold-blooded Sauropsids, with a horny exoskeleton of scales or scutes, but into which processes of the cutis are continued; sometimes forming surface spines (Moloch, Phrynosoma); not formed in follicles. The dermis may ossify, forming bony scutes. The vertebral bodies have spheroidal, never cylindroidal faces, and are usually differentiated into cervical, dorsal, lumbar, sacral, and caudal. The sacral vertebræ are usually two, with large ribs to support the ilia. The sternum may be absent, or rhomboidal: never ossified from two or more points, nor replaced by membrane bone; often with a single or double median extension backwards, supporting dermal ribs. The interclavicle is separate or none. The metatarsals do not ankylose together nor to the distal tarsals. The ilia extend farther behind the acetabula than in front, and the floor of the acetabulum is completely ossified or nearly so. The pubes are directed downwards, and form a symphysis, as do the ischia. The mandible bears teeth, or a horny sheath. The cerebral vesicles do not remain on the same plane, but the anterior and posterior bend downwards. The optic lobes are on the upper surface of the brain, and there are twelve pairs of cerebral nerves. When limbs exist, the manus and pes have at least three clawed digits. The ventricle of the heart has a (rarely perfect) septum dividing it into a right (*cavum venosum*) and a left (*c. arteriosum*) portion. The aorta and pulmonary vessels have two or three semilunar valves. There are two aortic arches which unite below the heart, forming a dorsal aorta; the right arch is the stronger, and gives off carotid and subclavian arteries; the left, before their union, gives off a large cæliaco-mesenteric artery, and is much diminished

when it joins the right. The veins form reno- and hepato-portal trunks. Special copulatory organs are present, often in both sexes. The liver has always a gall-bladder.

Reptiles may be divided into nine orders, of which only four have living representatives.

Order I. *Chelonia* (*Brongniart*).—Tortoises and Turtles, having the ten dorsal vertebræ immovably united, and

Fig. 27.



Right side of Plastron of Trionyx perocellatus.—*c*, clavicle; *i*, half of the median interclavicle; *h*, hyo-plastron; *h'*, hypo-plastron; *x*, xiphi-plastron.

their spines expanded (except those of the first and last), forming a medio-dorsal row of eight bony plates, united to each other by suture. These vertebræ have no transverse processes, but the ribs unite with the sides of the persistent neuro-central suture; over and fused with the ribs, on each side, eight long ectosteally ossifying plates unite in front and behind by suture with each other, and inter-

nally with the expanded vertebral spines. All these form an immovable dorsal shield (or carapace), and around them is a border of 24–5 parosteally ossifying marginal plates, of which the anterior is in front of the first flattened spine (nuchal plate), and two posterior (pygal) lie one at each side of the last flattened spine, and behind these lies a median plate. Nine dermal bones unite around the umbilicus, to form a ventral, thoracico-abdominal shield, or plastron (fig. 27); these are, 1st, a median inter-clavicle; 2nd, two clavicles: behind these are (3rd), two hyo-plastra; then (4th), two hypo-plastra, and (5th), two xiphi-plastra. The carapace and plastron unite together at each side, and are separate in front and behind, where, through six notches (three confluent in front and three behind), the head, tail, and limbs project, these parts being usually covered by soft warty or scaly skin, and often retractile into the shell. Over the bony carapace and plastron, but not corresponding to the bones, are horny, epidermal plates [in Chelonia imbricata the tortoise-shell of commerce].

Of these plates there are five medial, or vertebral scutella, bordered by four costal and eleven marginal on each side, with one or two caudal, and one or two nuchal shields. On the plastron are six pairs, which from before backwards are named gular, humeral, pectoral, abdominal, femoral, and anal; sometimes a single intergular plate exists in front. Where the carapace and plastron join, there are, 1st, an anterior, axillary, and 2nd, a posterior, inguinal plate. In Trionyx and Sphargis the surface is leathery, not scaly. The cervical vertebræ are eight, directly articulating together, with small spines and no transverse processes or ribs. The atlas is a ring with two lateral processes, except in Chelydra, and its body ossifies to the body of the axis in all but Chelydra, forming the os odontoideum. The fourth vertebral body is convex in front and behind, so that the third is opistho-cœlous; the fifth to the eighth, are procœlian. The last cervical only has a spine; the first dorsal has articular processes uniting with those of the last cervical and its spine. Its rib is united to the anterior border of the first costal plate with the second rib: its neural arch is narrow, while that

of the second is wide. The tenth has a small rib with no costal plate. The bodies of the dorsals are plane or procœlian, joined by cartilages. There are no lumbar, and two sacral vertebræ with free ribs. The movable tail consists of 16-27 pro-, rarely opistho-cœlian vertebræ, with intermediate chevron bones, no spines, and weak transverse processes. The solid skull has all its components united by suture except the mandible and hyoid arch. The supra-occipital has a vertical crest directed backwards, and ankyloses with the epiotic, the opisthotic remaining separate from the pro-otic and ex-occipital, and the latter unites with its fellow, excluding the basi-occipital from the foramen magnum, but not from the trefoil-shaped condyle. The basisphenoid is large; the ali-, pre-, and orbito-sphenoids are unossified, and the interorbital septum is membranous. The parietals send on each side a vertical plate down to join the pterygoid. The frontals are large, and a large membrane bone (nasal or lachrymal) covers the persistent ethmoidal cartilages, otherwise nasal bones are absent, except in Hydromedusa. The premaxillæ are small, united in Chelys; the vomer is single, flattened below, and forming part of the roof of the mouth. There is a thin squamosal, a postfrontal, and an immovable quadrate fixed to the maxilla by jugal and quadrato-jugal bones. The broad fixed pterygoids unite together mesially by suture, only touching the upper part of the quadrate. The palatines are flat, and join the vomer and each other medially. The dentary bones of the mandible coalesce at the symphysis. There is no tympano-, stylo-, nor epihyal, but a broad basihyal, sometimes consisting of entoglossal and copular parts and two pairs of cornua, the second pair being longer and of two elements; the first may be absent (Testudo), rudimental (Emys), small (Chelone), or large (Trionyx). These, like the hyoidean columellæ of frogs, are rudiments of the common attachments of the hinder visceral arches. A wide outward extension of the middle ridge of the parietals joining the malar, postfrontal, and squamosals, roofs in the temporal fossa. The limbs originate outside the visceral cavity in front and behind; but as growth proceeds, the ribs, carapace, and plastron extend fore and aft to overlap the basal girdles which appear included within the bony shell; but as ventrally this is only a dermal case, their included position is the less remarkable. The rod-like scapula is attached to the spine by a cartilaginous suprascapula, ventrally in the adult fusing with the precoracoid. The flattened coracoid ossifies separately, and unites with the two others in the glenoid cavity. The intercoracoid fenestra is closed internally by an epicoracoidal fibro-cartilage. The humerus is short and thick, as are the ulna and radius. The first row of carpals consists of *radiale*, *ulnare*, and *intermedium;* the second, of centrale, and five carpalia supporting the metacarpals; a flattened accessory pisiform bone exists in some Chelonia. The outer and inner digits have

two, the others three phalanges. The pubes are wide, and, with the ischia, form a long symphysis, often with a prepubic bone (Chelydra), or the two may unite discontinuously, forming two symphyses. The ilia abut on the sacral ribs, and may join the last central plate (Chelodina, Chelys), and in Chelydidæ the pubis joins the xiphiplastron (hence they are called *Monimopelyca* of *Stannius*). The femur has two trochanters. The first row of the tarsal bones consists of an astragalus (the united tibial, intermedium, and centrale*), and a calcaneum (fibulare). The two fibular tarsals unite to form a cuboid, the others remain separate. The fifth metatarsal is medially bent at right angles.

Dermal glands exist in the sides of the carapace in aquatic Chelonia, opening by tortuous ducts between the horny plates of the shell. The dorsal muscles are weak or none, lying between the vertebral laminæ, the inner prolongation of the costal plates, and the back of the rib-necks. The longitudinal fibres form in the tail levatores caudæ, and in the neck complexus and recti capitis muscles. The strong, flat pubo-plastronic muscles may represent the pyramidales, or may be parts of the panniculus. The recti abdominis are weak. There is a trachelo-procoracoid retractor of the neck: a large serratus magnus passes from the first rib to the scapula, but no muscles pass from the head to the shoulder-girdle. The great pectoral arises from within the plastron, as well as from the epicoracoid.

The brain has no pons, a smooth cerebellum, often with rudimental lateral, lobes, a thick lamina terminalis, and an extension of the lateral ventricles into the olfactory nerves. The optic thalami project above, and have a posterior commissure; the 6-9th cervical nerves form the brachial plexus, of which the median is the chief stem. The olfactory nerves end on the ethmoidal cartilage. There is one nasal opening anteriorly (capable of closure in the aquatic forms), and the choanæ are far back, bounded by the palatines. The eye is in a closed orbit, and has bony sclerotic plates, a small lens, striped muscles in the iris and choroid, four recti and two obliques, and a retractor bulbi muscle. The nictitating membrane has a pyramidal and a quadrate muscle to move it, and the lids are opened by two palpebral muscles. A process from the quadrate, which forms part of the floor, divides the tympanic cavity into two—an inner, *antivestibulum Bojani*, into which the mastoid cells open, and an outer, or tympanum, from which the narrow Eustachian tube passes to open at each side of the pharynx. The slender columella passes through an opening in the partition to the membrana tympani. The cochlea is retort-shaped, and there are four

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* Except in Chelydra, where this is distinct, the calcaneum and astragalus coalesce in Emys.

ampullæ on the three semicircular canals. The fleshy, smooth (Chelone), or papillose tongue is probably sentient, as is the *tuberculum palatinum*, a hollow organ in front of the choanæ, perhaps a Jacobsonian organ. Fleshy lips exist in river tortoises, but there are no teeth, except as rudiments in some Trionyces. The two jaws are sheathed with a sharp-edged horny beak, and there is a sub-lingual mucous gland, whose ducts pierce the tongue. The œsophagus is short, straight, lined with soft or hard papillæ the stomach is oblique or transverse, with a thick muscular coat and a pyloric valve. The vertical mesentery contains smooth muscular fibres. In land tortoises the long intestine has a short colon, a cæcum, and an ilio-cæcal valve, and the cloaca opens by a longitudinal or round aperture.

The bilobed liver has the gall-bladder in its right lobe; the large lobed pancreas has one duct. The lungs are large spongy sacs fixed under the carapace, and extending to the pelvis. They are expanded by the forcing in of air, and compressed by diaphragmatic muscular bands arising from the vertebræ, which also constrict the œsophagus. The trachea is long, with incomplete cartilages in front. In Kinixys it is bent several times on itself; in Sphargis it is divided by an incomplete ventral septum. There is a ring-like crico-thyroid cartilage in the larynx, with two lateral arytenoids, no vocal chords, and a membranous epiglottis. The inter-auricular septum in the heart is sometimes perforate, and the two auricles are not synchronous in action; the left receives one pulmonary vein; the right receives venous blood from a muscular *sinus venosus*. The long ventricle is divided by an imperfect muscular or cartilaginous septum into a longer or left, and a smaller or right end, *the cavum pulmonale*, giving off the pulmonary artery. The larger portion receives the blood of the left auricle at its left end, which is called the *cavum arteriosum*, and into its right end, close to the origin of the aortic arches (*cavum venosum*), opens the right auricle; when the ventricle fills, the direction of the auriculo-ventricular valves keeps the arterial and venous blood to some extent apart, and its contraction drives the latter, as it flows from the right auricle partly into the cavum pulmonale, partly into the aorta. By the time the arterial blood reaches the right end of the ventricle the contraction of the cavum pulmonale has brought the free edge of the septum nearly in contact with the opposite (dorsal) wall, and this prevents its entrance thereinto, and drives it into the aortic arches, especially into the right, which is higher up. The aortic arches cross at their origin, the right arising to the left, and *v. v.* Their openings are guarded by two valves. A common muscular sheath incloses the aorta and the pulmonary artery. The caudal vein bifurcates in the pelvis, and each branch again forks (fig. 28 B *c*); the outer branch, receiving the ischiadic and crural

veins (*i–f*), forms on the abdominal wall the epigastric vein (*n*), which, entering the liver, joins the vena portæ, their blood thus reaching the inferior vena cava. The inner branches, united by a median communicating vessel, enter the kidney (*venæ renales advehentes*), where they break up into a reno-portal plexus, from which arise the venæ renales revehentes, that by uniting form the inferior vena cava. The large pre-cloacal allantois forms a urinary bladder, and has two veins. The pre-cloacal penis consists of two lateral *corpora cavernosa*, and a central grooved *corpus spongiosum*, whose extremity is quadrifid in Trionyx. The kidneys are small, compact, placed near the

Fig. 28.

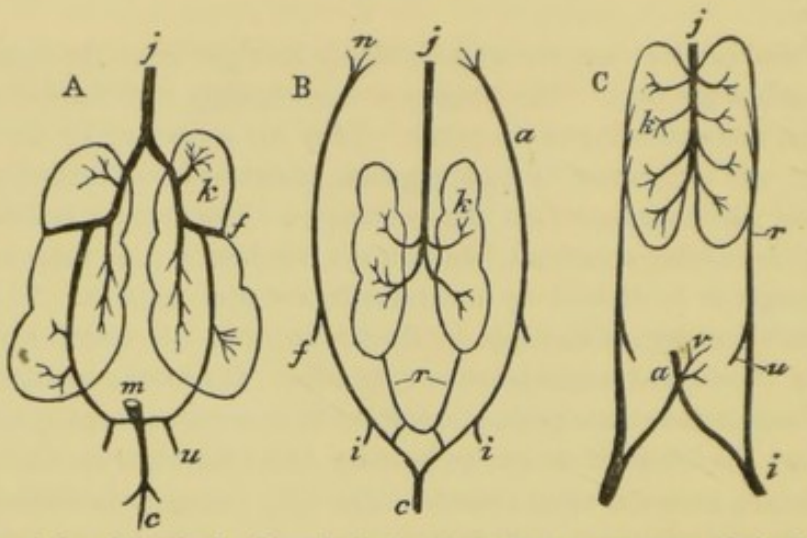


Diagram of the abdominal veins—A, in the Bird; B, in the Reptile; C, in the Frog: *c*, caudal vein; *i*, ischiadic vein; *r*, advehent renal vein; *f*, femoral vein; *k*, kidney; *j*, inferior vena cava; *n*, end of the epigastric vein in the liver.

cloaca, and two small cloacal glands open beside the anus. The testes have convoluted vasa deferentia. The ovarian eggs project like grapes, and have parchment-like shells; 3-50 are laid at once. The young in Trionyx has a premaxillary, tooth-like prominence (egg-tooth), to cut its way out of the shell.

About 200 species exist, none common to the eastern and western hemispheres. They are divided into four families:—

1. *Testudinidæ.*—Jaws horny, naked, with sharp edges; eyes lateral; membrana tympani exposed; carapace completely bony; pieces of the plastron united by suture not joined to the pelvis, and with 11-12 shields; the head and the thick limbs retractile; manus with 5-4 united toes; pes with four, rarely five or three, nails, hoof-like. This includes two sub-families:—1. Chersinæ.—Terrestrial, with a convex carapace, and the last phalanges immovably united into a rounded foot; tail-plate single, rarely double (Manouria). Testudo has an immovable carapace and

plastron, with twelve shields on the latter. 2. Emydinæ.—Amphibious, with flattish carapace and webbed toes, with a doubled tail-plate of the plastron. Chelydra, the serpent tortoise, and Cinosternon are examples. The extinct Colossochelys (five feet high), Atlantochelys, and Macrochelys, from India, America, and Germany, are allied to Testudo. Staurotypus has no interclavicle.

2. *Chelydidæ.*—Amphibious. The pelvis joined both to carapace and plastron, the latter being of two movable parts (or fixed in Pelomedusa). Head and feet not retractile; the former can only move laterally. There is an intergular plastronic scutellum, no nuchal axillary nor inguinal plates. The atlas and axis are like the other cervical vertebræ, procœlian; the valvular nostrils are prolonged. Feet webbed. Head large, convex, shielded in Peltocephalus. The toes are 4–4 in Chelodina and Hydromedusa; 5–4 in Chelys, Platemys; 5–5 in Sternotherus. Chelys has a triangular fold over each tympanum, and fringed folds on the neck.

3. *Trionycidæ.*—River or soft turtles, with soft lips, proboscis-like nose, and skin over the head, concealing the tympanic membrane; neck long; toes 5–5, the outer two clawless. Scutes covered with a hard flexible skin. Ribs united together and to the vertebræ above, free below. The plastron consists of a ring of bones, with callosities on the prominent parts. Trionyx, the snapping turtle, has distinct ossicles in its membrane and four sternal callosities.

4. *Chelonidæ.*—Natives of tropical seas; carapace flattish; snout blunt, with an exposed, hooked, horny beak; neck short, sub-retractile; tympanum covered by skin; ribs free at the end. The skin may be rugose, leathery (Sphargis), or with tortoise-shell plates. The rib-points are covered by marginal plates; lips none; feet paddle-like, with one or two claws. Sphargis has no shields nor claws, and a three-keeled body. Chelone has its shields either imbricated (C. imbricata, the tortoise-shell turtle), or not (C. viridis, the edible turtle), with thirteen dorsal scutella. Caouana, the loggerhead, has two accessory shields in front of the anterior costal plate.

Tortoises are long-lived animals. The heart pulsates long after its removal from the body, and the animals survive for a time the removal of the brain.

Order II. *Plesiosauria.*—Extinct mesozoic forms; heads small; integument with no scutes, and probably no scales; dorsal vertebræ, movable on each other, with long transverse processes and movable ribs; limbs paddle-like; sternum and sternal ribs absent or rudimental; cervical vertebræ 13–41, with short spines; thoracic vertebræ, with their rib-facets below or cut by the neuro-central suture: cervical ribs attached above it; atlas and axis frequently united; centres biconcave; sacral vertebræ 2; caudal 30–44, the

anterior with chevron bones. A median row of bones lies in the ventral wall, thinning at each end, and having on each side of it three rows of lateral bones, whose inner ends are pointed, and overlap each other. The nasal openings are in front of the orbits, not at the end of the snout. The maxillæ are larger than the premaxillæ; the ex-occipitals give off long parotic processes, and form little of the large basi-occipital condyle. The basi-sphenoid has a long rostrum. The choanæ are bounded in front by the palatines, and behind them are the pterygoids, which surround in front an oval fossa, sometimes mistaken for the posterior nares. There are transverse bones projecting outwards from the pterygoids, and the stylo-hyals are slender. The teeth are conical, curved, in sockets, not ankylosed. There is no sclerotic bone. The coracoids are long, flat, lying side by side ventrally. The scapula extends in front of the glenoid cavity as a bar, with a thin hinder lamina continued from it; an inter-clavicle lies sometimes transversely between the scapulæ. There are six carpals and five digits, the middle with 6–7 phalanges. The ilium is rod-like, the pubis quadrate, the ischia triangular and expanded, and both form symphyses. The radial bones are like those of the fore-limb. The intestine had probably a spiral valve, judging from their coprolites. They are divisible into three groups—1. Porpocrania, with a small brain-case. The quadrato-jugal, jugal, post-frontal, maxilla and premaxilla form most of the boundaries of the temporal groove, orbit, and nares; pterygoid pits are absent, and clavicles and inter-clavicle exist in the shoulder-girdle. Nothosaurus, Simosaurus, &c. (Triassic). 2. Placodontia.—Brain-case large; mandible with a high coracoid process; palatine, as well as maxillary teeth, which are broad and rounded (Triassic, Muschelkalk). 3. Placocrania.—Parietal bones large; trigonal, with large foramina.

CHAPTER XV.

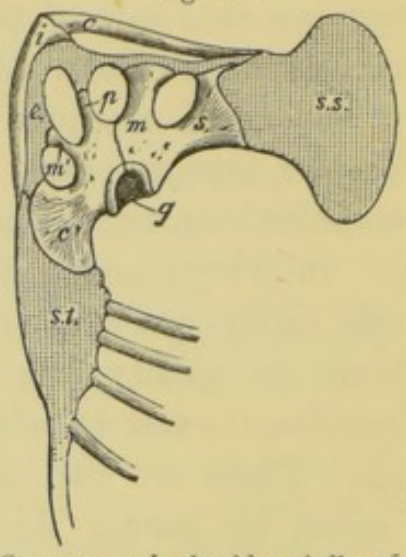
Lacertilia.

Order III. *Lacertilia* (*Huxley*), Lizards.—Scaly reptiles, often with spines or dermal horns, with dermal glands opening as a row of pores on the thigh, or pre-anally, usually with limbs, or at least a shoulder-girdle, and possessing a sternum and sternal ribs. An allantoic bladder always exists. The vertebræ are procœlous or amphicœlous, numerous; the precaudals are 15 in Draco, 19 in Phrynosoma, 15 in Trachysaurus. The cervicals rarely exceed 8, and all but the atlas usually have bony or gristly cervical ribs embedded in the neck-muscles, the last of which is as long as the first thoracic rib. There are two or three separate sacral vertebræ, united by strong ligaments, and the tail-bones have chevron bones, attached often to, not between, the vertebral bodies. Sometimes each caudal vertebra has in its middle a transverse unossified lamina, so that the tail, on being grasped, breaks off at one of these lines.

The scales in Ophisaurus and Pseudopus are bony. In Anolis and Chamæleon, owing to the presence of contractile chromatophores in the dermis, the skin can change colour. The dorsal vertebræ have transversely elliptical convexities on the hinder surface of their bodies, and are movable; they have short transverse processes, and sometimes the most anterior have long spines to support a dorsal crest. The atlas has an inferior and two lateral ossific centres, which do not unite. Sometimes there are sub-vertebral wedge-bones in front of the inter-vertebral spaces, and there may be 1-3 lumbar vertebræ. The last rib, or the transverse process of the foremost caudal vertebra, is often flattened to protect the lymph heart. Occasionally hypaxial spines are developed below the vertebral bodies. The neural arches articulate by zygapophyses, and in some (Iguanidæ) there are also projecting lateral trigonal spurs, called zygosphenes, on the front of each lamina, which

fit into hollows or zygantra in the lamina in front. On the ribs there are often uncinate processes, which pass backwards, overlapping and attached to the rib behind. The vertebral ribs ossify ectosteally, the sternal endosteally. The sternum is rarely absent (Amphisbænoida), and sometimes, when present, the ribs are not attached to it (Chalcididæ, &c.), or the foremost ribs may be attached to the hinder angles of a rhomboidal sternum, or to a single or double abdominal prolongation of it, or to their fellows of the opposite side (Ascalabota, &c.), or the ventral ends may be free in the abdominal wall, or as in Draco, the five or six hinder ribs may be expanded and included in a lateral parachute of skin. The sternum is rudimental, pentagonal in Anguis, Pseudopus, and Ophisaurus, and there is an inter-clavicle beneath its pre-sternal part. In Anguis there is a præ-coracoid partly separate, and a supra-scapula and epi-coracoid are recognizable, as well as a parostotic clavicle. In Chirotes there is a pre- and a meso-xiphisternum. In Acontias the pre-sternum is in halves. In others there is a central opening in the meso-sternum. In the limbless forms the shoulder-girdle usually consists of a continuous scapulo-coracoid rod, wider at the ends, narrow mesially, and not touching the small sternum. These may meet, or one, usually the right, may overlap the other. When fore-limbs exist, the coracoid and pre-coracoid are distinct, capped by an epi-coracoid, and uniting with the sternum. A meso-coracoid sometimes forms an outgrowth of the coracoid, cutting the anterior fontanel of the girdle into two parts. There is a wide super-scapula, a scapula with a meso-scapular segment, the fenestra between the meso-scapula and the scapula being peripheral, not basal, as in many Amphibians. Free xiphi-sternals exist in many species, and an inter-clavicle and clavicle are often present, except in the chamæleons, in which also the supra-scapula, pre-, and epi-coracoid are unossified. The limb may be a styliform rudiment or perfect. The proximal carpals consist of two bones, radio-ulnare and centrale; the distal row of 5, 3 or 2. The humerus is usually shorter than the forearm, and the ulna has sometimes an olecranon. There are five fingers in most, with (from within outwards) 2, 3, 4, 5, 3 phalanges respectively. The femur has one trochanter; the proximal tarsals are 1 or 2, fixed

Fig. 29.

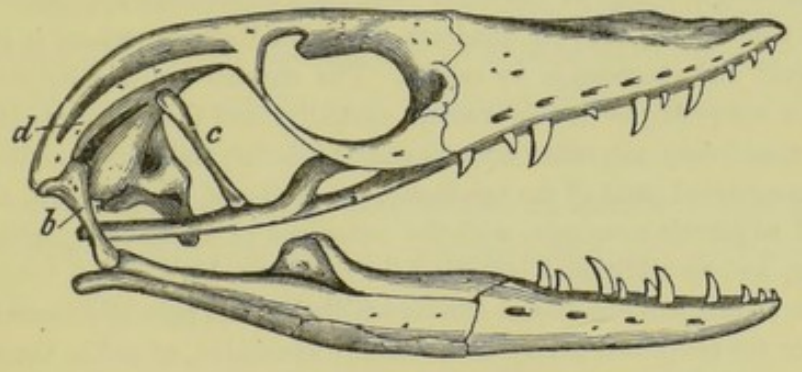


Sternum and shoulder-girdle of Iguana, side view: *ss*, supra-scapula; *s*, scapula; *m*, meso-scapula; *g*, glenoid cavity; *p*, pro-coracoid; *m*, meso-coracoid; *c'*, coracoid; *s.t*, sternum; *e*, epi-coracoid; *c*, clavicle; *i*, inter-clavicle.

to the tibia; the distal are 2–5, and the toe phalanges of the five toes (from within outwards) are in general 2, 3, 4, 5, 4. The last phalanges of the hand and foot are usually claw-bearing. The pelvis consists of short ilia, movably jointed to the sacral ribs by cartilage; the pubis (os ileopectineum of *Gorsky*, pubo-ischium of *Fürbringer*) meets its fellow in a symphysis; behind this is an ischium, from whose symphysis an *os cloacæ*, or central bony rod, extends backward, supporting the front wall of the cloaca, and completing the obturator foramen internally. The pelvic girdle is absent in some limbless forms.

The skull has a lateral squamosal arcade and a wide *os transversum*, passing from the fixed palates and pterygoids to the maxilla; this is sometimes called ecto-pterygoid, but has no relation to the plate of that name in mammals.

Fig. 30.



Skull of Lizard, showing—*c*, columella; *d*, post-frontal arcade; *b*, quadrate bone.

The pterygoids articulate behind with the inner face of the quadrate externally, and with lateral or basi-pterygoid processes of the basi-sphenoid internally. In most lizards a separately ossified membrane bone (*columella*) stretches from the parietal to the pterygoid, like the descending lamina of the parietal of tortoises, replacing the unossified sphenoidal elements of the cranium. Three temporal fossæ are obvious on each side of the skull, bounded by bony or ligamentous bridges; a post-temporal between the parietal, occipital, and parotic; a lateral between the quadrate, jugal, squamosal, and post-frontal, and the quadrato-

jugal; lastly, a supra-temporal between the parietal, post-frontal, and squamosal. The premaxillæ (which are often ankylosed), maxillæ, and sometimes the palatines, are dentigerous. The mandible consists on each side of a cartilage-bone (articulare), touching the quadrate, two dentaries medially united by suture (except in Hatteria), and splenial, angular, coronoid, and often supra-angular splints; some of these may be absent. Several mental foramina usually co-exist in the dentaries.

There is a single or double frontal bone, one or two parietals, perforated with a medial parietal foramen, and articulating with the top of the parotic process. They join the pro-otic and occipital by fibrous tissue, not by suture. A bony inter-orbital septum only exists in Amphisbæna; the quadrato-jugal is ligamentous, except in Hatteria. The palato-maxillary apparatus may be slightly moveable, as is the quadrate, except in Hatteria, where it joins the pterygoid and squamosals by suture. The choanæ are usually elongated, and lie between the double vomers medially, and the palatines laterally. The nasal bones are often absent, and the lachrymals are variable. The postero-external parts of the opisthotic, pro-otic, and ex-occipitals, are prolonged as parotic processes, with the outer end of which the quadrate articulates, and an additional pterotic bone may form here. The hyoid has a median copula and two lateral cornua which join the parotic process in Hatteria, or are continued nearly to the skull (Scincoidæ), or end in the neck.

The teeth are conical, incisive, serrated or flat-crowned, either solid (*pleodont*), or with a pulp cavity (*cælodont*), placed along the edge of the jaw (*acrodont*), or along the inner edge of the margin of the jaw (*pleurodont*); rarely in sockets (*thecodont*). The number is rarely constant, and they may undergo frequent and irregular change, new teeth growing at the bases of the older.

The tongue may be fleshy, not protrusible, or long, worm-like; and, when long, it is usually bifid, and lies in a sheath at the base of the glottis; it is often papillose or scaly, and has horny epithelium on its tip. The stomach is longitudinal, divided into a wide cardiac and a narrow pyloric end. There are no poison-, nor salivary glands, but a row of labial follicles. The intestine is short, and

the cloaca opens transversely. The lungs are saccular; the liver often marginally lobulated, with the gall-bladder close to its surface; the mesentery contains muscular bands passing to the intestine; the heart is like that of the turtle, with persistent third and fourth aortic arches giving off the carotids and subclavians. The eye has usually two lids and a membrana nictitans, to which is attached the tendon of a muscle (named *bursalis*) which arises from the inner wall of the orbit, and draws the lid over the eye. There is a choanoid muscle, which is sometimes double, co-existing with eyelids, and a ring of bony plates in the sclerotic, and a pecten, except in Hatteria. The Eustachian tubes are wide; the ear columella has a basal operculum. The urinary bladder is present and large, and copulatory organs are present in the males, as a pair of long eversible sacs, with erectile walls and grooved side, placed on the hinder wall of the cloaca, often extending into the tail. The oviduct has a wide, abdominal muscular opening, a middle glandular area, and a narrow lower end; the eggs are numerous, with leathery shells.

From the base of the sheath of the tongue, processes arise in Phrynosoma which encircle the faucial opening. In many, a thread-like glosso-hyal cartilage is continuous into the tongue. The œsophagus is longitudinally folded. The lungs often have spongy lobes or pointed air-sacs, as in Chamæleons. Anguis and Bipes have the left lung only half the length of the right, but in Pseudopus they are equal. The larynx has vocal chords attached to the arytenoid cartilages in many, and in Chamæleons an air-sac lies between the larynx and the first ring of the trachea. Some have an epiglottic cartilage. Special hepato-gastric muscular bands exist in Grammatophora and others. The olfactory nerves are large, the nasal membrane plicated, often with a nasal gland on either side of the frontal bone. The eyes are covered by skin in Geckos, &c., or have circular lids, as in Chamæleons, but in the majority have two lids. The ovaries and testes are symmetrical; the vasa deferentia have frequently vesicular dilatations at their lowermost end.

There are about 400 species of Lizards now living, and they are divided into the following sub-orders:—

Sub-order I. *Rhynchocephalia* (*Günther*).—This sub-order consists of one species from New Zealand, characterised by having the quadrate bone fixed in the skull; the tympanum covered by skin, opening into the fauces; no pecten in the eye; no copulatory organ; a parieto-pterygoid columella; amphicœlian vertebræ; acrodont teeth, which on the jaws and palate are trigonal, compressed; a large rodent-like incisor in each premaxilla. The lateral rami of the lower jaw are united by ligament, the paired vomers are attached to the alisphenoid, the cochlea shows a primary coil in the lagena, and the lungs are large-celled, amphibian-like. This lizard (Hatteria punctata) has a head covered with small shields and a transverse skin-fold in the throat. The temporal fossæ are bridged over by a bony arch; the tail is compressed, trigonal, and the back and neck are crested.

Sub-order II. *Amphisbænida* (*Fitzinger*).—Worm-like, cylindrical, mostly limbless Lizards, with the surface ringed, each ring being made up of quadrate scale-like markings; tympanic cavity, palatine teeth, eyelids and zygoma are absent; the tongue is not protrusible, and is without a sheath; a urinary bladder is present, and a single parietal bone. This includes four families—1. Trogonophidæ, acrodontal forms, with no pre-anal pores. 2. Amphisbænidæ, pleurodontal, with pre-anal pores and equal scales. 3. Lepidosternidæ, pleurodontal, with pre-anal pores and large ventral shields. 4. Chirotidæ, the only limb-bearing forms, having a well-developed sternum, and small, five-toed fore-feet, pleurodontal, with pre-anal pores.

Sub-order III. *Ascalabota* (*Wiegmann*).—Geckos, small, thick-tongued Lizards, with large flat heads, amphicœlian vertebræ, a ligamentous post-fronto-squamosal, and a maxillo-quadrate band, with rudimental jugal and squamosal bones, and a parieto-pterygoid columella. There are no eyelids, except in Eublepharis and Ptenopus. The skin is naked, or rarely finely scaly, usually papillose. The teeth are pleurodont, but there are none on the palate. The digits are flattened, and each bears a sucking disk on its under surface, made up of transverse lamellæ; by these they can walk up vertical walls, or even on ceilings. Teratolepis is scale-clad; Stenodactylus has the toes not expanded; the other genera are grouped according to the extent of the toe-expansions, thus the toes are only dilated at the basis, and the hinder outer toe is thumb-like in Gymnodactylus, Hemidactylus, &c., while the whole under-surface of the toes is expanded in Gecko and Platydactylus, &c., and the tips alone are expanded in Ptyodactylus and Phyllodactylus. The Geckos are so called from the grunting sound which they emit.

Sub-order IV. *Cionocrania* (*Stannius*).—Procœlian lizards, with a columella, united pterygoid and quadrate bones, and an inter-orbital septum;

orbital and zygomatic arches more or less perfect. The parietal bones are fused, and the frontals remain separate; the individual toes have mostly 2, 3, 4, 5, 3 phalanges (from within outwards). The toes are rarely expanded, and, except in Anolis, have no suckers. They have mostly eyelids and are scale-clad, with scales arranged quincuncially or in girdles. The following families are included:—

1. *Varanidæ.*—Scaly, long-tailed, long-bodied lizards, with elongated, two-pointed tongues, retractile into a sheath; one nasal and premaxilla; teeth pleurodont, compressed, none on the palate; no femoral pores. Varanus and Hydrosaurus reach the length of five to six feet, and are among the largest of living lizards. Psammosaurus has the scapula entirely covered by an ectosteal crust.

2. *Lacertidæ.*—Elongated lizards, with shielded heads and granular or rhombic dorsal scales; teeth pleurodont, hollow; tongue sheathless, long and bifid; orbit with bony plates. Lacerta includes our common British lizards; Eremias has transparent eyelids; Ophiops has none.

3. *Trachydermi.*—American lizards, with tubercular scales and head-shields; tongue papillose at the base, with two smooth points; teeth pleurodont; zygoma complete, and no premaxillary opening into the palate. The teeth are grooved in Heloderma, like poison-fangs.

4. *Ameividæ.*—American, elongated lizards, with regularly shielded head, and with two transverse folds on the throat; teeth emphyodont and pleodont; tongue with imbricated scales at base; zygoma incomplete. Ex. Tejus, Ameiva.

5. *Ecpleopoda.*—American, with four approximated feet; scaly tongue, with two points; teeth pleurodont and pleodont, none on the palate; tympanum visible; upper eyelid short, often transparent.

6. *Chalcididæ.*—American, elongated forms, with short, remote limbs, and concealed tympanum; scales in girdles, and tongue elongated, two-pointed.

7. *Cricochalcidæ.*—African round-bodied lizards, with keeled scales; tongue papillose, scarcely bifid.

8. *Zonuridæ.*—Laterally grooved, palæotropical (except Ophisaurus), with regularly shielded heads and quadrate body-scales keeled on the back; Pseudopus has rudimental hind-limbs. Ophisaurus has no trace of limbs fore or aft.

9. *Scincoidæ.*—Smooth, regularly, quincuncially-scaled, short-tongued lizards, with pleurodont teeth, no lateral groove. The tongue is bifid, sometimes protrusible. Ex. Scincus, Trachysaurus. In Anguis there are no limbs, only limb-girdles concealed beneath the skin. A. fragilis is the common blind-worm. Ophiodes has short-pointed, toeless hind feet. Pano-

lopus has no digits on the fore feet, only one on the hinder. Microlepis and Sauresia have tetradactylous feet, with unequal hinder toes. Seps has 2–3 or 3–3, rarely more, toes. Scelotes has only hinder feet, with two simple toes.

10. *Typhlophthalmidæ.*—Scincoids, with no upper eyelid; rudimental or no limbs, and nostrils in a single rostral scale, with a deep groove behind them. The eyes are under the skin in Typhlosaurus, but have a lower lid in Acontias. Anniella, a closely allied genus, has no columella.

11. *Pygopidæ.*—Australian Scincoids, with rudimental immovable circular eyelids; only rudimental hind-limbs, and nostrils over the first labial scale. Delma has no pre-anal pores.

12. *Aprasiidæ.*—Australian Scincoids, with large fronto-nasal shields, no limbs, and no pre-anal pores; nostrils between the nasal and first labial shields.

13. *Lialisidæ.*—Australian Scincoids, with imbricated scales on the head; nostrils at the back of a small nasal plate; hind-limbs two, flat, undivided.

14. *Gymnophthalmidæ.*—Scincoids, with circular rudimental eyelids and weak unequal legs. Ex. Menetia.

15. *Xantusidæ.*—Neotropical lizards, with large polygonal head-shields, granular back-scales, and large, transverse, abdominal shields; tongue broad, long, not extensile, tip slightly notched; teeth pleurodont. Toes with a row of transverse smooth scales; eyelids none or rudimental. Ex. Xantusia.

16. *Agamidæ.*—Thick-tongued, palæotropical, with many little shields on the head; acrodont teeth, and none on the palate; eyelids two; scales mostly equal, quincuncial. This large family includes numerous (thirty) and varied genera. Draco is a small Malayan form, with a lateral parachute, formed of skin stretched over the expanded five or six latter false ribs; it has a long, conical, medio-gular pouch, and two smaller lateral appendages. Otocryptis has a similar throat-sac, but no wings. Ceratophora has a horn-like process on the nose. Chlamydosaurus has a wide dermal ruff or collar around the neck. Moloch, Phrynocephalus, and others, are abundantly armed with sharp, conical, tubercular spines.

17. *Iguanidæ.*—Thick-tongued, neotropical, with many small-headed shields, pleurodont, and often with an armature of pterygoid teeth; eyelids two; scales mostly in transverse rows on the back. This large family includes many forms, contained in about fifty-six genera, many of which are slender, laterally compressed, arboreal, as Polychrus and Anolis (which has sucking disks on its toes). Basiliscus has a crested back and fringed toes. Iguana is eaten in the West Indies, and is esteemed a delicacy. Other forms are depressed, terrestrial, as Leiosaurus, Phrynosoma, Hoplurus, &c.

Sub-order V. *Rhiptoglossi* (*Wiegmann*).—Chamæleons, with procœlian

vertebræ; a complete zygoma; no tympanic membrane; a circular eyelid; a complete post-fronto-squamosal arcade; no columella; a single parietal bone. The tongue is elongated, dilated at the tip, muscular, and capable of exceedingly rapid protrusion, as both the tongue and the hyoid arch can be separately and simultaneously moved in the same direction. There is no olfactory bulb; pleurodont teeth, and none on the palate. They make one family, principally palæotropical, arboreal, with five-toed digits arranged in two opposed groups of two and three; the surface is covered with minute granular scales, and the power of changing colour has been before referred to. They all belong to one genus, Chamæleo.

CHAPTER XVI.

Ophidia.

Order IV. *Ophidia*, Snakes.—Cylindrical, scale-clad reptiles, without dermal ossifications, sternum, shoulder-girdle, urinary bladder, eyelids, tympanum, or functional limbs; with numerous vertebræ (422 in Python molurus). The atlas and axis are the only differentiated cervical vertebræ, the former alone being ribless, the latter possessing an odontoid process. The other vertebræ are dorsal or caudal; dorsals have short transverse processes, articulating with the simple heads of the ribs. Their bodies are procœlian, posteriorly hemispherical. The neuro-central suture disappears early, except in the atlas. The laminæ have additional articular processes, called *zygosphenes* and *zygantra*. The ribs are often hollow, and end in free cartilages. The foremost tail vertebræ have long transverse processes and two ventral, hypaxial processes, functionally representing chevron bones; some pre-cloacal vertebræ have also strong hypaxial spines, especially in some poisonous forms. In Dasypeltis the 8–13 foremost dorsals have these spines long,

enamel-tipped, projecting through the wall of the œsophagus, and acting as teeth, used to break the eggs on which the animal feeds. The transverse processes of the first and last rib-bearing vertebræ are flattened, to protect the lymph hearts. Some snakes have rudimental ischia; a few have also a pterygium, bearing a little pointed claw (*calcar*), placed beside the transversely-opening cloaca. The mandible consists of the same parts as in the Lizards, but its rami are usually joined by elastic ligaments at the symphysis.*

The hyoid is rudimental, and consists of a lateral cartilaginous cornu on each side, joined medioventrally, and not connected to the skull. The premaxillæ are usually fused, rarely dentigerous, united by a ligament to the maxilla. The nasal segment of the skull is often movable, notossified; the long palatines never join the vomer nor the base of the skull, nor bound the choanæ posteriorly, but are joined to the quadrates by the movable pterygoids, and to the maxillæ by the long transverse bones. The brain-case is firmly built, the floor flat, the roof sloping forwards, and the cavity not constricted between the orbits. There are no parotic processes. The basisphenoid is prolonged forwards into a long rostrum, on whose upper face the two cranial trabeculæ lie as rods, which do not unite anteriorly (in this point differing from the trabeculæ of the higher craniotes).

The wall of the brain-case consists of two large anterior bones (like frontals), which, however, unite medio-basilarly over the trabeculæ; these are developed in cartilage, and so may be enormously extended orbitosphenoids; behind these are two large hinder bones (parietal-like), which, like the parietal in Chelonia, dip in basilarly to touch the basisphenoid, as the parietals do in the turtle, but, unlike them, are developed in cartilage, and may be extended alisphenoids. There are membrane post-frontals and lachrymals, large nasals and pre-nasals, which extend from the septum of the mesethmoid to the maxilla over the nasal gland. The jugal and quadratojugals are absent; the squamosals articulate movably with the skull wall, and support the quadrate. The maxillæ are short, the vomer double. The teeth are ankylosed, not in sockets, placed on the palatines and pterygoids, as well as on the jaw arches; they are curved, sharp, conical, prehensile, or retentive.

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* The scaly epidermis is shed periodically, as a continuous "slough;" the scales are often flat, sometimes keeled, rarely tubercled (Acrochordus).

The columella of the ear from the fenestra ovalis lies between the temporal muscles, and is often united to the quadrate. There is no choanoid muscle, and the fibres of muscles of the iris are striped. As in Geckos and Amphisbænæ, the eye is covered by a continuous transparent skin, which leaves a closed conjunctival space, washed by the tears, between its deeper surface and the front of the cornea; this tear-space communicates by a duct with the nose. The trunk muscles are very complex, but reducible to a few series of protractors and retractors of the ribs, intervertebral muscles, and two sets of muscles passing from the ribs to the ventral scutes. There is no transverse abdominal muscle. To move the jaws there are basi-sphenopterygoid and masseter, pterygoid, levatores pterygoidei, levatores quadrati, temporal and digastric muscles.

The upper margin of the mouth has no lips, but a row of labial scutes, the foremost median being called rostral. The lower has a similar row of inferior labial scutes, below which are 2–4 mental shields. Behind the rostrals are two or four frontal scutes, posterior to which is a single vertical scute, after which follow two occipitals. Between the frontals and labials are the nasals, bounding the nostrils, and between these and the eyes are two shields, named respectively loreal and anteorbital. The upper and hinder edges of the orbit are bounded by supraciliary and postorbital scutes, behind which are temporals. The body scales are generally arranged in spiral lines. The ventral surface has usually a row of broader shields, to whose inner surface muscles are attached. Some snakes have cuticular head appendages, or the cuticle of the terminal tail-scales may harden into a spine, or into a series of hard, horny rings, as in the rattlesnake.

The brain and nervous system resemble those of lizards—the cavity of the optic lobes communicates with the third ventricle.

There is no eleventh pair of nerves, nor a distinct sympathetic cord. The tongue lies in a sheath ventrad of the trachea, and is protrusible, forked, and made up mostly of hyoglossi and longitudinal linguales, sheathed by circular

fibres; its tips are covered with horny epithelium. A set of buccal glands with many ducts open external to the teeth. The intestine is transversely folded in short coils, which are united by connective tissue within a common peritoneal sheath which does not follow the intestinal flexures. Some have a cæcum, others (Trigonocephalus, Elaps, Python,) have in the end of the intestine several ring-like constrictions between which there are dilated areas. The right auriculo-ventricular opening has two valves, and the coronary artery arises from the right arch. The gall-bladder is far from the one or two-lobed liver, and near the duodenum. There is but one epigastric vein. The larynx has a single, ring-like, fenestrated cartilage, consisting of two longitudinal lateral strips joined by 4-16 cross bands; a single arytenoid cartilage is placed on its dorsal forward border, and may be consolidated to the first cartilage, and there is no epiglottis. The trachea has complete rings, and is long, ending in bronchi, which usually open directly into the unsymmetrical, long, saccular lungs, whose walls anteriorly are cellular and vascular; behind are smooth, thin-walled air-sacs. This part of the lung, like the swimming-bladder of fishes, only receives blood from the arteries about it. The lungs are rarely subequal (Python), or the left may be half as long as the right (Boa), or still less, only reaching to the last tracheal ring (Naja), or a rudiment, lying to the left of the apex of the heart (Tropidonotus); it may be absent altogether (Hydrophidæ, Viperidæ), and then the hinder part of the trachea is vascular. In Pelamis the bronchus stretches to the hinder edge of the lung. The thyroid gland is large; the right sex-gland and kidney lie in front of the left. The copulatory organs are paired, eversible sacs, as in lizards. Snakes are mostly oviparous, except some Hydrophidæ and Viperidæ, and the embryos have a premaxillary egg-tooth.

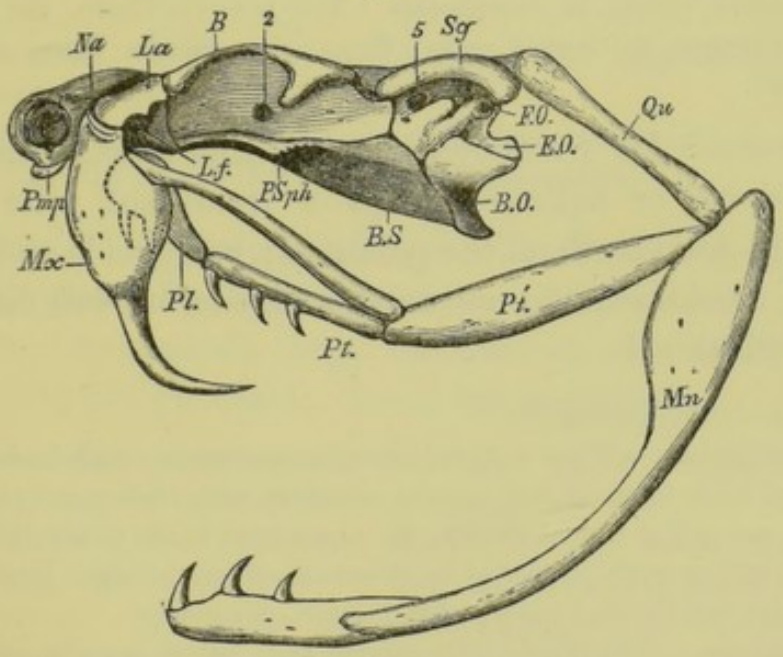
About 900 species are known, of which 300 are possibly poisonous. They are mostly natives of tropical countries, are long-lived animals, and feed at long intervals. They are divided into the following sub-orders :—

Sub-order I. *Solenoglypha.*—Poisonous; head mostly trigonal, well-defined (except in Atractaspis); neck narrow; tail moderate or short; maxilla short, small, often hollow (Crotalidæ), with few, fang-like, tubular teeth.

The concave upper end of the maxilla can bend backwards and forwards on the rounded front end of the lachrymal. The rod-like transverse bone (directly below *L.f.* in fig. 31) forms also a hinge-joint with the maxilla, and the lachrymal itself is often movable on the frontal. The short flattened palatines bear a few teeth, and lie external to the choanæ,

attached in front to the base of the skull by ligament. The long, dentigerous pterygoids are attached behind to the quadrate, so that when the mouth opens and the lower end of the quadrate is advanced, the pterygoid is pushed forwards, and, acting through the transverse bone, rotates the maxilla, and erects the poison fang. When the mouth closes, the quadrate, pterygoid and transverse bones are drawn back, so that the maxilla folds back, the poison fang becoming more horizontal. These fangs are long, curved and sharp, made of a single dentinal lamina rolled in to form a tube, whose margins unite along the back of the tooth in a suture, which is open near the tip as a slender fissure. Into the hollow of the tooth a duct is continued

Fig. 31.



Skull of Rattlesnake, *Crotalus durissus; Mn*, mandible; *Qu*, quadrate; *Pt*, pterygoid; *Pl*, palatine; *Mx*, maxilla; *Pmp*, premaxilla; *Na*, nasal bone; *La*. lachrymal bone; 2, optic foramen; *Sq*, squamosal; 5, exit of 6th nerve; *F.O*, foramen ovale; *E.O*, epiotic; *B.O*, basioccipital; *B.S*, basisphenoid; *Lf*, lachrymal foramen; *B*, supraorbital.

from a poison-gland seated below and behind the eye, under cover of the spheno-pterygoid muscle. In biting, the contraction of the muscle squeezes the poison out of the gland, and from the ampullar swellings in its ducts into the tooth, and thence into the wound. The fangs, when not in use, lie under hood-like folds of mucous membrane. The nature of the poison is not fully understood; it may be yellow (viper), green (rattlesnake), oily or watery, soluble in water, not in alcohol; does not cause death when applied to mucous surfaces, but, introduced into the blood, alters the corpuscles and

produces the development of minute granules (*Halford*). $\frac{1}{10}$th of a drop of viper poison will kill a mouse.

This Sub-order includes two families :—

1. *Crotalidæ.*—Rattlesnakes ; head often scaly, having a deep pit on each side between the nose and eye, dipping into the hollow maxilla, and lined by fine scales ; pupil vertically elliptical. Crotalus, the rattlesnake of North America, has at its tail several successive loose cuticular rings, which, on being shaken, produce the rattle. The young snake has no rattle, but after the first moult one ring appears, after the second two, &c. The subcaudal shields are undivided. Crotalophorus has a shielded head. In Craspedocephalus the tail ends in a spine.

2. *Viperidæ.*—Vipers ; mostly viviparous ; head with no facial pit ; scales keeled, except in Acanthophis. This includes Clotho, the African viper ; Cerastes, the horned snake ; Pelias, the common viper, or adder (P. berus).

Sub-order II. *Proteroglypha.*—Maxilla short, with several grooved or hollowed fangs in front, and solid teeth behind ; solid teeth on the palatines ; pterygoids and mandible ; head shielded ; not usually trigonal or well defined ; no loreal shield.

This includes two families :—

1. *Hydrophidæ.*—Water snakes ; laterally compressed, with keeled abdomen and high flattened tail ; caudal vertebræ, with high upper and lower spines ; one pair of frontal shields ; the nasals meet in the middle line ; nostrils directed upwards, protected by valves ; small poison fangs. Mostly from the Indian and Pacific Oceans. Ex. Pelamis, Hydrophis.

2. *Elapidæ.*—Cylindrical, with pointed tail, lateral nostrils and large fangs. This includes about twelve genera. Ex. Naja tripudians, the cobra ; N. haje, Cleopatra's asp ; Elaps, the coral snake.

Sub-order III. *Opisthoglypha.*—Maxilla long, with several long grooved fangs behind, and solid teeth in front ; head and abdomen with large shields. They are doubtfully poisonous, and include six families :—

1. *Homalopsidæ.*—Freshwater snakes : body round or slightly compressed ; head thick, broad ; tail prehensile, conical ; nostrils up-turned, valvular ; ventral shields small ; preanal bifid, subcaudals two-rowed. The American genera Calopisma and Helicops have no grooved teeth ; but in the

S. Asiatic forms fangs exist. Herpeton has two scaly tentacle-like appendages.

2. *Scytalidæ.*—Head defined, flat; pupil elliptical; mouth not very wide; fangs moderately long; tail pointed; scales smooth; one loreal; front maxillary teeth equal.

3. *Psammophidæ.*—Long, rounded snakes, with narrow head and a deep loreal groove; scales smooth; the fourth or fifth anterior maxillary tooth longer than the others.

4. *Dipsadidæ.*—Body long, compressed, slender; head short, broad behind, distinct from the neck; eye often very large; anterior teeth are never long without grooved ones behind. In Amblycephalus (Java) the mandibular rami are not separable, and there is no grooved tooth nor chin-groove.

5. *Dryophidæ.*—Tree-snakes; usually green, very long, slender; head long; snout often movable; eyes small.

6. *Calamaridæ.*—Body cylindrical, often rigid; tail short: front maxillary teeth short, equal. Oligodon has no palatine teeth.

Sub-order IV. *Aglyphodontia.*—Teeth all solid; premaxillæ generally large; palatines firmly joined to pterygoids; squamosals long, movable on the skull, and supporting the quadrates; facial bones extensile.

1. *Lycodontidæ.*—Front teeth of both jaws longest; hinder frontal shields large; rostral rounded; moderate rounded bodies.

2. *Colubridæ.*—Head moderately distinct; nostrils lateral; no long anterior or middle maxillary teeth; they may be *isodont* (equal and at equal intervals); *syncranteric* (the posterior longest, but the intervals equal); or *diacranteric* (the posterior separated by longer intervals than the front). Four sub-families are included: 1. Natricinæ.—Body moderate, with flat belly and depressed head; tail distinct from trunk; posterior maxillary teeth longest. Tropidonotus is the common ringed snake. 2. Coronellinæ.—Body moderate, with broad back and flat belly; tail not distinct; head depressed; always one loreal; ventral plates not keeled; scales smooth; the hinder teeth may be grooved. 3. Colubrinæ.—Tail not distinct; eye with round pupil. 4. Dryadinæ.—Long, not much compressed; tail long, not distinct from trunk; head distinct from neck; loreal often absent; eye large; pupil round; posterior frontals truncated behind.

3. *Rachiodontidæ.*—Teeth as before described; body moderate; jaw teeth weak; tail not distinct from trunk; eyes small; pupil round. Ex. Dasypeltis.

4. *Dendrophidæ.*—Very long, slender, pentagonal; head long, with the upper jaw exceeding the lower; ventral scales narrow; mouth deeply cleft; eyes large.

5. *Acrochordidæ.*—Head and body covered with rhombic, tubercled or tricuspid scales; the post-orbital bones are elongated; the small labial shields have a larger row above than over the orbits.

6. *Pythonidæ.*—Body long; tail round, prehensile; rudimental hind limbs present; premaxilla dentigerous; the labial shields are often pitted.

7. *Boidæ.*—Body slightly compressed; tail variably prehensile; head often shielded; rudimental hinder limbs, and no premaxillary teeth. This includes Boa and Eunectes, the anaconda.

8. *Erycidæ.*—Tail short, not prehensile; head indistinct; subcaudals one-rowed; no premaxillary teeth nor extended post-orbital bone; rudimental limbs.

Sub-order V. *Angiostomata.*—Gape small; quadrate fixed to the skull, as is the squamosal when present. The post-frontal is absent, and the teeth are never grooved. The skin covers the eyes, and is thick, and a rudimental pelvic girdle is present.

1. *Tortricidæ.*—Cylindrical, with small, scarcely discriminable head; very short tail; hind limb rudiments present; scales imbricate, smooth.

2. *Typhlopidæ.*—Small worm-like snakes; head small; conical scales in regular rings; pelvic rudiment as a pillar-like bone. Stenostoma has a united palato-pterygoid bone, a post-frontal and a pelvic rudiment, with a trace of a pubis. In others the teeth are only present in the short upper jaw, and no post-frontal nor pubis exists.

3. *Uropeltidæ.*—Vermiform; head pointed, small; no rudiment of a pelvic limb or girdle; few jaw teeth, and no palatine teeth. Ex. Uropeltis.

Order V. *Ichthyosauria.*—Extinct large aquatic neckless forms, with a large head, narrow snout, wide orbits; supra-temporal fossæ wide; infra-temporal fossa bridged by bone. The basi-occipital is separate, and forms the condyle. The ali-, pre-, and orbito-sphenoids are unossified. The parietals present a foramen, and may be completely divided, and the opisthotic is small. The premaxillæ are large; the maxillæ reduced to rod-like bones. The vomers are elongated, The pre- meets the post-frontal above the orbit. There are two intercalary post-orbital bones between the post-frontal and the large quadrato-jugal. The quadrate is fixed, and the posterior nares are far forward, bounded by the palatines. The pterygoids are attached pos-

teriorly by three processes to the basi-sphenoid, quadrate, and squamosal: in front they are slender rods lying internal to the hinder ends of the palatines. The anterior nares are bounded by the nasals, lachrymals and premaxillæ. The lower jaw has two rami joined by a long symphysis, into which the splenial as well as the dentary enters. The ribs have forked vertebral ends articulating with the two tubercles which take the places of the two transverse processes. The tail is nearly as long as the body. There is a wedge-shaped hypophysial bone interposed between the front arch of the atlas and the occipital, and another between the atlas and axis. The fore-limb is a paddle, with a narrow scapula, a wide coracoid meeting its fellow mesially, a T-shaped interclavicle, and two stout clavicles, which extend along the anterior margin of the scapula; the humerus is short and thick; the radius and ulna polygonal, followed by radial, ulnar, and intermediate bones, succeeded by one, two, three, four carpalia and metacarpalia. Some of the digit rows bifurcate. The hind-limb is also paddle-shaped, but smaller. The ilium does not join the vertebral column, but the ischium and pubis each form a symphysis. There is no sternum, but there are abdominal ribs, like those of Plesiosaurus. The eye had sclerotic plates. Ichthyosauria lived in the Lias and Chalk periods. The teeth were strong, conical, pointed, longitudinally striated on the surface, placed in a common alveolar groove. The vertebral bodies are biconcave, with ligamentary union of the arches, in place of a neuro-central suture. The intestine, probably, had a spiral valve. The tail had, possibly, a dorsal fin, as its end is often found dislocated.

CHAPTER XVII.

Crocodilia and Extinct Saurians.

Order VI. *Crocodilia* (*Oppel*).—Lizard-like reptiles, with four ambulatory legs, bearing webbed toes; clothed with hard, epidermal, often keeled shields, beneath which there are often underlying quadrate bony dermal scutes. The tail is clad with even girdles of scutes, each ring corresponding to a vertebra, and the whole is surmounted by a dorsal crest. The limbs are fringed each with a dermal crest, and the foot-digits, from the hallux outwards, have

respectively 2, 3, 4, 4 phalanges, the fifth toe having a rudimental metatarsal, and no phalanx. The skull is lizard-like, the bones being united by suture, and sculptured with surface-pits. The pterygoid bones form part of the hard palate, and unite by suture in the middle line, thus throwing the choanæ far back, as in ant-eaters. The teeth are conical, tolerably constant in number in each species, rootless, with large pulp cavities, lodged in distinct alveoli, and only found in the maxillæ, premaxillæ, and mandibles. The heart has separate right and left ventricles, but the two aortic arches communicate by a small opening (*foramen Panizzæ*).

There are 24 pre-sacral, 2 sacral, and at least 35 caudal vertebræ, which, with the exceptions of the atlas, axis, sacrals, and first caudal, are procœlous in living forms. The neuro-central suture persists, and the bodies are united by fibro-cartilages. The atlas consists of a basal, two supero-lateral, and one upper median part. The odontoid bone is separate; the atlas has two ribs attached to its basal part; the second pair of ribs is connected to the odontoid and to the axis. The five following neck vertebræ have double-headed ribs, the heads attached below and the tubercles above the neuro-central suture, their shafts lying parallel to the vertebral column, overlapping each other. The eighth and ninth vertebræ have ribs, running parallel to the first dorsal rib. The thoracic vertebræ have elongated capitular and tubercular processes for the corresponding parts of the ribs, at first separated by the neuro-central suture, but farther back the whole rib articulates with an exogenous transverse process, bearing two facets, and attached to the arch alone. The summit facet on the process is for the tubercle, a step-like facet at the base is for the head, but this approaches the tubercular facet, and finally fuses with it. The lumbar vertebræ are 2–4, with long transverse processes. The first sacral is concave in front and flat behind; the second is flat in front and concave behind. The first caudal is biconvex. The sacral vertebræ have wide ribs; the foremost caudals have ribs attached to the neuro-central suture, and all but the first, and sometimes the second, have chevron bones. Eight or nine of the dorsal ribs join the sternum by sternal ribs, and a strip of cartilage at the hinder edge of the foremost vertebral ribs unites them together, and represents the uncinate processes of Hatteria and birds. The pre-sternum is rhomboidal, and joins the last

cervical and first dorsal rib. The meso-sternum ends in two xiphoid cornua, to which the other sternal ribs are attached.

In the abdominal wall there are seven series of dermal bones over the recti muscles, commonly called abdominal ribs. Each series consists of two on each side, of which the inner meets its fellow of the opposite side, and forms with it an angle salient forwards; the outer is overlapped at its inner end by the inner bone. The dermal scutes form a complete (Caiman, Jacare) or partial sheath, especially developed on the back of the trunk, the neck, and occiput, rarely on the abdomen. These have epidermal shields over them, and their surface is sculptured with pits; many of the plates have a pair of glands opening at their hinder edge. The shoulder-girdle consists of a scapula and coracoid, with no fenestra nor cleft across the glenoid cavity; no clavicle, but a median interclavicle. The humerus is larger than the fore-arm, and has a strong spine; the ulna has no olecranon. The first carpal row consists of a large *radiale* (in which the centrale is probably combined) and small *ulnare*, with a pisiform on the flexor side; distally on the ulnar side is a cartilage representing the first and second carpalia, and an oval *lenticular* bone representing the fused third, fourth, and fifth carpalia, and supporting three metacarpals. The three inner digits are the stronger, the two outer nailless; the pollex has two, the succeeding fingers three, four, four and three, phalanges respectively. The pubis and ischia form symphyses; the ilium abuts on the sacral ribs. The hind-limbs are larger than the fore. The tibiale, intermedium, and centrale unite to form an astragalo-scaphoid bone, almost immovable on the tibia, but freely movable on the calcaneum; the large outer and small inner distal tarsals are immovably united. The "heel" process of the calcaneum is larger than in any other reptile. The palatine plates of the maxillary and palatine bones are large, unite suturally in the middle line, concealing the vomers, except in Jacare, and separate the nasal and mouth cavities. The pre- and orbito-sphenoids are absent or cartilaginous; the alisphenoids are large; there is a membranous inter-orbital septum, no parietal foramen, a large immovable quadrate, fixed to the pterygoid, which sends a process that touches the inner surface of the mandible. The basi-occipital chiefly forms the condyle, and the supra-occipital is excluded from the border of the foramen magnum. The basi-cranial bones are pneumatic, even the roof-bones contain air-spaces, and from the air-holding quadrate an ossified canal passes into the articular part of the mandible. There is an unpaired parietal and frontal, and two nasal bones. The tympanum communicates by a wide opening with the mouth in embryonic crocodiles, but the basi-sphenoid and basi-occipital, extending downwards, divide the Eustachian canals into three—one large median, which ascends between the basi-sphenoid and occipital, and then

divides into right and left branches, each of which again branches into an anterior (basi-sphenoidal) and a posterior (basi-occipital), both of which enter into the tympanum. The two lateral tubes ascend vertically to communicate with the posterior of these branches. The jaws are long and strong. The skull has strong transverse bones. The ethmoids remain cartilaginous, and the lachrymals are imperforate. The parotic processes are large. The mandible has five parts in each of the firmly united rami. The hyoid consists of a minute stylo-hyal cartilage, and two bony cerato-hyals attached to a flat, cartilaginous basi-hyal. The teeth are irregularly replaced by others which grow on the inner side of the first set. The tongue is flat, immovable, and there are no salivary glands. A soft palatine fold forms a valve to shut off the mouth from the pharynx, and there are four tonsils. The cerebral hemispheres are large. The cerebellum has a distinct middle lobe and small bird-like lateral ones. The optic lobes are not covered by the cerebral hemispheres. The glosso-pharyngeal nerve arises with the vagus. There is a valve-like external ear, capable of closure by muscles, a lageniform cochlea, two eyelids, and a membrana nictitans, moved by a pyramidal muscle arising from the inner side of the eyeball, and inserted into the membrane (this sends no fibres to the lower lid, as it does in Chelonia). There are no sclerotic bony plates, but there is a rudimentary pecten. The pupil is vertical, and the iris has striped muscular fibres. The sympathetic nerve in the neck lies in the vertebral canal. The round stomach has a muscular coat, with two tendinous plates, from which the fibres radiate, as in a bird's gizzard. There is an *antrum pylori* separated from the duodenum by a narrow opening, a short intestine, and no cæcum. Each organ has a special serous sac for its reception. In the heart the septum between the *cavum venosum* and *c. asteriosum* is perfect, thus dividing the ventricle. From the left ventricle arises the right aortic arch, which gives off the innominate artery, and forms the abdominal aorta. From the right arises the pulmonary artery and a left aortic arch, which crosses the right, and where they cross the foramen Panizzæ is placed. The left gives off visceral branches, and joins the right by a very small branch. The cavum pulmonale has its septum as a small muscular band. The carotid is single on the under part of the neck. The liver is two-lobed. The larynx has no epiglottis. The bronchi traverse the lungs, giving off lateral pouches like those in the lungs of lizards. The tubes lose their cartilages soon after entering the lung, and muscular fibres in the peritoneum act in respiration. There are two musk-glands beside the lower jaw, and others in the longitudinally-opening cloaca, which has no urinary bladder. The ureters open behind the rectum. The ovaries are grape-like. The penis is single, as in Chelonia. The eggs have a thick calcareous shell. There are twenty-five living species, divided as follows:—

Sub-order I. *Procœlia.*—Pre-sacral vertebræ procœlian; choanæ bounded below by the pterygoids. This includes three families:—1. *Alligatoridæ.*—American; head short, broad; nasal bones entering into the border of the anterior nares; teeth unequal, the first and fourth of the mandibular teeth fitting into pits in the overlapping upper jaw when the mouth is closed; premaxillo-maxillary suture straight or convex forwards. Mandibular symphysis not extending beyond the fifth tooth, and the splenial not extending thereinto. Ex. Alligator, Jacare, Caiman. 2. *Crocodilidæ.*—Teeth strong, unequal. The foremost mandibular teeth fit into a fossa in the premaxilla, and the fourth (canine) fits into a maxillary notch; the symphysis of the mandible extends to the eighth tooth, and the splenial is not continued into it. There are no ventral shields in any living form. The choanæ far back and elongated. This includes the genus Crocodilus, natives of Egypt, India, Sunda, Molucca Islands, &c. 3. *Gavialidæ.*—Nearly isodont, the front mandibular teeth lying in premaxillary notches; mandibular symphysis reaching to the fourteenth tooth, and the splenials involved therein; premaxillary suture convex backwards; no ventral shields; nasal bones excluded from the anterior nares. Ex. Tomistoma, from Borneo; Gavialis, from the Ganges.

Sub-order II. *Teleosauria.*—Extinct Mesozoic reptiles, with terminal nares; pre-sacrals amphi-, sometimes opistho-cœlian (Streptospondylus, Cetiosaurus (?)).

Sub-order III. *Belodontidæ.*—Triassic reptiles, with nares at the upper part of the base of the snout, near the orbits.

Order VII. *Dicynodontia.*—Triassic, lizard-like reptiles, with biconcave vertebræ; one long rootless tooth in each upper jaw (Dicynodon), absent in Oudenodon; premaxillæ united and, like the mandible, toothless, probably inclosed in a turtle-like beak; four or five vertebræ unite in the sacrum; clavicles none. The ischium, as well as the ilium, joins the sacrum, and the pubes and ischium coalesce, closing the obturator foramen. A foramen parietale exists, and the anterior ribs have bifurcate heads.

Order VIII. *Ornithoscelida.*—Mesozoic reptiles, some with dermal scutes, having some of the foremost vertebræ opisthocœlian, the rest flat or slightly amphicœlian; teeth never ankylosed, in sockets in both jaws; quadrate immovable; no clavicle; sacrum of four or more crocodilian or bird-like vertebræ. The ilium stretches in front of the acetabulum, whose floor is not complete. The long ischium is possibly united medially to its fellow. The pubes are narrow; the femur moderate, with a large trochanter; the tibia has a large outer crest, and the fibula is slender. The astragalus has a short ascending process, and is immovable on or ankylosed to the tibia. They had probably a broad sternum and sternal ribs, as well as abdominal bones. The fore-

limbs are shorter than the hind, the metacarpals are immovably united together, and the third digit is the longest. They are divisible into two groups—1, Dinosauria, including Iguanodon, Megalosaurus, &c.; and 2, Compsognathida, including the small Compsognathus longipes, about twenty inches long, which has a bird-like head, with many teeth, long neck vertebræ, a short femur, a long tibia, and small fore-limbs. The astragalus is ankylosed to the tibia, but the distal tarsals, though immovable, are yet separate. One specimen of this kangaroo-like form has been found in the Solenhofen lithographic slate.

Order IX. *Pterosauria.*—Possibly warm-blooded Mesozoic flying reptiles, with long necks, light and delicate heads, with a small brain-case; sometimes the temporal groove is bridged over by bone stretching between the post-frontal and the squamosal. The sclerotic has a bony ring; the teeth are conical, in sockets, either in the whole jaw (Pterodactylus) or only in the hinder part of the jaw (Rhamphorhynchus). The cervical vertebræ are seven or eight. The atlas is short, the axis long; there are about 15 dorsal, 2 lumbar, and 3-7 sacrals; the tail is short (Pterodactylus) or long (Rhamphorhynchus). The broad sternum has a keel, and there is no clavicle. The dentary bones of the mandible are fused together at the symphysis; the occipital condyle is inferior. The coracoid has no fontanelle. The hind-limb has a prepubic (marsupial) bone, as well as a pubis; an imperfect fibula, which, like that of a bat, coalesces with the tibia at the distal end; the digits are four or five. The fore-limb has a crested humerus, four separate metacarpals, of which the ulnar one is larger in thickness than the others; the pollex has 2, the succeeding digits 3, 4, 4 phalanges. The last digit (fourth) has long phalanges for the support of the wing; the three radial digits are clawed. Ornithopterus has two joints only in the ulnar digit; the other genera have four. The brain, if we may judge from the skull, was rounded like that of a bird, all the large bones were pneumatic. There is a separate proximal carpal bone, but the distal is ankylosed to the metacarpal. From the size of the head, it is probable the centre of gravity was farther back than in either a bird or a bat. The wing membrane was probably like that of Draco. Pteranodon, from the Cretaceous rocks of Kansas, had no teeth, and the vertebral borders of their scapulæ articulated with one of the dorsal spines. Some of these had a spread of wings not less than twenty-five feet (*Marsh*).

CHAPTER XVIII.

General Characters of Birds.

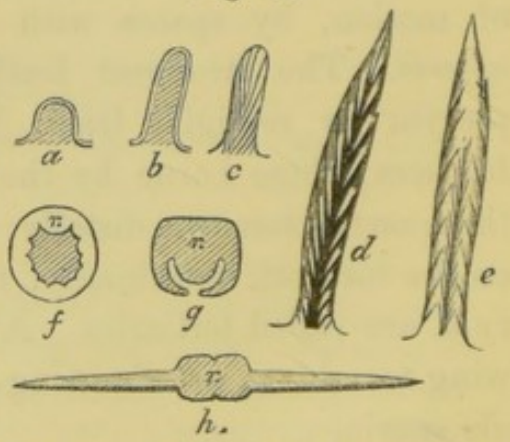
Class II. Aves. Birds.—Warm-blooded (103°–104° F.) bipeds, having fore-limbs generally fitted for flight, the bones dense, rich in earthy matter. The surface is clothed with feathers, each of which consists of a central shaft and lateral barbs. The strongest of these are called contour-feathers, or pennæ; the weakest are clothing-feathers, or plumes. The contour-feathers are rarely in continuous series, as in penguins, mostly in special tracts called *pterylæ*, separated, for convenience of motion, by spaces with no contour-feathers, called *apteria*. The strongest feathers are those of the alar pteryla or remigial tract, including the large wing-feathers; those borne by the hand are called primaries; those on the forearm, distally, are called secondaries; those on the forearm, proximally, reaching to the humeral pteryla, are called tertiaries. Along the upper edge of the wing membrane are the wing-coverts; on the thumb is the ala spuria.

The neck is freely movable, and usually equals the other vertebral regions in length, having 9 (sparrow)–25 (swan) vertebræ, with sub-cylindrical saddle-shaped or opisthocœlous articular ends, small spines, and often hypapophyses. The dorsal vertebræ are 3 (white stork), 4–11, ankylosed or free.

The bones contain red marrow in the embryo, which, as growth advances, is often absorbed, and replaced by air-cavities. At an early stage, dermal papillæ form over the surface, each of which is grooved, one deep furrow

running from base to apex along one (axial) side, giving off numerous lateral oblique grooves, which become shallower as they approach the opposite (*antaxial*) side. The surface of the papillæ secretes an envelope of epidermal plasma, which, moulded in the grooves and drying as it is pushed off by new formations below, splits anteriorly into an epidermal branched process, or feather. The papillæ, later on, sink into dermal pits (feather follicles). The feathers thus formed (plumules) consist each of a short scape and lateral barbs, which are free from each other. In most birds a second growth of larger feathers takes place in some regions, but the papillæ for their secretion form at the bottom of follicles, and have a deeper axial groove. Contour feathers are moved by 3–5 small dermal muscles. An intermediate group, semiplumes, occupy the edges of each feather-tract; sometimes long, as the ornamental feathers in Leptoptilus Marabou. As the feather grows, the papilla elongates until the full size is reached, when the vascular matrix shrivels. Each contour-feather consists of, 1st, a tubular quill, or *calamus*, the last growth from the papilla before shrivelling, with a terminal opening (lower umbilicus), through which the base of the papilla entered, and a fissure above (upper umbilicus), where the papillary sheath had ceased to split; 2nd, the *vexillum*, having a four-sided solid axis (*rachis*), with a groove on its inner surface continued from the upper umbilicus: from this axis spring the two lateral sets of radii or barbs, long, slender, tapering plates, linked to each other by marginal processes (barbules), usually toothed with straight barbicels or hooks, which interlock with the thickened margins of the barbules of the neighbouring barbs. The lowermost barbs of each feather are free. The barbules may have *barbulules*, as in the feathers of a peacock's tail. As the feather papilla may have an antaxial groove, there is often a second, usually a small vexillum, or aftershaft (*hyporachis*), under the main shaft.

Fig. 32.



Development of Feathers (diagrammatized from sections of feather-papillæ in the blackbird and goose): *a*, *b*, early stages of feather-papillæ; *c*, early stage of papilla, showing grooves; *d*, full-grown feather-papilla, preaxial side; *e*, the same, postaxial side; *f*, section of papilla with its epithelial sheath, *n*; *g*, section of feather opposite the umbilicus superior; *h*, transverse section of feather, showing *r*, the rachis.

Of clothing-feathers, some have a slender axis and rudimental barbs (*filoplumes*); others have a hair-like shaft with no barbs (*vibrissæ*). Fine vibrissæ margin the eyelids of diurnal birds of prey, toucans and ostriches. Some plumes have the barb-tips breaking off as dust (powder-down), and

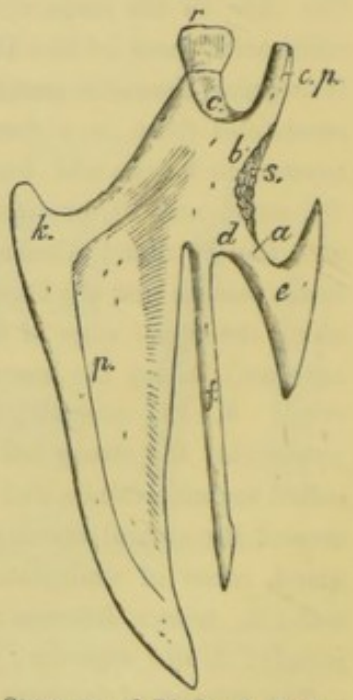
these may be scattered (and transitory, as in Gypætus), or dorsal, or on each side of the notæal tract (some kites); or post-emoral and inguinal (herons, Leptosoma, tinamous). As a rule, the smaller the contour feathers in a pteryla, the smaller is the apterium. Some tracts are densely, others sparsely feathered (*densi-*, and *rari-pennæ*). The pterylæ are: 1. Pt. notæi or spinalis, from the nape to the tail, the front of it being uncovered (aprica), and the hinder part covered (tecta) by the folded wings. It varies in breadth in different parts, or may have real gaps or false ones covered by degraded contour-feathers. It may be rhombic (many passerines), elliptical (oriole), with a central island, or divided into parts. 2. Pt. humeralis, a narrow band from the middle of the shoulder, running parallel to the scapula along the humerus; strong in the Aetomorphæ. 3. Pt. femoralis; an oblong band on the outside of each thigh, sometimes coalescing with the Pt. notæi; wanting in Gypaetus, Falco brachypterus, and Bubo. 4. Pt. gastræi; simple, or divided into two parallel lateral tracts, and stretching from the chin to the anus, it bifurcates at the breast, and its branches often unite with those of the Pteryla humeralis. Three parts are recognised in it:—gular, thoracico-gastric and a lateral offshoot on each side of the breast; sometimes there is a fourth or furcular part. 5. Pt. colli lateralis, only present in herons and bustards (Tetrax); paired, intervening between the Pt. notæi and Pt. gastræi on the neck, and continuous into both, or only into the P. notæi (Cancroma, Nycticorax). 6. Pt. capitis; small on the head, passing into the Pt. notæi and gastræi. 7. Pt. alaris, before described; along the upper edge of the upper arm is the upper accessory wing (parapterum); along the lower surface is the lower accessory wing (hypopterum). 8. Pt. cruralis; double on the legs. 9. Pt. caudales on the pygostyle; the strong tail-feathers are called rectrices; the tail coverts are called tegmina caudæ, and are superior and inferior. 10. Pt. analis; a ring around the cloacal opening. 11. Pt. uropygialis; a circlet around the fat gland, often of umbellated down feathers. The Apteria are, 1, *laterales colli;* 2, *trunci laterales;* 3, *mesogastræi;* 4, *spinale* (in middle of Pt. notæi); 5, *alæ superius;* 6, *alæ inferius;* 7, *crurale;* 8, *capitis.*

The colours of feathers depend on an entoptic pigment said to contain copper in Touracous. The plumes are changed by periodic moulting; the colours are livelier in the males, and especially in young birds. Feathers are made of keratin; they are bad conductors and imperfect radiators of heat. The skin has no sudoriferous glands, nor sebaceous follicles. A bilobed gland with branched tubular follicles, opening by a central single or pair of ducts, covered by skin or by the tendinous expansion of the levatores caudæ, is placed on the pygostyle, between the quills of the rectrices. It is largest in Pandion, smallest

in Caprimulgus, absent in Otis, Casuarius, ostrich, Rhea, some parrots, Argus, Goura, &c.; under stiff feathers in penguins. Male birds often have crests, wattles, spurs, &c. The first-named appendages may contain erectile tissue.

The upper five or six cervical vertebræ bend freely forwards; the middle (6–13) bend backwards; the lowest (13–1st dorsal) move slightly forwards. The atlas is a ring with a strong, often bony (cockatoo, Picus, raven) transverse ligament, small transverse processes, and no spine. The odontoid is ossified to the axis. The others have generally ankylosed rudimental ribs, bounding the canal for the vertebral artery, in which lies the cervical part of the sympathetic nerve. The foremost dorsals have their ribs joined by hinge-joints to sternal ribs, which ossify primarily by ectostosis. They may have hypapophyses and spines. Each rib has a bifid head uniting with the body, and transverse processes, and on its shaft are uncinate processes. The articular faces of the bodies are like those of the cervicals. The lumbars are 1–5, free, or the hinder may ankylose to the sacrum. The first has broad transverse processes; the others have these farther forwards, and ossification extends into them from the centrum as well as from the neural arch. The true sacrum consists of 3–5 vertebræ, with no expanded ribs. The last pair of lumbars and upper caudals may unite with them, so as to form a long single bone of eleven (Alcedo), twelve (Ciconia, Fratercula), thirteen (Fulica), &c., pieces. The tail is short; the caudals are 7–9, or many (Saururæ). The foremost have wide transverse processes touching the ilium; the last few unite into a ploughshare bone, or *pygostyle*, supporting the oil-gland and the rectrices. The movable vertebræ have between them biconcave discs of fibro-cartilage (menisci), perforated in the centre attached round their rim, sometimes reduced to fibrous rings; a synovial membrane lines the central hollow, and is prolonged round the free thin edge of the ring. In the tail the menisci are attached to the vertebral faces, and the synovial cavity is small or none. The inner sheath of the intervertebral part of the notochord, containing altered notochordal cells in the embryo, is modified into a ligament lying in the centre of the opening of the menisci.

Fig. 33.



Sternum of Bird: *k*, keel; *p*, pectoral ridge; *f*, internal xiphoid process; *e*, external xiphoid process; *d*, pleurosteon; *c*, coracoid facet; *r*, rostrum; *c.p*, costal process; *b*, facets for the ribs.

The sternum begins by endostosis, in cartilage, and, except in Ratidæ and Alectoromorphæ, is completed by ectostosis. It has no medial abdominal rib-bearing processes, and always has two lateral ossific centres (pleurostea). A median single point of ossification projects forwards as a keel (lophosteon). The adult sternum presents a keel, having at its front edge a median rostrum, bordered by two grooves for the coracoid bones, outside which are costal processes with lateral sterno-costal regions for the ribs; behind these are on each side an outer and inner xiphoid process, and sometimes a middle xiphoid process.

There may be a second pair of lateral centres, developing lateral, back-directed processes (*metostea*). Supero-lateral paired centres (*coracostea*) exist in Turnix, and an infero-median centre exists in Dicholophus (*urosteon*). Rhea has two *pro-ostea* in front of the first rib.

Fig. 34.

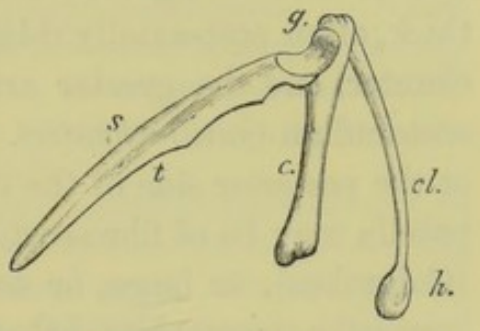


Fig. of Shoulder-girdle of Bird: *h*, hypocleidium; *cl*, clavicle; *c*, coracoid; *t*, origin of teres major; *s*, scapula; *g*, glenoid cavity.

The scapula is long, narrow, and curved, with no prescapula, nor separately ossified superscapula, nor epicoracoids. The clavicles may be absent (ostrich, Agapornis, Melopsittacus, &c.), separate (emu, some owls, syndactyls), or united into a furculum or merrythought. The humerus has a transversely elongated head, a pre-axial pectoral crest, a post-axial concavity, and a pneumatic foramen, for the admission of air. The shoulder and elbow move only in certain planes, pronation and supination being impossible. The carpals are two—a small radial and a larger ulnar; the metacarpals are 1–3 (four in Archæopteryx). They may be all ankylosed, or the first may be free (ostrich, diver). The pollex is

clawed; the index has usually two or three, the middle, one or two, rarely three phalanges.

The long ilium stretches forwards over the lumbar region, and backward post-acetabularly; it is attached to the whole so-called sacrum. The pubis is rib-like, free from the ischium in front, and does not unite with its fellow (except in Struthio). The ischia stretch backwards, and may unite together dorsally (Rhea), never ventrally. They join the ilia by suture or by an ossified sciatic ligament, and are separated from the pubis by a space, in front of which is a round post-acetabular hole for the obturator tendon. The acetabulum has a membranous fundus and a ligamentum teres. The femur is short, thick, often post-axially ridged, has no neck nor lesser trochanter, and the greater articulates with the brim of the acetabulum (*antitrochanter*). It has a pneumatic foramen at the posterior side of the neck, except in Apteryx. The patella may be of fibro-cartilage (Apteryx), or bone, small (Colymbus), or large, or double (ostrich). The fibula is generally incomplete below, articulates with the femur above, and is often ankylosed to the tibia. The knee has two semi-lunar inter-articular cartilages, and two inter-articular crucial ligaments. The astragalus ankyloses early to the lower end of the tibia, forming one bone (*tibiotarsus*), which has a large cnemial process in front at the knee end; below and in front is a transverse bridge of bone, under which pass the extensor tendons of the toes; the lower articular surface is pulley-like. The metatarsals early ankylose together, and with an ossified cartilage, representing the distal tarsal bones, thus forming a *tarso-metatarsus*, whose distal end retains the traces of the primitively separate parts. The metatarsus of the hallux is free, joined to the rest by ligament (except in Phaeton).

The fifth digit is always absent. The tarso-metatarsus has often a hypo-tarsal process behind, which is grooved, or perforated for the flexor tendons. The hallux has usually two phalanges, the second toe has three, the third four, and the fourth five.

There are three primary kinds of feet—walking, wading, and swimming. These are divided into the following forms:—1. *Pedes fissi*, with all the toes separate, three directed forwards; 2. *P. ambulatorii*, the two outer united at the base; 3. *P. gressorii*, the three foremost all united at the base; 4. *P. semi-colligati*, the two outer united by a very short web; 5. *P. colligati*, wading feet, with the three foremost webbed at the base; 6. *P. insidentes*, walking feet, with toes as last. 7. *P. adhamantes*, with the four toes turned forwards; 8. *P. cursorii*, with two or three fore toes, and no hinder; 9. *P. scansorii*, with two fore and two hind toes; 10. *P. cuculiformes*, with the outer toe capable of being turned either forwards or backwards; 11. *P. fisso-palmati*, the toes separate, each with a continuous, membranous margin; 12. *P. lobati*, this membrane lobed; 13. *P. semi-palmati*, the toes half webbed; 14. *P. palmati*, all the front toes webbed as far as their tips; 15. *P. stegani*, the fourth toe included in the web.

The skull-bones ankylose early. There is a spherical (tinamou), reniform (ostrich), or elliptical occipital condyle, usually formed by the basi-occipital, in some (ostrich, penguin) by the ex-occipital as well. The supra-occipital ossifies from one (pigeon) or two centres; the foramen magnum is large, and sometimes (Columba, Didus) supra-occipital vascular holes exist. The occipito-parietal fontanelle may be open (flamingo, auk, crane, plover, &c.), and there may be a nuchal post-occipital ossicle in the space between the two biventres muscle (Phalacrocorax, Plotus). The basi-occipital has a sub-condyloid fossa for the front ring of the atlas in flexion of the head. There is a central basi-sphenoid Eustachian tube and a long rostrum. The pre- and orbito-sphenoids vary in degree of development. The mesethmoid appears on the front of the skull between the frontals and nasals in the ostrich, goat-suckers, and many young skulls; it has no cribriform plate, except in the Apteryx. The prefrontals are united to the ethmoid. The tympanic is rudimental or none, often distinct in the embryo. The lachrymal is large, and joins the prefrontal internally, and is sometimes fused into it; it ankyloses to the frontal, and touches the nasal in Turdus, Alauda, &c.: these states are reversed in Vanellus; it joins the palate in the ostrich, the malar in Balæniceps, auks, &c., the maxillæ in Podargus, the ethmoid in the raven, &c. The zygoma is complete; the quadrato-jugal is slender, and joins the

jugal in front, and its hinder end fits into a pit in the outside of the quadrate. These are never pneumatic. The inter-orbital septum is partly bony. There are no long parotic processes nor post-temporal fossæ, but there is often a space between the lachrymals, nasals, and maxillæ. The vomers are separate, united, or none, and when present they join the palatines behind, except in the ostrich. The beak is flexibly united to the frontals by the long nasals and frontal processes of the premaxillæ; this forms a movable joint in parrots. The pre-maxillæ have three branches—frontal, palatine (joining the palate bone), and maxillary, fusing with the maxilla, and forming the edge of the beak.

The maxillæ are slender, joining the jugals behind, sending maxillo-palatine processes inwards, to form part of the roof of the mouth; sometimes an ossified tendon stretches from the jugal to the mandible, the *metagnathium* of *Nitzsch*. The choanæ are between the palatines and the vomer, neither the former nor the pterygoids uniting to separate the mouth and nose. The nostrils are at or near the base of the beak (except in Apteryx), and supra- and infra-orbital bones sometimes exist (Casuarius and Rhea, *infra* alone in Sterna). Accessory lachrymals of a similar nature may exist (3–4 in the ostrich and Psophia). The bony opening of the anterior nostrils may have a rounded hinder edge, as in the domestic fowl, or may be prolonged backwards as a fissure, behind the level of the premaxillo-frontal suture, the former condition has been named *holorhinal*, the latter *schizorhinal* (*Garrod*). There is often a post-orbital exogenous process of the frontal (rarely autogenous, if so it may ankylose to the alisphenoid). The long concave palatines lie under the maxillo-palatine processes in front, and join the premaxillæ; behind they touch the pterygoids, and often articulate with the basi-sphenoid rostrum. There is a tympanic bone in the pea-hen, Picus viridis, &c. (*Parker*). The movable pterygoids are oblique, the inner front ends are jointed to each other, and frequently to the rostrum of the basi-sphenoid, on which are often developed lateral basi-pterygoid processes for articulation, postero-externally with the inner articular head of the distal end of the quadrate. The quadrate is movable, articulates with the alisphenoid, pro-otic, and squamosal proximally, with the mandible below, with the pterygoid internally, and the quadrato-jugal externally. The air enters the quadrate at its squamosal process. The ramus of the mandible consists of six pieces—articular, angular, supra-angular, dentary, splenial, and complementary; the dentaries unite early in the middle line, the symphysis varying in depth from $\frac{2}{3}$ the length of the mandible (in Buceros) to $\frac{1}{71}$ (in the pelican). The hyoid arch consists of a pair of anterior and of posterior cornua, a uro-hyal body, and an ento-glossal style. The cornua are fastened to the skull in Picidæ and Trochilidæ.

The long spines are well-marked, especially in the neck. The dermal muscles are widely expanded laminæ or separate erectores plumorum. There is no splenius, a strong biventer cervicis; there are inter-articulares, as well as inter-spinales, and there may be one or no scalenus, a levator, and a depressor coccygis, an upper (pubic) and a lower (ischiatic) adductor of the tail attached to the pygostyle, and a quadratus coccygis attached to the shafts of the rectrices. There are three strata of abdominal muscles, and an anterior rectus. Triangularis sterni has 3 slips (Columba, Psittacus, Ara), 4 (Larus, Avocetta), 5 (Sterna), or 6 (Turdus, &c.) The quadratus lumborum is small and triangular. Trapezius springs from the lowest cervicals and upper dorsals, and inserted into the hinder edge of the scapula and the outer end of the furculum, sometimes split (Falco, Charadrius, Œdicnemus). The rhomboid underlies it, and is as usual; a short strong coraco-sternalis exists separate from the sterno-costalis. There is a large infra-spinatus (teres major of *Selenka*) from the scapular dorsum, and a smaller detached slip (infra-spinatus, *ibid.*) sometimes above, but overlapped by it. The sub-scapularis from the under surface of the scapula is often split by the anterior slip of the divided serratus magnus. There are three coraco-brachiales—one stretching from the sternum and coracoid to the humerus (often called third pectoral), a second from the inner side of the coracoid and sterno-furcular ligament, inserted beside the last; a third underlies the scapular head of the biceps—they seem to represent the hind-limb adductor magnus longus, and pectineus respectively. The scapular deltoid may have a slip from the humero-scapular bone. There are two parts of the latissimus dorsi, one from the dorsal spines, and a lower from the lowest angle of the scapula, or the ribs below it; the lower is inserted farther forward; they are united in the penguin. The acromial deltoid (from coracoid and epicleidium) is continued by one, two, or three tendons into the membrane of the wing in front of the elbow; the chief tendon is elastic at its lower end, then becomes fibrous, and extending as far as the base of the pollex metacarpal. The great pectoral is enormous, and its origin is from the keel of the sternum; sometimes it is divisible into an upper and lower part. The subclavius (pectoralis secundus) is very large and penniform, lies under the last, passes over the inner side of the scapulo-coracoid joint through the foramen triosseum, where it is often clasped by the meso-coracoid, and ends in the humerus; two coraco-humeral gemelli supplement it at its insertion.

The biceps is two-headed, coraco-humeral in origin, radial or radio-ulnar in insertion; the brachialis small, arising low on the humerus. The two-headed triceps is scapulo-humeral in origin; the dorsi-epitrochlearis arises from the middle ribs, and is inserted at the base of the secondary feathers.

There are two humero-radial pronators; a slip of the second may be detached and go to the ulna (*Weidemann* describes this as a separate muscle). A short, but no long supinator is present, and the radialis internus arises from the ulnar only; sometimes it has a lower second slip (radialis internus profundus). There is a single radialis externus; the common extensor sends a tendon to the pollex, and there is a separate extensor indicis and an extensor pollicis longus, together with two digital flexors; there are three short polliceal muscles and two interossei. There are no sterno-mastoids, omohyoids, pharyngeal constrictors, nor psoas parvus. Several remarkable muscular slips exist in the wing attached to the patagium, for the purposes of varying the tension of its several parts, and acting on the feathers. Some of these have been shown by *Mr. Garrod* to be of taxonomic value.

Sartorius is large, and inserted into the patella or tibia. The biceps femoris tendon passes through a tendinous ring in the origin of the gastrocnemius; the gluteus maximus is very small, and there are two or three deeper glutei, of which the medius is the largest. Iliacus is absent or small, with a marginal origin. Popliteus often arises from the fibula. Peroneus longus arises from the outer side of the knee and femoral condyle; its tendon, passing outside the ankle, joins the first perforate flexor (plantaris) of the middle or third toe. Rectus femoris (Gracilis, *Autt.;* Ambiens, *Garrod*) may be absent, or may arise above the acetabulum as a slender muscle whose tendon passes in a ligamentous sheath over the knee, winds to the outside of the fibula, and joins the origin of the plantaris, which sends tendons to the three toes. The flexor digitorum sublimis pedis sends tendons to the second phalanges of the three anterior toes. The combined tendons of the flexors profundus and hallucis send slips to all the toes. These tendons, passing behind the mesotarsal joint, are so arranged that the weight of the body flexing the joint makes tense the tendons and forcibly flexes the toes, making them grasp the perch firmly. Division of the rectus does not prevent perching, but causes inversion of the toes. In the hind-limb there are also the following muscles: femoro-caudalis, from the upper part of the back of the femur to the sides of the caudal vertebræ; femoro-caudalis accessorius, below the last from the femur to the ischium; flexor accessorius, from the lower end of the femur into the semitendinous tendon. These muscles are of taxonomic value, as has been pointed out by *Mr. Garrod*, and in order to be able briefly to indicate their respective presence or absence, he uses the letters A, B, X, Y, to represent respectively the femoro-caudal, the accessory femoro-caudal, the semitendinosus, and the accessory semitendinosus; thus the muscular formula of the falcon is A, while that of the secretary bird is B, X, Y; meaning that while the falcons possess only the first muscle of this group, the secretary bird wants this muscle only.

Teeth are absent in recent birds, but the horny sheaths of the mandible and maxillæ are used for dividing the food. The upper jaw-sheath has a dorsal ridge (*culmen*), an apex (*dertrum*), and edges often sharp or toothed (*thomia*). The mandible sheath has a tip (*myxa*), an under margin (*gonys*). At the base of the beak is a soft skin (*cera*), covering the root of the horny portion. A naked or feathered, often coloured, stripe (*lore*) stretches between the beak and the eye. There are no lips. Tooth-like tubercles exist along the bill of an embryo parrakeet (*St. Hilaire*), which may be rudimental teeth. (In another species of parrot, *Blanchard* describes undoubted tooth-germs with caps of dentine.) Salivary glands are absent or small; buccals (Coracomorphæ), anterior palatine (Ætomorphæ), follicular palatine or lingual (Gallinula) glands may also exist, and submaxillary (two pairs in turkeys). The tongue is generally angular, pointed, and can often be suddenly protruded; it is usually coated by a horny epithelium, with no papillæ except at the base, to which branches of the glosso-pharyngeal nerve are distributed; it is absent as a free organ in Plotus. The inferior maxillary nerve has no gustatory branch. The tongue has lateral recurved spines in the flamingo and goose, a brush-like tip in the humming birds, a bifid tip in some raptores. The dilatable œsophagus may have a submental pouch (cormorant, pelican); the canal lies usually to the right in the neck, and has a transverse muscular coat externally, a longitudinal internally; above and behind the furculum it dilates usually into a crop (*ingluvies*), from which, in Touracous, a species of rumination has been noticed. Below this is a lower œsophagus leading to the glandular stomach (*proventriculus*), secreting gastric juice in its racemose follicles. Then follows a constriction, followed by the gizzard (*gigerium*), or

muscular stomach, placed below to the left and behind the liver, lined in granivorous birds by dense rugous epithelium, often holding stones, and made up of several sets of transverse and oblique striped fibres, passing from one lateral radiating tendon to another. The cardiac and pyloric openings are close together, the latter often guarded by a mucous fold.

The stomach is thin-walled in Ætomorphs and fish-eaters. The intestine is three (eagle), five (hen), or nine times (ostrich) the length of the body. The looped duodenum may be saccularly dilated (Ratidæ), and always incloses the pancreas in its bend, and receives the bile and pancreatic ducts. The small intestine has sometimes internal mucous folds, often long villi and Peyerean glands, sometimes (Gallinula, ibis) it has a diverticulum at the persistently dilated end of the duct of the umbilical vesicle. The cœca may be none (stork, Toucan, Yunx, Buceros, parrot, Alcedo, Touracou, &c.), rarely one (heron, bittern, Podiceps minor), or two, rudimental (Gypogeranus), or very long (owl, ostrich), or three. There is no distinction between large and small intestine in the Phalarope. The large intestine may be short and straight, or long and curved (ostrich), and ends in a cloaca. The liver has right (larger) and left lobes, sometimes a spigelian (pigeon, cormorant, swan) or left central (pheasant). All but parrots, toucans, cuckoos, ostrich, some pigeons, Numidæ, Anthropoides, and Botaurus, have a gall-bladder, with hepato-cystic and hepatic ducts. The pancreas is usually bent, two- or three-lobed, with one (quail, Ratidæ, stork, diver), two or three ducts (Ætomorphæ, Picus, Otis, Ardea, penguin, flamingo, &c.), of which one opens above the hepatic and the other usually between it and the cystic; the last-named is always the lowest. The small round spleen is below the liver, to the right of the proventricle.

The heart has four separate cavities. The septum of the cavum pulmonale forms a muscular right auriculo-ventricular valve, which gives a trigonal shape to the opening which it guards. The right auricle has a large fossa ovalis. The two superior and the one inferior venæ cavæ open into a sinus with a membranous Thebesian valve, where it joins the auricle. The fourth aortic arch on the right side forms the aorta; the left forms the brachio-cephalic trunk, but in some Ætomorphs is continued by a ligament to the descending aorta. There may be two innominates (Ætomorphæ, Columbæ, ostrich, hen), or both carotids may come from a left innominate (Ægithognathæ, Rhea). The carotids are often unequal; sometimes only one exists, or two, with one in front of, and much larger than the other, and

sometimes, as in the bittern and flamingo, two separate carotids may unite into a common trunk. The ulnar is larger than the radial artery. The femoral arises opposite the hip-joint above the renal. The sciatic gives off the crural in most birds, but in Pipridæ and Cotingidæ the crural is derived from the femoral; in all, the chief vein of the lower limb is the femoral. During incubation the vessels of the abdominal wall dilate enormously, forming a vascular plexus (the brood-organ of *Barkow*). There is a rudimental reni-portal system, and the epigastric vein opens into the inferior vena cava near the heart, (In diving birds the vena cava is dilated before entering the sinus venosus). A vascular rete runs along the anterior tibial artery; other retia are found on the carotids and in the eye (pecten). The small veins have many valves. The larynx consists of thyroid, cricoid, and two arytenoid cartilages, often ossified, with (coot, albatross) or without an epiglottis, or with a rudimental one (pelican), with no vocal chords. Its muscles are crico-thyroid, thyro-arytenoid, and proper arytenoid muscles. The trachea has complete, and sometimes bony rings. At its lowest end (Thamnophilus, Opetiorhynchus), or between the trachea and bronchi, or in the bronchus alone, ten rings below the bifurcation (Steatornis) is the second larynx, or syrinx, the true organ of voice. It consists of a cavity formed by several coalescent rings (tympanum), in the middle of which rises a vertical membranous fold, with a free edge forming a septum, and containing a broad-based cartilage attached to the wall behind and in front. The free edge of this is the *membrana semilunaris*. The upper bronchial rings are incomplete internally. Within the tube there is attached to these rings on the outer side a free-edged membranous fold (*membrana tympaniformis externa*), which is so placed that the air in expiration passes through the slit between it and the central membrana semilunaris, and causes the edges of both to vibrate. Sterno-tracheal and cleido-tracheal (extrinsic) muscles act on the trachea above the syrinx, and compress it. From the trachea to the proximal bronchial rings there may run from one to six pair of intrinsic muscles, which vary the tension of the membrane. The trachea is sometimes divided before entering the thorax, as in humming birds; within the thorax it may be divided by a perfect (Procellaria, Aptenodytes) or imperfect septum (Clangula). The lungs are wedged in around the vertebræ and heads of the ribs; they are covered by a layer of fibrous membrane containing muscular fibres in falcons, &c., forming a perfect diaphragm in the ostrich and Apteryx; but this does not act as a muscle of inspiration. The bronchus enters the lung about its middle, dilates, loses its rings, passes through, and ends in an air-sac on the side of the abdomen (the right being larger than the left), from which a tube passes above the kidneys to the second vertebræ and femur. The femur is not pneumatic in pigeons and owls. In the course of the bronchus, canals

are given off to the lateral air-sacs, which are: 1st, the anterior thoracic ventrad from the lung; 2nd, the posterior, still farther back; 3rd, the cervical above this, sending tubes into the neck and dorsal vertebræ and spinal canal. The fourth pair of air-sacs occupy the sides of the abdomen. There is also a ninth median interclavicular sac, with a muscular coat (except in vultures, in which it is divided, the crop lying between the two), formed by tubes from the bronchi, and sending air-canals into the sternum, coracoid and humerus (the last is not pneumatic in Picus). The other branches of the bronchus subdivide often in the lung, and end in minutely-sacculated air-cavities. A pair of thyroid bodies lie in front of the carotids, one on each side of the trachea. The thymus may be similarly paired in front of the anterior thoracic air-sac, or else is rudimental.

The symmetrical kidneys are usually three-lobed, sometimes undivided or multifid; they lie along the lumbar vertebræ, and receive blood from the femoral and sciatic arteries, as well as from the aorta (see fig. 37). The small, often bright orange, supra-renal capsules are above and internal to the kidneys. The urine is semi-solid (a condition favourable to the conservation of heat), and consists of urate of ammonia in herbivorous birds (it contains Urea in Ætomorphs).

The brain is wide and round—in the goldfinch $\frac{1}{23}$rd, in the goose $\frac{1}{300}$th, in the ostrich $\frac{1}{1100}$th of the weight of the body; the optic lobes are, below and laterally on the base of the brain, joined by a commissure over the sylvian aqueduct. The cerebellum is transversely furrowed into lamellæ, and has distinct flocculi. The olfactory nerve does not divide before it leaves the skull, except in the Apteryx. The spinal cord dilates into a large lumbo-rachidian bulb, in which the central canal expands into a *sinus rhomboidalis*, and ends in a filum terminale. Two cervical and one or two dorsal nerves form the brachial plexus, five or six form the sacral. The neck part of the sympathetic is paired, the thoracico-ventral part unpaired.

There is no movable nasal cartilage, the nasal septum is complete (except in swans, &c.), and there are three pairs of spongy bones or cartilages. There are large Jacobsonian nasal glands lying on the frontal bone, whose ducts open into the nose. The Harderian gland at the inner canthus has its duct or ducts opening internal to the third eyelid. The true lachrymal gland at the outer canthus is one- or two-lobed. The ostrich has a caruncula lachrymalis at the inner canthus. The membrana nictitans is large, and its pyramidal muscle springs from the lower and inner part of the sclerotic; its tendon runs upwards and outwards through a loop in the free end of the square bursalis muscle, which here is also sclerotic in origin. A thickening of the sclerotic above the optic nerve keeps the tendon in its place. There are four recti and two oblique eye-muscles. The eyeball is irregular in shape,

the hinder part hemispherical, the front somewhat conical. In the front of the sclerotic are 10–30 tile-like bony plates. The ciliary muscle consists of striped fibres. The choroid has a vascular plicated eminence projecting at the fundus of the eye (*pecten*), composed of many folds (sixteen in the stork), sometimes pouch-like (as in the ostrich, hence called marsupium), or absent (Apteryx). The lens is flattened, except in owls and waterfowl. The ostrich alone has a tapetum. The upper lid has no cartilage, the lower has a cartilage or bone and a special depressor muscle.

The external meatus of the ear has no auricle, except in the owl; the two Eustachian tubes traverse the basisphenoid to a common central opening, and the tympanum contains a single bone (columella or stapes) attached to the membrana tympani externally, to the fenestra ovalis internally. The stapedius muscle runs from the opisthotic to the tympanic end of this bone. From the tympanum three pneumatic canals pass to the skull-bones, and an air tube (siphonium), sometimes ossified, to the os articulare of the mandible. There is a fenestra rotunda, a curved (concave backwards), but not coiled, cochlea, dilated at one end into a lagena (*Windischmann*). The sacculus and utricle of the membranous labyrinth are fixed into a common alveus, from which the canalis reuniens starts in the young bird, but is often obliterated in the old specimens, with a septal lamina. The anterior semicircular canal is the largest, and the crura of the vertical canals overlap before they unite; the horizontal canal is the smallest.

The lacteals are loose connective vessels, with no valves. There are two thoracic ducts. In some birds (Rhea, ostrich, goose, &c.) they have at their bases cavities with striped muscular walls, but not rhythmically contractile. The lymphatics are numerous, with valves, and often form sheaths round the bloodvessels.

The testes, white and rounded, are placed high in the abdomen, often above the kidneys, one or both becoming periodically enlarged; the epididymis is slender, and there are often vesiculæ seminales. The spermatozoa have usually slender bodies, narrowing to the flagellum, often corkscrew-like (in Ægithognathæ), fasciculate in development. There are no accessory male glands. The penis is a single erectile process grooved posteriorly, lying in the sac of the cloaca, to the front of which it is attached (not protrusible in the bustard and ostrich), or it is composed of two united fibro-erectile crura, with a dorsal groove, whose extremity is kept invaginated by an elastic ligament, except when distended. This may be small (Aetomorphs) or long and spiral (Chenomorphæ). There are two fasciculate ovaria, of which one only (the left) is developed and functional; the left oviduct is large, and consists of—1st, a funnel-like upper extremity; 2ndly, a longitudinally-folded albumen-secreting part; and 3rdly, a shaggy

ovisac, with calciferous glands where the shell is formed. The embryo bird has a calcareous knob on the upper mandible, whereby, when hatched, it frees itself from the inclosing shell. The females of those with a penis have a clitoris. The right oviduct remains as a hydatid; sometimes it is developed anomalously, while the left atrophies; rarely the two may remain (pigeons and parrots). Into the posterior part of the cloaca there opens a sac, the *bursa Fabricii*—this is larger in young than in old birds, sometimes atrophies with age, or even vanishes, and becomes ligamentous (*Forbes*). Its walls are glandular, and in structure resemble the tissue of lymphatic follicles. The parent birds usually hatch their young, and care for them. In pigeons, ibises, and some parrots, a peculiar milky secretion of the parent's crop is used for the nutrition of the young. No known bird hybernates.

CHAPTER XIX.

Saururæ and Ratidæ.

About 8000 species of birds exist, of which 470 are European. They are divisible into three sub-classes.

Sub-class I. Saururæ (*Haeckel*).—This includes but one form, the extinct Archæopteryx, from the Oolitic lithographic slate of Solenhofen, characterised by possessing a tail longer than the body, of about twenty caudal vertebræ, and clothed with lateral feathers. The metacarpals are four, not ankylosed. The first and second digits are clawed. The ilium is elongated; the skull is as yet unknown. This is a connecting link between the true birds and the Ornithoscelidæ.

Sub-class II. Ratidæ (*Merrem*).—Birds with rudimental wings, uninterrupted pterylosis (the first feathering being persistent); no oil-gland; the feather barbs disunited, and a short tail. The skull-bones do not unite as

early as in the carinate birds; the upper end of the quadrate is undivided; the hinder ends of the palatines and the front ends of the pterygoids imperfectly articulate with the basisphenoid rostrum, and are supported by the broad cleft hinder end of the vomer. There are strong basisphenoid processes from the body, not from the rostrum, of the sphenoid. The coracoid has no clavicular process; the long axis of the adjacent parts of the scapula and coracoid are parallel or identical, and the scapula has no acromion. The clavicles are rudimental or none. The metacarpals are ankylosed. The sternum has no keel, is wide and flat, and in general the femur alone is pneumatic.

The feet have papillose soles and flat nails on the toes; the legs are usually shielded with wide half rings in front and small shields behind. There is no inferior larynx, and the diaphragm is strong and muscular. The pelvis is long, the tongue rudimental, with a cartilaginous entoglossal. They possess a fourth gluteus, an iliacus muscle, and an enormous biceps femoris. They are the only birds that void their urine separately. About fourteen species survive, divided into five families:—

1. *Struthionidæ* (ostriches).—African and Arabian, reaching to seven feet in height. Feathers with no after-shafts; head nearly naked, with short feathers; ear-opening directed forwards; nostrils oval; tail coverts long, forming an apparent tail. There is no clavicle, a longer humerus than scapula, and three digits, of which two are clawed; the pubes unite in a ventral symphysis; the ischia are free. There are two patellæ, one above the other. The sternum has two shallow notches in its hinder border. The precaudal vertebræ are thirty-five. The foot has two toes, the third with four, and the fourth, which is smaller and clawless, with five phalanges. The occipital condyle has three facets; the maxillary processes of the palatines are prolonged under the maxillo-palatines, the inner edges of which are thick, and articulate with facets on the side of the vomer, which is large, short, and does not touch either the pterygoid or the palatines. The prefrontal is slightly ossified. The gizzard is strong; there is no crop, nor gall-bladder; the large intestine is longer than the small, and there are two long cæca, with a spiral valve within. The abductor muscles of the wing exceed the adductors. The rectus femoris is large, as is the iliacus, but the obturators are smaller than in Rhea. The eggs are up to 3 lbs. in weight.

2. *Rheidæ* (American ostriches).—Three-toed, with the pubes free; the ischia unite beneath the sacral bodies into a median symphysis. The caudal vertebræ are free, and the precaudals are thirty-two. The sternum has a median hinder notch and pro-ostea in front of the first rib. The long, slender, late-ossifying bodies of the sacral vertebræ and the ischio-pubis ankylose. The humerus exceeds the space between the shoulder-girdle and the ilium in length. The left carotid alone exists. The nostrils lie in a membranous groove. The tail is invisible. The maxillary processes of the palatines are short, and articulate with the posterior and inner edge of the maxillo-palatines, which are large, thin, fenestrated, and do not touch the long vomer. The prefrontal is slightly ossified; no gall-bladder exists. There is a rectus femoris (ambiens), but it is smaller than in the ostrich, as is the iliacus.

3. *Casuarinidæ.*—Maxillary processes of the palatines Rhea-like, the long vomer articulating behind with the palatines and pterygoids; the maxillo-palatines are flat, imperforate, joined to the premaxillæ and vomer. The prefrontals are large; the precaudal vertebræ thirty-five, of which five are lumbar; the bodies of the sacrals are not joined to the ischium or pubis, neither of which form symphyses. The humerus is shorter than the scapula; the sternum is long, diamond-shaped, pointed behind. They have a gall-bladder, and are three-toed; the rectus femoris is absent, and the obturators often double, small. There are two genera—Casuarius (cassowary), of the E. Indian Archipelago and Australia, with five rayless remigial quills on the wing, no pollex, and one clawed digit (the middle (?)); there is a crop; the after-shafts of the clothing feathers are as long as the primary shafts; the inner toe is shorter than the outer, and has a long claw; the head and neck are naked, the former with a solid bony crest. The clavicles are rudimental. Dromæus (the emu of Australia) has larger clavicles, remaining separate; also separate post-orbital bones, and a ligamentous episternal apparatus. The tracheal rings are deficient for a short distance above the sternum, and there is a membranous pretracheal sac, into which air can be driven, producing a booming sound. The left carotid is the smaller; the wing has no remiges, and the head no crest.

4. *Dinornidæ* (Moas).—Extinct post-tertiary birds from New Zealand; three-toed, with a prominent occipital condyle, a high arched beak, very stout legs, a broad sternum with two posterior notches, a small glenoid cavity, almost obsolete wings, and an emu-like pelvis. The feathers had an after-shaft. The maxillo-palatines are imperforate and emu-like. The allied Æpyornis of Madagascar laid eggs six times the size of that of the ostrich (possibly the roc's eggs of the Arabian fables).

5. *Apterygidæ* (Kiwi).—Small monogamic birds from New Zealand, with

long snipe-like beaks, obtuse at the tip, where the nostrils are placed. The feathers are narrow, long, hair-like, with no after-shafts. The prefrontals are long and spongy; the long vomer unites with the palatines and pterygoids; the palatines are short and broad, joining by an oblique suture the expanded maxillo-palatines. There are no clavicles; a rudimental humerus longer than the scapula, and half the length of the space between the shoulder-girdle and the ilium; one ungual phalanx with a sharp claw; a small hallux; the ischium and pubis free in front. The precaudal vertebræ are thirty-two; the sacral bodies are free from the ischium or pubis. The broad sternum has two hinder notches. The eye has no pecten, and there is a muscular diaphragm. The female lays an egg little less than one-sixth the weight of the parent.

CHAPTER XX.

Carinatæ.

Sub-class III. Carinatæ.—Birds with keeled sterna (except Strigops), with developed functional wings, a short tail, ankylosed metacarpals, and having the long axis of the sternum placed at a smaller angle with the coracoid than in the Ratidæ. This includes nearly all living birds, and they may be grouped into seventeen orders.

A good primary method of division of these orders is desirable, and several have been proposed. Professor Huxley has arranged them according to the conditions of the structures at the base of the skull, the vomer and palato-pterygoid apparatus. In the Tinamous, these apparatuses being emu-like, he puts them in his first order, which he calls Dromæognathæ. The second order, or Schizognathæ, includes all such birds as have the lateral maxillo-palatines ununited in the middle line, separated from the vomer by a fissure, and with the vomer pointed in front; these are the waders, penguins, gulls, cranes, poultry and pigeons. The birds of the third order, Desmognathæ, have a small vomer or none, and the maxillo-palatines are medially united in the palate; this includes the birds of prey, parrots, storks, pelicans, cuckoos, geese, flamingoes, &c. His fourth order, Ægithognathæ, includes all those birds

whose vomer is broad, truncated in front, cleft behind, and embracing the sphenoidal rostrum between its forks, while the maxillo-palatines do not unite medially. These are the small birds, songsters, humming-birds, woodpeckers, &c.

These characters, though natural, are scarcely in themselves sufficient to be made the entire basis of a classification.

Professor Garrod has made many and valuable additions to our knowledge of the anatomy of birds, and has constructed a classification based upon certain muscular arrangements, which is interesting, as showing forth in a tabular form these morphological peculiarities. He divides the Carinatæ into those with and those without a rectus femoris (which he calls the ambiens muscle); the former he calls Homalogonati, the latter Anomalogonati; the former are the Ratidæ, poultry, cuckoos, geese, storks, doves, and plovers; the latter the woodpeckers, passerines, and swifts. The numerous exceptions, which must always occur in artificial classifications like these, founded on single characters, detract from their utility, while they are valuable as simple means of giving a synoptic view of structural peculiarities. The primary divisions which I have adopted are those of Carus slightly modified.

Order I. *Pygopodes* (*Nitzsch*).—Mostly marine birds, with hard, compressed, and pointed beaks, and schizognathous palates; short, often inefficient wings, scarcely reaching to the base of the tail; legs placed very far back, with the tibia included in the body nearly to its tarsal end: in consequence of this position the birds stand nearly upright. The toes are webbed; the hinder is free, and directed inwards, or absent. This order includes two sub-orders.

Sub-order I. *Spheniscomorphæ* (*Huxley*).—Penguins, having an uninterrupted pterylosis, a straight compressed beak, almost slightly bent at its apex, with linear nostrils. There are no free phalanges in the pollex. The remiges are not distinct from the other feathers, all of which are flat and scale-like, with after-shafts.

There are no basi-pterygoid processes and flattened pterygoids; the maxillo-palatines are cleft; most of the cervical vertebræ have spheroidal facets;

the third dorsal is concave behind, and from this to the last dorsal the bodies are opisthocœlous. The humeri are flat, with edges directed backwards and forwards, not pneumatic. The sternum is long; the innomino-sacral joint is ligamentous; the tarso-metatarsus has two longitudinal clefts, marking out its three component parts; the front toes are fully webbed, the hinder is rudimental or absent; the sternal ribs ossify endosteally at first, ectosteally afterwards; the uncinate processes of the ribs are broad, not ankylosed, but attached by ligaments to the ribs. The mandible has often a fontanelle; the triceps has two sesamoids in it above the olecranon. The rectus femoris is present, as are the two femoro-caudals and the semitendinosus; the intestine has cæca; there are two carotids, a great pectoral prolonged above the furcular symphysis, and a tufted oil-gland. They are chiefly Antarctic. Aptenodytes, the king penguin, has a longitudinal septum in the trachea. Pyoscelis has a higher beak and stronger tail; other genera are Eudyptes and Spheniscus.

Sub-order II. *Urinatores* (*Cuvier partim*).—Marine birds, with short wings, short feathers, a short tarso-metatarsus, communicating nostrils, with no crop, a thin-walled gizzard, and very short cæca; there are no basi-pterygoid processes; the angle of the mandible is not recurved.

The beak is hard, pointed; the quadrate-bone has a hook-like process, directed forwards, sometimes reaching to the orbit; the lachrymal often reaches the jugal (Colymbus), but there are no lachrymo-palatine bones; the sternum has an entire (Alca) or a singly notched border, the notch being sometimes converted into a foramen; there may be a central notch as well, as in Grebes. The ischium is bound by a bony bridge to the pubis at its anterior end; the tibia has a long cnemial crest, produced in front of the knee, with the patella at its inner side. The tongue is always fleshy, and the cerato-hyals have cartilaginous stylo-hyal appendages; the penis is absent.

There are five families included:—

1. *Colymbidæ*.—Divers, with cylindrical, upright bodies, a separate antrum pylori, a strong beak; a rectus femoris is present, and a free hind toe, with a lobe-like appendage, linear nostrils, with feathered lore and one or two carotids.

2. *Podicipidæ*.—Grebes. Beak more slender; nostrils oblong; lores naked; toes fisso-palmate; only the base of the skull is pneumatic; only the accessory femoro-caudal present; no rectus femoris, nor semi-membranous; often one carotid. Podiceps includes the Grebes, dabchicks, &c.

3. *Alcidæ.*—Auks; beak moderate, flat; wings short, concave, functionless in Alca, toes fully webbed; humeri non-pneumatic; apex of the mandible directed downwards. There is no rectus femoris, but two femorocaudals. The great auk, Alca impennis, is now extinct. Utamania has larger wings.

4. *Phaleridæ.*—Puffins; bills grooved, compressed, short, with a membranous swelling at base. Cerorhina has a median horn. Mormon and Fratercula are the puffins.

5. *Uriidæ.*—Guillemots, with moderately compressed bills, with rounded culmen, and no lateral grooves nor basal swellings. Mergulus, the little auk, and Uria, the guillemot, are examples.

Order II. *Longipennes* (*Cuvier*).—Marine, schizognathous and schizorhinal birds, mostly of powerful flight, with laterally-compressed hooked bills, nostrils in grooves or tubular, wings long, pointed, remiges short, leg feathered to the ankles, and with the front toes webbed; hallux turned backward, small, or absent; an after-shaft is present in the feathers (except in the albatross). The oil-gland has a feather circlet. The primaries are ten.

The frontal has a large supra-orbital groove for the nasal gland. There are no basi-pterygoid processes, except in Ossifraga gigantea. There are often infra-orbital or lachrymo-palatine bones between the large lachrymal and the palatines. The fissure between the maxillo-palatines is often very slight, as in Diomedea. There is also in this genus a round fontanelle in front of the articulation of the quadrate. There are 12–14 cervicals; 6–8 dorsals; 12–13 united lumbar, sacral, and upper caudals; and 6–8 lower caudals. The sternum has two hinder notches, often with a developed manubrial process. The hypocleidium may be ankylosed to the sternum. The cnemial crest is not prolonged in front of the knee. The tongue is soft in some gulls, and the gizzard thin-walled; the cæca two, small; the two carotids exist, and there is no penis. This group includes the following families:—

1. *Diomedidæ.*—The albatross of the equatorial seas, with long hooked bill, tubular nostrils, and no hind toe, with the largest proportional trapezius of any bird, and the largest greater pectoral in proportion to lesser pectoral. The tibia has a cnemial process; it has also the largest number of remiges (forty) of any known bird.

2. *Procellaridæ.*—Petrels, with shorter beak, tubular nostrils, and a hind toe. The bill may have short horny lamellæ and two marginal teeth (Fulmarus), or no lamellæ (Pterodroma), or no teeth (Procellaria). The fulmars have two cæca and a rectus; the stormy petrels (Thalassidroma) have no rectus. Bulweria has no accessory femoro-caudal, and no accessory semi-tendinosus.

3. *Laridæ.*—Seagulls, with the beak shorter than the head, nostrils fissure-like, neck short. The beak may have a membranous covering at base, as in Lestris, the skua, or a naked base, as in Larus, the gull.

4. *Sternidæ.*—Terns, with a long straight beak, with linear nostrils; tail long, forked; wings long, pointed. Sterna includes the terns, or sea-swallows.

5. *Rhynchopidæ.*—Skimmers, with the beak scissors-like, strongly laterally compressed; lower jaw much longer than upper, and the feet semi-palmate.

Order III. *Dysporomorphæ* (*Huxley*).—Large aquatic birds, with weak scapulæ, clavicles sometimes ankylosed to the sternum, a long, pointed, basi-sphenoid rostrum, but no basi-pterygoid processes. The upper bill ends in a hooked unguis, and has a basal groove, in which the small nostrils lie. A vertical crest extends from the junction of the palatines behind the choanæ (except in Phaeton). The maxillo-palatines are spongy, and the angles of the mandible are truncated; wings moderate, with long, pointed remiges; tibia feathered to the ankle. The hallux is turned forwards and inwards, so that the foot is steganate. An oil-gland exists in a feather circlet, and the feathers have no after-shafts, but down occurs between the contour-feathers.

The head and neck are continuously feathered. There is a dorsal apterial island, except in Phalacrocorax and Plotus. There is no outer branch of the gastræal tract. The first remigial is the longest. The rectrices are 24 (pelican) 16–12. The leg is reticulated on the surface. There is often a post-occipital nuchal ossification. The premaxilla and maxilla unite for their whole length, and the nasals unite with both. The strong, inferiorly lengthened lachrymal is joined to the jugal by ligament, and (Tachypetes)

there may be a lachrymo-palatine bone. The sternum has two shallow notches or none; it is broad, with the keel not stretching to its hinder edge, but it is extended forwards, and often ankyloses to the hypocleidium. The ilium and ischium unite posteriorly to close the sciatic notch. The tongue is very small, double in the cormorant, and there is no basi-hyal. There is no crop, but in pelicans there is a large sub-mental pouch, and in cormorants a fusiformly-dilated œsophagus. The cæca are small; there is no flexure in the trachea, which is often dilated, or the bronchi may dilate. There is no penis. The carotids may be two (cormorant), or one (pelican). The following families are included:—

1. *Pelicanidæ.*—Pelicans, with long neck, small head, with a long flat beak and a sub-mental pouch; rectrices 20-24. The ossified inter-orbital septum has a suddenly upward-turning under border, leaving a free space; there is a small iliacus, no rectus femoris, semitendinosus, nor accessorius. The metatarsals lie on the ground in progression.

2. *Sulidæ.*—Solan geese; beak long, straight, laterally compressed, pointed; nostrils scarcely visible; wings long; inter-orbital septum, with a horizontal lower border attached to the sphenoidal rostrum; subcutaneous tissue pneumatic.

3. *Tachypetidæ.*—Frigate-birds; beak long, strong, hooked, with a sharp point; nostrils basal, scarcely visible; wings of enormous length; tail forked, with twelve rectrices; skull like Sula. T. aquila, the frigate-bird, has very short tarsi.

4. *Phalacrocoracidæ.*—Cormorants; bills moderate, with concave culmen and hooked apex; nostrils imperceptible; toes long; skull like that of Sula.

5. *Plotidæ.*—Anhingas, darters; bill long, straight, not hooked at tip; neck long, with one carotid and no free tongue; head small; lores and cheeks naked; tail long, with twelve rectrices; wings long; pylorus protected by a mat of bristly hairs; there is no crop, and a diverticular proventricle; post-occiput with a nuchal bone, as in cormorants.*

6. *Phæthonidæ.*—Tropical birds; bill laterally compressed, straight at tip; thomia serrated; nasal groove apparent; wings long, pointed; rectrices 12-14; the middle longest, with few barbs; legs short. There are often subcutaneous, fibrous-walled air-cells through the body, filled from the axillary air-sacs. Similar spaces exist in Sula.

Order IV. *Chenomorphæ* (*Huxley*).—Water birds, with

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* For a description of the curious neck muscles of Plotus, see *Garrod*, "Proceedings Zoological Society," 1876, p. 338.

the beak as long as the head, hard only at the point; the borders with transverse, soft, or horny lamellæ along the edge. The lachrymal region is long, and there are short oval basi-pterygoid processes; flat, lamellar, desmognathous, maxillo-palatines, forming a bridge across the palate. The palatines are small, with the inner lamella rudimental, and the mandibles have prominent sutures and recurved angles; supra-occipital fontanelles are present. The feet are webbed, and the inner toe is small, free, often raised. The middle finger of the manus has a third phalanx, the third metacarpal is smallest, and the pollex often clawed. The sternum has one pair of notches and often a manubrium. The oil-gland has a feather circlet. The syrinx has no intrinsic muscles.

The bill lamellæ are freely supplied by the branches of the large superior maxillary nerve. There are no after-shafts, and several down-feathers, or filoplumes, around each contour-feather. The pterylæ are broad, and there is no neck apterium. The meso-gastræal apterium is narrow, and only corresponds to the sternal carina and a strip from it to the cloaca. There is a notæal apterial island, and no separate lumbar pterylæ. The primaries are 10; the rectrices 12–24; the legs placed far back and very short. There are 14 17 (in swans 23) cervical, 6–8 dorsal, 16–21 pseudo-sacral, and 6–8 caudal vertebræ. The nostrils always communicate; the tongue is large, toothed along the edge, soft medially, and fills the mouth. There is no crop; a gizzard strong and muscular (weak in Mergus); the cæca long (short in Mergus). The umbilical duct remains as a diverticulum. There is always a gall-bladder, two carotids, and the semitendinosus has no accessory slip. The trachea may be convoluted under the skin or in the sternum (Cygnus). The wall of the syrinx may be ossified. The penis is large and spiral. The eggs are clear, not spotted. There are several families:—

1. *Palamedeidæ.*—S. American, with compressed pointed bill and numerous weak lamellæ; wings with horny metacarpal claws; legs long, only semi-palmate; a crop-like dilatation exists between the proventricle and the gizzard. Palamedea has a cylindrical horn on the head and a feathered lore, no crop, a strong gizzard, a long intestine and cæca, a nearly uninterrupted pterylosis, and bones pneumatic to their extremities. Chauna, which is

placed here by *Parker* and others, has a naked lore and no horn; it has also sphincters to the cæca, and has no uncinate processes to the ribs (*Mr. Garrod* refers Chauna to the poultry group, beside the Curassows).

2. *Cygnidæ.*—Swan; hallux with no membrane; maxillary lamellæ in one row; neck long; legs reticulate; cere reaching between the eyes.

3. *Anseridæ.*—Geese; beak higher at base and smaller in front, the whole tip horny; neck long.

4. *Plectropteridæ.*—Spur-winged geese; beak and legs long; carpus with a strong spur.

5. *Tadornidæ.*—Sheldrakes; beak long, higher than broad at base, point with a strong nail; wings long, pointed; rectrices fourteen.

6. *Anatidæ.*—Ducks; legs shorter than middle toe; hallux with no broad membrane. The wild duck, Anas boschas, has sixteen rectrices; Querquedula, the teal, fourteen.

7. *Fuligulinidæ.*—Scoters, with large heads, a membranous lobe on the hallux, and a short thick neck.

8. *Erismaturidæ.*—Old World forms, with long necks; a small terminal nail on the bill; feet far back, with long toes; wings short; rectrices eighteen, stiff, with exceedingly small coverts.

9. *Mergidæ.*—Goosanders; bill high at base, strongly compressed lamellæ directed backwards in two rows on the upper bill.

Order V. *Amphimorphæ* (*Huxley*).—These desmognathous birds have proportionally the longest necks and legs of any birds, and long lachrymo-nasal regions. The basi-pterygoids and mandible are as in geese. The maxillo-palatines are spongy, not lamellar; the lower end of the crus is bare, and the feet fully webbed. There is an accessory semi-tendinosus, but no caudo-femoralis. The notæal pterylosis is stork-like, and the primaries are eleven. The beak is strongly bent, with close lamellæ. The tongue is serrated; the lower bill has lamellar edges; the toes are short and fully webbed. Phœnicopterus includes the flamingoes, natives of S. Europe, Africa, and America. They seldom swim.

Order VI. *Pelargomorphæ* (*Huxley*).—Wading birds, with basi-pterygoid processes; palatines united behind the choanæ, but with no vertical plate at their junction;

mandible with prominent sutures; maxillo-palatines spongy; mandibular angle truncated (except in Ibis and Platalea). The sternum is much longer than broad, with 2–4 hinder notches; the hallux long, not directed forwards and inwards, and the toes semi-palmate; an oil-gland and feather circlet exist, and the feathers have after-shafts. There are characteristic powder-down tracts and narrow pterylæ, except on the neck of Eurypyga; there is often a lateral weak space. The beak at base is as high and broad as, and longer than the head, with no cere; the lores, the eyelids, and often the whole head are naked; the neck and legs are long. The eggs are white, rarely spotted. The clavicles have a hypocleidium, sometimes ankylosed to the sternum. The forearm is longer than the humerus, in this respect differing from the last order.

There is no crop, but the œsophagus is dilatable, and cæca are absent in Platalæa, but others have cæca and a gall-bladder. There are two carotids (in Ardea stellaris the two unite). Storks and herons have an ossified epiglottis and one pair of broncho-tracheal muscles.

They are divided into four families:—

1. *Ardeidæ.*—Herons; bill with sharp thomia, point arched; lores naked; toes long, thin, inner edge of middle comb-like; some have a straight, pointed, narrow beak, longer (Ardea, 12 rectrices) or shorter (Botaurus, 10 rectrices) than the long neck. Nycticorax has a short thick bill, six powder-down tracts, and a naked space on the neck. Cancroma (S. America) has a broad depressed bill and a twelve-feathered tail. Balæniceps (Africa) has a similar bill and free toes. (For an account of its osteology see *Parker*, "Trans. Zool. Soc.," vol. iv., p. 7.)

2. *Scopidæ.*—African. Bill high, compressed, larger than head; tail short, straight; middle claw comb-like.

3. *Ciconiidæ.*—Body plump; beak thick; toes shorter; middle toe not toothed; naked spaces on head and neck; bronchi very long; trachea convoluted, as in Tantalus. Ciconia, the stork, has a long, straight bill, narrowing equally to the tip. Mycteria has an upturned bill, and a short broad tail. Leptoptilus, the marabou, has a very large bill and a naked throat-sac. Anastomus, the boat-bill, has the tips and base of the bill so in-turned that the intermediate edges cannot meet, but gape.

4. *Hemiglottides.*—Smaller, with closely-feathered neck and naked lores; tongue small, short; toes long. The bill may be long, arcuated, and slender (Ibis), or flat and spoon-shaped (Platalea, the spoonbill).

Order VII. *Grallæ* (*Bonaparte*).—Carinate birds, with long legs, fitted for running, and with feet usually fitted for wading. The vomer tapers to a point in front, and the maxillo-palatines are lamellar, free internally. The bill is clearly marked off from the head, and often has a distinct cere; the lores are closely feathered; the neck moderate, or long; the tarso-metatarsus is shielded in front and behind; the hind toe is small in general, rarely with a long claw. There are ten primary remiges, and all the feathers have after-shafts (except in Podoa). The skull shows often a post-periotic fontanelle, and there are two carotids and a gall-bladder. The eggs are usually uniformly coloured, or spotted on a dark ground.

The following families are included:—

1. *Scolopacidæ.*—Snipe, with long slender bills, which are flexible and sensitive; narrow prominent basipterygoid processes; maxillo-palatines not swollen; mandible shorter than the upper jaw, with the angle prolonged into a recurved process, and with a fontanelle in its ramus; maxillæ laterally grooved, the small nostrils being at the base; tongue long and slender; stomach muscular. The legs are usually, the toes always, short, colligate, semi-palmate or lobate, the hinder toe short or absent. The wings reach or extend beyond the end of the tail, the outer remiges being the longest. Feathers cease above the suffrago, and the tail is short. Mostly small, round-bodied birds, which are divisible into five sub-families: Scolopacinæ—with a sensitive, soft-pointed beak, colligate toes, and strong, thick feet. The bill may be longer than the head, or than the naked parts of the foot, and the outer ear under the eye, as in Scolopax, the snipes and woodcocks, and Rhynchœa; or there may be a shorter bill, with a broader point and no groove, and the outer ear behind the eye, as in Tringa, the sandpipers. The hind toe is absent in Calidris, the sanderling, and Limicola. Machetes, the ruff, has a denticulated palate. Totaninæ consists of slight-bodied birds, with hard, horny tips to their beaks, long necks and feet, and colligate toes. Some, like Numenius, the curlews and

whimbrels, have often unankylosed mandibular rami. Limosa has a slightly upturned bill. Phalaropinæ.—The phalaropes have slender straight beaks, round tails, long pointed wings and lobate feet. Recurvirostrinæ, Avocets, have long pointed beaks, upturned in the Avocet, straight in Himantopus. The feet are very long, and the legs clothed with hexagonal scales. The toes are colligate, often closely united. Dromadinæ have the hind toes reaching the ground, and a long bill with sharp edges.

2. *Charadriidæ.*—Plovers, with shorter compressed beaks, hard at the tip; nostrils oval, occupying at least one-third of the beak; nasal groove closed in front. The legs are long, with colligate or semicolligate toes, a short hallux, or none, and a concave middle claw. The mouth and œsophagus are narrow, the gizzard muscular, the cæca long. Basipterygoid processes, mandible and skull are similar to those in the last family, like which, there is a second femoro-caudalis. This includes Strepsilas, the turnstone, and Hæmatopus, the oyster-catcher, which have basal nostrils, as well as the plovers proper, Charadrius, whose nostrils are farther forward, and which have no hallux; it also includes Œdicnemus, the thick-knee, Vanellus, the peewit, and Hoplopterus, whose wings are armed in front with strong spines. A hind toe is also wanting in Cursorius and Pluvianus, but is present, and elevated at base, in Glareola, the pratincole, which has a short, broad-based bill.

3. *Chionididæ.*—Sheath-bills; beaks compressed, moderate; nostrils basal, covered by a horny or bony shield, or sheath; wings long, pointed; hinder toe high, raised. The palate in Thinocorus presents a combination of Dromæognathism, with fissuration merging into Ægithognathism. Oceanic and S. American birds.

4. *Parridæ.*—Jacanas, S. Asiatic (Hydrophasianus) and American (Parra), with long slender beaks, carunculated at base, and with a frontal plate. The toes are very long, and the hallux has a very long claw; there are slender basipterygoid processes. The mandible has a truncated angle, and the sternum is narrow, elongated.

5. *Otidæ*—Bustards, with no basipterygoid processes nor hind toe, heavy bodies, short stout bills; nostrils in a groove, feathered at the base. The legs are strong, with short blunt claws, and clothed with small scales. They have long cæca, a rudimental penis, and the males of some species have a large pre-laryngeal gular air-pouch, with a faucial opening extending in front of the neck. There are no down-feathers among the contour-feathers, and the caudo-femoralis is absent.

6. *Dicholophidæ.*—Screamers. S. American, with beak strong, compressed, and hooked at tip; nostrils in a feathered groove; wings strong, with twenty-five remiges; tertiaries elongate; tail large, with twelve rec-

trices; oil-gland naked, differing thus from the foregoing families. Pterylosis of head and neck is uninterrupted, but feather tracts elsewhere are narrow. Toes colligate; sternum with a urosteon on the middle xiphoid process. Maxillo-palatines united by harmony. Gypogeranus, the secretary bird, is so closely allied, that it is unnatural to separate them.

7. *Psophiidæ.*—S. American birds, the beak compressed shorter than head; nostrils communicating; wings convex, short, rounded; legs long; toes short; a circlet of feathers round the oil-gland; sternum not notched posteriorly. Psophia has a pouch like that of the bustard.

8. *Rhinochetidæ.*—New Caledonian and S. American, with the beak slender; nasal groove long. Lore and beak root feathered; occiput often crested; in other respects like the last.. These are passage forms between the rails and the cranes.

9. *Rallidæ.*—Beaks short, compressed, grooved; nostrils medial, communicating; necks long; wings scarcely reaching to the base of the tail, the whole hallux resting on the ground. The rails have long, straight bills, with no frontal plate, and short tail (Crex, Rallus, Porzana). The tail is long in Ocydromus. Frontal plates at the bases of the bills exist in Gallinules, Podoa (whose feathers have no after-shafts), Notornis (Apterornis, nearly wingless, the blue bird of Madagascar), Fulica (with lobate toes).

10. *Gruidæ.*—Cranes, with long beaks, with nostrils in wide sulci; necks longer than the very long legs, which have much of the tibiotarsus bare, and long, broad wings; short tails. The hallux only touches the ground by its tip. The trachea is often convoluted within the hollow crest of the sternum, as in Anthropoides. The tertiaries are often tufted. A fontanelle often exists between the supra-occipital and the periotic.

Order VIII. *Dromaeognathae* (*Huxley*).—Carinate birds, somewhat grouse-like in habit, with functional wings, with broad coalescing vomers, which in front join the broad maxillo-palatines, and behind receive the hinder end of the palatines (which do not articulate with the basisphenoid), and the anterior ends of the pterygoids. Basi-pterygoid processes project from the sphenoidal body, not from the rostrum. The head of the quadrate bone is single, and the sciatic notch is completed by fibrous tissue.

This order includes but one family, *Tinamidæ*, the tinamous, American

birds, with straight bills, more than half the length of the head, covered with membrane at the base, and often suddenly hooked at the tip ; tail short, of 10–12 rectrices, or with none, as in Tinamus, and with long coverts ; wings short, concave, toes long, the hinder being small, and high up or none, as in Tinamotis. The tarsi are scutellate in front, and there is a patch of powder-down among the feathers. The sterna have coracostea. In the hind limb there is a well-developed rectus femoris, and two femoro-caudales muscles.

Order IX. *Alectoromorphæ* (*Huxley*).—Heavy-bodied, mostly polygamous birds, with strong legs and feet, fitted for scraping in search of their food ; with rounded short wings, which usually produce a whirring sound during flight. The feathers have downy after-shafts, but there are no true down-feathers among the contour-feathers. The beak is variable, seldom longer than the head (Rhynchotus), usually arched. The basipterygoid facets oval, sessile on the basisphenoidal rostrum ; palatines long, narrow ; maxillo-palatines lamellar ; the angle of the mandible prolonged and upturned. The last cervical and first dorsal are often ankylosed, and the penultimate dorsal is free, the last dorsal ankylosing with the sacrum and lumbar vertebræ. There are usually 12–15 cervicals, 6–8 dorsals, 12–17 pseudo-sacrals, and 5–6 caudals. The acromion is short ; the coracoid with no subclavicular process. The hypocleidium is well marked ; the humerus has no supinator spine ; the sternum has one or two deep notches behind on each side, and two outer lateral processes, of which the external is the shorter, bent outwards, and expanded at the end ; there is also a manubrial rostrum. The feet are colligate, never webbed ; the hypotarsus has a single canal, except in Argus, and there is a deep fossa on the side of the ischium ; there is a uropygial gland within a feather circlet. The two branches

of the gastræal pteryla unite behind the sternum, and pass as a single strip to the anus. The first sternal ossification is ectosteal. There are no intrinsic syringeal muscles except in Talegalla. The second pectoral is larger than in other birds, as is the biceps. The thumb has two free joints. The integument of the neck often develops wattles; the claws flat, blunt. All have two carotids, a single crop, a long proventiculus, a thick gizzard; cæca often narrower at their mouth than at their base. There are no erectile elements in the penis (except in Crax).

The following families are included :—

1. *Tetraonidæ.*—Grouse; body large, with short neck, short beak, thick at base; short, rounded wings and tail; nostrils protected by a hard scale, or feather; hallux above the level of the other toes; hinder region of skull-base broad; quadrate excluded from the bony ear-vesicle, with a long orbital process. Spurs absent; toes long, sometimes feathered (Lagopus, the ptarmigan).

2. *Odontophoridæ.*—American, with compressed beak, with high culmen, under bill with two teeth on each side; nasal groove featherless; the outer toe longer than the inner, as in Ortyx.

3. *Perdicidæ.*—Partridges, mostly Old World forms, with the under-bill entire; basal groove naked; tarsi long, scutellate, often spurred, as in Francolinus. In Coturnix, the quails, the tail is concealed by the long tail-coverts.

4. *Phasianidæ.*—Beak moderate; wings rounded, often with long remiges; tail long, broad; tarsus spurred in the male; toes colligate; head with naked spaces. Orbital process of quadrate smaller. Natives of the Eastern Hemisphere. Lophophorus, the impeyan, Phasianus, the common pheasant, Chrysolophus, the golden pheasant, Gallus, the domestic fowl, all natives of India and China, are examples. Gallophasis, the silver pheasant. Ceriornis, the horned Tragopan, has large mandibular lobes and horn-like ear processes. Pavo, the peacock, has extraordinarily long upper tail-coverts, forming the beautiful tail. Argus, the Philippine pheasant, has very large secondary quills on its wings, adorned with ball-like eyes, no oil-gland, and twenty-six remiges. The two middle rectrices are enormous.

5. *Megapodiidæ.*—Australian mound birds; small-headed, strong-beaked

birds, with large feet, having the metostea and lophosteon widely united. The skull-base is smaller than in the last, the quadrate has a doubled upper head, the lachrymal bone has no inferior process, and the ethmoidal septum is strongly ossified. The skeleton is massive; the hinder toe is on the level of the others. They build mounds of earth and of decomposing vegetable matters wherein they deposit their eggs.

6. *Talegallidæ*—also Australian—differ from the Megapodii in having stronger bills, which are higher, and not compressed at the base.

7. *Cracidæ*.—American, long-beaked birds, with very pneumatic skeletons and spurless limbs; the quadrate with an obvious, but not sharply-defined, second process, which lies in the tympanic cavity. The lachrymal is spongy, and the maxillo-palatines are often united by small ossifications in the ethmoidal septum. The sternum is as in Megapodius. This includes the Curassows (Crax), and Penelope, with a more slender bill and a crest. Meleagris, the turkey, has a carunculated head and neck, a soft fleshy wattle at the base of the bill, and eighteen rectrices.

Order X. *Turnicimorphæ* (*Huxley*).—A group of small incompletely ægithognathous, straight-billed birds, in which the upper beak slightly overhangs the lower at the tip, and the nostrils are covered by a long linear scale. The wings, moderate in length, are rounded; the tail is short, with 10–12 rectrices, overlapped by long coverts. The hinder toe is absent (Turnix), or slender (Pedionomus), and the outer toe exceeds the inner. The sphenoidal rostrum is thick; the upper articular end of the quadrate bone is doubled, and there is a supra-occipital fontanelle above the foramen magnum. The sternum has coracostea.

These are mostly Palæotropical birds, some of which have powder-down patches.

Order XI. *Columbæ* (*Bonaparte*).—This Order includes the pigeons and sand grouse, plump-bodied monogamic birds, with straight, compressed bills, swollen at the tip, covered, at the base by a soft, membrane-clad, cartilaginous cere, in which the nostrils lie under a valvular fold. They

have soft-pointed tongues, with an indented hinder edge, and a long entoglossal cartilage. The œsophagus has in its middle a laterally double crop, whose walls secrete a milky juice in the parent, a few days after the young are hatched, for their nutrition. The gizzard is muscular (weak in Carpophaga, ossified in Colœnas); the intestine is long, the cæca absent, or short; the gall-bladder absent (except in Lopholæmus, Ptilonopus, Pteroclidæ, and Carpophaga). The syrinx has one pair of muscles, and there are two carotids. The pterylosis is remarkable for the absence of after-shafts (except in Pteroclidæ), and for the width of the feather tracts, in which there is no down between the contour feathers (except in Pteroclidæ). The oil-gland is absent in Didunculus, Goura, Treron and Starnœnas, but is present and naked in the others. The neck pterylæ are almost uninterrupted, and the young have no down lamina.

The leg has an ambiens, and is clothed with short transverse scales in front, but is reticulate behind. The skull has large orbits, with a septum perforated by 1-3 holes. The maxillo-palatines are spongy and prolonged backwards, and the vomer is absent. The posterior external angle of the palatine is rounded. The basipterygoids are narrow, long processes (absent in Didus). The pterygoids are curved. The articular head of the quadrate for the mandible is transverse (in Didunculus elongated from before backwards, and the cranial end is bifurcated). The mandibular angle is not prolonged nor incurved. The sternum has two pairs of hinder notches (the inner of which may be foramina); the outer xiphoid processes are shorter, and directed forwards, and there is no hypocleidium nor manubrial rostrum. The wings are long and pointed. There are 11-13 cervical, 5-6 dorsal, 12-13 pseudo-sacral, 6-7 free caudal vertebræ. The hallux is on the level of the other toes, and has a twisted metatarsal. The toes are usually free; rarely the outer and middle are semi-colligate. On the head of the humerus the second pectorals have an independent place of insertion at some distance from the pectoral ridge (*Garrod*), and the pectoral ridge ends in a point. There is no deep ischiatic fossa in the pelvis. The

fourth gluteal muscle is absent. There are about 250 species known, which may be grouped in the following families :—

1. *Pteroclidæ.*—Sand grouse, which are truly pigeons with a grouse-like habit; small birds with very long intestinal cæca, a rectus femoris, a gall-bladder, short compressed straight bills, slightly curved at the tip, nostrils under a scale, wings and tail long and pointed, 14-18 rectrices, and an oil-gland with no feather circlet. The pterylosis is pigeon-like, with a uniformly-broad gastræal tract with parallel sides, and the hypopterum separate from the gastræum. The lateral neck-spaces are short, and there are 27-28 remiges, but no superior wing-space. The feathers have after-shafts, and the pterylæ have a very weak downy coating. The outer digit has usually four phalanges. Syrrhaptes has no hinder toe, but this digit is present, though rudimental in Pterocles.

2. *Columbidæ.*—Pigeons with short cæca, a rectus femoris, a naked oil-gland, and no gall-bladder; rectrices twelve; the tarsi are feathered; the beak horny, pointed: this includes Columba, the pigeon; Turtur, the turtle, and Ectopistes, the passenger-pigeon.

3. *Phapidæ.*—Pigeons with no intestinal cæca, a rectus femoris, rectrices 12-14-16-20; all have an oil-gland, and some have a gall-bladder (Carpophaga, Lopholæmus). Lopholæmus alone has no accessory femoro-caudal muscle.

4. *Pleiodi.*—This includes one form, the Didunculus, from Navigator's Island, which has developed wings and tail, a compressed beak, the mandible with two marginal teeth, the upper bill hooked. There is no oil-gland nor gall-bladder, and an enormously long intestine.

5. *Inepti.*—This includes the extinct dodo and solitaire, from Mauritius and Rodriguez, which were characterised by the possession of rudimental wings and tail, large, heavy bodies, long, even-edged beaks, much longer than the head; clavicles scarcely ankylosed, sometimes ossified to the coracoids. The skull had no basipterygoid processes. There was no oil-gland, and no cæca.

6. *Treronidæ.*—Pigeons with no rectus femoris, with mostly fourteen rectrices; feet short, thick, with fleshy toes and sharply-curved claws. A gall-bladder exists in Ptilonopus, but is absent in the others, and cæca are present only in Phlogænas and Starnœnas. An oil-gland is mostly absent, but present in Geopelia and Phlogœnas. Goura, the largest living pigeon, from New Guinea, has a head-crown of feathers, and an almost uninterrupted neck pterylosis. Ptilonopus has a gizzard of four pads.

Order XII. *Heteromorphæ* (*Huxley*).—Large South American birds, with schizognathous palates, a curassow-

like, convex, arched, thick beak, bristled at the base, lore; eye-margins, and cheeks naked. The fifth and sixth remiges are the longest, and the first is the smallest. The tail is broad, with ten rectrices, and the toes are long and free. The occiput is crested or tufted, the vomer broad in front, and forked, and the maxillo-palatines are broad, far removed from each other; the nasal bones are ankylosed completely with the lachrymal, which is not attached to the frontal, and moves with the hinged beak. The furculum is ankylosed to the manubrial rostrum and to the coracoids. There is one genus, Opisthocomus, the Hoazin.

CHAPTER XXI.

Classification of Carinate Birds (*continued*).

Order XIII. *Raptatores* (*Illiger*).—Birds of prey. These are carnivorous birds, with desmognathous palates (that is, having the maxillo-palatines united across the middle line directly or by ossifications in the nasal septum). In these also the vomer is absent or small, slender, and pointed in front; the hinder end of the palatines and the front ends of the pterygoids directly articulate with the basisphenoid rostrum. In these respects the basicranial structure agrees with that in the Lamellirostres, storks and pelicans, as well as with the parrots and cuckoos. Correlative to their predaceous habits, they have hooked beaks, the upper being the longer, and the nostrils are in a cere. The hallux is on the level of the other toes, all of which are colligate (rarely free), and strongly clawed. The contour feathers

are large, but few in number, and the tail is broad, of not less than twelve feathers, rarely forked (Nauclerus). Some have no after-shafts, and those thus characterised have no feather circlet around the oil-gland. The notæal pteryla is forked, and degraded at the interscapular part. The two lateral stems of the Pt. gastræi are widely separated, sometimes enormously expanded in front; frequently there is no lumbar tract. The primaries are ten, the alular feathers four, the remiges twelve to twenty-seven.

The skull has long lachrymal bones, forming the upper orbital margin, free or ankylosed, and the maxillo-palatines may join with each other and with the nasal septum, or only with the septum (owls); while in the vultures of the New World they may remain ununited. Basipterygoid processes exist in owls, in vultures of the New World, and Gypogeranus, and there is a median septo-maxillary bone. The interorbital septum is almost completely ossified, and the articular surface of the quadrate is transversely elongated. There are 9–13 cervical, 7–10 dorsal, 10–14 pseudo-sacral, and 7–9 free caudal vertebræ. The sternum is quadrate or elongate, strongly-crested, and convex behind. The wing-bones are strong, the pelvis wide, the claws curved, pointed, and hollow below. The tongue is often toothed behind, the œsophagus laterally dilated into a crop, with muscular walls, the stomach thin-walled, not gizzard-like, and both cæca and a gall-bladder exist. There are two carotids, a supra-olecranal sesamoid in the triceps, rarely a suture or fontanelle in the mandible, and a large brain. The right ovary may be developed, but its products are rarely perfected. The eggs are usually rounded, often speckled.

The following families are included:—

1. *Strigidæ.*—Owls. Predaceous birds, of moderate size, with large

heads, having the facial region flattened and the beak short, strong, an external, often operculate ear, with a feather circlet round it, and eyes directed forwards, also with eye circlets of feathers. There is a short, small tail, long wings, short, almost wholly-feathered legs; the outer toe can be turned backwards at pleasure, and its first three phalanges are shorter than the penultimate. The feathers are soft and downy, with no after-shafts, and the oil-gland is without a circlet. The skull is broad, and its bones have a spongy diploë. Basipterygoid processes are present, and the maxillo-palatines are spongy, separated partially by a fissure; the lachrymal is also spongy, and mostly free. The sternum has two fissures and a manubrial process, and the scapular end of the coracoid is prolonged to touch the clavicles. The foot extensors pass under a bony arch. The œsophagus is wide, the crop absent; cæca are two, long and wide, intestine short; the syrinx has one pair of muscles. There is no rectus femoris, accessory femoro-caudal, semitendinosus, nor accessory semitendinosus. The sub-family *Striginæ* have no ear-tufts; pneumatic skulls, operculate auricles, fully-feathered feet, and the middle toe toothed internally; it includes the barn owl, Strix flammea. Syrniinæ, with large inoperculate ear-openings, small, or no ear-tufts, rounded wings, no toothed claws, and feathered toes, include Syrnium, whose clavicles are joined by fibro-cartilage, Nyctale and Otus. Buboninæ, with long erectile ear-tufts and imperfect eye-disks, include Bubo, the great eagle owl and Ketupa of Ceylon, which has the tarsi and toes covered with a warty skin. Surniinæ have imperfect eye-circlets, no ear-tuft, and long wings and tail. This sub-family includes the snowy owls (Nyctea), Surnia, and Athene, the burrowing owl, which in America inhabits the burrows of the prairie dog.

2. *Grypomorphæ.*—An anomalous family, probably related to the storks, having long beaks, with large oblong communicating nostrils in the basal cere, beyond which the beak is constricted. The head and upper part of the neck are naked, the eyes lateral, the wings long, pointed, and the tail with twelve rectrices. There are no after-shafts, nor is there a circlet round the oil-gland. Basipterygoid processes are present, and the sphenoidal rostrum is long. The maxillo-palatines are separated by a wide space, which is crossed by a small ossified bridge in the nasal septum, and the lachrymal bone is fully ankylosed. There is a rectus femoris, a double great pectoral, a femoro-caudal, a semitendinosus and its accessory. The manubrial process of the sternum is rudimental, the clavicles are broad at the symphysis, and there is no syrinx. The hinder border of the ilium and ischium is deeply notched. This American family includes Sarcorhamphus, the condor, with a fleshy head-crest, and Cathartes, the turkey buzzard without a crest.

3. *Gypætidæ.*—Vultures, having the beak moderate, without communicating nostrils, and the feathers with after-shafts. There is also a feather cir-

clet to the oil-gland. There are no basipterygoid processes, spongy, united maxillo-palatines, distinct lachrymal bones, long, pointed wings, and one pair of muscles in the syrinx. The outer toes are colligate, the hallux on a little higher level, the head and neck are fully feathered, and the cere is completely covered by feathers. Gypætus barbatus, the bearded vulture of the Alps, is an example.

4. *Vulturidæ.*—Beak moderately long, higher than broad, and suddenly hooked at the tip; cere long, partly naked; head either naked or clad with filoplumes. The eyes have no brow ridges. The sternum has a pair of fontanelles. Each half of the pteryla gastræi is detached, and there is a collar-like jugular apterium. Vultur, Gyps, the griffon, and Neophron, which has a naked head and neck, are included. In Gypohierax, from West Africa, the beak is strongly compressed, and one-third embraced by the cere. The eye-border, lore, and two stripes under the jaw, are naked.

5. *Falconidæ.*—The typical birds of prey, having short beaks and sharp claws, eyes under projecting brow-ridges, a feathered head and neck, upper bill with a sharp tip and toothed edge, and often a separate supra-orbital bone. The deltoid muscle is longer proportionally than in any other birds. There is often no pteryla lumbalis, and the gastræal pteryla has a freely-diverging lateral branch, except in Haliætus and Theratopius, and the wings are long and pointed. The sub-families are—Polyborinæ—with straight-based long bills, weakly hooked at tips, short wings and naked lores, including Polyborus, the Caracara of Brazil, and Polyboroides of S. Africa. Circinæ—harriers, with owl-like facial pterylosis, sinuated bill-margins, and short toes. Accipitrinæ (sparrow-hawks), with short bills, broad at the base, small nostrils, and with wings reaching to the middle of the tail. Astur, the goshawk, has a sharply-curved beak, with a short tooth. Milvinæ (kites) are slender, graceful birds, with small heads, weak bills, long, pointed wings, and tails often forked, having powder-down patches among the feathers. Ictinia has a sharp beak, and its wings exceed the tail. Milvus, the kite, has a weaker bill. Pernis, the honey buzzard, is also an example. Buteoninæ, buzzards, have larger bodies, flat heads, short, compressed, toothless beaks, and short and weak toes. Aquilinæ, eagles, are strong, large birds, with perfectly feathered heads, high, toothless, but sinuous beaks; legs fully feathered; claws strong. This includes Aquila, the golden eagle, &c., with beak hooked even under the cere, and whose wings reach to the end of the moderate tail; while in Spizætus they reach to the middle of the tail. Pandion, the osprey, has prominent eyes, wings exceeding the short tail, and the outer toe can be turned back at pleasure; the feathers have no after-shafts; the femur is non-pneumatic; the extensor digitorum passes under a bony ridge; the alula may have five feathers. Haliætus, the sea eagle,

has a high beak, naked lores, and the tail slightly forked. Falconinæ, falcons, have large heads, short, strong beak, with a lateral tooth on the margin of the upper bill; wings long, pointed; eye-margin naked.

6. *Gypogeranidæ.*—Secretary birds, aberrant forms allied to Cariama (p. 173), having the body slender, legs and neck very long, head broad, flat, with strong arched bill, half covered by membrane. The feathers have after-shafts, and the skull has basipterygoid processes. The spongy maxillo-palatines are fully united, and the lachrymal is distinct, nasal septum ossified, the sternum entire, with seven very shallow hinder notches, and the hypocleidium is often united to the sternum. The post-acetabular part of the ilium is not arched downwards and forwards, as in the other Ætomorphs. The basal phalanx of the outer toe is longer than the second and third together, and these than the fourth. There are spur-like processes at the wrist, and the two gular branches of the gastræal tract are united as far as the point at which the inner branch issues from them. There is a long manubrium sterni. The secretary bird should be placed near to Otidæ or to Cariama, with which it agrees in the presence of a semitendinosus, of an accessory semitendinosus, and an accessory femoro-caudal muscle, all of which are absent in Falconidæ.

CHAPTER XXII.

Passerine Birds.

Order XIV. *Coracomorphæ* (*Huxley*).—This Order, the Passerine Order of *Nitzsch*, includes the largest number of the smaller birds of all regions, and is thus numerically the most extensive of all the divisions of the class. They are all Ægithognathous, that is, they have the vomer (which is single) broad, truncated in front, cleft behind, and embracing the sphenoidal rostrum between its forks; the palatines likewise have their postero-external angles produced, and the maxillo-palatines (which are rod-like, slender at origin) extend inwards over the palatines, and

do not join the vomer or one another. The nasal septum is often ossified in front of the vomer, but never unites therewith. A bony siphonium stretches from the tympanum to the os articulare of the mandible, which latter has a fontanelle. There are no basipterygoid processes; behind the mandible there is often a separate bone, the metagnathium. The sternum is forked at the manubrium, and has an excavated anterior edge, lateral long and rib-like processes, and simple notches at each side. There are conical humero-scapular bones, long and weak coracoids, tarso-metatarsals, with five canals for the flexor tendons, and slender feet, the inner (hinder) toe exceeding the second in length, while the two outer toes are colligate for the length of their first joint. The contour-feathers, which are few in number, have downy after-shafts, but have no down-feathers among them, except in Cinclus, in which genus alone the oil-gland has a feather circlet. There is often a temporal apterium, and the pteryla notæi forms a ribbon-like streak, not interrupted on the shoulders, but which behind this region dilates into a rhombic or elliptical saddle, containing frequently an apterial island. On each side a row of single feathers often extends onward from this to the caudal pteryla. There are nine or ten primaries, nine or ten secondaries, ten to twelve rectrices; the wing-coverts are short, leaving at least half of the remiges uncovered, and there is no hypopterum.

The vertebræ are few (9-14 cervicals, 6-8 dorsals, 6-13 pseudo-sacrals, and 6-8 caudals). There is a hypocleidium, often an epicleidium and a supra-olecranal sesamoid. The forearm is a little longer than the humerus, but neither it nor the hand are disproportionately elongated. The pollex has one phalanx; the hallux is always directed backwards. There is but one (left) carotid, and the syrinx is complex, with 1–6 pairs of muscles. When these muscles are attached to the ends of the bronchial semi-rings,

the syrinx is called acromyodic; when to the middle of the semi-rings, it is said to be mesomyodic. The beak has no soft membrane at its base, and there is a long parotid and smaller sublingual glands. There is a proventricle, a gizzard, and a pair of cæca, a gall-bladder, and two or three separate pancreatic lobes; the crop is often absent. The tibia is feathered to the ankle, and the tarsus has usually seven large shields in front, or the fore and hind shields are united into a boot, with occasionally a row of separate shields externally. The rectus femoris is always absent, as is the accessory femoro-caudalis, but the semitendinosus and its accessory always exist. The flexor hallucis longus is separate from the flexor digitorum profundus. There is also in the wing a tensor patagii brevis, arising from the outer end of the furculum, and inserted into the tendon of origin of the extensor radialis longus, from which insertion a second recurrent tendon passes to the humerus below the point of origin of the extensor. This muscle is characteristic of Passeres (*Garrod*). Three types of Ægithognathism have been described by Mr. Parker: 1st, that in which the labial cartilages are imperfectly ossified by the vomers, and separate centres exist in the alinasal cartilages, as seen, for example, in Cotingidæ; 2nd, that in which the labials are small and completely ossified by the vomers, as in the majority of Passerines, and, in the next Order; 3rd, those in which the maxillo-palatines unite desmognathously to a highly ossified alinasal wall, as in Paradisea, Gymnorhina, Artamus.

The Passerine birds are divisible into the following sub-orders:—

Sub-order I. *Clamatores* (*Wagner*).—Syrinx tracheal or simple, only with lateral muscles (mesomyodic); first primary feather longest; legs scutate in front; sole naked, or with granules, or little scales. This includes eight families:

1. *Cotingidæ*.—American; bill large, broad, with hooked point and a notch behind it; the round nasal groove at the base of the bill is often bristle-clad, wings long, pointed, often longer than tail; rectrices twelve. The males of many are crested (Rupicola). The femoral artery is the main vessel of the thigh, except in Rupicola, and the syrinx is not tracheal (haplophonic, *Garrod*). Four sub-families are included, Coracininæ, Cotinginæ, Piprinæ and Tityrinæ.

2. *Phytotomidæ*.—S. American; bill short, strong, broad-based, compressed at tip, notched; culmen convex; tail straight; hallux long; syrinx not tracheal: sciatic artery the main vessel of the leg, as in other birds; the first and second remiges are graduated in length; the third and fifth are equal.

3. *Tyrannidæ*.—American: beak as long as head, and as broad as high, hooked at tip; bristles adorn the round nostrils and the mouth-angles; wings

long, pointed; legs scutate behind and externally, with a narrow, naked inner part; syrinx not tracheal. This includes three sub-families, Tyranninæ, Todinæ, and Fluvicolinæ.

4. *Anabatidæ.*—American; beak compressed at tip; tail long, stiff; rectrices with the points of their shafts naked; outer toes equal, semi-colligate. They are mostly tracheophonic, that is, they possess a tracheal syrinx; primaries ten. This includes four sub-families, Dendrocolaptinæ, Anabatinæ, Synallaxinæ and Furnariinæ. Some of these last are the oven birds, which build clay nests of two chambers (Furnarius).

5. *Pteroptochidæ.*—S. American; bill moderate, convex, strong, often notched; wings short; tail short, with 12-14 rectrices; claws sharp, compressed; syrinx tracheophonic; the first three primaries are graduated, the fourth is the largest.

6. *Menuridæ.*—Australian lyre birds; tail with long lyre-shaped outer feathers; rectrices sixteen in the male; twelve in the female; bill moderate, keeled, broad at base; nostrils in a membrane-clad groove; eyelids naked; syrinx tracheal, acromyodic; the first five primaries are graduated; the seventh to the ninth are the longest; the maxillo-palatines are rudimental.

7. *Formicariidæ.*—American ant-birds; bill shorter than head, or equal, straight, or nearly so, with a terminal hook and notch; nostrils naked, or under a membrane; wings short, rounded, with ten primaries and nine secondaries. This includes three sub-families, Thamnophilinæ, Formicivorinæ and Formicariinæ.

8. *Pittidæ.*—Palæotropical; beak strong, thick; culmen straight; tip scarcely bent; nostrils in a groove half closed by membrane; tarsus two or three times as large as the middle toe, in front with transverse scutes, laterally with a continuous shield; the syrinx has one pair of bronchial muscles, and is mesomyodic.

Sub-order II. *Oscines.*—Singing birds; syrinx occupying parts of the trachea and bronchi, acromyodic; intrinsic muscles usually five pairs; first primary feather short, or absent; tarsal shields united into a caligula, or boot. There are two sections:

§ 1. Spizognathæ, having the outer lamella of the palate bone elongated into a vertical plate, with a notched hinder edge, the anterior palatine process being broad, and united to the upper beak. This includes three families:—

1. *Ploceidæ.*—Palæotropical, weaver birds; primaries ten; bill strong, conical, flattened at base; culmen broad, arising among the forehead feathers; convex to the tip; tail short, rounded, on the male during the breeding season developing long feathers in the sub-family Viduinæ, not in Ploceinæ nor Spermestinæ.

2. *Fringillidæ.*—Finches; beaks strong, conical, with a basal swelling; primaries nine, the first three being the longest; hind scales on tarsus united. This large family includes six sub-families, Emberizinæ, or buntings, with conical, pointed, compressed bills, the upper being weaker than the lower bill, and the hallux longer than the inner toe. This includes Emberiza, the common bunting, and Plectrophanes, the snow bunting. Pyrrhulidæ have short, strong, compressed, entire-edged bills, short legs, unequal, lateral toes, and moderate, rounded wings. It includes Pyrrhula, the bulfinch, Pinicola, the pine grosbeak, &c. Loxiinæ, the cross-bills, with the curved point of the upper bill overlapping or crossing that of the lower beak. Fringillinæ, the true finches, have conical bills, with straight culmen, lateral nostrils, no bristles on the lores, and moderate tails. This includes the sparrow (Pyrgita), finches (Fringilla), and haw-finches (Coccothraustes). Spizellinæ are mostly American, and have a slightly-curved culmen, large feet, and long primaries. Polytinæ, likewise American, have large, curved beaks, the under bill being broad at base, the first primary short, and the tail long.

3. *Tanagridæ.*—American birds; beak trigonal at base, with a convex culmen; the upper beak toothed, or notched, or serrated; wings pointed, moderate; legs and toes short and weak; hallux long; claws curved.

§ 2. Coracognathæ have the palate bones broad and flattened, with elongated outer angles, not developed into a vertical plate. This includes twenty-three families:—

1. *Mniotiltidæ.*—American; beak slender, conical, or depressed; culmen straight, or convex; primaries nine; hallux shorter than middle toe; claws curved. This includes the Vermivoræ, Icteriæ, Sylvicolæ, &c.

2. *Motacillidæ.*—Wagtails; beak slender, shorter than head, notched, and with no bristles at rictus; the wing is long and pointed, and the hinder toe is long. This includes Motacilla, the wagtail, and Anthus, the pipit, &c.

3. *Alaudidæ.*—Larks; beak moderate, straight; frontal feathers extending along the side of the beak; hallux with a long straight claw; the hinder scales of the tarsus not united. Otocorys has nine; Alauda, the lark, has ten primaries.

4. *Sylviidæ.*—Small, silky-feathered birds, with subulate bills, moderate, usually rounded wings, and tarsus with separate shields in front, united at the back; the outer toe is longer than the inner. This includes Accentor the hedge sparrow, with moderate bill, third and fourth remiges the longest, and short tail; Regulus, the crested wren, and Sylvia, the warblers.

5. *Maluridæ.*—Nostrils free, in a membranous groove; beak narrow, straight, upper bill curved; wings short, rounded, and weak in flight.

This includes Cysticola, Drymoica, Ortholonus, &c., all of which build remarkable nests.

6. *Turdidæ.*—Thrushes; moderate-sized or small birds, with large heads and short necks; bills slightly curved; wings moderate; the first primary short; tarsus long, with undivided scales. This includes Cinclus, the dippers; Luscinia, the nightingale, with large eyes and owl-shaped beak, dun-coloured feathers; Rubicilla, the redstart, Erythacus, the robin, Saxicola, the stonechat. Pratincola, &c., are also included, as well as the true thrushes, blackbirds, Mimus, the mocking-birds.

7. *Cærebidæ.*—American; beak short, slender, straight, broad at the base, compressed at tip; nostrils under a hard shield; tongue divided into two lobes; the hind toe is very short.

8. *Meliphagidæ.*—Honey-eaters: Palæotropical; bill long, curved, sharp-pointed; nostrils in a wide groove, often covered by a scale; tongue protrusible, with a brush of bristles at the tip; legs short, strong; outer toes semi-colligate. This includes the sub-families Zosteropinæ, Melithreptinæ, Meliphaginæ, Myzomelinæ.

9. *Cinnyridæ.*—Sun-birds; Palæotropical; body small: beak long, thin-pointed; tail variable; tongue tubular, protrusible, deeply cleft.

10. *Hirundinidæ.*—Swallows; beak short, with wide rictus; nostrils lateral, round; wings very long; humerus short; head long, approaching the condition in swifts; primaries, nine, the first the longest; toes long, narrow; leg with divided shield in front; tail forked, with twelve rectrices.

11. *Ampelidæ.*—Bee-eaters; beak short, depressed, with arched culmen; wings long, with ten primaries, of which the first is very short; scales of tarsus separate. This includes the singular Chasmarhynchus, with a long, straight, frontal horn.

12. *Muscicapidæ.*—Old World; fly-catchers; beak short, strong, broad-based, depressed, hooked, and notched in front; tail lobate, sometimes elongated.

13. *Dicruridæ.*—East Indian; bill broad-based, keeled; tail forked, with ten rectrices, the outermost usually of great length; nostrils feather-covered; mouth-angles bristled; wings long.

14. *Oriolidæ.*—Old World forms; beak conical, not keeled; wings long, with ten primaries; tail moderate; toes strong. Artamus and Oriolus are examples.

15. *Laniidæ.*—Shrikes; bill strong, compressed, point strongly hooked, and toothed, the lower bill being upturned at the point or notched.

16. *Timaliidæ.*—Mostly Palæotropical; beaks weak, with arched culmen, not notched at the tip; nostrils bare; the hind toe is particularly strong and long. Cissa, Leiothrix, Crateropus, &c., are examples.

17. *Troglodytidæ.*—Wrens; small short-winged birds, whose fourth or fifth primaries are the longest; beaks compressed, with curved culmen and owl-like apex. The angle of the mouth has no bristles, and the tail is moderate in length.

18. *Certhiidæ.*—Creepers; have slender, arched bills, usually longer than the head, and not notched; the first primary is less than half the length of the second; the outer toe is longer than the inner, and the hinder than the middle. Sitta, the nuthatch, Certhia, the creeper, are included.

19. *Paridæ.*—Tomtits; bills short, conical, straight; wings moderate, the third primary being the longest; seldom notched; tails long; toes colligate.

20. *Icteridæ.*—American; beaks long, straight, conical, not notched; the commissure arched downwards; primaries, nine; feet strong; plumage usually yellow.

21. *Sturnidæ.*—Beak as long as the head; hind toe long; culmen straight; apex hooked; wings long, pointed; primaries ten. Here are included the starlings (Sturnus), the metallic-tinted Lamprotornis, the broad-billed Buphagus, and the short-tailed Pastor.

22. *Paradiseidæ.*—Bill moderate, straight, with a feathered skin at base. The sixth and seventh remiges of the long wing are the largest; the middle rectrices are very long, with a few terminal rays or none. The feathers of the male are extraordinarily tufted. This includes the birds of Paradise, natives of New Guinea and the neighbouring islands: Epimachus has a long, slightly-curved bill, and has its nostrils free, in a feather-clad groove at the base of its bill, together with long, strong feet, hence it is made the type of a separate family by *Gray*.

23. *Corvidæ.*—Crows, &c., the largest of the passerine birds; beaks large, thick, strong, straight, bristled at base, and with feathers covering the nostrils; tail short; feet strong and large. This includes Garrulus, the jays, with short wings and long tails; Fregilus, the chough, with large, slender, arched bill; Nucifraga, the nut-cracker, with longer legs and conical bill; Pica, the magpie, with a curved, pointed bill; Monedula, the jackdaw, with shorter bill, and Corvus, the crow, raven, rook, &c.

CHAPTER XXIII.

Swifts and Woodpeckers.

Order XV. *Macrochires* (*Nitzsch*).—This order, the Cypselomorphæ of *Huxley*, includes all those Ægithognathous birds whose single vomer is truncated in front, whose sternum is broad, without a forked manubrium, and often with no hind notches, whose furculum has no hypocleidium, and whose wing has a short humerus, a longer forearm, and a very long manus. The wing-coverts overlap the secondaries. The primaries are always ten, and feathers have after-shafts.

The syrinx has usually one pair of intrinsic muscles, and the rictus of the mouth stretches often beneath, even behind the level of the eye. The tibia and the upper part of the tarsus is feathered; the skull has a deep interorbital depression, and the mandible is divided on each side into two parts, united by a joint. They have a supra-olecranal ossicle, no semitendinosus, nor its accessory; no rectus femoris, nor accessory femoro-caudal muscle; the crop is absent, and the gizzard is weakly muscular.

Three families are included:—

1. *Caprimulgidæ*.—Goatsuckers; mostly American; crepuscular birds, with short, broad, depressed trigonal bills, of which the culmen is much narrower than the length of the gape; the outer toe is not larger than the inner, and the middle has a serrated claw (except in Podargus), while the index and pollex have nails. The feathers are soft, owl-like, with very small after-shafts. The skull has basi-pterygoid processes, and the toes have usually 2–3–4–4 phalanges respectively; the tongue is broad, flat, and serrated along the sides, and the angle of the mouth is generally bristled (not in Podager). There are rudimental intestinal cæca, two carotids, and a gall-bladder. Some of these birds have curious notes, such as Antrostomus vociferus, the whip-poor-will of N. America; Steatornis has a long polliceal metatarsal; it is also remarkable for the enormous development of fat under the skin and in the abdomen; the syrinx is doubled, as there is one in each bronchus. Other representatives are Caprimulgus, the night jar, and Podargus.

2. *Cypselidæ*.—Swifts; swallow-like birds, with short depressed bills broad at the base; wings very long; tail short; toes short and thick, all directed forwards except in Chætura, Cypseloides, and Collocallia. The nostrils are large, oblong, margined, and sometimes there is a small gular pouch. Down exists between the contour-feathers, and the wing-coverts are very long. The toes have usually 2, 3, 3, 3 phalanges respectively, except in Chætura and a few others. The tongue is sagittiform, sometimes two-pointed in front. Cæca are absent, a gall-bladder exists, and only the left carotid is present. Cypselus, the swift, is a native of Europe and Asia; Panyptila, with feathered toes, inhabits S. America; Chætura has a straight tail, with stiff pointed rectrices; Cypseloides has not the sharp shaft-ends of the rectrices projecting; Collocalia of the Moluccas, &c, secretes from its large salivary and jugular mucous gland a glutinous material, of which it builds its nest, which are the "edible birds' nests" of Chinese commerce.

3. *Trochilidæ*.—Humming birds; South American; the smallest of all birds; beak long, thin; with no bristles at the mouth-angles; tongue long, split into a brush-like bundle of bristles: wings long, pointed; primaries ten, rarely nine; other remiges six, very short; feet weak; the two outer toes colligate; the coracoids are joined to the sternum by a ball and socket joint, the ball being sternal. The notæal tract is divided by a neck apterium. There are no cæca, nor gall-bladder, and a left carotid only is present, as well as two pairs of syringeal muscles, and no sterno-trachealis. This enormous and varied family includes about 138 genera, all of very small size. Melisuga minimus weighs about 25 grains, and its pea-like eggs are laid in a nest about the size of a walnut.

Order XVI. *Celeomorphæ* (*Huxley*).—The woodpeckers which form this group are small, or moderately-sized Ægithognathous birds, which exhibit several peculiarities of structure. They have straight, strong, conical beaks, with no cere, and no basi-pterygoid processes. There are two vomers, which are delicate, rod-like, lateral and median septo-maxillaries, and the maxillo-palatines are short, lamellar, or rudimental; the inter-orbital septum has a single opening, and the quadrate is short. There is an unusually simple nasal labyrinth, and the cornua of the trabeculæ are retained and ossified. From these peculiarities,

which *Parker* regards as reptilian in character, that author has given to this group the name *Saurognathæ*.

The sternum has two posterior notches on each side and a forked manubrium, to the summit of which the carina extends. The humero-scapular bone is present, but the weak clavicles have no hypocleidium. The tarso-metatarsus has canals for the digital flexor tendons, and the feet are scansorial.

The tongue is long, stiff, capable of rapid protrusion, and the hyoid bone has long great cornua, which are elastic and coiled, their extreme tips being attached to the base of the beak, while they groove the frontal bones on each side. There are numerous buccal and salivary glands, no crop, cæca, epiglottis, nor right carotid; a wide proventricle, a gizzard and gall-bladder, and one pair of syringeal muscles. The oil-gland has a feather circlet; the wing-coverts are short, and there are twelve rectrices, the outer of which are weak. The young are naked, with no downy clothing.

The following families are included:—

1. *Yungidæ*.—Wrynecks; bills straight, short, pointed; feathers soft and loose; rectrices soft, flexible, forming a rounded tail; front toes colligate; the second primary is the largest.

2. *Picumnidæ*.—Small birds with straight beaks, as long as the head; tails short; plumage sometimes with scarcely any stiff shaft-ends, as in Hemicircus.

3. *Picidæ*.—Woodpeckers; beak chisel-shaped, as long as, or longer than, the head; tail wedge-shaped; rectrices with stiff shaft-ends.

CHAPTER XXIV.

Cuckoos and Parrots.

Order XVII. *Coccygomorphæ* (*Huxley*).—This well-marked group of Desmognathous birds is at once differentiated from the other small perching and climbing birds by its basi-cranial structure, which is not Ægithognathous, the vomer being small or absent. There are no basi-pterygoid processes, and the maxillo-palatines are spongy. Most of them have large straight or arched beaks, but in this respect there is a considerable variety of form and size in the order. The distal end of the quadrate bone is simple; the sternum has two notches on each side; the furculum is strong and convex forwards; the tarso-metatarsus is short. They have short, flat tongues; not more than two pairs of syringeal muscles. The pterylæ are few-feathered, and there is only one shoulder-tract.

In many respects the constituents of this order are variable. Thus the feathers have no after-shafts in cuckoos, capitos, and toucans, while they possess such in the other families. The kingfishers alone have a down clothing. Podargus has powder-down tracts. The oil-gland has no circlet in the cuckoo, Coraciadæ, Meropidæ, Galbulidæ, and Capitonidæ, while it has a circlet in the others. The rectrices are 8 in Crotophaga; 10 in most species; 12 in Indicator, Leptosomus, &c. The cervical vertebræ vary from 10 to 13; the dorsals 7–8, the pseudo-sacrals 9–13, the free caudals are 5–8. The œsophagus has rarely a crop, usually a thin-walled gizzard, and no cæca in toucans nor kingfishers, but cæca are present in others. There is no gall-bladder among the toucans, trogons, buccos, and cuckoos. Only a left carotid is present in Pteroglossus, Merops, and Upupa.

The following families are included:—

1. *Rhamphastidæ*.—South American toucans, small birds, with enormous bills, as long as the whole body, and marginally serrated; the mouth-angle is not bearded; the tongue is small, with papillæ along the edge; the wings

are rounded; the tail large; the clavicles with no symphysis, each one tied by ligament separately to the breast-bone. They have a perfect cranio-facial hinge and a median septo-maxillary bone. The three terminal caudal vertebræ are ankylosed, the six anterior being free, with synovial surfaces; there is no rectus femoris.

2. *Coliidæ.*—Palæotropical, with all the four toes directed forwards; bill short, stout, with nostrils in a membranous groove at each side of its elevated base.

3. *Capitonidæ.*—Barbets. Bills stout, conical, laterally swollen, bristled at base; tails round, broad; the first and fourth toes turned backwards.

4. *Galbulidæ.*—Jacamars, neotropical, with long strong straight bills, bristled at base; wings moderate, with the fourth quill longest; the rectus and semitendinosus accessorius are usually absent.

5. *Trogonidæ.*—Trogons, with strong, short, broad, triangular bills, with an arched toothed edge to the upper bill, except in Calurus; the rictus of the mouth is wide and bristled at the angle; the wings are short, rounded; the tail and its coverts are long; the weak feet have the inner and second toes turned backwards, and the third and fourth turned forwards; the rectus femoris and semitendinosus are absent.

6. *Musophagidæ.*—Plaintain-eaters, African; bill strong, hard, high, broad at base, which sometimes expands into a frontal plate, as in Musophaga; the upper bill is toothed, strongly notched at the tip; the tail has ten rectrices. Turacus, the touracou, has a head-crest; Schizornis has the three outer toes turned forwards; they all have the rectus femoris.

7. *Bucconidæ.*—Neotropical; bills stout, conical; nostrils hidden under the bristles of the forehead; tails moderate. Megalaima has a median septo-maxillary bone between the maxillo-palatines.

8. *Cuculidæ.*—Cuckoos. Palæotropical for the most part; bills moderate, strong or slender, compressed, often with a wide gape reaching under the eye; the nostrils are in a membranous groove, and the tails are long, with 10–12 rectrices; there is a rectus femoris, but no accessory caudo-femoralis. They mostly lay their eggs in strange nests. Cuculus, the cuckoo, can turn the outer toe forward or backward at pleasure, and in it the fifth primary is the largest; in Coccyzus the third; in Eudynamys the fourth. Scythrops, the channel bill of Australia, has a lateral groove in each side of the long hooked upper mandible. Coccygus (American) has a feathered lore and short round wings. In Saurothera the tip of the bill is suddenly hooked. Indicator, the honey-guide (African), has a short bill, nine primaries, and twelve rectrices. Leptosomus (Madagascar) has a short bill, with the nostrils in the middle of its length, and it has legs with two rows of shields in front; tail with twelve rectrices. Phœnicophæus has a longer beak, linear

nostrils, and long tail, and like Rhamphococcyx, has naked rings round the eyes. Lepidogrammus has also scale-like throat-feathers. Crotophaga (S. American) has the bill shorter and laterally compressed; lores naked; eight rectrices; upper bill crested or not (Octopteryx). Centropus has a short, strong, arched bill; the hallux has a long, straight spur, and there is a caudo-femoralis accessorius present.

9. *Bucerotidæ.*—Hornbills. Large palæotropical birds, with large bills, surmounted by a horn of light, cancellous, bony substance. The palatines, as well as the maxillæ, are united in the medio-palatine line, and they have a septo-maxillary bone. The sternum has neither notches nor holes, and the wings are moderate; the tail long, rounded, with 10 rectrices; the leg may greatly (Buceros) or slightly exceed the middle toe in length. Toccus has no horn. Anorrhinus has a grooved crest, Buceros a horn. The neck is naked in Rhinoplax. In this form the skull-bones are sculptured with pits. The genus Euryceros, with round-processed upper bill, has 12 rectrices.

10. *Alcedinidæ.*—Kingfishers. Beak long, straight, angular, with keeled culmen; neck short; wing-coverts long; the two outer toes are united, and the hallux is the only back-turned toe. In Alcyone this toe is rudimental. There is no vomer nor septo-maxillary. Halcyon has the base of the bill broad, and a blunter-grooved culmen. Dacelo (the laughing jackass of Australia) has a broad bill and short tail. Astacophilus has a longer tail.

11. *Meropidæ.*—Bee-eaters, with long, curved, pointed bills, strong at the base, the gape stretching under the eye, the upper beak longer than the lower, but not hooked at tip; wings moderate, pointed, with long coverts; tail broad, the two middle quills elongated; legs very short; the outer toe united as far as the second; the inner as far as the first phalanx. They have a manubrial process on the sternum, and no rectus femoris.

12. *Upupidæ.*—Hoopoes. Head with or without (Irrisor) a feather-crest; beak thin, higher than broad, thomia not toothed, and vomer absent; tongue short or long, and split, as in Fregilupus; wing-coverts short; the two outer toes are colligate, but only to a small extent in Upupa; the hind toe has a long claw; the sternum is pierced by lateral fontanelles, and the rectus femoris is absent.

13. *Coraciadæ.*—Palæotropical birds, with beaks not longer than the head, broad at the base, and with sharp thomia; rectrices 12; wings round, broad. Coracias has all its toes free, while in Eurylæma the outer toes are united as far as the second joint.

14. *Momotidæ.*—Neotropical, with bill compressed, longer than the head, with serrated thomia and bristled mouth-angle; the tongue is pectinated, and the long outer is colligated to the middle toes.

Order XVIII. *Psittacomorphæ* (*Huxley*).—Parrots, the most specialized of birds in many respects, non-predaceous in habits, and characterized by possessing strong, arched, upper bills, which are Desmognathous, and usually shorter than their height, and having a cere at the base, in which are the nostrils. The tongue is thick, fleshy, and movable; the legs are feathered to the tarsus; the middle toes are semi-colligate, the outer turned backwards; the tarso-metatarsus is short and thick; the clavicles are weak, disunited, or rudimental, and the sternum is not notched, but may have two holes on each side.

The cervical vertebræ are 10–12, or, as in Strigops, 14; the dorsals are 8–10, the pseudo-sacrals 10–13, and the free caudals 5–7. There are no basi-pterygoid processes; spongy maxillo-palatines, joining together and to the thick bony nasal septum internally, giving a desmognathous character to the palate. The palatines are vertically elongated posteriorly, horizontally flattened in front, and movably articulated to the rostrum. The cranio-facial cleft is more complete than in any other birds, and the hinge between the frontal and nasal bones is perfect and transverse; the malars also movably articulate with the maxillæ, frontal bones have post-orbital processes, the nasals ankylose with the premaxillæ and maxillæ. The vomer is absent, and an ant-orbital bone joins the sphenotic to the lachrymal, and is itself often united to the zygomatic process of the squamosal. There is a complete orbital septum. The orbital process of the quadrate is small; the distal end has a single facet, elongated antero-posteriorly; the mandible is deep, with neither suture nor fontanelles, and a rounded symphysis.

The plumage is generally brilliantly coloured. The contour feathers are few, and have large after-shafts, and the oil-gland has usually a feather-circlet; there are often down-feathers, and those with no oil-gland (Chrysotis, Pionus, and Brotogerys) have powder-down patches. They have a well-marked crop, a proventricle, separated by a narrow glandless tract from the gizzard, which is thin-walled and shaggy within; there are no cæca; seldom a

gall-bladder; often no bursa Fabricii; the brain is large, and the membrana nictitans often absent.

The notæal pteryla bifurcates at the level of the scapula, and there is sometimes a double humeral pteryla, often an apterium around each eye; the alula has 4 feathers; the tail 12 rectrices.

The syrinx has three pairs of broncho-tracheal muscles, and a very weak sterno-trachealis; there is no epiglottis, and the carotids are either two, close together, or the left is superficial, and the right on the vertebræ, or the right is absent, as in Cacatua. The tongue in Trichoglossus is beset with numerous thread-like horny papillæ. The penis is absent.

Parrots are the most intelligent of birds, and are capable of being taught; they are divisible into five families:—

1. *Cacatuidæ.*—Cockatoos. Head with an erectile crest; beak strong; wings long, pointed; tail broad, even. This includes Cacatua, the cockatoo, whose sternum has no fontanelles. Calopsittacus has slender clavicles and large sternal foramina. Nasiterna has no clavicles and lateral sternal holes. Calyptorhynchus, the black cockatoos, and the large beaked Microglossus, are also examples. Melopsittacus has a bony ring in the ali-nasal cartilage.

2. *Platycercidæ.*—Macaws, with long tails; strong beaks, with long, down-curved, upper mandibles and pointed wings. Ara, the macaw, has clavicles, and no sternal foramina, while Platycercus has the former rudimental, and Pezoporus has no clavicles.

3. *Psittacidæ.*—Parrots. Brightly-coloured birds, with short, broad, or rounded tails; the cheeks, and usually the lores, are feathered; the beak is more moderate in size than in the other families; the feet long, with pointed claws. This includes the common parrot, Psittacus erythacus, and others. Psittacula Galbula has no clavicles.

4. *Trichoglossidæ.*—Lories. Bill moderately curved and compressed tongue, with long, horny papillæ.

5. *Strigopidæ.*—Kakapos. Beak short, thick; wings short, almost functionless, not reaching to the root of the tail; clavicles absent, keel on the sternum obsolete. New Zealand burrowing or ground parrots.*

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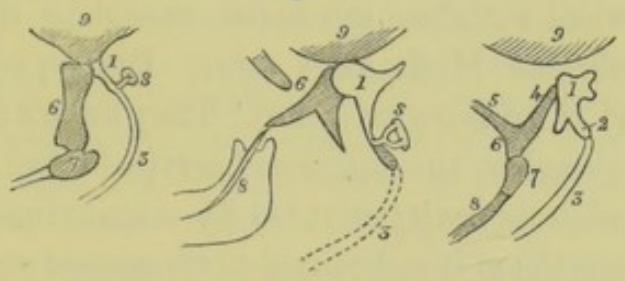
* A remarkable series of birds have been described from the American upper Cretaceous rocks, which bear distinct enamel-coated teeth. Professor Marsh has described two series of these, forming two distinct orders—1. *Odontotormæ*, Carinate birds, with amphicœlous vertebræ, large wings, teeth in sockets, and the metacarpals ossified, example Ichthyornis. 2. *Odontolcæ*, Ratide birds, with vertebræ as in recent birds, rudimental wings, and teeth in grooves, not in sockets. Hesperornis was about six feet high.

CHAPTER XXV.

Characters of Mammalia.

Class V. *Mammalia* (*Temminck*).—Hair-clad, viviparous vertebrates, nourishing their young by the secretion of modified dermal glands (milk). The warm blood has both non-nucleated, circular (elliptical in camels), discoidal, red, and nucleated white corpuscles. The quadrilocular heart has a membranous right auriculo-ventricular valve. The aorta arches to the left, and gives off a right brachio-cephalic branch. The embryo has an amnion and allantois, and never has gill-filaments on its

Fig. 35.



Forms of the suspensorium in Hatteria (p. 128), in Mammalia, and in a fish: (after *Huxley*) 1, incus (in Hatteria the supra-stapedial cartilage, in the fish hyomandibular); 2, stylo-hyal; 3, hyoid arch; 4, meta-pterygoid; 5, pterygoid; 6, quadrate (in Mammal the malleus); 7, os articulare of mandible; 8, Meckel's cartilage; 9, periotic capsule; *s*, stapes; 1, 2, & 3 form parts of the hyoid arch; 4, 5, 6, 7, 8 of the mandibular. The stapes is a segmentation from the periotic capsule.

visceral arches. The outer part of the second visceral cleft is usually guarded by a dermal and cartilaginous flap (the external ear). The middle (tympanum) is divided from the outer part by a membrane (membrana tympani), and is surrounded by a membrane-bone (tympanic), inclosing—1st, the diminished quadrate (malleus*); 2nd,

* The malleus is kept in its place by two ligaments between the layers of the membrana tympani; a part of it often remains cartilaginous (*Moos, Prussak, Gruber*).

the separate supra-stapedial part of the hyoid arch (incus); 3rd, an ossicle (orbicular), representing the proximal end of the symplectic; and 4th, the stapes. The mandible articulates with the squamosal by a convex or flat condyle, and consists of two rami, joined by a median symphysis. The brain-case has ossified walls, whose elements are united by suture. The occipital bone has two condyles. The parasphenoid,* post-frontal,† and quadrato-jugal bones are absent. The elements of the periotic early coalesce; the cartilaginous pre-frontals or ect-ethmoids join the mesethmoid, and form the lateral masses and *ossa plana* of the ethmoid. The single vomer is bi-laminar, and may form part of the roof of the mouth.

The cervical vertebræ are seven, except in the Manatee (six), Cholœpus Hoffmanni (six), Bradypus torquatus (eight), and B. tridactylus (nine). They have a lateral arterial canal, closed by the ankylosed cervical ribs. The atlas is ring-like, with its cavity divided by a transverse ligament. The *os odontoideum* is ankylosed to the second vertebra (axis or epistropheus). The dorsal vertebræ vary from ten (Dasypus niger) to twenty-four (Cholœpus); the lumbars are two (Ornithorhynchus) to nine (Stenops). Usually the number of trunk vertebræ is constant in each group. The sacral vertebræ range from one (Perameles, Halicore) to ten (Priodonta). The tail vertebræ may be from two (Anura) to forty-six (Manis).

One dorsal vertebra (8th to 14th) has generally a straight spine; in front

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* Its rudimental representative may be the lamellar membrane ossification forming the surface of the sphenoidal rostrum.

† This may be represented by the intercalary or Wormian bone, often present in the spheno-parietal suture in man.

of this the spines slope backwards, behind it they slope forwards; this is the anticlinal vertebra, and *Giebel* regards it as the true division of the dorsal and lumbar areas. Such vertebræ only are truly sacral as support the ilium; those ankylosed to these, but not touching the ilium, are pseudo-sacral. Below and between the caudal vertebræ are V-shaped chevron bones, ossifying from lateral centres, to protect the caudal artery. The vertebral bodies have usually plane surfaces, but in the necks of Ungulates the faces are opisthocœlous; in some Primates they are spuriously pro-cœlous. The vertebral bodies are united by ligamentous inter-vertebral disks, in the soft centres of which remain traces of the notochord. Mammals with heavy heads have a bilaminar, elastic, supra-spinous ligament (ligamentum nuchae) attached to the occiput and to the long anterior dorsal and lower cervical spines (withers). The spine of the axis extends upwards as a flat plate.

Each dorsal vertebra bears a pair of ectosteally-ossifying ribs, whose vertebral end has usually a head and a tubercle, but the hinder ribs lose one or the other. To each in front is articulated a cartilaginous sternal rib, partly ossifying by endostosis. The sternum consists of pre-, meso-, and xiphi-sternum; when a clavicle exists the pre-sternum is wide and flat, otherwise it is narrow. Clavicles are absent in mammals that use their fore-limbs for support only. The pubes unite in a symphysis. The movable ankle-joint is between the leg-bones and the first row of tarsal bones, which never ankylose to the tibia. The outer toe of the pes has never more than three phalanges. The last phalanx of each digit may be completely enveloped in a horny epidermal sheath, which may be dilated and flattened (ungula, hoof), or compressed and sharp-pointed (falcula, claw), or the sheath may be on one (dorsal) side alone, as a flat (unguis laminaris), or a swollen nail (unguis tegularis). Some mammals walk on the entire sole (plantigrada), others on the fingers (digitigrada), others on the last phalanx only (unguligrada), others on the backs of the digits (dorsigrada). The long bones of the limbs contain marrow.

A supra-spinatus muscle clothes the pre-scapula. There is generally a trachelo-acromial muscle, a cephalic extension of the trapezius, and often of the rhomboid. The serratus magnus has a cervical portion, which may be separate (levator anguli scapulæ). There is a large ilio-psoas muscle; the rectus femoris is always present, and attached to the patella. The long peroneal muscle seldom joins any of the digital flexors.

When the adult is naked, as in whales, hair has existed in the embryo. According to the shape and size of the secreting papilla (see p. 146, fig. 32), hairs may be simple (*pili*), curled and rough-edged (wool), spines (as hedge-hog), horn (as in the rhinoceros), plates (as in armadillo), imbricating scales

(as in Manis), or rigid, with sentient bulbs at base (as the vibrissæ or whiskers of a cat). In cold climates the pelage thickens in winter.

Mammary glands consist of numerous cæcal tubes, which branch from a number of ducts that open on the surface of the skin by separate or clustered openings, surrounded by circularly-disposed, dartoid, muscular tissue. Milk consists of fatty globules and protoplasm-corpuscles suspended in a fluid; it contains casein, butyrin, lactose, water, salts (especially phosphates) of soda, potass, and lime, and is of sp. gr. 1·015–1·045. The milk secreted by animals immediately after the birth of their offspring (colostrum) is richer in butter and lactose than ordinary milk; its fat vesicles are altered epithelial cells, and are nucleated, while ordinary butter cells have been so altered as to lose their nuclei. There are two sets of dermal glands, sebaceous or fat-secreting, and sudoriparous or sweat-exuding; the first set open into the hair follicles. The latter are absent in whales, mice, moles, &c. Specially modified dermal glands exist on the temple of the elephant, the occiput of the camel, the back of the peccary, the side of the shrew, the ankles of ruminants, the tail of hyrax, &c.

In the craniometry of mammals certain lines are of importance—1st, the basi-cranial axis, stretching medially from the fore-lip of the foramen magnum through the basi-occipital and basi-sphenoid to the pre-sphenoid; 2nd, the basi-facial axis extending from the inter-premaxillary suture to the spheno-vomerine articulation; where these meet they inclose the cranio-facial angle.

The mouth has soft lips (except in cetaceans and monotremes). The nostrils open into the pharynx, and the separate Eustachian tubes open laterally, and are usually closed, but open during deglutition.* The œsophagus has a striped muscular sheath, and the larynx a cartilaginous epiglottis; salivary glands (see Cetacea), spleen, liver, and pancreas always exist; the duodenum contains *Brunner's* glands. The intestine is 4–5 (flesh-eaters), 6–9 (fruit-eaters), or 10–28 times (herbivores) the length of the body,

* Cleland states that in man the tube is normally open. The bursa pharyngea of Mayer in man and monkeys may be the representative of the median opening found in reptiles and birds.

and a cæcum is usually present. The Wolffian bodies remain only as rudiments. The compact kidneys consist of cortical and medullary parts, and have no reno-portal system.*

There is no syrinx, and the bronchi never open on the surface of the lung, nor are there thoracic air-sacs. The diaphragm is a complete, infra-cardiac, thoracico-abdominal septum, with a central tendon (which is small in Orca and Delphinus).

All but Manis, Myrmecophaga, and Echidna have teeth in sockets—horny in Ornithorhynchus and Rhytina, dentinal in others; these are confined to the maxillæ, premaxillæ, and mandible, and are usually heterodont (some having two or more fangs), rarely homodont and numerous, as in Cetaceans. Most mammals are diphyodontal; and as the milk teeth are fewer than the permanent, the latter may be successional or primary, according as they have had predecessors or not. The premaxillary teeth are named incisors, and have usually chisel-like crowns. The first maxillary tooth next the premaxillo-maxillary suture (the canine) is usually strong, conical, and one-fanged, and the successional maxillary teeth behind it are called pre-molars; the primary teeth still farther back are called molars. The mandibular teeth corresponding to these are similarly named. Gaps often occur in the line of teeth, and are called *diastemata*. Professor Owen formulates the teeth of a mammal by placing the numbers of mandibular teeth below, of upper jaw teeth above, a horizontal line, and prefixing to the numbers the initials of the sorts of teeth,

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* Unless minute anastomosing branches in the capsule of the kidney may represent it.

thus the dentition of man is written—

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

that is, two incisors—one canine &c.—on each side of each jaw. In the succeeding pages I have omitted the bilateral repetition, as, with the exception of the Narwhal, the teeth are symmetrical among mammals.

The brain has lateral cerebellar lobes, covered by the flattened upper or median lobe; a corpus callosum, joining the cerebral hemispheres, and a commissura mollis. The eye has no bony sclerotic plates and a rudimental nictitating apparatus. The cochlea is coiled, except in Monotremes, and its whorls may be nearly on the one plane (whales), or steeply helicoid (Cavia). The brachial plexus consists of four cervical and one dorsal nerve. The ciliary and iridal muscles are unstriped.

Mammals have existed since the days of the Trias, and the oldest known forms are marsupials.[1] About 2300 species are living, divisible into three sub-classes.

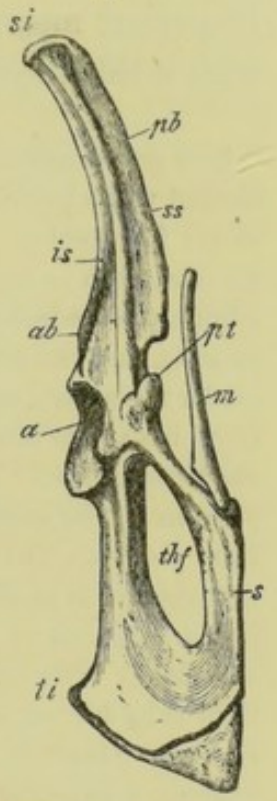
CHAPTER XXVI.

Non-placental Mammals.

Sub-class I. *Ornithodelphia* (*Blainville*).—Small, unguiculate mammals, with large coracoid bones, articulating with the pre-sternum, having epicoracoids in front of them, and between them a median T-shaped interclavicle. The acetabulum is perforate, and has no ligamentum teres. The urogenital ducts open into a cloaca separate from the urinary bladder (also opening therein).

The male has a cloacal penis, free from the ischium, and the penial urethra is separate from the cystic. The female has no vagina, but the two uteri (whose Fallopian tubes are not fimbricated at the free end) open separately into the cloaca. The mammary glands are placed far back on the abdomen, and resemble the pre-anal glands of lizards. Each consists of many cæcal tubes opening on a bare spot, not on a nipple, and is surrounded by panniculus. There is no placenta developed.

Fig. 36.



Marsupial bones of kangaroo, shown in its position on the os innominatum: *si*, crest of ilium; *ps*, posterior surface of ilium; *is*, gluteal surface; *ss*, iliac fossa; *pt*, pectineal tubercle; *a*, acetabulum; *thf*, thyroid foramen; *s*, symphysis pubis; *ti*, tuber ischii; *m*, marsupial bone.

This sub-class includes one order, Monotremata (*Geoffroy*) containing two Australian genera, which possess long supra-pubic ossifications in the tendon of the external oblique muscle of the abdomen, called marsupial bones. The vertebral centra have no epiphyses, and some of them unite by synovial joints. The odontoid bone long remains separate from the axis, as do the cervical ribs, of which the sixth and seventh are the smallest. The ribs touch the vertebral bodies with their nearly undivided heads chiefly below the neurocentral suture, and the dorsal spinal nerves pierce the neural arches. Between the sternal ribs and the vertebral (which, except the first, ossify ectosteally) are intermediate ribs, which ossify by endostosis. The cranial bones early ankylose, and the cribriform plate of the ethmoid is nearly horizontal. The tapes is imperforate. The scapula has its meso-scapular

edge directed forwards, so that its outer surface consists of the post- and sub-scapulæ, only separated by a slight tricipital spine, while the pre-scapula is internal. The optic lobes are simple, the corpus callosum absent, and the cerebral hemispheres small, smooth, not covering the cerebellum. They possess a gall-bladder, and but one (superior) mesenteric artery, no outer ear, and small eyes, with a third eyelid.

Two genera are included:—1st. Ornithorhynchus, the platypus, aquatic, clothed with close-set, flattened, contour hairs, and fine grey wool-hair; legs short; feet webbed; muzzle duck-bill-like, flat, made of the separated premaxillæ, with an intermediate prenasal, covered by a leathery skin, which is minutely foraminated, and forms a free fold at its base. There are cheek pouches, and two flat, horny, maxillary teeth, with raised outer edges (the hinder the larger), and corresponding mandibular teeth. The tongue, soft in front, has a wide hind-lobe, with horny spines. The sub-maxillary gland has one tortuous duct. The alæ of the thyroid cartilage surround the sides of the pharynx. The small intestine has large valvulæ conniventes and a vermiform process. The cerebrum is not convoluted; the pons is small, and the falx cerebri is ossified; the spinal cord extends to the sacrum. The heart has a large sinus venosus, two precaval veins, and the right auriculo-ventricular valve consists of two membranous and two muscular flaps. The right lung has an azygos lobe lying on the diaphragm, and the spleen is bilobed. There is no outer ear, a small membrana nictitans, a strong zygoma, a post-orbital process, no jugal bone, united condyloid and jugular foramina, and a basi-cranial fontanelle internal to the foramen ovale. The xiphi-sternum is unossified, but there is a pro-osteon in front of the pre-sternum, uniting in the adult with the inter-clavicle; there are two clavicles, and the right epicoracoid overlaps the left. The femur has two equal trochanters; the fibula has a large, flat, styloid process; the fourth and fifth tarsals remain separate; the astragalus has a bifid head for the tibia and fibula, and the fifth metatarsal is the longest. The vertebræ are *d.* 17, *l.* 2, *s.* 3, *c.* 22. The sterno-mastoid arises below the inter-clavicle, the sterno-hyoids and thyroids are fused, and the omo-hyoid unites with the mylo-hyoid; the rectus abdominis extends to the first rib, and the pyramidalis is broad. There is an occipito-nuchal rhomboid, a double trachelo-acromial, the hinder inserted in front of serratus magnus; the latissimus dorsi and teres major extend to the inner condyle of the humerus.

There is an epicoraco-brachial, as well as a short and a long coraco-brachial. The scapular muscles follow the displacement of the bone. The dorsi-epitrochlear is large; the biceps coraco-radial, with a double coracoid head; there are two anconei, and the supinator longus is continued into the carpus. The flexor sublimis is confined to the manus. The psoas parvus is larger than the p. magnus. There is no obturator internus, but a large gemellus, and some fibres segmented from the gluteus maximus are described as *inter-tibialis*. The sartorius arises from the pectineal eminence, and the popliteus occupies a large tibial area, and is chiefly fibular in origin. The plantaris arises from the fibular spur, the soleus is inserted into the astragalus, while the extensor brevis digitorum is carried up the front of the leg. The flexor digitorum is short, and the peroneus quinti large. Ornithorhynchus paradoxus, about 18″ long, is in habit like a water-rat, and is insect-eating. The male has a tarsal gland, from which a duct passes through the perforate post-tarsal spur, supported on an accessory tarsal bone.

Echidna, the spiny ant-eater, about 1′ long, is covered with spines, stronger than those of the hedgehog. Its feet have stout, conical claws; the tongue is long, cylindrical, papillose, as is the palate, and the rictus of the mouth round. The sub-maxillary gland is large, with dilated ducts, which divide and open into the mouth by many pores. The stomach is globular; the intestine has weak mucous folds, a glandular cæcum, and a vermiform appendix. The liver is four-lobed, the spleen three-lobed. The two precaval veins are joined by a transverse branch, and there are two venæ azyga. The fœtus has a ductus arteriosus, a foramen ovale, a premaxillary caruncle, and a thymus. There is no prostate, and the testes are abdominal and periodically enlarged. At the front of the cloaca is the orifice of the uro-genital duct, into which open in the male centrally the bladder, laterally the vasa deferentia and ureters (there are no seminal vesicles). Posteriorly the anus, with its lateral saccular glands, opens into the cloaca.

The blood corpuscles are $\frac{1}{3000}$″ in diameter; the eye has a circular pupil, and no tapetum; the external auditory meatus is long, and strengthened by incomplete cartilage rings, like those of a bronchus, the series being united by a cartilage strip. The malleus is large, and the incus very small; the cochlea is but slightly bent, not coiled. The brain is larger than in Ornithorhynchus, and slightly convoluted; it has no septum lucidum, and a rudimental corpus callosum overlying the large anterior commissure. The spinal cord ends medio-dorsally. The vagus is separate from the sympathetic in the neck, but is united to the hypoglossal.

The pelvic bones remain long separate; the symphysis is equally made up of the pubis and ischium on each side. The humerus has long condyles and a supra-condyloid foramen, the ungual phalanges are tubular in both

manus and pes, and the males have a tarsal gland and spur. The carpus has no os centrale, and the large pisiform articulates to the ulna; the vertebræ are *d.* 16, *l.* 3, *s.* 2, *c.* 13. The xiphisternum is unossified; the nasals do not reach the anterior nares, but the premaxillæ, which form the snout, unite above and below that opening. The pterygoid forms part of the wall of the tympanic cavity, the tympanic bone being slender; the squamosal is large, and there is a pterotic element in the cranial wall, between the occipital, the squamosal, and the parietal. The palatine partly bounds the optic foramen, and the jugal process of the maxilla has no post-orbital process. The tympano- and stylo-hyals are ligamentous, and the slender mandible has a rudimental condyle and coronoid process.

The stomach has horny papillæ at its pylorus, the ovaries are lobulated, the glans penis is four-lobed, the snout long, cylindrical, the teeth none. The mylo-hyoid muscle extends to the occiput, as well as to the mandible; the rhomboid is occipito-nuchal; the latissimus dorsi is in two parts, of which the lower or dorsi-epitrochlear, arising from the ribs, sends a slip into the flexor carpi ulnaris. The supra-spinatus is on the costal surface of the scapula; the palmaris brevis is large, ulnar in origin; the forearm flexors are to the extensors as 14 : 37. The gluteus maximus is tripartite, the hindmost slip extending to the ankle. There is an ilio-peroneal muscle, as well as an epicoraco-humeral; the tibialis anticus is double; the gastrocnemius is small, with one belly; the tibialis posticus is inserted into the astragalus; there is a peroneus quinti and a p. quarti digiti in front of the ankle; the psoas parvus is large.

How the young are suckled is unknown. In 1854 a female was found carrying a naked young one 1½" long, with the snout in a sort of pouch. Mr. Bennett describes ("Proceedings Zoological Society," 1877, p. 161) the singular burrows of Ornithorynchus and the condition of their young.

CHAPTER XXVII.

Non-placental Mammals (*continued*).

Sub-class II. *Didelphia* (*Blainville*).—Implacental unguiculate mammals, with marsupial bones (figure 36, page 205), and having the coracoids as hooked processes of the scapula, not reaching to the sternum. The clavicle

(only absent in Chœropus and Perameles) has a pre-coracoid segment at its scapular, a meso-scapular at its sternal end, which is separated from the sternum by an omo-sternum, but there is no epi-coracoid nor inter-clavicle. The skull has persistent sutures and large nasal cavities at its most anterior part, the zygoma is complete, the orbit incomplete behind, and the ascending process of the pre-maxilla never touches the frontal. The mandible has an inflected angle (except in Tarsipes). The teeth are numerous, heterodont; the only deciduous tooth is a molar placed over the hindmost pre-molar, and this may be functionless (Thylacinus, absent in Koala and Dasyurus). The upper incisors are usually more numerous than the lower; the molars are never complex. There is an external ear, a coiled cochlea, a circular pupil, a pre-penial scrotum, with the *tunica vaginalis* communicating permanently with the peritoneum. The female has a pre-cloacal abdominal pouch (rudimental or none in opossums and Sarcophilus), in which the young, born in an imperfect state of development (39 days in kangaroos, 17 days in opossums), are placed by the mother, who uses her mouth for this purpose. The mammæ are on the abdominal wall in the pouch, covered by muscular fibres (representing the cremaster of the male?). The mouth of the fœtus receives the nipple, and remains persistently attached there for a time, while the mother injects the milk, which the feeble embryo would be unable to suck (*Owen*). At this period the larynx is elongated, and the glottis is embraced by the levatores palati muscles, so that respiration through the nostrils continues unimpeded. The cerebral hemispheres are smooth, and leave the cerebellum and often the optic lobes uncovered; the corpus callosum is very small. The valves of the heart are membranous. There is no

inferior mesenteric artery, and the internal iliacs arise separately from the aorta. There are two venæ azyga and two precaval veins, as well as two thoracic ducts, beginning in a plexus, not in a sac, and coalescent above. They form one polymorphic order, Marsupialia (*Illiger*), and, except the American opossums, are confined to Australia, Tasmania, and the Australian Islands.

The rudimental cervical ribs early ankylose; those of the axis remain separate in Perameles. The odontoid early unites to the axis. In wombat and Koala there is no bony nucleus in the fibro-cartilaginous anterior half-arch of the atlas, or it may become ossified by an inward extension from the lateral masses (Hypsiprymnus, Macropus); rarely a central detached ossicle exists, joined to the lateral masses by ligament (Thylacinus), or by suture afterwards uniting (Didelphys, Perameles). The dorso-lumbar vertebræ are 19, of which the last may be ankylosed to the sacrum; 13 are usually rib-bearing (11 in Koala, 15 in the common wombat, 12 in Petaurus). The anticlinal vertebra may be the 9th (Dasyurus), 11th (Perameles), 12th (kangaroo), or 13th (Petaurus). The arterial canal in the 7th cervical vertebra is incomplete in Dasyurus. The sacral vertebræ vary from 7 (3 true and 4 false) in the wombat to 4 (Myrmecobius, 2 + 2), 3 (Petaurus, 1 + 2), or 2, as in Dasyurus (1 + 1). The caudals vary from 6 in Koala to 25 in Macropus, 35 in Didelphys, or 31 in Phalangista; the last-named forms have prehensile tails. Chevron bones are only absent in wombat and Koala. The meso-sternum has four sternebers; the xiphi-sternum is long, and early ossified, with an expanded cartilage. The sternal ribs join the sternum by synovial joints, and have no intermediate ribs.

The procoracoid joins the acromion by ligament, except in the wombat; the humerus has a supra-condyloid foramen, except in Hepoona and Dasyurus; the radius and ulna are distinct, mobile; the carpus has no *os centrale*, and has separate scaphoid and lunar bones (the lunar is absent in the kangaroo, variable in wombat). The fore-limb digits are usually five, except in Chœropus, which has no pollex, a rudimental trapezium, large second and third digits, and a rudimental fourth finger, with no fifth; Perameles has very small first and fifth, a very large third, and a small second, with a still smaller fourth. The ungual phalanges are often split, as in Perameles; sometimes the pisiform is long, like a sixth finger (Chironectes).

The ilium is laterally compressed, with a narrow fossa (Dasyurus), or flattened, with the iliac and gluteal fossæ uniting at a crest (wombat) (see fig. 36).

The symphysis is ischio-pubic, and the pectineal tubercle is large. The marsupial bones are cartilaginous in Thylacinus, largest in Macropus. The acetabulum is imperforate, and a ligamentum teres exists, except in the wombat and Koala. The femur has a third trochanter only in wombat. The fibula is complete at its distal end, ankylosed or free, and is surmounted by a sesamoid bone, which may ankylose to its styloid process. The tarsals are seven; the astragalus small and flat; the second and third toes are syndactylous (contained in a common sheath of skin), slender, except in Thylacinus, wombat, and Sarcophilus. The hallux is rudimentary in Dasyurus, absent in Thylacinus and Macropus, opposable and nailless in the opossum, nailless and of one phalanx in wombat. In Perameles, Macropus, and others the metatarsus is long, the fourth toe large, and the fifth rudimental; a hallux is present in Perameles, absent in Chœropus, which has the second, third, and fifth toes very small, and a very large fourth.

The parietals early unite; the carotid canal is in the basi-sphenoid, which has no clinoid processes. The tympanum is bounded in part by the dilated alisphenoid (which, with the squamosal, contain air-spaces in Petaurus). The malar, which touches the lachrymal in front, usually forms part of the glenoid cavity for the lower jaw. The squamosal, tympanic, and peri-otic remain separate, and the last has a large floccular fossa. The squamosal extends behind the tympanic to join the large paroccipital process of the ex-occipital. The optic nerve traverses the sphenoidal fissure; the mesethmoid is extensively ossified. The nasals are large, and prenasals exist in Perameles. There are deficiencies in the hind part of the hard palate and lamelliform pterygoids. The epi-, stylo-, and tympano-hyals are unossified: the malleus and incus are ankylosed in wombat and Perameles, and the stapes is either undivided or simple for half its length. Canine teeth are absent in Macropus and wombat. The marsupial pouch has its mouth directed forwards, except in Thylacinus and Chœropus. The panniculus extends into its wall, and can constrict it. The nipples are 4 (Macropus), 8–13 (opossums), or variable; they are long, each having a number of non-ampullated ducts opening in a circle on its surface. The compressor mammæ muscle is attached to the marsupial bone, as is the gracilis, so that each limb movement may be attended with an ejaculation of milk (?). The fœtus has a slit-like foramen Botalii, which leaves no fossa ovalis; there is no thymus, but symmetrical thyroid bodies. The umbilical vesicle is large, the chorion smooth, the allantoid small. The female has a shallow cloaca, with a sphincter, and two approximating vaginæ, often communicating at their mouths; the Fallopian tubes are fimbriated; the ova are small, in botryoidal (wombat) or smooth ovaries. Two wide lateral canals of *Gärtner* also exist (see fig. 13 *d*., p. 42). The ureters open into the bladder, the genital

ducts into the urethra or vagina, and the penial and vesical urethræ are continuous. The male urethra has a bilobed bulb, corpora cavernosa not attached to the ischium, and a double glans penis. There are also three pairs of Cowper's glands, a sacral retractor penis, and no vesiculæ seminales.

The biceps flexor cubiti is double, and consists of coraco-radial and glenoulnar parts. Cheek-pouches exist in the Koala and Perameles. Dasyurus and opossum have no sublingual glands. The stomach is simple in Dasyurus, with a large cardiac gland in wombat and Koala, long and colon-like, and sacculated in Macropus, its left end being bifid, ending in two *culs-de-sac*. The cæcum is absent in Dasyurus, short, with a vermiform appendix in wombat, longer than the body in Koala. There is a simple vertical mesentery for the whole intestine, and the liver is many-lobed, with a gall-bladder. There are two anal glands. The aorta gives off a right innominate artery and separate left carotid and subclavian branches, or a common innominate, from which both carotids and the right subclavian arise (Macropus). The blood corpuscles are $\frac{1}{3000}$″ (wombat), $\frac{1}{3800}$″ (Sarcophilus), $\frac{1}{400}$ ″ (Perameles). In Phalangista the 29 anterior tracheal rings are complete. The lungs may be uni- (wombat) or multi-lobate. The epiglottis is large, and the vocal chords are rudimentary, hence few have any voice.

The marsupials vary much in habit, and may be grouped into four sub-orders.

CHAPTER XXVIII.

Subdivisions of Marsupialia.

Sub-order I. *Rhizophaga* (*Owen*).—Including one genus, Phascolomys, the wombat of N. S. Wales, nocturnal, tailless, heavy, burrowing animals, about 2″ long. $I.\ \frac{1}{1}\ c.\ \frac{0}{0}$, $p.\ \frac{1}{1}$, $m.\ \frac{4}{4}$. The chisel-shaped incisors grow from permanent pulps, as do the other teeth. The foot bears five digging claws.

The clavicular trapezius flows over the clavicle into the clavicular deltoid. The serratus posticus is attached to all the ribs; a sterno-scapularis is

present; the rectus abdominis is attached to the first rib; there is no separate teres minor; a short coraco-brachialis; a large pronator teres inserted into the lower half of the radius, while p. quadratus is small. The palmaris longus is double; the extensor minimi digiti supplies the fourth and fifth digits; gluteus quartus is remote from g. medius; there is no obturator internus nor quadratus femoris; psoas parvus is weak. The femur has scarcely a trochlea, and the patella is cartilaginous. The large thin popliteus is fibulo-tibial, not femoral, in its attachments; the pectineus is double; the semi-tendinosus has no tendinous inscription; the sartorius arises from the iliac spine; there is a sesamoid fabella in the outer head of the gastrocnemius; no plantaris; the peroneus quinti is an offshoot from p. brevis, and *no* tertius exists; the liver has a rudimental Spigelian lobe, and the stomach has a gland. Three living species are known.

Sub-order II. *Rapacia* (*A. Wagner*) *or Sarcophaga.*— Having teeth of all kinds in both jaws; cæcum none or small; stomach simple; feeders on flesh or insects.

This sub-order includes four families:—

1. *Edentula.*— Teeth small, separate, *i.* $\frac{3}{1}$, *c.* $\frac{1}{1}$, *m.* $\frac{3}{3}$ or $\frac{4}{4}$, pointed, inconstant; snout long, pointed; mandibular angle not inflexed; tongue long, slender; ears round, small; pes five-toed; hallux nailless; second and third toes syndactylous, sharp-clawed; fourth and fifth toes with flattened nails; cæcum none; tail prehensile. The single genus Tarsipes is from King George's Sound.

2. *Saltatoria.*—Teeth *i.* $\frac{5}{3}$, *c.* $\frac{1}{1}$, *p.* $\frac{3}{3}$, *m.* $\frac{4}{4}$; snout pointed; muffle naked; hind-legs longer than fore; cæcum small; outer toe rudimentary, fourth large. This includes Perameles, the bandicoot, whose teeth have elongated, pointed cusps. The deltoid has a slip from the axillary costa of the scapula (*Owen*); the biceps has no coracoid head, but has two insertions into radius and ulna; the carpus has one radial extensor. The pyriformis is large, superficial; the psoas parvus is large, and p. magnus is only attached to two lumbar vertebræ; sartorius runs parallel to the rectus femoris, and it inserted into the patella. The tibialis anticus has a second insertion into the meso-cuneiform; the plantaris is small; the *tibial* peroneus very small. Chœropus has I. $\frac{4}{3}$, but otherwise resembles Perameles.

3. *Scansoria.*—*I.* $\frac{5}{4}$, *c.* $\frac{1}{1}$, *p.* $\frac{3}{3}$, *m.* $\frac{4}{4}$; pes plantigrade, five-toed, with the hallux opposable (hence the name pedimana applied to them); tail long, often scaly, prehensile. The cæcum is simple, short. The mammary gland has nine (D. dorsigera), eleven (D. Virginiana), or ten

teats. Didelphys dorsigera has no pouch, and the young are borne on the mother's back, with their tails twisted round that of the parent.

They have a distinct omo-hyoid muscle, a coraco-brachialis brevis only; a sterno-scapularis attached to the outer end of the clavicle, acromion, and supra-spinous fascia; the rectus abdominis is attached to the first rib; the pronator teres is large; the p. quadratus is attached to ⅓ of the radius; the flexor profundus digitorum gives off its polliceal tendon across the other inner tendons; the supinator longus is inserted into the scaphoid; the two radial extensors are separate; the extensor ossis metatarsi pollicis is inserted into the trapezium and first metatarsal; the extensor indicis supplies the middle and index fingers; the psoas parvus is ⅓ of the p. magnus; the quadratus femoris is large; the obturator internus is represented by a large gemellus. There is a fourth hamstring, *biceps accessorius*, arising by a tendon from the first and second caudal vertebræ, and inserted into the fascia of the leg. The semi-tendinosus has an inscription, from which two bellies pass to the tibia, one above the other. The popliteus and tibio-peroneal occupy the whole of the inter-osseous space of the leg. There is no *tensor vaginæ femoris*, nor solæus, but a plantaris; the flexors of the toes are with difficulty separable; the extensor digitorum does not rise to the femur. There is a peroneus quartus inserted behind into the second, third, and fourth toes: the peroneus longus rises to the femur, and there is a p. brevis and quinti. Didelphys, the opossum, and Chironectes, the aquatic Yapock (web-footed) are the genera included, both American.

4. *Dasyuridæ.* — *I.* ⅘ *c.* ¼; toes not webbed; pes four-toed; pollex often rudimental; tail not prehensile; cæcum none. Sarcophilus, the Tasmanian Devil, has no hallux, a stout body, a short broad head; the entire mass of the temporal and masseter muscles equals in weight all the scapular and brachial muscles; there are two trachelo-acromiales, a minute teres minor, a slender ulnar insertion of the biceps, no supinator longus, a subclavius, a palmaris longus tendinous at both ends; the flexor carpi ulnaris sends a tendinous slip to the little finger; the indicator supplies the second and third, sometimes the fourth, finger; the palmaris brevis arises from the pisiform; the psoas parvus is one-fourth of the ilio-psoas; the pectineus is small; the quadratus femoris large, with sling-like origin from the caudal vertebræ. The semi-tendinosus has a caudal, as well as an ischiatic head, joining at the inscription, and the biceps accessorius is inserted with it. There is a fibular soleus, a plantaris from the outer lateral ligament of the knee (in Dasyurus from the fibula—*Owen*), peronei longus, brevis, quinti, quarti, and tertii digiti passing *behind* the malleolus, but no p. tertius.

Dasyurus has equal incisors, p. ⅔ m. ¼, a slender, often white-spotted,

body, and a wart-like hallux. Thylacinus, the Tasmanian wolf, has a black-striped body, a dog-like head and general aspect; the outer incisors are the largest, $p.\ \frac{3}{3}\ m.\ \frac{4}{4}$, with no hallux, and blunt claws; the liver has the gall-bladder at its left side. Phascogale is arboreal, with large median incisors, $p.\ \frac{3}{3}\ m.\ \frac{4}{4}$, the last upper molar being small, transverse, and the hallux opposable, nailless. Myrmecobius, the banded ant-eater, has $p.\ \frac{3}{3}\ m.\ \frac{6}{6}$; no pouch in the female, but, like the last, eight nipples in a circle; tongue long, slender.

Sub-order III. *Carpophaga* (*Owen*).—Median incisors large, I $\frac{3}{1}$; stomach simple; cæcum large; hallux present; second and third toes syndactylous. This includes two families:—

1. *Phascolarctidæ.*—The Koala, *c.* $\frac{1}{0}$ *p.* $\frac{1}{1}$, *m.* $\frac{4}{4}$. The cæcum is enormous, the hallux nailless, the tail rudimental, the pollex and index both opposable to the three outer digits. The female is uniparous. The omo-hyoid is large, monogastric; the anterior belly of the digastric unites with the omo- and sterno-hyoids; there is a large trachelo-acromial, a pectoralis minimus, a subclavius, a thread-like teres minor, a small pronator quadratus (one-sixth of the radius). The supinator longus arises from the humerus and the deltoid, and is inserted into the scaphoid. The radial extensors of the carpus are inserted into the middle of the shaft of the metacarpals. The psoas parvus equals the p. magnus; there is a pectineus, with a double origin; a quadratus femoris; a bilaminar gluteus maximus; no biceps accessorius; no separate tensor vaginæ femoris, soleus, nor flexor accessorius (but a muscle arising like the accessorius is inserted into the halluceal sesamoid). The popliteus is tibio-fibular; the plantaris arises from the fabella in the outer head of the gastrocnemius, from which part of the peroneus longus arises. The tibialis posticus is double; the flexor brevis digitorum arises from the surface of the flexor profundus on the back of the leg, like the superficial flexor of the manus. There is a large inferior tibio-fibular muscle, and peronei brevis, quinti, and quarti metatarsi.

2. *Phalangistidæ*—Phalangers, *c.* $\frac{1}{1}$ *p.* $\frac{2}{1}$, or $\frac{2}{2}$ (Acrobates), or $\frac{3}{2}$, or $\frac{3}{3}$ (Dromicia, Belideus), *m.* $\frac{4}{4}$ (in Dromicia, from Tasmania, $\frac{3}{3}$). The stomach has no gland; the tail is prehensile, scaly, or naked beneath at the tip; the lower canine is usually functionless, as in Phalangista. In Hepoona the two inner fingers are opposable to the others. Petaurus has a parachute of skin, or patagium stretching from the fore- to the hind-limb, along the side of the body. The muscular anatomy resembles that of the opossum. Thy-

lacoleo, a large fossil form, was either a carnivorous form (*Owen*) or, having no lower canine and m. $\frac{1}{2}$, was allied to Belideus (*Krefft*).

Sub-order IV. *Poephaga* (*Owen*).—*i.* $\frac{3}{1}$ (lower horizontal, chisel-shaped), *c.* $\frac{0}{0}$ or $\frac{1}{0}$, *p.* $\frac{1}{1}$, *m.* $\frac{4}{4}$. The stomach is sacculated, long; the cæcum long; the eyelids with marginal cilia; the fore-limbs are smaller than the hinder; the nipples, four in number, are within the pouch. The one family, Macropodidæ, or kangaroos, are grass-eaters.

Macropus has no upper canine, or a functionless one. The second and third toes of the pes are syndactylous, and the fourth and fifth alone are functional. The tail is large, used as an organ of support, with a very large caudal artery. There is a subclavius muscle, the supra- equals the infraspinatus (being larger in the other genera). The short coraco-brachialis only is present. The biceps is double, coraco-radial, and gleno-ulnar. The pronator teres is weak; the p. quadratus occupies four-fifths of the interosseous space. The supinator longus is inserted into the trapezium and first metacarpal. The extensor minimi digiti supplies the third, fourth, and fifth digits. The tensor vaginæ femoris, pyriformis, and quadratus femoris are large. There is no obturator internus, but the gemellus extends for a short distance into the pelvis. The psoas parvus is seven times the size of the psoas magnus, and twice that of the whole ilio-psoas. The popliteus arises from a sesamoid bone; the semi-membranosus is closely connected to the adductor magnus and to the semi-tendinosus; there is no biceps accessorius; the tibialis anticus has a double tendon, and there are four peronei, longus, brevis, quinti, and quarti. The arboreal Dendrolagus, from New Guinea, has its nasal bones medially narrowed, and an upper canine. Dorcopsis has also a canine, a broad pre-molar, and a long skull. Hypsiprymnus, the kangaroo rat, has the pre-molar larger than the molars, and large inflated tympanic and alisphenoid bones.

The oldest fossil mammals known are the Triassic forms, Microlestes, and Dromatherium, which were allied to Myrmecobius. Other generalized extinct forms have been met with, which unite the characters of several of the sub-orders, such as Procoptodon, Phascolotherium. Some of these were of enormous size, as Diprotodon, Dinotherium.

CHAPTER XXIX.

Placental Mammals.

Sub-Class III. *Monodelphia* (*Blainville*).—Mammals, with a single vagina; a coracoid, as in Didelphs; a spiral cochlea; an odontoid ossifying to the axis; an imperforate acetabulum; no inter-clavicle, marsupial bones, nor cloaca. The chorion of the embryo is externally beset with large vascular villi, which, coming in contact with the uterine mucous membrane, sink into pits therein, not the glandular crypts of the uterus. They may be withdrawn from these on the birth of the young, or they may contract so close an adhesion to the uterine mucosa that the chorion tears a layer of this membrane (called the *decidua*) away with it during parturition, and thus denudes the lining of the uterus of its surface. Animals with no decidua are called indeciduate, and in these the villi may be uniformly diffused, or in scattered patches or cotyledons. In the former case placentation is said to be diffuse; in the latter it is called cotyledonary. Deciduate mammals differ in their placentation, according to the shape of the placental area, which may be dome- or bell-shaped, zonary, or discoidal.

The vagina is divided by a septum in Orycteropus, and as an anomaly in some others. A cartilaginous structure is described by Professor Huxley in the dog, as a rudiment of the marsupial bone, but I have failed to find it in many dogs, and have never seen it in the wolf, dingo, jackal, fox, nor hyena.

In some Cetaceans the excretory openings appear to end in a cloaca, but this is only a skin-folding.

The testes are abdominal, inguinal, or in a post-penial scrotum. The compressor mammæ is not present. When the ovum enters the uterus in deciduate mammals the mucous membrane thickens, and forms vascular

folds around it, inclosing it in a chamber. The uterine mucous membrane is called *decidua vera*, the wall of the fœtal chamber is called *d. reflexa*, and the thickened base *d. serotina*.

Blainville and Huxley have divided Monodelphs into groups, depending on the form of the placentation, but this is not always available as a character of primary taxonomic value.

Monodelphia are divisible into fifteen orders.

CHAPTER XXX.

Edentate Mammals.

Order I. *Edentata* (*Cuvier*).—A polymorphic order of claw-bearing, usually indeciduate mammals, with thoracic mammæ, abdominal or inguinal testes; no median incisors, nor canine teeth, and when any other teeth exist they have permanent pulps, and seldom have enamel, or milk predecessors. There is no os centrale in the carpus, nor *antrum maxillare*. Their food consists of insects or carrion. The mandibular rami are separate, and the malar has no down-directed spur; the coracoid and acromion processes are separate. The femur has a third trochanter, and the humerus a supra-condyloid foramen.

Two sub-orders are included herein—1st. Entomophaga (*Wagner*), ant-eaters, terrestrial or arboreal, long-tailed, having the scaphoid and trapezium bones distinct (?) Skulls long, with incomplete zygomata (except in Orycteropus) and elongate maxillæ; tongue long, worm-like; sub-maxillary glands enormous, covering the front of the neck, and often the upper edge of the thorax, and secreting a viscid fluid; the hind-legs longer than the fore.

Three families are included:—

1. *Myrmecophagidæ*.—South American, toothless; skin tough, clad with coarse hair (or soft wool, Cyclothurus). The brain is convoluted, with a

large corpus callosum and anterior commissure. The uterus with one (Cyclothurus) or two mouths (?), placentation deciduate, discoidal (*Mayer* (?) (*M. Edwards* did not find it so); the placenta lying in a special uterine pouch The peritoneum forms a single mesogastric fold for the intestines. The stomach is somewhat balloon-shaped, with a thick gizzard-like pylorus, and a slightly dilated duodenum. The trachea divides into three bronchial tubes; the heart receives one pre-caval vein, and has a moderator band in the right ventricle, and a deep fossa ovalis; the aorta gives off one innominate artery and a left subclavian; the premaxilla is small and loose. The outer digit of the manus is clawless, and progression is on the outer edge of the foot. Myrmecophaga, the great ant-eater, has four large claws on the manus, five on pes. The pterygoid bones stretch backward behind the tympanic, over the basi-sphenoid, and they meet medially, hence the choanæ are bounded below externally by this bone (as in the crocodile), between which and the ali-sphenoid is an air sinus. The squamosal has no zygoma; the mandible has neither angle nor coronoid process; the hyoid arch is incomplete, the tympano-hyal being unossified, and the epi-hyal being rudimental. The laryngeal cartilages early ossify, and there are two vocal chords and two median pouches—one between the tongue and the basi-hyal, the other between the thyroid and cricoid cartilages. The cervical vertebræ have annular inter-vertebral substances, with a soft central sac, filled with a gelatinous material; the vertebrarterial canals pierce the pedicles obliquely; the vertebræ are *c.* 7, *d.* 15, *l.* 3, *s.* 5, *c.* 30; the eleventh to the thirteenth dorsals have each a second articular facet on each side on the laminæ; the two hindmost dorsals and the two anterior lumbars have an additional pair of facets farther back on the laminæ, while the third lumbar has a fourth pair on the transverse processes, or may ankylose to the sacrum. The meso-sternebers are eight, each with a club-like ventral process, articulating to its neighbours by synovial joints; each sternal rib has a head and a tubercle in front, the former articulating in the intervals between the sternebers, the latter with the club-like process of the sterneber above. There is no metacromion, but a large Retzian tubercle on the scapular spine, and a post-scapular ridge; the tibia and fibula are distinct, and there are no clavicles. The trapezius has no occipital origin, nor has the rhomboid; the coraco-brachialis is long; the inner head of the triceps is inserted into the flexor digitorum profundus, winding behind the elongated internal condyle. The biceps is double, and the brachialis anticus is absent; the palmarus longus has a second (olecranon) head. There is no subclavius, but it is functionally represented by one of the deep slips of the great pectoral. The serratus magnus is enormous; the pronator teres is inserted very low down, and the pronator quadratus is

large. There is a biceps accessorius, a caudo-femoralis from the sciatic ligament and ischium, inserted into the lower three-fourths of the femur. The semi-membranosus with separate lower slip. The popliteus arises with a fabella, and the femur has a ligamentum teres. The tongue is over 2′ long, and the tonsils are saccular, while the sub-maxillary duct has a large an p ılla.

Tamandua has a prehensile tail, hairy only at base, scaly at tip; ali-sphenoids with two air-sinuses, but otherwise resembles the last. It has a rudimental coraco-brachialis brevis, as well as a c. longus and a radio-carpeus. It has also an eighth cervical vertebra, with a long rib. Cyclothurus is small, arboreal, claviculate, with a prehensile tail of forty vertebræ, a short head, and short pterygoids. The mandible has an angle; there are fifteen wide overlapping ribs; an enormous third finger, with only two phalanges; the second is similar, slender, and the fourth is represented by a styliform metacarpal. The others are aborted, the pisiform large. The foot is four-toed, with a large sesamoid strigil bone on its tibial side. The trapezius is occipital in origin; the teres major is enormous; the coraco-brachialis is absent, and the biceps has no coracoid head, but has two insertions; the brachialis anticus is small; the flexor carpi ulnaris is very large, and tripartite, condyloid, olecrano-ulnar, and infero-ulnar. There is a small obturator internus.

2. *Manidæ*.—African or Asiatic, toothless, non-claviculate, uniparous, with diffuse indeciduate placentæ, dorsigrade, and covered with large imbricating scales; rictus of mouth small; tongue round, protrusible; outer ear very small, valvular; tail wide, powerful; manus and pes each five-toed; skull long, smooth, pneumatic, with no malars nor lachrymals, loose pre-maxillæ, and long pterygoids not uniting medially. The mandible has an ascending ramus. The vertebræ are *d.* 13, *l.* 5, *s.* 3, *c.* 46 (Manis longicaudatus) 40 (M. multiscutatus). The lumbars have no accessory articular facets, and the dorso-lumbar metapophyses point backwards. The coracoid is rudimental; the scaphoid and lunars are ankylosed; six mesosternebers exist, and the xiphi-sternum is split into two long cornua, which in M. multiscutatus are coiled to the left side, and from its end arises the sterno-glossi muscles, which pass continuously behind the sternum, below the trachea, into the tongue. In the last family this long retractor also exists, but the xiphi-sternum is not elongated. Rudimental abdominal ribs are also attached to one of these cornua (in Manis four, to the right cornu). The stomach has a pyloric gizzard, in which often little stones are found. There is an occipital rhomboid; a secondary slip detached from the latissimus dorsi; an enormous double teres major; a long coraco-brachialis; a gleno-ulnar biceps, with a brachialis anticus; a cartilaginous palmar nodule; no

pronator quadratus; a supinator brevis arising from a fabella; a masto-acromial; united gluteal muscles. The plantaris arises high up from the femur, and is inserted over the tendo-achillis. There is no biceps accessorius, nor pyriformis, a double-headed semi-tendinosus, and no ligamentum teres in the hip.

Manis, the Pangolin, is African, has no sternal pro-osteon, and long xiphi-sternal cornua. Pholidotus, from Malaya, has shorter cornua, ending in a broad end-plate, and separate pro-ostea.

3. *Orycteropidæ.* — The Aardvark, S. African, hairy, thick-skinned, plantigrade, burrowing, with deciduate, discoidal placentæ (?); ears large, erect; mammæ inguinal and thoracic; pes five-toed, the hallux with one phalanx, and sole with a callosity; manus four-toed; claws flat, strong; tongue long, flat; tail short; zygoma complete; pre-maxillæ large; lachrymals large. Tympanic bones annular, peri-otic very large, hyoid arch complete, epi-hyal with an epiphysis between it and the stylo-hyal. Mandible with an ascending ramus and a forward-directed condyle; teeth $m. \frac{5}{6}$, of which the anterior $\frac{3}{3}$ fall out early; these and the hindmost are simple cylinders, the $\frac{1}{3}$ intermediate being made of two cylinders united; each tooth is a cluster of simple dentine columns. The vertebræ are *d.* 13, *l.* 8, *s.* 6, *c.* 16 (?) The articular surfaces as in Manis. The clavicles are strong; the scapula has a metacromion. The stomach has two compartments, and the intestine has a cæcum; the two uteri open separately. The ductus arteriosus remains long pervious. The panniculus is thick; there is no clavicular trapezius, but a subclavius extending to the pre-scapula, sometimes with a sesamoid bone in it. The clavicular deltoid is inserted with the biceps. There is a teres minor, a long coraco-brachialis, a rudimentary c. brevis, a gleno-radial biceps, a radio-ulnar insertion of the brachialis anticus; a double long head for the triceps; the pronator teres passes to the lower end of the radius. P. quadratus fills the whole interosseous space. Supinator longus is inserted into the fascia over the wrist dorsally. The one radial carpal extensor has two tendons; a sesamoid bone exists in the radial flexor tendon. Gluteus maximus is attached to the third trochanter, tensor vaginæ femoris is large, and biceps extends to the heel; pyriformis. obturator internus, biceps accessorius, solæus, and plantaris are all large. The gemelli arise from the sacrum; quadratus femoris is absent; pectineus is bifid; the sartorius has an ilio-pectineal origin above the gracilis. The semi-membranosus is large; the popliteus femoro-tibial. The tibiales, front and back, have two tendons each, and there are four peronei—long, short, quinti, and quarti.

Sub-order II. *Loricata.* — Armadillos, S. American,

burrowing, claviculate mammals, with discoidal, deciduate placentæ (?), a dorsal carapace of epidermal polygonal plates and ossified dermal scutes, usually divided into cephalic, nuchal, thoracic, abdominal, and pelvic bands. Teeth always exist, those in the mandible and maxilla alternating; an enamel organ has been described in Tatusia, and a milk tooth has been found in the same genus. There is a palmar ossicle in the tendon of the digital flexor. The brain has Sylvian and calloso-marginal fissures, and the anterior commissure is double the size of the corpus callosum, behind which the quadrigeminal bodies project. These constitute one family, Dasypodidæ.

The skull has large pre-maxillæ, small pterygoids, a complete zygoma, long nasals giving a downward direction to the nostrils. The mandible has an angle and a coronoid process. The vertebræ *c.* 7 (the second and third, sometimes the fourth and fifth, ankylosing by bodies and arches), *d.* 10–12, *l.* 5–7 (articulating as in ant-eaters), *s.* 9–10 (uniting to ischium as well as ilium), *c.* 15–25, with chevron bones, which in Priodonta have lateral processes. The sternum is flat or keeled (Priodonta), and the ossified sternal ribs have often bifid heads. The vertebral ribs overlap each other. The acromion is large in Priodonta, articulating with the humerus. The cuneiform and fifth metacarpal, when such exist, articulate together; the first and second digits are slender, third and fourth short and thick, the fifth often absent. The tibia and fibula often ankylose in the adult. Progression is plantigrade, except in Tolypeutes, which is digitigrade, and Priodonta, which is dorsigrade. The abdominal dorsal shield consists of movable bands.

Two sub-families are included:—

1. *Dasypinæ*, with large external ears, and a pelvis protected by no post-ischial bony shield.

Priodonta has many (96) maxillary and mandibular teeth, 12–13 abdominal movable rings. The tympanic is ring-like, and the parietals fuse early, as in Euphractus. Euphractus and Xenurus have $\frac{8-9}{8\cdot 9}$ teeth. Tolypeutes, who is able to roll himself in a ball, has $\frac{6-8}{6-8}$ teeth, and a xphi-sternal hu-

meral band of the pectoralis major. Dasypus has $\frac{9-10}{9\cdot 10}$, the upper front pair being in the pre-maxilla. The stomach is globular, the cæcum double, the tongue with two nasal circumvallate papillæ, and the tympanic bone is bullate, pierced by the carotid canal. There is an enormous rhomboideus capitis; a separate occipito-acromial slip of the trapezius; a clavicular trachelo-acromial; a costo-scapular sub-clavius; two coraco-brachiales, long and short; a two-headed biceps; no supinator longus; a separate extensor quarti digiti; no pronator quadratus; a small p. teres; a separate pyriformis; no internal obturator, but two gemelli; a large quadratus femoris; pectineus double at origin; psoas parvus one-ninth the psoas magnus, and from the tendon of the former sartorius arises. There is a large biceps accessorius; a fibular soleus; a popliteus, with a double femoral head; a double tibialis posticus and three peronei; longus, brevis, and quinti.

Tatusia has $\frac{8}{8}$ teeth, 5–8 bony dermal rings, a four-toed manus, and a five-toed pes. It has a strongly developed panniculus in seven bands, abdomino-femoral, abdomino-tergal, ischio-tergal, pectoro-brachial, bucco-lateral, and nucho-lateral; a medio-cervical band is specialized for the depression of the lower jaw. There is an occipital rhomboid; no masto-scapular slip, nor trachelo-acromial; a double sub-clavius, one part being costo-acromial; a gleno-ulnar biceps; a short and long coraco-brachialis. Pronator teres is attached low down to the radius; a rudimentary p. quadralus; a gluteus quartus muscle; obturators as in Dasypus. The sartorius arises from Poupart's ligament. The vastus externus receives an iliac slip; a large popliteus; a femoral peroneus longus; double tibiales, anticus, and posticus.

2. *Chlamydophorinæ.*—Teeth $\frac{8}{8}$; manus and pes five-toed; pelvis with a vertical, bony, ischiatic shield, or sphæroma, attached by four strong processes, or fulcra, to the tubera ischii. The two small animals constituting this family inhabit limited districts in S. America. Chlamydophorus truncatus, from Mendoza, in Chili, has a dorsal shield, only attached in front to the forehead to two knobs on the frontal bone, medially by vincula to the vertebral spines, posteriorly to the margin of the sphæroma; otherwise this scaly pent-house is free, and covers the body as a cloak with free margins. The stomach is roundly triangular, the cœca double, with a long vermiform appendix. The dermal musculature is feeble; the digastric muscle thin, small; a double latissimus dorsi; a flexor of the thoracic vertebral column; a large sub-clavius, with a separate retro-clavicularis; a short coraco-brachialis; a palmar ossicle; a fibrous rudiment of the pronator quadratus; fused glutei; a triangular quadratus femoris; no biceps accessorius; a strong psoas parvus; a plantaris, whose tendon traverses a calcaneal canal to the sole; a single tibialis anticus, but a double t. posticus.

The great fossil Armadillos, Glyptodon, Schistopleuron, &c., have no movable dorsal rings, and have a sloth-like malar spur. The seventh cervical and upper two dorsals ankylose as an os meta-cervicale, and movably articulate with the third vertebra, while the other trunk vertebræ have early ankylosed.

Other generalized types of Edentates are Macrotherium, a Miocene Pangolin, and Moropus, the oldest known representative of the order.

CHAPTER XXXI.

Sloths.

Order II. *Tardigrada* (*Illiger*).—Sloths. Plant-eating, claw-bearing, coarsely-haired, uniparous S. American mammals, with deciduate, dome-like, multilobate placentæ, short round heads, short or no tails; living suspended by the long, flexed, hook-like claws of their inturned feet from tree branches. The fore-limbs are longer than the hind-limbs, the mammæ are pectoral, and the long bones have no medullary canals. The cervical vertebræ vary in numbers (see p. 200); the caudals have no chevron bones. The lumbars have accessory articulating facets on the anapophyses, and short neural spines. The femur has no ligamentum teres, nor third trochanter. The teeth are not successional, nor enamel-coated, never in the pre-maxillæ.

The palatine part only of the pre-maxilla exists. The malar does not join the zygomatic process of the squamosal, but sends down a vertical spur. The mandible is short, with a slightly recurved angle, and a deep, rounded, ossified symphysis. The ears are covered, the eyes are directed forwards, the orbit is incomplete behind, the sutures ossify early, and the glenoid cavity is transversely narrow. The periotic has no floccular fossæ, but there are large olfactory fossæ, and a long tympano-hyal process. The pelvis is wide: the acetabulum looks back-

ward; the sciatic foramen is bounded behind by the ischio-pseudo-sacral symphysis. The long forearm bones are freely movable, and have a wide interosseous space. The long, ectosteally ossifying coracoid has an apical epiphysis joined by cartilage to the acromion. The pre- is longer than the post-scapula. The stomach has two parts—a cardiac, lined by a dry epithelium, and divided by a mucous fold into two pouches continued into a short cæcal tube. The pyloric sac is also divided into two by a fold, one pouch adjoining the second cardiac, and communicating with the œsophagus, having mucous processes functionally representing the *liber* folds of ruminants (which see). The second pyloric pouch is muscular and glandular, ending in the duodenum. The living forms make one family, Bradypodidæ, including two genera, Cholœpus, the Unau, or two-toed sloth, with $m \frac{5}{5}$, the first pair being caniniform, but not successional, and when the mouth is closed the first maxillary lies in front of the first mandibular. The premaxilla ankyloses to the maxilla; the tympanic is ring-like, and remains separate. The fore-limb has large second and third digits, the first and fourth represented by small metacarpals; the trapezoid and os magnum are separate. The clavicles join the coracoid and acromion, and articulate with the pre-sternum by a cartilaginous omo-sternum. The tarsal bones are separate; second, third, and fourth toes are developed, and the first and fifth are rudimental. C. Hoffmanni has *c.* 6, *d.* 23, *l.* 3, *s.* 7, *c.* 6; C. didactylus has *c.* 7, *d.* 23–4, *l.* 2–3, *s.* 7, *c.* 6; the pre-sternum is narrow, keeled; the meso-sternum has twelve sternebers; the humerus has a supra-condyloid foramen. There is a columelliform stapes, as in Manis and Bradypus, and a pre-nasal ossification. The sub-lingual gland is rudimentary, and the parotid and submaxillary are united. There is no omo-hyoid, a slender trachelo-acromial, an occipital rhomboid, long and short coraco-brachiales, a subclavius, a tripartite deltoid, a detached subscapulo-humeral, a single-headed biceps, with radial (uniting with the acromial deltoid), and ulnar (uniting with the brachialis anticus) bellies. The sartorius is double, as is the external obturator; an ilio-capsular is present, but no biceps accessorius. Semitendinosus unites with the double-headed gracilis. Popliteus has a large fabella in its origin.

Bradypus, the Ai, or three-toed sloth, has the second, third, and fourth digits functional in the hand; the trapezoid, os magnum, and metacarpals are ankylosed together, as are the rudiments of the first metacarpal and trapezium. The fibula at its lower end has an incurved conical spur, which fits into a hollow on the outside of the astragalus, limiting the motion of the ankle. The calcaneum, scaphoid, cuboid, and cuneiforms ankylose, as do the metatarsals; the first and second phalanges are immovably united. The vertebræ are *d.* 15–17, *l.* 3–5, *s.* 6, *c.* 9.

The cervicals are eight or nine, the eighth and ninth having small movable ribs, and the ninth has no arterial canal. The pre-sternum is wide, and there are eight meso-sternebers. The small clavicle joins the coracoid externally, and a slender omo-sternum internally. The acromion is cartilaginous, the supra-condyloid foramen absent, the olecranon small. The anterior sternal and vertebral ribs become ankylosed, and the posterior are separated by intermediate ribs, as in Monotremes. The trachea is convoluted in the thorax in front of the right lung. The carotid, axillary, and femoral arteries form retia mirabilia. The laryngeal ventricles are shallow, with no upper vocal chords. The penis is cleft, so that the urethra opens at its root. The deltoid is not divided, and a short coraco-brachialis, a humero-scapular biceps inserted into the radius and ulna, and a radio-carpeus, are present, as are two long supinators, a pyriformis, an obturator internus, a double obturator externus, a wide sartorius, an enormous gracilis, an ischio-femoral biceps, a femoral extensor longus digitorum, a three-headed tibialis anticus. The plantaris is very large, as also is the flexor of the toes. Some forms have inflated pterygoids (Arctopithecus of Gray).

The gigantic American tertiary Megatherium, Mylodon, Megalonyx, form a family, Gravigrada, intermediate between the Tardigrades and the Glyptodons; they have sloth-like skulls, with closed jugal arch; strong claviculate limbs, with a 4–5 toed manus and a 3–4 toed pes; a strong tail, capable of acting as an organ of support; teeth mostly $m\frac{5}{4}$.

CHAPTER XXXII.

Lemurs.

Order III. *Prosimii* (*Brisson*).—Lemurs. Arboreal, small, claviculate, claw-bearing mammals, chiefly limited to Madagascar and the vicinity of the Indian Ocean; having a coating of loose fur, with the fourth digit of the pes and manus the longest, the last joint of each digit with a nail, the claw-bearing hallux being often opposable. The placentæ are dome-like, diffused, indeciduate; the mammæ pectoral or ventral. The face is hair-clad; the nostrils kidney-shaped, convex outwards; the ears and eyes large. The fore-limbs are shorter than the hind,

and the humerus has a supra-condyloid foramen. They never have cheek pouches, nor glutæal callosities, and the main limb arteries form retia mirabilia. The teeth are heterodontal, enamel-coated, and successional.

The mammæ are pectoral or ventral; the penis often with a bone; the clitoris perforated for the urethra, except in Chiromys; the uterus bicornate, with two mouths in Stenops. The brain is smooth, with pointed frontal lobes; the hinder lobe short, and the cerebellum uncovered; the Sylvian fissure is large, with a trace of the insula; there is a calcarine sulcus, large olfactory lobes, a small pons, and a large flocculus. The vertebræ are *c.* 7, *d.* 12–16, *l.* 6–8, *s.* 2–5, *c.* 5–29 (never prehensile). The cervical transverse processes have large lower lamellæ. The orbital process of the palatine may join the frontal in the orbit, which is in its cavity continuous with the temporal fossa, as the union of the malar and post-orbital process of the frontal is only superficial. The foramen rotundum merges into the sphenoidal fissure; the nasal duct opens outside the orbit; the nasal bones are elongated, the malars often perforated by large holes. The os planum does not extend into the inner wall of the orbit. The tympanic is bullate; the mandibular rami are ununited. The hyoid arch has stylo-, epi-, and cerato-hyals, with very short thyro-hyals. The carpus has an os centrale (except in Indrisidæ and Nycteromorpha), sometimes a radial sesamoid (Perodicticus). The pelvis is wide, except in Loris, Potto and Tarsius, with narrow ilia, and the ento-cuneiform has often a spur. The second digit is claw-bearing. The brain-case equals in length the basi-cranial axis. The hard palate is long and thick posteriorly. The sublingual fringes are often large, pectinate, like a second tongue. The stomach is simple, the intestine moderate, the cæcum long, with no appendix, and the subclavius is small. The deltoid is single in Nycticebus, two-cleft in Tarsius, trifid in Lemur and Chiromys. There is a small teres minor; a two-headed biceps in Lemur, Potto, Tarsius, and Chiromys; one-headed in Nycticebus and Loris. There are long and short coraco-brac iales, except in Galeopithecus. The semitendinosus has a caudal head and the tibialis anticus is double in Chiromys. The tendons of the flexor digitorum sublimis in the manus are distributed to the third, fourth, and fifth fingers, while of the deep tendons, those to the first, second, and third come from the flexor pollicis, which is closely united to the flexor profundus. Otolicnus and Tarsius have a depressor scapulæ muscle, and the occipital trapezius only exists in Chiromys, though an occipital rhomboid is present in all. The trachelo-acromial is usually attached to the metacromion, but in Nycticebus is inserted into the clavicle, while it is absent in Potto. There are no laryngeal air-sacs, but well-marked ventricles. The lemurs are divisible into four families:—

1. *Pithecomorpha* (*Lemuridæ*).—Pollex opposable; digits free; *i.* $\frac{2}{2}$, or $\frac{2}{1}$, or $\frac{0}{2}$ (a central gap in the upper series, the lower convergent, nearly horizontal), *c.* $\frac{1}{1}$, *p.* $\frac{3}{2}$ or $\frac{3}{3}$ (the first lower sometimes caniniform) *m.* $\frac{3}{3}$; the upper molar crowns have four cusps, with an oblique ridge from the antero-external to the postero-internal. The sub-families included are:—

1. *Lemurinæ* with *p.* $\frac{2}{2} - \frac{3}{3}$, *m.* $\frac{3}{3}$; no mastoid processes, nor more than twenty pre-sacral trunk vertebræ; tail at least two-thirds the length of the body. Lemur has a long snout and tail, a long coraco-brachialis, separate extensor and flexor muscles for the hallux, a single tibialis posticus, and a double temporal muscle. Cheirogaleus has the astragalus and calcaneum elongated, frog-like. Lepilemur has no upper incisors. In Microcebus the calcaneum is one-third the length of the tibia, the cuboid is also elongated, and there are large palatine deficiencies.

2. *Indrisinæ*, with *p.* $\frac{2}{2}$, *m.* $\frac{3}{3}$, and shorter snout, as in Indris. Microrhynchus has a long mandibular angle, and large orbits.

3. *Nycticebinæ*.—Round-headed, large-eyed, shortened forms, with *p.* $\frac{3}{3}$; tail less than half the length of the body, or none; tarsus short; mastoid inflated; dorso-lumbars twenty-one or more. Nycticebus is tailless, with *d.* 16, *l.* 7–8. The lower end of the tibia has a sharp crest between the tendons of the flexor hallucis and the tibialis posticus. The former is separate from the flexor profundus digitorum, which supplies all the digits but the fifth, while the flexor pollicis sends slips to the first second, fourth, and fifth. The extensor digitorum arises from the femur. There is no plantaris and a double set of interossei. Stenops is slender, with *d.* 14–15, *l.* 9; and an elongated palate bone. Perodicticus has a rudimental, nailless index, with two short phalanges; *d.* 15, *l.* 7. The axis has a trifid spine, and the nerves pierce the vertebral pedicles; the anterior dorsals have long spines, which project beyond the level of the surface as eminences. The pes has a sesamoid plantar ossicle. The plantaris is absent.

4. *Galagininæ*.—Tarsus long, the rod-like calcaneum being more than one-third the length of the tibia, the scaphoid being longer than the cuboid, the tail longer than the body. The mastoid is inflated, the dorso-lumbar vertebræ 19 (*d.* 13, *l.* 6). The lumbar spines have at their hinder edges two *hyperapophyses* directed backwards, embracing the next spine; the mammæ are two pairs, pectoral; the gall-bladder appears on the upper surface of the liver. There is a rotator fibulæ muscle from the top of the back of the tibia to the anterior surface of fibula, as in Lemur.

2. *Theridiomorpha*.—Teeth with no diastema, *i.* $\frac{2}{1}$, *c.* $\frac{1}{1}$, *p.* $\frac{3}{3}$, *m.* $\frac{3}{3}$, Head short; eyes very large, in enormous orbits, with thin inter-orbital septum; tibia and fibula ankylosed below; calcaneum rod-like, half as long as tibia; scaphoid long, rod-like; astragalus short; digits free, the third of the manus and the fourth of the pes being the longest; the second and third

pedal digits are clawed; the tail is long, sparsely haired; the mammæ are two pectoral and two ventral. The omohyoid muscle has a central tendon; the subclavius is large, the deltoid double, and a fourth gluteus. Ex. Tarsius.

3. *Gliromorpha.*—*I.* $\frac{1}{1}$ (from permanent pulps, and entirely surrounded with a coating of enamel), *c.* $\frac{0}{0}$, *p.* $\frac{1}{0}$, *m.* $\frac{3}{3}$; digits free; pollex not truly opposable, all the other digits with claw-like nails; ungual phalanges, except that of the hallux, curved; tail long, bushy; mammæ two, inguinal; humerus with a large supinator ridge; the third digit equals the fourth in length, but is very slender. The anus has two follicular glands, and the seminal vesicles are large. The fundus of the gall-bladder is directed forwards, not backwards, as in other Lemuroids. Chiromys, the Aye-aye, has a deciduous dentition, *i.* $\frac{2}{2}$, *c.* $\frac{1}{0}$, *m.* $\frac{2}{2}$; a double masseter, and the mandibular incisors stretch as far as the root of the coronoid process.

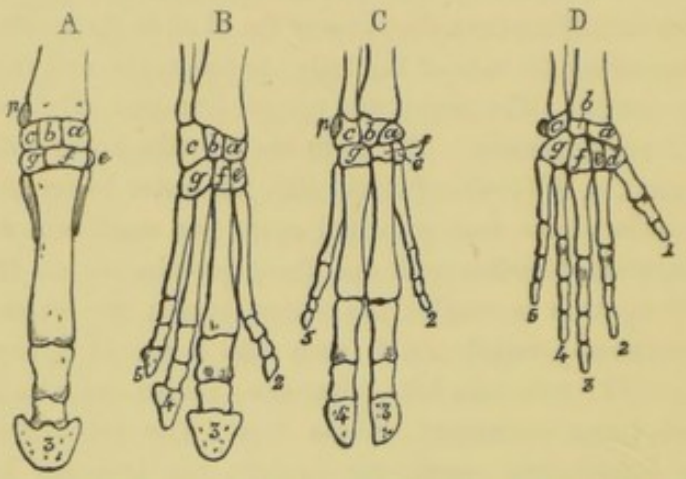
4. *Nycteromorpha* (*Galeopithecidæ*) connect the Lemurs to the Insectivora, or the bats, and should probably be more correctly relegated to the first-named order (*Peters*). They are small mammals, with a lateral hair-clad patagium extending from the sides of the skull to the wrists, and thence from the arms, along the side of the body, to the ankle, and from the inside of the legs to the tail. The manus and pes are five-toed, all clawed, and with the first digit not opposable. The teeth are *i.* $\frac{2}{3}$ (the lower with comb-like, divided crowns), *c.* $\frac{1}{1}$ (double-fanged, like the outer lower incisors), *p.* $\frac{2}{2}$, *m.* $\frac{3}{3}$. The molars have four principal cusps and small accessory cusps on the outer cingulum, together with one sharp prominence on the inner cingulum. The stomach is simple; the cæcum large; the mammæ pectoral; the penis pendulous; vertebræ *c.* 7 (each with a pair of hypapophyses), *d.* 14, *l.* 5, *s.* 5, *c.* 22; coracoids long, bifurcate; radius and ulna fused below; scaphoid and lunar coalescent; fibula free. The infra-orbital canal is double; the manubrium small, not keeled; the humerus has a supra-condyloid foramen; the proximal phalanges are small; the ribs broad; the clavicles long. There is a mandibulo-polliceal muscular slip, a short and a middle coraco-brachialis, no pronator quadratus, palmaris longus, nor omohyoid, a coraco-cutaneous slip of panniculus, a large levator claviculæ, a dorsi-epitrochlearis from the dorsal vertebræ separate from the latissimus dorsi, a deep scapular deltoid, and a large teres minor; a sartorius from the middle of Poupart's ligament, a marginal iliacus, a femoro-tibial extensor digitorum, and a carpo-tarsal muscle. Galeopithecus, the flying lemur, from the Malay Archipelago, has doubled pectoral mammæ, and reaches a length of 20″.

The extinct Miocene forms, Palæolemur, Adapis, &c., have been grouped into a family Pachylemurida (*Filhol*), and have affinities to Carnivora?

CHAPTER XXXIII.

Order IV. *Ungulata* (*Wagner*).—Herbivorous, indeciduate, diphyodont, non-claviculate mammals, whose limbs are only used in progression, the ungual phalanges of each digit being cased in hoofs. The body is slung on the fore-limbs by a large *serratus magnus* muscle, passing from the anterior 8–10 ribs, and from the transverse processes of the hinder five cervical vertebræ to the hinder

Fig. 37.



A, foot of horse; B, foot of tapir; C, foot of artiodactyl; D, human hand; *a*, radiale; *b*, intermedium; *c*, ulnare; *p*, pisiforme; *d*, carpale 1; *e*, carpale 2; *f*, os magnum (carpale 3 and os centrale); *g*, carpale 4 and 5 united (os hamatum).

margin of the scapula and supra-scapula. They are proportionally small-brained and large-sized.

The biceps humeri has one (glenoidal) head, and is penniform; the cleido-mastoid, cleido-occipital, and trachelo-acromial muscles are continuous into the clavicular deltoid, a tendinous inscription marking the point of union. The extensor longus digitorum has a femoral origin, and the plantaris tendon passes over the heel, to form a strong fascia in the elongated sole, splitting for the passage of the united tendons of the flexor digitorum and flexor hallucis muscles.

The mucous membrane of the mouth is papillated, the abdominal cavity is large, and the intestine long. The masseter muscle exceeds the temporal; the condyle of the mandible is flat-crowned, and often somewhat quadrate, and capable of free lateral motion. The cerebrum is convoluted, and the cerebellum is uncovered.

Two Sub-orders are included :—

Sub-order I. *Perissodactyla* (*Owen*).—Ungulates, with an odd number of toes on the hind foot (five, three, or one). The third toe on the fore-foot always consists of symmetrical halves. There are at least twenty-two dorso-lumbar vertebræ, a third trochanter on the thigh-bone, a large astragalo-scaphoid, and a small astragalo-cuboid joint. The os magnum, third metacarpal, and third metatarsal are large. There is a simple stomach; a large, often sacculated cæcum; inguinal mammæ; no gall-bladder, and a bicornate uterus. The tympanic bone is small, and there is an ali-sphenoid canal for the external carotid at the base of the pterygoid plate.

The posterior nares are usually opposite the penultimate molar, and the palate is not notched behind; the facial part of the skull enormously exceeds the cerebral. The par-occipital processes are large; the canines usually small or none; the premolars often as large as the molars. The medullary artery of the thigh-bone is at the middle or inferior third of the bone.

There are five extinct families, and three which include living forms; the latter are as follows :—

1. *Tapiridæ*.—Somewhat pig-like animals, with a short, movable proboscis; soft, hairy, thick skin; short tail, and two inguinal mammæ. The skull has wide, incomplete, up-directed anterior nostrils, extending above the orbits. The fore-foot has four toes, the pollex being absent; the second scarcely functional; the third is the largest, unsymmetrical with the others, but its lateral halves are symmetrical. The teeth are $i.\ \frac{3}{3}$, $c.\ \frac{1}{1}$, $p.\ \frac{4}{3}$, $m.\ \frac{3}{3}$; the molars

have one external and two transverse enamel ridges; the outer upper incisor is larger than the canine; the outer lower is smaller and deciduous.

The skull has a sagittal crest; large post-glenoid and post-tympanic processes, not uniting behind the meatus, but the latter joins the large par-occipital, a strip of the opisthotic being superficial between them. The periotic is free; the tympanic small; the mandible has an incurved process at the angle, a long symphysis, and a high coronoid process. The short, leaf-like nasals are supported on an ossified mesethmoid, which may extend in front of them, and separated from the pre-maxillæ, which are small, and soon ankylose. The maxillo-turbinals are large, and simply plicated; the hinder part of the nasal is deeply grooved for an air sinus. The basi-hyal has no glossal spur. The vertebræ are *c.* 7, *d.* 18 (20?), *l.* 3–5, *s.* 7, *c.* 13. The cervicals have short bodies and long processes, the odontoid is wide and hollowed above. The hindmost lumbars articulate with each other by their transverse processes. The sternum has no xiphoid cartilage and a separate, narrow, anterior pro-osteon. The hinder meso-sternebers widen, and the last is divided in the mesial line. The scapula has a deep coraco-scapular notch, no acromion, and a small coracoid. The supra-spinous fossa is large; the ulna and fibula are complete, the former ankylosing to the radius. The flexor digitorum and hallucis tendons unite, and then divide into perforating tendons; there is no tibialis posticus. The stomach is simple, oval, with a short concave edge; the cæcum is small; there is no third bronchus, nor Eustachian valve, nor septal bone in the heart; one superior vena cava; elongate testes; vesiculæ seminales; a prostate and Weberian organ, but no scrotum, nor Cowper's glands.

Tapirus includes two South American and one Malayan species. The American extinct genus Harlanus was allied.

2. *Rhinocerotidæ.* — Massive, palæo-tropical, naked, thick-skinned land animals, with blunt, rounded muzzles; two inguinal teats; one or two azygous horns, composed of consolidated, hair-like, epidermal processes, into which long dermal papillæ extend. When one horn exists it rests on the nasal bones; when two, the hinder rests on the frontal. The second, third, and fourth toes are deve-

loped on both feet, and are hoofed, and behind them there is in each foot a thick sole-pad, on which the weight chiefly rests.

The vertebræ are opisthocœlian, *c.* 7, *d.* 19–20, *l.* 2–4, *s.* 4, *c.* 22. The lumbar transverse processes articulate, as in the horse. The sternum is narrow; the xiphoid spatulate. The skull has large air-cells in the occipito-parietal bones. The tympanic is small, forms no distinct bulla, and is ankylosed to the periotic. The tympano-hyal is very large. The mastoid is covered by the para-mastoid and post-tympanic. The hard palate ends opposite the ante-penultimate molar. There is no post-orbital process, but a rough papilla on the lachrymal, which joins the palate bone in the orbit. The premaxillæ are small; the nasals enormous, ankylosed, and rough above for the horn. The post-glenoid process of the squamosal is enormous, joining the post-tympanic, and surrounding the cartilaginous ear-tube. The mandible has a slender recurved coronoid, a transversely convex condyle, the basi-hyal has a glosso-hyal anterior process. The first rib has a scalene tubercle. The scapula has no acromion, but a large epiphysis to the spine. The humerus has a strong deltoidal crest; the ulna and fibula are complete, the former being early ankylosed to the radius. The carpus has eight bones; the second and fourth digits are sub-equal, and a rudiment of the fifth metacarpal is attached to the unciform. The femur has no neck and a large third trochanter; the lesser is only a rough line. The meso-cuneiform is very small, the seven tarsal bones exist, and there is no fifth metatarsal. The cleido-vertebral muscle is only attached to the axis. The cephalo-humeral, trachelo-acromial, and upper trapezius are as in the horse. There is no occipital rhomboid, nor has the ear more than three muscles to move it (the four accessory slips of the horse are absent). There is a large dorsi-epitrochlear, a sterno-scapularis, and a bilaminar great pectoral; a middle (and short?) coraco-brachialis. The supra-spinatus is to the infra- as 8 : 5. The brachialis anticus is radial in its insertion. There is no pronator, nor supinator, but there is a radial and an ulnar flexor of the wrist, and a palmaris, from the olecranon to the palmar pad. The flexor sublimis sends three perforated tendons, the f. profundus and f. pollicis give off conjointly three perforating. There are two radial extensors, and one ulnar extensor of the carpus. The last is inserted into the pisiform, and acts with the flexor ulnaris. The extensor communis digitorum and extensor minimi digiti are inserted together, and an extensor ossis metacarpi pollicis exists; each digit of the manus and pes has a dorsal and palmar interosseous. The sartorius arises from the supra-acetabular line; the psoas and iliacus are separable;

the pectineus is separate, as are the three adductors; the gluteus maximus is large, inserted into the third trochanter, and the popliteus is inserted into half the tibia; the plantaris into the plantar pad, and forms perforated sheaths for the tendons of the single flexor digitorum. There is a tibialis anticus, but no t. posticus, an extensor digitorum sending a slip to the ento-cuneiform and annular ligament, a peroneus longus ascending to the femur, and inserted into the ento-cuneiform; a p. quinti to the first phalanx of the fourth toe, and an extensor brevis for the middle toe. There is a large, thick panniculus, which in the species with folded skin is attached along the folds; the abdomino-femoral muscle being very strong in all. The dentition is $i.\frac{1}{1}$ or $\frac{0}{0}$, $c.\frac{0}{0}$, $p.\frac{4}{4}$, $m.\frac{3}{3}$. The milk teeth are $i.\frac{3}{2}$, $m.\frac{3}{3}$. The early developed first permanent pre-molar has no milk predecessor. The manus and pes have inter-digital glands, whose ducts open above the sole, on the dorsal surface. The stomach is large, lined with a white, hard epithelium. The small intestine has a shaggy lining of villiform processes; the whole canal is 65–95 feet long. The cæcum is large, and the colon wide, and the anus very dilatable. The kidney is lobed. The trachea has about thirty rings, and the larynx has a large sacculus. The nose is simple, and the upper lip prehensile. The thyroid body has no isthmus. The testes lie below the abdominal rings in the groin, but there is no scrotum; a single prostate, a long Weberian organ, vesiculæ seminales, and Cowper's glands exist. The arteries of the head and fore-limbs arise from a common innominate, which first gives off the left sub-clavian. There are several species of living rhinoceros, which have been made types of sub-genera—Rhinoceros with folded skin, incisors in the adult, and one horn, Asiatic; Ceratorhinus, with two horns and folded skin, Sumatran; Atelodus with two horns, and skin not folded, and no incisors in the adult, African. Acerotherium, from the middle tertiary, has no horn, and two incisors above and below; it and Rh. tetradactylus, from the later tertiary, had a trace of a fifth toe. Diceratherium, also extinct, had two transversely placed horns. In the one-horned forms the post-glenoid and post-tympanic processes unite below the ear-meatus: in the two-horned forms they do not.

3. *Equidæ*.—Horses. Maned, hair-clad, mostly graceful and active, with one toe (the third) alone functional.

The skull is elongated, with complete orbits, the zygomatic process of the squamosal articulating with the post-orbital process of the frontal. There is a quadrate inter-parietal, which consolidates in the adults with the parietals, and a short naso-premaxillary suture. The symphysis menti is consolidated; the hyoid arch complete, with long stylo- and nodular epi-hyals, and a glosso-hyal spur from the front of the basi-hyal. The lachrymal is large,

and the sphenoidal foramen ovale is merged in the foramen lacerum medium. The surface of the glenoid cavity is convex from before backwards; the tympanic is not ankylosed. The antrum maxillæ is large, and the Jacobsonian organ well developed, with no duct of Stenson. The mastoid is short; the teeth *i.* $\frac{3}{3}$, *c.* $\frac{1}{1}$ (often concealed in mares and young horses), *p.* $\frac{4}{4}$, *m.* $\frac{3}{3}$. The incisors have a superficial transverse median cavity, lined by an inflection of enamel, causing the central "mark" on the tooth. The first premolar falls out early, has no predecessor, and hence might be taken for a milk tooth, but it is permanent in Hipparion. The molar crowns have four enamel folds. The vertebræ are *c.* 7 (opisthocœlous, with feeble neural spines), *d.* 18 (19 in the quagga), *l.* 5–6, *s.* 5, *c.* 17–21. The cervicals have hypapophyses, and a bilaminar ligamentum nuchæ; the sixteenth dorsal is the anticlinal; the fifth dorsal spine is the longest. The two lowest lumbar and first sacral have accessory articular facets on their transverse processes, and some spinal nerves perforate the pedicle. The long scapula has a Retzian tubercle, no acromion, and a small coracoid. The ulna is imperfect below, and attached to the radius. The carpals are seven, there being no trapezium. The scapho-lunar joint is opposite the middle of the lower end of the radius. The outer half of the large (third) metacarpal is narrower than the inner; along its side are the rudiments of the second and fourth metacarpals as splints. The single (third) finger has three phalanges—1st, pastern; 2nd, coronary; 3rd, coffin or hoof bone—between the second and third is a navicular sesamoid, and at the metacarpo-phalangeal joint are two others. The bones of the pes correspond to those of the manus. The upper end of the fibula is only present as a rudiment ankylosed to the tibia, which is longer than the femur; the latter has a fossa above the outer condyle, and a pit for the ligamentum teres. There are seven tarsals, but the ento- and meso-cuneiforms early ankylose. There is a large omo-hyoid muscle, a cleido-vertebral from the transverse processes of the 1–4 cervical vertebræ inserted into the cephalo-humeral (or conjoint occipital trapezius and clavicular deltoid). The cleido-mastoid is attached to the mandible. The coraco-brachialis medius and brevis co-exist; there is a large dorsi-epitrochlear, a palmaris longus inserted into the tendon of the flexor profundus, two carpal flexors, and two extensors (radial and ulnar); the flexor pollicis has a separate belly from the flexor digitorum profundus, but their tendons unite, and an extensor ossis metacarpi pollicis is inserted into the inner side of the proximal end of the cannon bone; a single lumbricalis and an undivided adductor femoris exist. The hinder portion of gluteus maximus arises from the tuber ischii. There is a gluteus quintus; and there are vertebral origins for the very large semi-membranosus and semi-tendinosus; a peroneus tertii (in the ass), inserted into the proximal end of the first phalanx, but there is no p. longus;

the infra- exceeds the supra-spinatus, and the teres minor is one-third of the teres major (1·20 : 3·71). The stylo-hyoid is attached to the paroccipital. There is a sterno-scapularis, but there is no pronator teres, nor quadratus, no supinators, nor soleus, nor tibiales, nor rudimental interossei. There is an extensor minimi digiti inserted near the end of the third digit. The gluteus maximus is $\frac{1}{18}$th the size of g. medius. There is no separate pyriformis. The sartorius arises around the tendon of psoas magnus. The tensor vaginæ femoris is twice as large as the gluteus maximus; both levator and tensor palati are attached to the cartilage of the Eustachian tube. The brain is equally broad in front and behind; the cerebellum uncovered and unsymmetrically convoluted; the cerebrum convoluted, and the insula uncovered. The stomach is lined by a firm epithelium at its cardiac end, where there is a valve-like fold and a spiral sphincter at this opening. The intestines are 77–108 feet long. The cæcum is twice as large as the stomach, and the kidney is entire. The larynx has a groove in the epiglottis, across which (in the mare) stretches a semi-lunar membrane; the trachea has 48–52 rings, and has no middle bronchus. The thyroid body has an isthmus; large air-sacs communicate with the Eustachian tubes; a cartilage exists in the septum of the heart, and the aorta gives off from its arch one trunk, from which arise—1st, the left subclavian; 2nd, a common stem, giving off the two carotids and right subclavian. There is one (right) upper vena cava. The testes are scrotal, but the inguinal canals are open. The prostate is single, and the vesicula prostatica long and bifid. The male mammillæ are on the prepuce, and there is a sacral retractor penis. Placentation is diffuse. The living genera are two—Equus, the horse, with warts (sallanders) on the inside of metatarsals and metacarpals, neither a dorsal line nor stripes, and a holotrichal tail. Asinus, with callosities only on the wrists, colour bands, and a tail hair-tufted at tip. There are six living species of ass—the wild ass, the hemionus, onagga, zebra, Burchell's zebra, and quagga, differing chiefly in the disposition of the colours.

The researches of Professor Marsh among the American tertiary beds have revealed a most remarkable ancestral line of horses, beginning with the little Eohippus, an Eocene generalized form, about the size of a fox, with forty-four teeth, and with four toes, a rudimental fifth, and a separate fibula and tibia. This is followed in subsequent Eocene beds by Orohippus, which loses its rudimental fifth toe. In later (Miocene) beds this is succeeded by Mesohippus, about the size of a sheep, and with three toes functional and a rudimental metacarpal; two of its premolars have become similar to the molars, and the ulna or fibula are no longer separate or entire. Still later appears Miohippus, with three nearly equal toes and a rudiment of the fifth metacarpal. The lower Pliocene contains a still larger form,

about the size of an ass, Protohippus, having three toes, of which the middle is the largest, and is the only one which comes to the ground. Pliohippus, also Pliocene, loses the phalanges on the second and fourth metacarpus, and becomes assimilated to the true horse genus Equus, representatives of which are found in post-tertiary formations.

In European tertiaries Hipparion, like Protohippus, is a Pliocene horse, with rudimental, though functionless, phalanges on the second and fourth metacarpals, and Anchitherium, somewhat like Mesohippus, an earlier form, in which these toes are functional, are also related genera. Elasmotherium seems to join the horses to the rhinoceroses.

The extinct families of Perissodactyls are:—

4. *Coryphodontidæ.*—Imperfectly known, very generalized, tapir-like, Eocene forms, with short limbs, a third trochanter on the femur, five digits on both manus and pes, an extremely small brain-case, large cerebellum and olfactory lobes, and small cerebral lobes. The orbital and temporal fossæ communicate, the zygomatic arch is wide, and the lachrymal foramen is within the orbit. The nasals are narrow in front, and wide behind, and there are par-occipital and post-glenoid processes. The dentition is $i.\ \frac{3}{3}$, $c.\ \frac{1}{1}$, $p.\ \frac{4}{4}$, $m.\ \frac{3}{3}$. To this belonged the European and American Coryphodon, Lophiodon, Hyracotherium, &c.

5. *Palæotheridæ.*—Also Eocene, tapir-like, European forms, with three digits on each foot, and a somewhat rhinoceros-like dentition, $i.\ \frac{3}{3}$, $c.\ \frac{1}{1}$, $p.\ \frac{4}{4}$, $m.\ \frac{3}{3}$.

6. *Macrauchenidæ.*—South American, Pleistocene, llama-like forms, with long upright necks, three toes, short nasal bones, closed orbits, and horse-like skulls. The vertebral artery lay within the spinal canal, and the dentition was $i.\ \frac{3}{3}$, $c.\ \frac{1}{1}$, $p.\ \frac{6}{4}$, $m.\ \frac{3}{3}$.

Certain curious American forms, at present imperfectly known, may be types of separate families. These are Limnohyus and Palæyssops.

7. *Brontotheridæ.*—American, Miocene, somewhat rhinoceros-like forms, with horn cores in front of the maxillaries anterior to the orbits; large nasal bones, and wide infra-orbital foramina, but no post-orbital processes. They had an excavated palate and a small brain cavity. The angle of the mandible was produced downwards, and the condyle was wide. The dentition was $i.\ \frac{2}{2}$, $c.\ \frac{1}{1}$, $p.\ \frac{4}{3}$, $m.\ \frac{3}{3}$; the vertebræ opisthocœlous; the tail long and slender; the radius and ulna separate, the latter bone not touching the semi-lunar. The thigh-bone has a third trochanter and a pit for the round ligament. The fibula is slender, and there were three toes on the pes and four on the manus. Menodus had a post-orbital process. Megacerops had no lower incisors, and was of very large size. This family was apparently represented in Eocene times by Diplacodon, and in later Miocene Chali-

cotherium took its place, and spread *viâ* Japan, China, and India, to Europe.

8. *Dinocerata.*—An Eocene group of Ungulates, probably deserving of being made the types of a separate order. They were large-sized, long-faced mammals, with three transverse pairs of bony horn cores on the skull, varying in size with age—one pair was placed near the end of the nasals; a second, like the horn of Brontotherium, on the maxillaries, in front of the orbits; a third, and largest pair, on the parietal bones, supported by a crest which surrounds the cranium posteriorly. There is also a transverse posterior crest on the supra-occipital, and an alisphenoid canal. The nasals are half the length of the skull; the orbits and temporal fossæ are confluent, and there is a post-glenoid process. The post-tympanic process, which bounds the auditory meatus posteriorly, unites with the par-occipital, thus excluding the mastoid from the surface as in rhinoceros. The lachrymal bone is perforated, and the premaxillæ were long and without teeth, but they were covered with a pad, as in ruminants. The brain-case was extremely small; the teeth were *i.* $\frac{0}{3}$, *c.* $\frac{1}{1}$, *p.* $\frac{3}{3}$, *m.* $\frac{3}{3}$, the canines being small in the female. The mandible has a back-directed condyle, an ossified symphysis, and a descending process below the diastema, possibly to protect the tusk. The ulna articulates with the lunar as in the elephant, and the other fore-limb bones are elephant-like, but the radius and ulna were not crossed. The manus had eight carpal bones and five digits. There was no ligamentum teres, nor third femoral trochanter, a perfect fibula and an astragalus articulating with the cuboid, as well as with the scaphoid; there were seven tarsal bones, and five toes on the pes.

Sub-order II. *Artiodactyla* (*Owen*).—Ungulates, in which the third and fourth toes are symmetrical, and bearing the weight of the body. Sometimes the second and fifth toes form a second pair, or one of them may be deficient. The dorso-lumbar vertebræ rarely exceed nineteen, and never are as many as twenty-two (the smallest number found in living Perissodactyls). There is never an azygous horn, nor a third trochanter. The stomach is never quite simple, and the cæcum is small or none.

Horns are paired when present, and are outgrowths from the frontal bones; the last milk molar is trifid, and the hindmost premolar differs from the molars in pattern and size. There is no alisphenoid canal; a large

tympanic bone, a small post-tympanic process, and a larger par-occipital, which is close to the occipital condyle, separated from them by a groove. The hard palate ends behind the level of the last molar tooth. There is an ischiatic, as well as a pubic, symphysis. The femoral nutrient artery enters the bone anteriorly, and near its upper end, and the front of the astragalus has nearly equal facets for the scaphoid and cuboid. The uterus is bicornate; the mammæ abdominal, not inguinal, except in Hippopotamus. They are mostly large-bodied and muscular animals.

Two sections are easily distinguished in this sub-order; in one the enamel of the teeth is arranged in surface tubercles; these are called Bunodontia. In the other the enamel folds form crescentic ridges on the crown; these are called Selenodontia.

§ 1. *Bunodontia* (*Kowalevsky*).—Non-ruminating, hornless artiodactyls, with bunodont, lamellar, or rhinoceros-like molars, with stout heavy bodies; thick, naked, or bristled skin, and short legs. The placentation is diffuse, and there is more than one pair of functional upper incisors.

The metatarsals and metacarpals are free, except in Dicotyles, and sometimes in Hippopotamus; the stomach is often bi- or tri-cavitary, but has no groove from the œsophagus to the last compartment. The ulnæ and fibulæ are complete, the orbits not closed, and the foramen ovale in the sphenoid complete. They have always canine teeth.

Three families are included —

1. *Hippopotamidæ.*—Massive, African, sparsely-haired, thick-skinned Bunodonts, with four functional toes on the same level; and large head, with dilated muzzle, small eyes and ears, short tail, inguinal mammæ, and no scrotum. There is a four-pouched stomach, a gall-bladder (none, *Crisp*), a lobulated kidney, and no cæcum. The axis has a conical odontoid (as in pigs). The cervical centra are slightly opisthocœlian; the others planiform, The sternum is pig-like, and the last pair of lumbar transverse processes articulate with those in front and behind. The vertebræ are *d.* 15, *l.* 4, *s.* 4, *c.* 8(?). The brain-case is small; the orbits almost tubular, nearly complete; the premaxillæ rugged, massive; the lachrymal dilated into a thin-walled capsule; the palate long and narrow, extending behind the last molars. The cancellous tympanic bulla early joins the squamosal, and the meatus is

long. There is no malar process bounding the glenoid cavity externally, as in pigs, but a large paroccipital process, a small periotic, an interacranial opisthotic. The lower jaw has an ossified symphysis; its rami widen, and its angle is produced backwards. The rami widen anteriorly. The scapula has an acromion, a Retzian tubercle, and a long coracoid. The ulna and fibula are complete. The carpus has a trapezium. The long canines are curved, bevel-topped, tusk-like. The lower incisors are horizontal. There are two genera:—Hippopotamus, amphibious, short-legged, nocturnal; $i.\frac{2}{2}$, $c.\frac{1}{1}$, $p.\frac{4}{4}$, $m.\frac{3}{3}$; molar tubercles, when ground down, are doubly trilobate. The first premolars are simple, conical, one-rooted, appear with the milk teeth, and fall out before middle life. The canines, where they rub upon each other, wear flat surfaces on each other; the two central lower incisors are the longest. The milk teeth are $i.\frac{2}{3}$, $c.\frac{1}{1}$, $m.\frac{4}{4}$. There are large cutaneous glands, an intestine 180 feet long; no isthmus to thyroid body. Chæropsis.—Liberian, smaller, less aquatic, with longer legs, and a large brain-case, and more richly convoluted brain; $i.\frac{2}{1}$, retains the first premolar. The trachelo-acromial is blended with the acromial trapezius. There is an occipital rhomboid, no dorsi-epitrochlear, a nearly separate subscapulo-humeralis, a coraco-brachialis longus, and no c. brevis; a sterno-scapularis. The deltoid arises from the spine of the scapula and from the infra-spinous fascia; the supra-spinatus exceeds the infra-spinatus (14 : 9). The serratus magnus is attached to ten ribs and six cervical vertebræ. The biceps has a radio-ulnar insertion, and the triceps longus has an enormous origin. There is no pronator teres, supinator longus, nor brevis. The flexor digitorum sublimis is inserted into the inner digits. The pronator quadratus is small and deep. There is one radial extensor of the carpus; an extensor digitorum longus to second, third, and fourth digits; an extensor minimi digiti to third and fourth. Sartorius arises from the ilio-pubal eminence, within the pelvis, and by a second head from the fascia over iliacus; the pectineus is very small; the adductor magnus, quadratus femoris, and semi-membranosus are inseparable. There are two obturators, and the gluteus maximus and biceps are inseparable. The gluteus medius arises from the lumbar fascia for a distance above the dorsum ilii. There is a gluteus quintus arising fleshy under the origin of the rectus femoris, and inserted into the place where a third trochanter should be. The tensor vaginæ femoris is inserted into the knee by a strong band. The popliteus is extensive, and there is no plantaris, nor soleus. The tibialis anticus is in two parts—femoral and tibial. The synovial membrane of the knee consists of two sacs, separated by a transversely vertical septum, which is only perforated behind the common tendon of the tibialis anticus and the extensor digitorum. There is a sub-pericardiac space between that sac and the diaphragm, in which the inferior vena cava

dilates. Some fossil species have *i.* $\frac{3}{3}$ (Hexaprotodon). The Miocene Merycopotamus has bi-crescentic lower and four-crescentic upper molars.

2. *Anoplotheridæ.*—Extinct Eocene Bunodonts, with no diastema; *i.* $\frac{3}{3}$, *c.* $\frac{1}{1}$, *p.* $\frac{4}{4}$, *m.* $\frac{3}{3}$; tail long; orbits incomplete; two functional and usually two smaller toes (absent in Xiphodon, one only in Dichobune); metacarpals and metatarsals free. The canines are like to the incisors, and do not project. These are the connecting links with Ruminantia.

3. *Setigera.*—Swine. Bristle-clad Bunodonts, with slender limbs, four metacarpal and metatarsal bones, having the third and fourth toes long, and the second and fifth toes short. The skin is moderately thick; the mammæ are abdominal, and there is a slight scrotum. Prenasals intervene between the nasals and premaxillaries; the molar teeth are multi-tuberculate, bunodont, increasing in size from before backward, and there are canines in both jaws. The supra-occipital bone forms a high crest, from which the skull slopes uniformly downwards and forwards. The parietals unite early, and contain air-cells. The frontals are broad and flat, and have post-orbital processes, but the orbital ring is incomplete. There is a large bulla tympani, cancellous within, and a long external meatus; a small separate periotic, small opisthotic, and long slender paroccipital. The face is elongated; the facial surface of the lachrymal is large, and it articulates with the malar. The palate extends backwards, behind the last molar tooth, and the different kinds of teeth are separated by diastemata. The mandibular rami ankylose; their vertical part is long, the coronoid short, the condyle transversely elongated, and the angle expanded. The small basi-hyal extends to the large thyro-hyal, but the cerato-hyal is separate, and the stylo-hyal scarcely ossified. There is no acromion; a complete ulna, usually joined to the radius, and touching the cuneiform below; the trapezius is absent, and the pollex may be rudimental. The presternum is long, slender; the cervical vertebræ nearly plane. The ilium has no sartorial pit, and the femur has a round ligament. The fibula is complete, and the tarsal bones all separate. The vertebræ are *c.* 7, *d.* 14, *l.* 5, *s.* 4, *c.* 16–23; the twelfth dorsal is the anticlinal. The cervical pedicles are pierced by branches of the spinal nerves. The conical truncated snout has two strong lateral levatores alæ nasi from the zygomatic arch and maxilla, and equally strong depressors (compressores nasi) also from the front of the zygoma. The one-headed biceps is inserted both into radius and ulna. The dorsi-epitrochlearis arises from the scapula, as well as from the latissimus dorsi. The serratus posticus is attached to all the ribs but the first; there is a sterno-scapularis and an extensor ossis metacarpi pollicis going to the metacarpal of the second digit. The pronator teres goes to the lower half of the radius, and the fascial insertion of the palmaris longus is pierced by the

single flexor perforans. There are two large lateral and two intermediate rudimental interossei from the functional toes, and no lumbricales. The psoas parvus equals the psoas magnus, and the sartorius arises from the iliac spine, while the gracilis and adductors are with difficulty separable. There is a small tibialis anticus, and the extensor longus digitorum has two heads, one tendinous and femoral giving off two bellies, one to the third, fourth, and fifth toes; the other receives the second tibial head, and is inserted into the fascia over the third metatarsal. The extensor hallucis pierces that expansion, passing from the fibula to the second toe; there is no peroneus brevis, but a p. quinti (to extensor tendon of fourth and fifth toes), and a p. longus to second metatarsal, are present; there is no soleus, nor tibialis posticus; a large plantaris, whose fascial end forms the only perforated tendon in the functional toes. The flexor digitorum and f. hallucis have separate bellies, but combined tendons. The palate is ridged; the tongue has a single central circumvallate papilla; the larynx has a narrow ventricle and a large sacculus, and the trachea gives off a third bronchus. The heart has no Eustachian valve, nor left upper vena cava. The common innominate artery gives off both carotids and the right subclavian; the intestine is twelve times the length of the body, the small being four times as long as the large, which begins in a small cæcum, with distinct valves. The pancreas is three-lobed, the gall-bladder sunk in the four-lobed liver; and there is a double sublingual gland. The male has a long bifid Weberian vesicula, a bilobed prostate, no penial bone, and large Cowper's glands. The female has two Gärtnerian canals, long uterine cornua, and lobulated ovaries.

There are three sub-families:—

1. Suinæ, with permanent premolars, forming one series with the molars, *i.* $\frac{3}{3}$, *c.* $\frac{1}{1}$, *p.* $\frac{4}{4}$ or $\frac{3}{3}$, *m.* $\frac{3}{3}$; milk teeth *i.* $\frac{3}{3}$, *c.* $\frac{1}{1}$, *m.* $\frac{4}{4}$; tail with 18–23 vertebræ; mammæ ten, rarely eight: canines utsk-like. This includes the wild swine with erect ears and convex foreheads, and the domestic ones with dependent ears and flat foreheads. The stomach has a cardiac pouch, with a mucous cardiac valve; the pylorus also has a pouch, and the middle area is marked by a longitudinal groove from one end to the other. This is well marked in the Malayan Babyroussa, with *i.* $\frac{2}{3}$, *c.* $\frac{1}{1}$ (very long and curled, the superior growing upwards, and piercing the upper lip), *p.* $\frac{3}{3}$ (the first early deciduous), *m.* $\frac{3}{3}$. The pharynx has air-sacs behind the choanæ, perhaps only in males. Potamochœrus has four teats, and has the face bones rough for the warts between the eye and snout. Porcula has rudimental incisors and an unsymmetrically small fifth toe; tail very short.

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* That is, the fourth developed toe, which represents the fifth, if the series were complete.

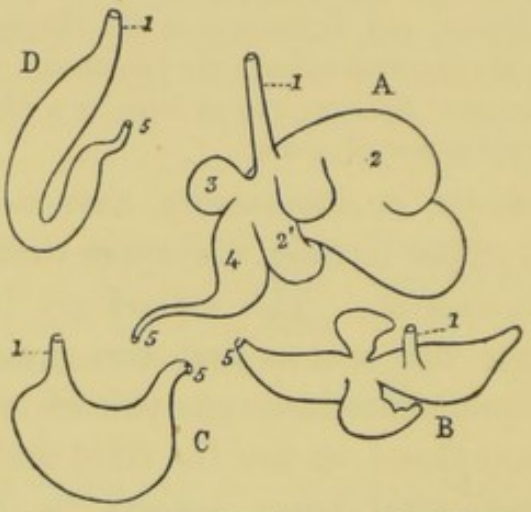
2. *Dicotylinæ.*—Peccaries. American, gregarious, with permanent premolars, *i.* $\frac{2}{3}$, *c.* $\frac{1}{1}$, *p.* $\frac{3}{3}$, *m.* $\frac{3}{3}$ (with transverse ridges, not tuberculated as in swine); ears small; tail short, of six vertebræ (D. torquatus), or nine (D. labiatus). A lumbar scent-gland and two mammæ are present. The third and fourth metacarpals and metatarsals ankylose, and the phalanges of the fifth toe abort.

3. *Phacochærinæ.*—S. African Wart-hogs, with deciduous premolars; *i.* $\frac{3}{3}$ (one or two of the upper early fall out), *c.* $\frac{1}{1}$, *p.* $\frac{3}{3}$, *m.* $\frac{3}{3}$, canines cylindrical, the upper up-turned; molars complex, formed of many rooted plates; intestines short; eyes and nostril on the level of the top of the head; a large wart under each eye. P. Œliani has two upper incisors, not deciduous, but all the front teeth fall out in P. Œthiopicus. Fossil pigs are numerous from the days of the early tertiaries. Eohyus and Helohyus in the Eocene, Perchœrus, Elotherium, and Thynohyus in the Miocene, Platygonus in the Pliocene form the ancestral series of the present day peccaries. Entelodon, from the European Miocene, was as large as a hippopotamus, while Hyracotherium was the size of a hare.

§ 2. *Selenodontia*, or *Ruminantia*, have no median (and rarely lateral) upper incisors, nor upper canines, nor their rudiments (*Pietziewicz*). The molars are behind a diastema, and have flat crowns and two crescentic enamel ridges. The premolars have one pair of crescents. The parietals are ankylosed, as are the third and fourth metacarpal and metatarsal bones (except in Hyæmoschus), forming a cannon bone. The astragalus has two articular surfaces in front. They usually have seven sternebers; paired horns, with bony centres, and a complex stomach, at whose cardiac side is a large sac (the paunch or rumen), lined by squamous epithelium and with papillæ, for receiving the food when it is at first swallowed, and mixed with saliva. The right end of the sac is narrowed, and opens into a smaller second pouch, whose walls are raised into intersecting folds, with intervening alveoli (the reticulum or honeycomb). A narrow opening above this, and below the œsophagus, leads into the long third sac, which has many longitudinal mucous folds like

book-leaves (psalterium or manyplies), and opens into a soft-walled, glandular, digestive stomach (abomasus or rennet). The lips of the cardiac opening are prolonged into parallel, longitudinal, mucous ridges, forming, when approximated, a canal leading from the œsophagus to the manyplies. The molar teeth in Selenodonts may be either of two kinds; in some they are *brachydont*, *i.e.*, short-crowned, the neck of the tooth being always on the level of the alveolar arch; in others they are *hypsodont*, *i.e.*,

Fig. 38.



Diagrams of various forms of stomachs: A, stomach of Ruminant; B, stomach of Manatus; C, Human stomach; D, stomach of Seal. 1, œsophagus; 2, paunch; 2', reticulum; 3, liber; 4, abomasus; 5, pylorus.

with short roots and long crowns, in which the neck of the tooth is buried in the alveolus, and does not come to the level until the tooth is much worn down (*Dawkins*). The process of rumination, or chewing the cud, is as follows:—The abdominal and gastric walls, contracting, drive the food into the œsophagus, or else, first into the honeycomb, and then into the œsophagus, by a sudden hiccough-like action; the bolus enters the mouth, is re-chewed and re-swallowed as a semi-fluid pulp, which trickles along the canal or groove into the psalterium,

whose lamellæ, strainer-like, refuse admission to coarse particles. Thence the chyme enters the abomasus, and is thoroughly digested. The paunch is never emptied by the process.

In the embryo the four stomachs are simultaneously developed, and are nearly of the same proportionate size as in the adult; just before birth the fourth enlarges, and during lactation it is the only functional stomach. The intestine is very long. The occipital condyles are close together. The heart has often a bone in the ventricular septum (Mr. Garrod found a similar bone in the tapir and rhinoceros).

The families are divisible into three groups :—

Group 1. *Tylopoda*, including one family, *Camelidæ*, digitigrade, hornless with elliptical red blood corpuscles, diffuse placentation, a split upper lip, and often a double velum palati. The œsophagus ends in a smooth paunch, which has several sets of large alveoli on its walls (the hypothetical water-cells). The opening into the honeycomb is very narrow, and the œsophagus has only its left ridge. The psalterium is small, tubular, and non-lamellated. The duodenum is dilated. The intestine is about twelve times the length of the body; the cæcum is short, and the large intestine is very long; the lower deeply lobed, with no gall-bladder. There is sometimes an ossification in the diaphragm; a Harderian gland; the axis has a crescentic odontoid process; the six long hinder cervical vertebræ have the artery piercing the pedicles, so that its hinder half in each vertebra is contained in the neural canal (as in Macrauchenia); the vertebræ are *d.* 12, *l.* 7, *s.* 4–5, *c.* 12·17. The skull has the occipital condyles touching each other; a cancellous bulla tympani; a humerus like that of a horse; united radius and ulna; distinct os magnum and trapezoid, and separate scaphoid and cuboid in the pes; no traces of second or fifth digits; the ankylosed third and fourth metacarpals are separate for a small space below, and their lower articular ends are simply rounded. The foot rests on the wide callous pad beneath the second and third phalanges, the last being small, not flattened on their contiguous surfaces, nor completely encased in the hoof; the teeth are $i.\ \frac{1}{3}$ (the upper incisors being lateral), $c.\ \frac{1}{1}$ (the lower pointed), $p.\ \frac{3}{2}$, $m.\ \frac{3}{3}$ hypsodont; the mandible has often a post-condyloid spur. Two genera are included—Camelus, African and Asiatic, with no digital glands; a neck concave, bent upwards and backwards; tail short, tasseled at end; back with one (C. Dromedarius) or two (C. Bactrianus) fatty humps fixed by strong reticular connective tissue to the vertebral spines; ears small, rounded. The hair is shaggy, scanty, absent on the callosities on the knees

and breast The femoral nutritious artery enters medio-posteriorly. The small nail-like hoofs are weak; the tongue has complex calyciform papillæ; the nostrils are slit-like, with a sphincter; intestine 120 feet long; trachea long, with 110 rings and a third bronchus, and there is often an occipital dermal gland. The flexor muscles of the leg and arm are covered by very strong longitudinal elastic bands. The coraco-brachialis is very wide, with a superficial short part and a deep bilaminar middle form. There is a sterno-scapularis, a trachelo-hyoid from the transverse process of the fourth cervical vertebra to the hyoid and mandible, and by a slip to the lower lip. The deep muscles of the neck and back are enormously strong. The scapular deltoid has a fascial origin stretching below the infra-spinatus. The acromial deltoid is distinct. The supra-spinatus is to the infra- as 55 : 36. The biceps is fibro-cartilaginous over the shoulder, and radial in insertion; the brachialis ascends high on the humerus, and is very oblique. The triceps is enormous (nearly 10 lbs. in weight in the adult dromedary), with a very small inner head, and a large outer, arching by a tendinous string over the brachialis anticus. There is no pronator teres, nor quadratus, flexor carpi radialis, supinator longus, nor brevis; a small extensor ossis metacarpi pollicis; a separate extensor minimi digiti from the E. digitorum longus; a palmaris longus arising with flexor sublimis, and inserted with ext. carpi ulnaris into the flexor side of the palm. There is an enormous metacarpo-phalangeal ligament. The semi-membranosus and adductor primus are inseparable. The semi-tendinosus has an inscription. The gluteus maximus is divisible into two parts, the posterior being three times the largest. The pyriformis is separate; there is a gluteus quartus separate from the medius and minimus, and a tensor vaginæ femoris. The popliteus has an enormous tendon of origin; the plantaris is represented by a strong round tendon from the external condyles. There is no separate solæus, nor tibialis posticus; the flexors digitorum and hallucis have separate bellies; the f. digitorum brevis is represented by a tendon from calcaneum to the digits. There are two tibiales antici, a femoral and tibial; a small extensor hallucis; a femoral ex. digitorum longus, peroneus longus, and quinti, but no p. brevis; the tendon of p. quinti joins the outer tendon of p. longus.

Auchenia, the llama, is S. American, with seventeen caudal vertebræ, a narrow double sole-pad, strong hoofs, and a digital gland; no dorsal hump, shaggy hair, a crescentic spleen, a pronator teres, a single extensor carpi radialis, large gemelli, and other muscles as in the camel. The neck is upright; ears long, pointed. Bezoar stones are common in their intestines.

Group 2. *Schizopoda.*—Includes one family, the *Tragulidæ*, palæotropical, with complete second and fifth, as well as third and fourth digits, and the

third and fourth metatarsals and metacarpal unite late, or not at all (Hyæmoschus). The trapezoid and os magnum are confluent. The fibula is long, slender, inseparable from the tibia below; the cuboid and navicular, and sometimes the ecto-cuneiform, are united; the ento-cuneiform is absent. The bulla tympani is cancellous. The odontoid process is conical, and the lachrymal canal is single, and opens in front of the orbit. They have canines in both jaws, brachydont molars, and sharp-cutting premolars. There is a dorsal osseous shield (in males only?), or ossified lumbar fascia, attached to the lumbar and sacral spines, and the pelvic ligaments are ossified. The lumbar shield overlaps the origin of the gluteus maximus and biceps, which are united at origin, and inserted into the fascia over the knee, and along the leg nearly as far as the calcaneum. The semimembranosus and adductor primus are inseparable unto their insertion. The psoas magnus is proportionally larger than in the deer. They have only infra-mandibular scent-glands; the œsophagus opens over the reticulum, which has a wide communication with the paunch. The psalterium is a short, narrow, smooth tube. The brain is feebly convoluted. The placentation nearly diffuse, as the bands of villi can scarcely be called cotyledons. The liver has a large Spigelian lobe and a gall-bladder; the blood corpuscles are very small ($\frac{1}{12000}''$ in diameter). The aorta gives off an innominate and left subclavian;* teeth *i.* $\frac{0}{3}$, *c.* $\frac{1}{1}$, the upper tusk-like, *m.* $\frac{6}{6}$. The heart has no bone. Tragulus, the Chevrotains, in which the metacarpals and tarsals ankylose, and the nasals unite with the premaxillæ, is of small size, about $1\frac{1}{2}'$ long. In the pig-like aquatic Hyæmoschus the metacarpals remain separate, and the metatarsals unite late; the premaxilla does not touch the nasal, and the muscles are pig-like in many respects (*Chatin*). There is a large thyroid cartilage forming a pouch; the intestine is twenty-two feet long, the cæcum simple, the spleen pear-shaped, and the gall-bladder large.

Group 3. *Cotylophora.*—Includes the Unguligrade forms, which are mostly horned, with cotyledonary placentæ; no basis for the second and fifth metatarsals or metacarpals; an external malleolus as a detached bony nodule (malleolar bone), ankylosed navicular and cuboid, and united third and fourth metacarpals and metatarsals; no ento-cuneiform; a cartilaginous super-scapula and a supra-acetabular pit on the ilium. The auditory bulla is hollow, not cancellous. The neck vertebræ are opisthocœlous. The aortic arch gives off all its branches from a common innominate, and the vertebral artery enters the spinal canal between the second and third, so

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* I prefer keeping to a uniform nomenclature, and calling this artery subclavian, not brachial, as that name has a special sense.

does not traverse the axis or atlas. The last is pierced by the anterior and posterior bands of the first nerve separately, the axis by the whole second nerve. The odontoid is somewhat spoon-shaped. The tuber ischii has an outer conical process; the circular blood corpuscles are rarely less than $\frac{1}{3000}$th of an inch in diameter, except in Moschus; no upper incisors exist. The nasals often do not touch the premaxillæ, and between them, the lachrymal, and maxilla a fontanelle often exists. The radius and ulna are fully united. The stomach has its four compartments, and the psalterium is laminated. There are five families:—

1. *Moschidæ.*—Asiatic, hornless, with scent-glands in the male, on the outside of the thigh (*Brandt*), on the tail (*Hodgson*), and much more distinctly in the medio-ventral wall, between the umbilicus and penis; these last are the true musk glands. They are all absent in the female, and there is no sub-orbital gland, nor interdigital gland. The right lung is often larger than the left, and the aorta gives off a common innominate, whose branches supply both fore-limbs and the head. The blood corpuscles are about $\frac{1}{7000}$. The cæcum is long; the auditory bulla small and rugged. The lachrymal canal has a single opening, and a gall-bladder is present, and the Spigelian lobe of the liver is pedunculated. Cowper's glands are present. Teeth *i.* $\frac{0}{3}$, *c.* $\frac{1}{1}$ (upper tusks in the male). *p.* $\frac{3}{3}$, *m.* $\frac{3}{3}$, brachydont. The vertebræ are *d.* 13, *l.* 6, *s.* 4, *c.* 14. Mammæ two. The frontal joins the upper maxillary. There are no second and fifth metacarpals, and rudiments of the lower ends of the second and fifth metatarsals. This includes one species, the Thibet musk deer.

2. *Camelopardalidæ.*—S. African, tall, long-necked, short-backed, and long-legged, the fore-quarters higher than the hind; teeth *i.* $\frac{0}{3}$, *c.* $\frac{0}{1}$, *p.* $\frac{3}{3}$, *m.* $\frac{3}{3}$. The palate has large, dentated, reflexed ridges; intestine long (245 feet in one, 134 in another), with Peyerian patches surrounded by marginal ridges, and a complex group of such patches around the ilio-colic aperture; two lateral, frontal, persistent, cancellous horns, covered by skin, with a terminal tuft of stiff bristles. These arise as distinct ossifications, and unite late with the skull, over the coronal suture. In front of these is a median prominence. The lachrymal is bullate, and all the upper skull-bones are pneumatic, air even extending into the horns, which are larger and more closely approximated in the males than in the females. There is a long narrow scapula, with no acromion; a short pelvis, with a shallow supra-acetabular pit; second and fifth toes absent. The vertebræ are *c.* 7, *d.* 14, *l.* 5, *s.* 4, *c.* 18–20. The cervicals have long bodies, short transverse processes, which are constricted mesially, as to appear made up of anterior and posterior parts. The ligamentum nuchæ extends back to the sacrum. The tongue is long, extensile, with long genio-glossi

muscles; the lingual arteries are often unequal in size; a digital pit exists over each tonsil, and there is a rudimental papillary uvula. A gall-bladder was found in one (?), but was absent in three; where it existed it was divided by a septum, and lined by a smooth membrane; both halves ended in a cystic duct. There is an *os cordis*. The trachea has ninety-two rings. The eyes are prominent. There are no digital glands. Sivatherium, with an elephantine head, was related to the single living genus, Camelopardalis (the giraffe). The Miocene Helladotherium connects these to the antelopes.

3. *Cervidæ*.—Elegant, graceful forms, with, in the males* or in both sexes (reindeer), outgrowths of the frontal bones as horns, at first covered by a velvety skin. These soon attain a large size, then a burr or ring of hard bony knobs develops around its base, dividing the skull part (pedicel) from the free part (beam). The pressure of these knobs strangulates the nutrient dermal vessels of the beam, which necroses, and is shed, a new beam soon growing over the burr. In some cases growth has been estimated at one pound per day. This process takes place periodically; at first the horn is a single shaft, but at each successive growth it becomes more complex, new tynes budding each year. The teeth are as in giraffes; the first upper premolar has three roots; they are all brachydontal; canines are large in the Muntjacs. There is no supra-scapular notch and a rudimental coracoid; the lower end of the fibula remains as a malleolar bone, while the upper part has vanished. The lachrymal canal has two openings, one above the other, at the brim of the orbit; the lachrymal bone has a suborbital pit for an odoriferous dermal gland (the *crumen*). The facial and cranial axes are nearly in the one line. The lateral toes have three small phalanges, and the distal ends of their metacarpal bones developed, but not attached to any part of the skeleton. The gluteus maximus, tensor vaginæ femoris, and biceps form one sheet, as do the adductor magnus and semi-membranosus, which can only be separated at their insertion. There is a pectineus, a pyriformis; the obturator externus extends through the foramen to the inside of the ischium and pubis. The popliteus extends for one-third the tibia; there is no soleus; the tibialis posticus joins the flexor hallucis above the heel, and the flexor digitorum joins them below that point. There is a double tibialis anticus, tibial and femoral, and a femoral extensor digitorum arising along with it. The peroneus quinti acts as an extensor of the outer toe, joining the extensor tendon; the peronei are as in the camel. The sterno-mandibular takes the place of a sterno-mastoid, and trachelo-hyal replaces the omo-hyoid. There is a sterno-scapular, no pronator teres, a penniform biceps, a flexor

* Hydropotes has no horns, nor has Lophotragus.

digitorum sublimis, f. profundus and f. pollicis, one radial carpal extensor; a short supinator and an extensor ossis metacarpi pollicis. The sartorius springs from the supra-acetabular pit and the sheath of the ilio-psoas. The deltoid is as in the camel. The semi-tendinosus has a tendinous intersection. The extensor carpi ulnaris acts as a flexor, and the palmaris longus is olecrano-fascial. There is a separate plantaris, large gemelli, a small obturator internus and a long quadratus femoris; the upper slip of obturator externus is often separate, and a rudimental interosseous often exists. Carpal and tarsal glands are present. The liver has not a gall-bladder,* nor a pedunculated Spigelian lobe. Cowper's glands are usually absent (except in Cervus humilis). There is a special dilator tubæ Eustachianæ medialis muscle separate from the ordinary dilator tubæ. This family extends over the whole globe, except Australia. They are usually uniparous. Alces, N. American elks, have a broad hairy snout, short thick-maned neck, strong forequarters, short nasal bones and palmate horns, with no brow antler. Rangifer, the reindeer, has a hairy snout and maned throat; horns in both sexes cylindroid, with a wide brow antler. Dama, the fallow deer, has round brow antlers and a broad beam above; the end of snout naked. Megaceros, the extinct great Irish elk, was allied to this. Cervus has a cylindrical branched beam, a naked muffle, a lachrymal groove, and sometimes canines in old males. The genus is subdivided into the following sub-genera:—Elaphus, the red deer, with low brow antlers and rounded tynes; Rusa, with no moustache line dividing the muffle from the upper lip (Sambur); Axis, with large pointed ears and speckled skin; Blastoceros, with the second antler tyne turned backwards, and a pencil of hairs at the ankle; Cariacus, brow antler short, up-directed (Virginian deer); Capreolus, lachrymal pit absent, short tail, short upright forked horns (roebuck); Furcifer, lachrymal pit large, beam short, simply forked at base; Subulo, with horns as simple-pointed rods; Dremotherium, a tertiary form, unites these to Moschidæ. Cervulus, the muntjacs, have large canine teeth, large lachrymal pits, and the external and middle cuneiforms ankylose with the navicular. In the closely allied Lophotragus the inner cuneiform unites with the metatarsus. They have no gall-bladder nor lateral metatarsals; the short unbranched horns have only basal buds, and are borne on ong bosses.

4. *Cavicornia.*—Unguligrades, with a symmetrical pair of horns, which consist of horny sheaths over a conoidal bony core of the frontal bone, often in both sexes; most have hind toes. There are three sub-families:—

1. *Antilopinæ.*—Deer-like, graceful forms, with straight or curved, round

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* *Crisp* found a gall-bladder in an Axis, and a Cervus superciliaris.

or conical, smooth, annulated horns, with compact bony cores or with ridges; upper lip grooved or smooth. The mammæ are two or four; the horns are rarely shed (Antilocapra). The nasals may be short. They rarely have a dewlap, always a glenoid foramen. They have two inguinal odoriferous glands, and, like deer, have a sub-orbital crumen or lachrymal follicle, and sometimes a post-auricular gland (as in the chamois), and interdigital glands. Some (Eland) have a pronator teres, the palmaris longus joining the flexor sublimis at the wrist, and rudimental muscles represent the extensor indicis and ex. ossis metacarpi pollicis. The vastus is bilaminar, and there is a small fibular soleus, and in the leg an interosseous, with a common belly and three tendons, one to each side, and one mesial to the inner toe. There may be a lachrymal sinus and a facial fontanelle (Gazella melanotis), or a tear pit and no vacuity (Catoblepas, Caama, Bubalis), or a vacuity and no tear pit (Rupicapra, Oreas, Portax). The vertebræ are *c.* 7, *d.* 13, *l.* 5–6, *s.* 4, *c.* 14. The genera are Saiga, with very short nasals ending on the level of the front edge of the orbit, the lachrymals forming part of the lateral wall of the anterior nares; to their edges the soft proboscis-like muzzle is attached. The females are hornless. Pantholops has a saccular appendix to the nose. Antilope has a simple nose, long horns, inguinal glands, and is moderate or small in size. It includes as sub-genera Gazella, with horns in both sexes and tear pits; Tragops, with no tear pits; Antidorcas, whose females have small horns, and the back has a movable skin-fold. Leptocerus has long-ringed parallel horns in both sexes.

Tetracerus has two stout horns over the orbit, and two straight horns behind these; it has also lachrymal grooves, and the female is hornless. Calotragus has horns only in the male, short, straight, and transverse tear pits. Oreas, the eland, has a spiral ridge on the horns. Tragelaphus has spiral horns, and like the last, no tear pit. Bubalis has horns doubly bent. Catoblepas has laterally bent horns; a glandular eminence in place of the tear pit. Portax, the Nylghau, has short, spiral, conical horns. Budorcas has a sheep-like head, four mammæ, and no scent glands. Rupicapra, the chamois, has hooked horns. Antilocapra, of N. America, with no hind toes and a forked horn, is made by some the type of a separate sub-family. The horns are deciduous, and there are no scent glands; the female is hornless. Nanotragus is a pigmy form, about 8″ high.

2. *Ovidæ.*—Smaller and more robust animals, with horns directed backwards or downwards, compressed, angulated, and transversely wrinkled; muffle hairy; back teeth with no accessory enamel columns; hind toes short, often only represented by the hoofs; mammæ two. The sartorius is double, the soleus present. The pectoralis major and latissimus dorsi are united by an axillary arch. There is no pronator teres nor quadratus, dorsi-epitrochlearis

supinator longus nor brevis; one radial carpal extensor and one ulnar; two carpal flexors, a palmaris, and three digital flexors. There is an indicator, an extensor digitorum longus, and an extensor minimi digiti; a very rudimental extensor ossis metacarpi pollicis; no distinct obturator internus, but a large gemellus, partly extending into the pelvis. The biceps and gluteus maximus are fused. The two vasti are bilaminar. There is a distinct plantaris, a double tibialis anticus, and peronei longus and quinti. Ovis (sheep) has the horns widest transversely at the base, usually spiral; forehead flat or concave; chin beardless; tear pit and digital glands present. Capra (goats) has horns antero-posteriorly, compressed widest at base, smooth on the inner side; forehead convex; chin mostly bearded; usually no tear pit nor digital glands.

3. *Bovidæ.*—Body robust; horns rounded, bent outwards, with cancellous cores; no tear pits, nor digital glands; muzzle broad; upper lip not grooved; molars with accessory enamel columns between the semicircular folds; tail long; teats four. The face is bent down on the cranio-facial axis. The occipital surface is flat, and ends in a transverse ridge between the horn cores; behind this ridge are the parietals, narrow above, and with their marginal sutures early synostosing. The frontal sinuses are large, and enter into the horns. The frontals are flat; the tympanic scarcely inflated, and early ankylosed. The basi-hyal has a median process. The large supra-orbital hole pierces the frontal with a longitudinal furrow, remote from the orbital margin. The alisphenoid does not reach the parietal, and has a pointed ridge in front. The tympano-hyal is large and rough: the nasals notched in front, as in goats; the premaxillæ are short, with large Stensonian canals. The lachrymals are large, with post-orbital tubercles and a toothed suture. There is no facial fontanelle. The sacral vertebræ are often five, and caudals eighteen. The muscles resemble those of antelopes, there is a pronator teres, and the peroneus longus ascends to the femur. There is a gall-bladder. The carotids and subclavians arise by a common trunk. The spinal nerves pierce the vertebral laminæ. The genera are Bos (oxen), with broad naked muffle, tail long, hoofs broad, frontal long and flat. Bubalus, with short, convex forehead, and sharply curved horns. Bison, with forehead broader than long, maned, and bearded. Poephagus, the Yak, with horse-like tails. Ovibos, the musk ox, with very short tail, hairy muffle, flat forehead, and long hair clothing.

CHAPTER XXXIV.

Sirenia and Aberrant Ungulates.

Order V. *Sirenia.*—Herbivorous, non-claviculate, sparsely bristle-clad, heavy animals, dwelling in the sea or in estuaries, with thick skin; a neck; a fleshy snout, with bristly lips, and separate valvular nostrils on the anterior and upper surface; a horizontal flattened tail, with two pointed lateral lobes, but no hind-limbs, nor dorsal fin. There are two thoracic mammæ, and no external ear. The fore-limbs are converted into pectoral fins or paddles, and have a movable elbow-joint, with a synovial membrane, and the hands have rudimental nails.

The cervical vertebræ are six (Manatus, the third, or sixth absent) or seven; their bodies may be free, or those of the second and third may be ankylosed, and their arches are occasionally incomplete, as is also the canal for the vertebral artery. The dorsals are nineteen (Halicore) or seventeen (Manatus), with no distinct surface epiphyses, triangular bodies, keeled above, all bearing rib facets, and the arches of some with metapophyses, but no anapophyses. The lumbars are four (Halicore) or two (Manatus). There is one sacral vertebra and about twenty-one caudal, of which the hindmost have processes, and are not mere bony discs, but the post-zygapophyses cease at the first lumbar vertebræ. The sternum consists of an ossified pre- and a xiphi-sternum, with a cartilaginous meso-sternum; to the first there is attached one pair of the broad ribs, to the central cartilage three pairs.

The skull-bones are of ivory hardness and rough, with no air sinuses, a small, but long and laterally compressed, brain cavity, truncated at both ends, flat above, and with the cerebellar fossæ behind the cerebral. The olfactory fossa is small, with a *crista galli*. The foramen magnum is large, and looks downwards and backwards. The supra-occipital bone does not stretch far forward, and the parietals form the roof of the skull, and have a median sagittal suture. The squamosal has a massive zygoma, flattened externally, sending down a strong, triangular, post-tympanic process, which articulates with a rough edge of the ex-occipital. The tympanic is a half

ring, ankylosed in front to the periotic, but free from the squamosal, a process of which holds it in its place, and there is a basicranial space, bounded by the squamosal, supra- and ex-occipital bones, partly filled by the periotic. The foramen lacerum medium is wide, the frontals narrow, forming the roof of the orbit. The prominent margin of the orbit is made by the large jugal, which has a large post-orbital process. The lachrymal is imperforate, scale-like in the Manatee, large and massive in the Dugong. The infra-orbital is large, and the anterior nares form a lozenge-shaped opening stretching behind the orbit, bounded by the premaxillæ and the frontals. The nasals are trigonal, pyramidal in Rhytina, lateral and rudimental, or absent (*Krauss*) in Halicore, or large, between the premaxillæ (*Rüppell*), or two, asymmetrical, attached to the frontal (*Brandt*). The vomer is delicate, and there is a large ossified mesethmoid, but no maxillo-turbinals, one anterior palatine foramen, and the hinder edge of the palate is opposite the last molar. The tympano-hyal is ankylosed to the periotic, the stylo-hyal is long, and the thyro-hyal unossified.

The scapula has an acromion and a spine. The shoulder-joint has a synovial membrane and a capsular ligament. The humerus is narrow in the middle, wide at each end, with two tuberosities, a bicipital groove in Halicore, but with no supra-condyloid process. The forearm bones are ankylosed above and below; there are seven carpal bones, but no pisiform, and the cuneiform articulates with the fifth metacarpal. These bones may ankylose in Halicore, especially those of the second row, and the scaphoid and lunar; there are five digits, none of which have more than three phalanges.

The pelvic bones are small in the Dugong, and consist of a rod-like ilium joining a slender ischium end to end, and often ankylosing therewith; the ilium is connected to the sacral vertebra by ligament, but there is no symphysis ischii. In Manatus the ischium is triangular, loosely joined to the sacrum, with no acetabulum. In both forms the pelvic bones lie along the axis of the body.

The premaxilla has on its palatine surface a horny plate, in which long dermal papillæ are sunk. In Halicore there are two tusk-like incisors in the male, rudimental in the female; no incisors in the mandible of the adult, but three on each side in the young, no canines in either jaw, and $\frac{6}{6}$ molars, which have had no distinct milk predecessors, no enamel, nor roots, and of these $\frac{3}{3}$ anterior very often fall out. Manatus has no adult incisors, but $\frac{1}{0}$ in the young, which is not replaced; the molars are $\frac{8}{8}$ or $\frac{10}{10}$, and each has two crescentic, three-cusped, transverse ridges; the upper have three, the lower two roots. The mandible has a firm symphysis, prolonged vertically down in the mesial line in the Dugong, having a large condyle and a some-

what inflexed angle. The eye has a nictitating membrane; the inferior maxillary nerve traverses the foramen lacerum medium along with the internal carotid, as there is neither an oval nor a carotid canal. The lingual nerve emerges through the anterior condyloid foramen. The tongue has no fungiform papillæ, and has little motion; there is a parotid gland, and no submaxillary. The stomach is constricted mesially (Fig. 38 B), and has a cardiac gland, over which the mucous membrane is disposed in spiral and radial folds. The pylorus presents two hind pouches, and the cæcum is bifurcated; the liver has shallow lobes and a gall-bladder, the kidney lobulated. The ventricles of the broad heart are separate for half their extent, so that the apex is deeply cleft. There are two superior venæ cavæ, a greater Eustachian valve, and several *retia mirabilia* (especially in the Manatee).

The diaphragm is very oblique, making a small angle with the front wall of the abdomen, so that the lungs (unlobed in Halicore, lobed in Manatus) extend backwards and downwards behind nearly the whole abdomen. The larynx is not capable of being prolonged into the posterior nares, and has short arytenoid cartilages, and there is no third bronchus. The male has abdominal testes and seminal vesicles; the female has a two-horned uterus.

Three genera are included:—1. Rhytina, Steller's seacow, which inhabited Behring's Island, and has been extinct since 1768; it had a horny plate above and below, in place of teeth; a crescentic tail fin; fore-limbs with a callosity; skin thick, almost hairless; it reached twenty-four feet in length. Halicore, the Dugong of the Indian Ocean, has a broad crescentic tail, no nails, and reaches about ten feet in length. Manatus, nearly the same size, has four digital nail rudiments, and its nasal bones are absent (*M. Senegalensis*) or present (*M. Americanus*). Its muscular anatomy is like that of whales, but it has well-marked paddle muscles, a cleido-mastoid, cephalo-humeral, no teres minor nor coraco-brachialis, but large interossei. The Pliocene genus Halitherium had an acetabulum and a rudimental femur, small mandibular incisors, and premaxillary tusks. The Pliocene Prorastomus, from Jamaica, was allied to the Manatee.

Order VI. *Toxodontia.*—This consists of American Pleistocene, imperfectly known forms, possibly aberrant ungulates. The skull is massive, with a forward-directed supra-occipital, strong zygomata; a long palate; *i.* $\frac{2}{3}$ (the outer upper ones large), *c.* $\frac{1}{1}$ (the upper rudimental), *m.* $\frac{7}{6}$, arched, convex outwards and concave inwards, persistently growing, with no enamel on their inner surface. The scapula is wide, with no acromion and a large prescapula; the femur is elephant-like; the astragalus flattened; the tibia and fibula, radius and ulna are separate. The genera are Toxodon and Nesodon, and were of immense size; their feet are unknown. Some of their affinities are possibly Rodential.

Order VII. *Tillodontia.*—American forms, from the lower and middle Eocene, with bear-like skulls, whose molar teeth are constructed on the ungulate plan, and whose wombat-like, large, permanently-growing incisors are faced with enamel, resembling those of Rodents. The femur has a third trochanter; the scaphoid and lunar bones are separate; the feet are five-toed, plantigrade, with long pointed claws; the mandible has an ossified symphysis, a broad condyle: the vertebræ are bear-like; the humerus has a supra-condyloid foramen, and the radius is expanded at both ends.

The skull has wide zygomata, no post-orbital process, long nasals, narrowing forwards, a post-glenoid tubercle in front of the auditory meatus; the post-tympanic process of the squamosal unites with the paroccipital; there is an alisphenoid canal, and the brain cavity is very small.

There are two families, one with a dentition, *i.* $\frac{2}{2}$, *c.* $\frac{1}{1}$, *p.* $\frac{3}{2}$, *m.* $\frac{3}{3}$, the last lower molar having a third lobe. Of this family the type is Tillotherium.

The type of the other family, Stylinodon, has all its teeth rootless.

CHAPTER XXXV.

Carnivora.

Order VIII. *Carnivora* (*Cuvier*).—Hairy, deciduate* mammals, with zonary placentæ, moderately-sized heads, and with both pairs of limbs developed. The fore-limbs are capable of prehension, with a pollex (except in hyæna), which is never opposable. The clavicles are imperfect or none, and the scapula have sub-equal supra- and infra-spinous fossæ (a part of the former being, at first, separately ossified). The radius and ulna are separate, sometimes freely movable on each other, aud the carpus has a scapho-lunar, no os centrale, and often a radial

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* There is no decidua reflexa, the omphalomeseraic vessels do not reach the chorion, and the allantoid is a perfect sac.

sesamoid, in or near the tendon of the abductor pollicis major. The last phalanges of all the digits have sharp curved claws, except in some seals.

The pelvis is long, narrow, and there is a fabella in the outer head of the gastrocnemius. The vertebræ are *c.* 7, *d.* 13-16,* *l.* 4-7 (*dl.* = 19-21), *s.* 1, *ps.* 3-7, *c.* 6-36. The atlas has wide transverse processes, deep cavities for the occipital condyles, a complete hole for the first spinal nerve; the axis has a long odontoid and a wide long spine. The other cervicals have long bodies, and hyperapophyses (*Mivart*) or tubercles behind the articular process on the laminæ; the fifth and sixth have wide inferior lamellæ of the transverse process (absent in the seventh). The long, narrow sternum has 8-9 segments, and is ossified by ectostosis.

The skull has strong occipital and meso-parietal muscular ridges, wide zygomata, large malars, with wide maxillo-jugal suture, but no jugo-lachrymal contact. The nasal bones are large and thin. The orbit is incomplete, the mastoid cells large; the glenoid cavity is transversely elongated, and the mandibular condyle corresponds thereto, limiting the motions of the jaw to the vertical plane. The hyoid arch is complete, with a small body and a many-jointed cornu. The turbinal bones are complex, the coronoid process large, and the tentorium is often ossified. The great pectoral is bilaminar, the trapezius divided into two or three parts. The biceps is gleno-radial, one-headed, and penniform; there is usually an omohyoid, a trachelo-acromial, and a dorsi-epitrochlear muscle; the masseter and temporal muscles are large, united, and the pterygoids are small. The salivary glands are proportionally small; the stomach simple; the intestine short; the cæcum small or none; the liver is deeply lobed, and has a gall-bladder.

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* The eleventh is usually the anticlinal vertebra.

There is usually an os penis, a vesicula prostatica, but no vesicula seminalis, a bicornate uterus, and a peritoneal sac enveloping the ovary. The brain is large, convoluted, with a large corpus callosum, the temporal lobe marked by fissures, and three or four arched gyri surround the sylvian. The corpus callosum is large, the cerebellum partly uncovered (except in the walrus). The mammæ are abdominal. The aorta gives off from its arch an innominate and a left sub-clavian trunk, the former giving off the two carotids and the right sub-clavian. The kidney may be lobulated.

The teeth are heterodont, simply enamel-coated; the incisors are small, canines very large; the largest molar or premolar is sharp-edged, with a hinder tubercle, and is called the sectorial or flesh tooth.

Carnivora may be divided into four sub-orders.

Sub-order I. *Pinnipedia* (*Illiger*).—Aquatic, with syndactylous, paddle-like fore-limbs, with small or abortive nails; a close, short, smooth pelage; a thick subcutaneous layer of fat; the hind-limbs short, directed horizontally backwards, parallel to the spine, and included in the same fold of skin as the tail.* Clavicles are absent; the acromion and coracoid small; the latter separate in early life; the suprascapula is large, slowly ossifying. The unciform bone is usually so small that the fifth metacarpal partly articulates with the cuneiform; the humerus has a large deltoid crest, but no supra-condyloid foramen. The fibula is often nearly as broad as the tibia, to which it may be ankylosed, and the lateral toes are longer than the median. The skull is large, wide behind, constricted frontally, with a wide orbital cavity and a depressed interorbital region. The lachrymal bone and duct are absent. The sclerotic coat of the eye is thick posteriorly, and at the corneal edge; the lens is nearly spherical, and there

* This fold extends beyond the middle of the tail.

may be a membrana nictitans. The outer ear is small, valvular, or absent.

The brain is wide, rich in convolutions, with a small anterior commissure and a small olfactory nerve. The testes are inguinal or abdominal, and the os penis is short, except in the walrus. The 2–4 mammæ are ventral; the uterus divided by a septum; the anus and vulva open in the same surface groove, surrounded by a common sphincter. The teeth are rather prehensile than masticatory; the incisors are sometimes caducous;* the mandible has rarely a post-angular process. The stomach is very narrow, the cæcum small, the kidney lobulated, and the arteries divide into retia on the vertebral column; the inferior vena cava also has a widely dilated sinus above the liver. The nostrils are kept closed by elastic cartilage, but are opened by muscle. They are for the most part social animals, living in communities, and are, with few exceptions, marine (Phoca Caspia, vitulina, Baikalensis and annelata live in the Caspian and Lake Baikal). The females are uni- or bi-parous. Pristiphoca existed in the Miocene period.

Three families are included:—

1. *Trichechidæ*.—Walruses, Palæarctic, monogamous, with no outer ears; a broad snout, with strong white touch-bristles compressed at the base, rounded at end, and a short flat tail. The skull has a large supra-orbital, but no post-orbital process, a small, rugged bulla-tympani, continuous with a strong mastoid process, an alisphenoid canal, an ento-parietal bony ridge, and a long palate. The vertebræ are *c.* 7, *d.* 14, *l.* 6, *s.* 1, *p.-s.* 3, *c.* 11. The tail is rudimentary; the fore-limb is smaller than the hinder, and has the radial edge of the manus outward, and the digits pointing backwards; the toes are sub-equal, with skin-folds; the calcaneum has a slight heel process, projecting backwards, and a sesamoid bone on the tibial side of the tarsus. The teeth are *i.* $\frac{1}{1}$,† *c.* $\frac{1}{0}$ (the upper rootless, enormously lengthened into down-growing tusks), *p.* $\frac{3}{3}$, *m.* $\frac{3}{1}$ (the last upper being very soon shed; other authors give for *p.-m.* and *m.* $\frac{3}{3}$, $\frac{3}{4}$, and $\frac{4}{4}$). The milk teeth never cut the gum, and are absorbed, not shed.‡ The brain is well convoluted, with a rudimental hinder cornu; the anterior commissure and olfactory nerve are

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* The outer incisors sometimes look like canines; the molars have rarely more than two fangs; the change of teeth takes place very early, often during the fœtal state.

† Owen gives *i.* $\frac{2}{1}$.

‡ They are *i.* $\frac{3}{3}$, *c.* $\frac{1}{1}$, *m.* $\frac{2}{4}$ (*Wiegmann*), or *m.* $\frac{4}{4}$ (*Malmgren*).

small; the cerebellum is covered by the cerebrum; the right bronchus bifurcates into a large and a small branch before entering its lung. The thyroid body is deeply hollowed by a fissure; the epiglottis is small.

2. *Otariidæ.*—Sea lions. Mostly Antarctic,* with small external ears, sub-equal hinder toes, limbs capable of supporting the weight of the body, neck long, skull with an alisphenoid canal, a post-orbital process of the frontal, and a separate mastoid process, a rough tympanic, a crest on the inside of the parietal bone; the vertebræ are *d.* 15,† *l.* 5, *s.* 1, *p.-s.* 3, *c.* 9–12. The pre- exceeds the post-scapula, and there is a ridge parallel with the spine. The ungual phalanges are prolonged beyond the nails into cartilage-rays, supporting dermal lobes. The teeth are *i.* $\frac{3}{2}$, *c.* $\frac{1}{1}$ (not large), *p.* $\frac{3}{3}$, *m.* $\frac{3}{2}$ or $\frac{2}{2}$ (in Eumetopias); the molars are single-fanged; the palate may reach the pterygoid (Otaria), or be remote from it (Phocarctos); the post-angular process of the mandible is incurved in Arctophoca.

3. *Phocidæ.*—Seals, with no external ears, and permanently extended legs, parallel to the tail; vertebræ *d.* 14–15, *l.* 5, *s.* 1, *p.-s.* 3, *c.* 9–11–16. The scapula is somewhat falciform, the coracoid making up a large part of the glenoid cavity; the pollex is longer than the middle digit, and in the pes the hallux and fifth digits are longer than the others; and the metatarsals and first phalanges have epiphyses at both ends; the calcaneal tuber is nearly obsolete, the femur has no ligamentum teres; the ilia are short, everted, the pubes are capable of separation during parturition at the short symphysis (*Knox*). The foot-sole is hairy, and there is no sesamoid bone at the tibial side of the tarsus; the short skull has a broad, often perforated, basi-occipital, wide condyles, a large supra-occipital intruding between the parietals, no alisphenoid canal, nor post-orbital process; the basi- and presphenoid remain separate; the large, thick-walled tympanic early unites with the other temporal elements: the mesethmoid is extensively ossified, and joins with the vomer, extending even in front of the nasals (Cystophora). There is a narrow inter-orbital region, with a compressed septum; the ethmo-turbinals are small, the maxillo-turbinal large, complex; the jugal large. The pre-sternum is long and cartilaginous, the meso-sternum of nine sternebers; the testes are abdominal; there are no *Cowper's* glands, but a small vesicula prostatica; no os clitoridis; a bicornate uterus, with a longitudinal septum; the right auricle has often a bifid appendix; the epiglottis is small, fixed to the narrow isthmus of the thyroid cartilage by a pedicle of the same substance; the tongue is slightly bifid at the tip; the trachea

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* Callorhinus and Eumetopias, from N. Pacific and Greenland.

† There is no anticlinal vertebra in any seal.

has 78–80 rings, of which 10–14 are sometimes perfect (*Wolff*). The teeth are *i.* $\frac{3}{2}$ or $\frac{2}{2}$ (Pelagius and Stenorhynchus), *c.* $\frac{1}{1}$, *p.* $\frac{4}{4}$, *m.* $\frac{1}{1}$; the milk teeth* are replaced by the second, third, and fourth premolars, the first having no milk predecessor; the teeth of the upper and lower jaws alternate and interlock; the ductus arteriosus remains occasionally open, and so may the foramen ovale in the heart, but not very often (one in nine); the left vertebral artery usually arises from the aorta separately; the aorta and pulmonary artery are dilated at their origin; and below the diaphragm the inferior vena cava dilates above the multilobular liver, and is surrounded by a muscular sphincter; the stomach has a pyloric flexure, and the digestive canal is ten to twelve times the length of the body; the great pectoral muscle stretches forward, even in front of the long presternum; the sterno-mastoid has a costo-mandibular slip; the cleido-mastoid, cleido-occipital, and trachelo-acromial are continued into the humerus; the palmaris longus is strong.

There is a very strong panniculus carnosus over the whole surface, which acts in locomotion; the inner hamstring is a single muscle from the first caudal vertebra to the inside of the tibia; the soleus and psoas magnus are absent; iliacus is rudimental from the outside of the ilium, above the acetabulum; pectineus is small; the adductors are inserted much lower than usual.

Of the forms included in this family, Cystophora, the proboscis and the bladder-nose† seals have $\frac{2}{1}$ incisors and conical separate molars, with simple roots. Halichœrus has only two of his five molars with double roots, while Phoca has the four hindmost two-rooted.

Sub-order II. *Arctoidea*‡ (*Flower*).—Plantigrade or sub-plantigrade carnivores, with no bony septum in the tympanic cavity;§ the paroccipital, which is remote from the prominent mastoid, does not touch the tympanic, the

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* Cystophora has *i.* $\frac{2}{1}$, *c.* $\frac{1}{1}$, *m.* $\frac{3}{3}$, as a milk dentition.

† The bladder only exists in the male; the female is crested, but with no dilatable sac.

‡ The following sub-orders consist of terrestrial forms (except the otters), have six incisors above and below (except in Enhydra), an aural pinna, the tail free at the base, and the hind-limb vertical, with a short hallux, differing in these respects from the seals.

§ A slight inferior ridge exists on the floor in many.

lower lip of the tubular portion of which is prolonged. The condyloid and glenoid foramina are present, the curved penial bone is not grooved, Cowper's glands and the cæcum are absent, and the prostate is small.

Three families are included:—

1. *Ursidæ.*—Plantigrade forms, mostly with naked soles; teeth tuberculated, not truly cutting; body rounded, often large, heavy; tongue smooth; skull elongate, with a flattened auditory bulla; clavicle completely absent. All have an occipital rhomboid, a biceps accessorius, and no omohyoid muscles.

This family may be divided into three sub-families:—

Ursinæ.—Bears, not perfectly carnivorous in habit, with *p.* $\frac{4}{4}$, *m.* $\frac{2}{3}$. There is no true sectorial tooth, and the hindmost upper and penultimate lower molar teeth are the largest, the anterior premolars small, deciduous. The hard palate is prolonged behind the teeth. Vertebræ *d.* 14, *l.* 6 *s.* 1, *ps.* 3–5, *c.* 8–10. Skull with an alisphenoid canal. Humerus with no supra-condyloid foramen; ilia short, everted; femur long, thick, somewhat human-like in outline, and with an equal development of flexor and extensor muscles; the digital flexors are much larger than the extensors; knee capable of extension to the right line; tibia and fibula wide apart; feet plantigrade, with bare or hairy (Thalassarctos, the polar bear) soles, and curved, but not very sharp claws.* The maxillo-turbinals are large, the nose tip is movable, proboscis-like;† the pupil circular; the tail short. The pharynx has a median posterior sac; the larynx has large cuneiform cartilages and wide thyroids. The great pectoral is the largest muscle in the body; the occipital rhomboid and trachelo-acromial are strong; the bicipiti accessorius is weak; there is a long supinator, a long and a short coraco-brachialis, a large teres minor, and no trachelo-scapular. These are the largest of the Carnivora, but the least carnivorous. They mostly hybernate. The living forms are distributed widely on the globe, U. Arctos, the brown bear, extending over the entire Palæarctic region. The Miocene Arctocyon seem to have been somewhat of a passage form from bears to dogs.

Procyoninæ.—*P.* $\frac{4}{4}$, *m.* $\frac{2}{2}$. Small, Neotropical, with no alisphenoid

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* Very much larger on the manus than on the pes in U. ferox, the grizzly bear.

† Valvular in Ursus Arctos, the brown bear of Europe; very long in Procheilus, the sloth bear.

canal, short non-retractile claws, straight toes, moderate limbs, and long tail; humerus with a supra-condyloid foramen. There is only a short coraco-brachial, a separate agitator caudæ muscle, a fourth gluteus; the tibialis anticus is single, and not femoral in origin, and the extensor digitorum ulnaris supplies the four outer fingers. Procyon, the racoon, has three ventral mammæ, a broader skull, with an inter-nasal slit and sharply tubercled teeth. Nasua, the coatimondi, has a long movable snout, smaller teeth, and a longer skull. Bassaris is an aberrant Procyonoid, with pointed muzzle, large post-orbital processes, hard palate ending at the level of the last molar, and coronoid slightly recurved.

Cercoleptinæ-—Arboreal, with claws semi-retractile; tail long, prehensile; toes short, curved. Cercoleptes, the kinkajou, has a long protrusible tongue; two ventral mammæ; *p.* $\frac{3}{3}$, *m.* $\frac{2}{2}$; and a short round snout.

2. *Ailuridæ.*—Asiatic, with *p.* $\frac{3}{3}$, *m.* $\frac{2}{2}$; molars with a much-lobed outer cingulum; with small rounded ears and a non-prehensile tail; a small, simple, auditory bulla; a large carotid canal; distinct mastoid, and par-occipital processes, glenoid foramen, and an alisphenoid canal. There are three sacral and eighteen caudal vertebræ, a bilobed liver, anal glands, and a mandible with a prominent angular process.

3. *Mustelidæ.*—Small, long-bodied Arctoids, with short legs and pentadactylous pes; skull long, but with a rounded face; a free par-occipital process; alisphenoid canal absent; temporal with a preglenoid bony ridge in front of the condyle of the lower jaw; sectorial molar tubercled, small behind; cæcum absent; the placenta has a saccular appendix, full of blood and hæmatoidin; a similar arrangement is present in some bears.

The following sub-families are contained:—

Mustelinæ.—Weasels; toes short, united at base, last phalanx bent upwards; claws sharp, compressed, retractile; tail cylindrical; last upper molar transversely elongate; anal glands present, except in Gulo, the glutton, which has *p.* $\frac{4}{4}$, m. $\frac{1}{2}$. Martes, the marten, has *p.* $\frac{4}{4}$, *m.* $\frac{1}{2}$, and is digitigrade; the bulla tympani is antero-posteriorly elongate. It has a slender omohyoid, no gluteus quartus nor bicipiti accessorius, a semimembranosus separate from the hamstrings, and a double tibialis anticus. Putorius has *p.* $\frac{3}{4}$, *m.* $\frac{1}{1}$, like Mustela (the weasel), but has not the narrow frontal region of the true weasel. Galictis, from Brazil, has similar teeth, but is plantigrade; it has a long coraco-brachialis, a caudal second head for the semitendinosus, and a biceps accessorius in the thigh, and four glutei.

Lutrinæ.—Otters. Back teeth equal in the two jaws; last upper molar large; toes webbed; tail flat, tapering; skull flat-topped, with a deep meso-frontal constriction, and with a flattened base. The pelage is close, smooth, and shining. There is a feeble omohyoid; the teres minor is

rudimental; the teres major large; a trachelo-scapular muscle lies between the levator anguli scapulæ and the trachelo-acromial; the clavicle is a tendinous line; the coraco-brachialis is short or absent, and there is a high origin from the supinator longus; the sartorius is double at origin; the ilio-psoas does not arise from the ilium, and there is a fourth gluteus, a caudo-femoral muscle from the first caudal vertebra to the outer popliteal ridge; the semitendinosus has a caudal origin. Lutra, the otter, has *p.* $\frac{4}{3}$, *m.* $\frac{1}{2}$, and sharp claws. Aonyx has small or rudimental claws; an intestine about $9\frac{2}{3}'$ long; a trachea of fifty-four rings, with the upper right bronchus arising near the bifurcation. In both genera the ovaries are not encapsulated, kidneys lobulated, no anal glands, pericardium free from the diaphragm, inferior cava dilated behind the liver, tonsils in valvular cavities, and uvula absent. Pteronura has a membranous edge to the tail. Enhydra is seal-like, with *i.* $\frac{3}{2}$ (the lower lateral early falling out), *c.* $\frac{1}{1}$, *p.* $\frac{3}{3}$, *m.* $\frac{1}{2}$, with early deciduous incisors. All these forms, being aquatic, have the inferior vena cava enormously dilated behind the liver. In all the flesh is extremely dark-coloured, like that of seals.

Melinæ.—Badgers. Plantigrade; feet long, soles often naked, toes straight, claws not retractile, fossorial; sectorial tooth with large inner tubercles; upper tubercular molar large, quadrate, or trigonal; anal scent-glands are present, and sometimes very large, as in Mephites, the skunk. The teeth may be *p.* $\frac{3}{3}$, *m.* $\frac{1}{2}$ (Conepatus), or *p.* $\frac{3}{3}$, *m.* $\frac{1}{2}$ (Mephitis, Mydaus, with a proboscis-like nose, and short ears and tail). Meles, the badger, has *p.* $\frac{4}{4}$; the first upper premolar often falls out. In the American Taxidea the first upper and lower premolars fall out early, and the molars are *m.* $\frac{1}{2}$, as in Helictus, which is provided with a tail gland. Taxidea has a largely inflated bulla tympani. The badger has the middle form of coraco-brachialis, a rudimental floating bony clavicle, an omohyoid muscle, a trachelo-scapular, and the supinator brevis (in one badger) had a sesamoid bone in its origin; there is a single tibialis posticus and anticus, and a slender bicipiti accessorius from the tail nearly to the heel. In Arctonyx the palate bones are widely expanded behind the last molar tooth, and the hard palate stretches back to the level of the glenoid cavity, while in Meles it only extends to the middle of the malar bone, and the tail is very long.

Mellivorinæ.—Ratels, African, with feet $\frac{3}{5}$ plantigrade, badger-like; *p.* $\frac{3}{3}$, *m.* $\frac{1}{1}$, with no lower tubercular molar, while the upper has a transversely elongated crown; hard palate not extended backwards; anal glands present; no ear-pinnæ; tongue with sharp papillæ. The ratel has only fourteen dorsal and four lumbar vertebræ.

Sub-order III. *Cynoidea* (*Flower*).—Small, or moderate,

digitigrade carnivores, having non-retractile claws, often a tail gland, but no anal glands; a long folded cæcum; a smooth tongue, with a worm-like, dense, cellular body in its median line; a large, straight, wide, grooved os penis; a distinct prostate, but no Cowper's glands. The ovary is in a peritoneal sac, the skull has a lachrymo-palatine suture, elongated jaws with a post-angular process, an alisphenoid canal, a glenoid foramen, and large ethmo-turbinal bones. The tympanic cavity is bounded partly by an extension of the cartilage of the periotic capsule, partly by a membranous tympanic, and when these are ossified there is a septal ridge, where the two elements meet, which divides the tympanic cavity imperfectly into two compartments; the large par-occipital is closely applied to the back of the tympanic bulla. The clavicle is a fibro-cartilaginous rudiment; the humerus has an inter-condyloid, but no supra-condyloid foramen, and the claws have attached to them a similar arrangement of ligaments and muscles as in the cats, but the elasticity of the ligaments is too feeble to retract the claws.

Professor Huxley describes a fibro-cartilaginous "marsupial" above the pubis, from whose anterior surface the pectineus arises. I have failed to satisfy myself of its existence as a constant structure in many dogs, in the common and Bengal foxes, in the dingo, jackal, Canis pallipes, and wolf. The fibula is closely applied to the tibia, thereby contrasting with the bears, among whom the two bones are separated by a wide interosseous space.

There is no omohyoid muscle; the cleido-occipital and the cleido-mastoid are united; there is no trachelo-scapular, but a trachelo-acromial; an extensor indicis et pollicis; no supinator longus in general (I found one in the right arm of a bull-dog); the sartorius is double, and the pronator quadratus occupies the whole length of the forearm. The pollex does not touch the ground in progression.

The incisors have notched crowns, and are trilobed above, bilobed below; the last premolar above is the carnassial or sectorial tooth, and it has exter-

nally two cusps, internally a tubercle; the lower sectorial tooth is the first molar. The molars have four primary cusps, and the upper ones have an internal point on the cingulum; the commonest dentition is *i.* $\frac{3}{3}$, *c.* $\frac{1}{1}$, *p.* $\frac{4}{4}$, *m.* $\frac{2}{3}$. The first premolar has no milk predecessor, and appears before the milk teeth are shed. The vertebræ are *d.* 13, *l.* 7, *s.* 2, *ps.* 1, *c.* 18–23.

One family is included:—

Canidæ.—The dogs, which have five digits on the manus and four on the pes. The tail is mostly long, and well clad with hairs, sometimes bushy. There are four gyri around the Sylvian fissure, which is short and oblique, not like the long sloping fissure in the bears. The calloso-marginal fissure ends in front in a superficial crucial sulcus, and the olfactory nerve is traceable distinctly back to the uncinate gyrus. The pancreas has two ducts, and there are zygomatic and accessory submaxillary salivary glands.

The genera are Canis, with round pupil and moderate tail, including wolves, jackals, dogs, dingos, &c. Lycaon is hyæna-like, with large, oval, upright ears, with four toes on both pes and manus. Megalotis has also large ears, a round skull, with no temporal crest, and is of small size. The wolf has ten nipples in the females; Chrysocyon, the maned wolf, has six. Vulpes, the fox, has vertical pupils, a bushy tail, and an evenly rising skull, with no vertical frontal convexity. Icticyon has webbed feet.

The dog is liable to considerable anatomical variety—thus the weight of the heart in male adult dogs has been found to be as follows:—

	Ounces.
Irish red setter,	9·4 to 10·25
"Master Magrath" (greyhound),	9·57
Russian staghound,	8·94
Bull-dog,	6·65
Large retriever,	5·43
Very small pug,	3·0

The brains of adult dogs have been weighed by Mr. Garner and Professor Wilder, and show the following variations:—

	Weight of brain, in grammes.	Proportion to weight of body.
Pomeranian,	68	.007
Italian greyhound,	65	·010
Spaniel,	62	·010
Skye terrier,	72	·009
Hound,	108	·005

	Weight of brain, in grammes.	Proportion to weight of body.
Setter, ...	106 . .	·004
Newfoundland, . . .	120 . .	·003
Bull-dog, ...	125 . .	·003
St. Bernard, ...	98 . .	·002

Most dogs, when born, remain with closed eyes for ten days; they change their teeth about the fourth month, attain full size in two years, and their life rarely exceeds twenty years; the female carries her young sixty-three days, and bears six to twelve at a birth.

Sub-order IV. *Æluroidea.*—Active, predaceous, digitigrade, purely carnivorous animals, with sharp, often retractile, claws; a prominent, smooth-walled, tympanic bulla, divided into two chambers by a very distinct septum; an outer, or tympanic chamber proper, bounded by the tympanic bone; an inner larger cavity, whose floor is formed by a lamella of the opisthotic. The bony meatus auditorius is short, or deficiently walled below. The carotid canal is represented by a small groove in front of the foramen lacerum posterius. The par-occipital is expanded over the bulla; there is no distinct glenoid foramen, and a small or no mastoid process. The condyloid foramen is in the same fossa as the jugular. They have a short, simple cæcum; a small, conical-tipped penis, with a small bone, or none; a lobed prostate, and Cowper's glands.

Three families are included:—

1. *Felidæ.*—The true cats, a well-defined family, with strong retractile claws; the metacarpal bones and metatarsals are nearly vertical; the proximal phalanges are placed obliquely, with their distal ends raised, so as to form an L with the metacarpals, while the middle and distal phalanges are arranged in a V, the point of the last phalanx being thus raised from the ground, and held up by strong lateral elastic ligaments, one of which is stronger than the other, and draws the ungual phalanx to one side of the middle phalanx (which is usually flattened, to accommodate the upturned

ungual). The long flexor tendon, passing around the salient angles formed respectively by the metacarpo-phalangeal and the meso-distal-phalangeal joints, when it acts, tends to straighten these angles, and so protrudes the claw, while the lateral elastic ligaments, on the relaxation of the muscle, at once retract the claw, and lift it off the ground. A similar mechanism, but too feeble for action, exists in Cynoids and many Musteloids. The base of the distal phalanges develops a wide bony sheath, which includes the root of the claw. The teeth in felines are $i.\frac{3}{3}, c.\frac{1}{1}, p.\frac{3}{2}, m.\frac{1}{1}$. The sectorial tooth is the last premolar above, the molar below. The upper has a very small inner tubercle, a small cusp in front and behind the large middle point. The lower has two equal sharp cusps and no inner tubercle. The incisors are small, notched; the canines large, with a sharp edge fore and aft. The small tubercular tooth above is transversely placed, and on a level internal to the other teeth.

Of these cusps on the sectorial teeth, the three outer represent the enlarged cingulum, united with the two outer cusps of the crown, while the inner tubercle is the rudiment of the anterior internal cusp, the posterior internal being represented in the molars of the dog, absent in the cat. The facial region of the skull in cats is short and rounded, longest proportionally in Felis viverrinus, shortest in the cheetahs. There is no alisphenoid canal; a straight ramus of the lower jaw, with a supra-angular process; there is a five-toed fore-foot and a four-toed hind-foot. The tongue has rough, horny, recurved papillæ. The clavicle is slender, floating, never extending either to the scapula or sternum; the humerus has a supra-condyloid foramen; the hallux is only represented by its metacarpal. The occipital rhomboid and acromio-trachelian are large muscles; there is a small teres minor, a short coraco-brachialis, a large pronator teres, but no supinator, and but one radial extensor of the carpus; the pronator quadratus fills nearly the whole inter-osseous space, and a strong fibrous band over it represents the flexor carpi radialis profundus. The extensor indicis et pollicis is as in the dogs; the sartorius is single; the adductors more or less united, and attached to the semimembranosus; quadratus femoris strong; a wide agitator caudæ inserted by a strong tendon into the patella, and supplied by a branch of the lesser sciatic nerve (characteristic of cats); a very small gluteus maximus; a fourth and fifth gluteus and tensor vaginæ femoris; a long bicipiti accessorius; a sesamoid bone in the tendon of the popliteus, and in the puma a two-headed semitendinosus.

The cats are singularly uniform in their anatomical characters, and differ chiefly in size and surface-markings. Thus the skulls of the lion and tiger are almost indistinguishable; in general, in lions the premaxillo-frontal suture rises higher than the fronto-nasal, while in tigers the reverse is the

case; also in lions there is a wider interspace between the infra-orbital foramen and the brim of the orbit, but even these marks are liable to very many exceptions.

The forms included are (A) Palæotropical, such as the lion, tiger, leopard, cheetah, and cats; and (B) Neotropical, such as the puma, jaguar, ocelot, &c. The cheetah has imperfectly retractile claws, and its upper carnassial tooth has no inner tubercle. The lynx has pencils of hair on its ear-tips, short tail, and often no first premolar. Machairodus was a Miocene feline, with a long sabre-like canine, which must have reached the chin when the mouth was shut. *Leydig* describes a terminal spur in the tails of some larger felines.

2. *Hyænidæ.*—Aberrant, Palæotropical, digitigrade Æluroids, with *p.* $\frac{4}{3}$, *m.* $\frac{1}{1}$, with high fore and low hind quarters; a short, wide pelvis, with everted ilia; a maned neck, non-retractile claws, thick sloping heads, erect large ears. There are fifteen dorsal and five lumbar vertebræ, three sacral and twenty-one caudal vertebræ. The auditory bulla is inflated, smooth, oval, most prominent behind, *with no* septum within, and a distinct carotid canal near the centre of the inner side of the bulla; the par-occipital is spread out over the back of the bulla, and the alisphenoid canal is absent. The cæcum is short, and Cowper's glands and the prostate are present; the penis is pendulous, without a bone. The anal glands open into a median pouch behind the rectum. In the female the vestibulum, or uro-genital canal, is elongated, and its mouth projects, simulating an elongated clitoris. There are also two large perineal swellings, like a false scrotum, behind the prominent vulva. The pollex is represented by a rudimental metacarpal. There is no supra-condyloid foramen. The genera included are Hyæna, which has tetradactylous feet and large anal glands. Proteles, the Aardwolf of S. Africa, has *p.* $\frac{4}{3}$, *m.* $\frac{1}{2}$; no sectorial tooth, nor temporal crest on the skull; an elongated palate; a five-toed manus; fifteen dorsal and five lumbar vertebræ. The external auditory meatus has a prolonged thickened anterior lip, and there is a small carotid foramen, but no glenoid foramen.

3. *Viverridæ*—Civets, are small, mostly digitigrade or subplantigrade Æluroids, with elongated skulls and pointed snouts; short legs; *p.* $\frac{4}{4}$, *m.* $\frac{2}{2}$; smaller canine teeth, and a strong inner tubercle on the sectorial tooth; orbit with a strong frontal post-orbital process, sometimes nearly closing its outer margin. There is an alisphenoid canal; a distinct foramen caroticum; a prominent, elongated, auditory bulla, with scarcely any lower lip to the meatus, and an inner septum, as in the cats. Sometimes its two parts remain distinct, as in Paradoxurus, the one being posterior to the other. The par-occipital is as in the cats, and the mastoid process small. There is a

small cæcum, and the characters of the reproductive organs are as in Felidæ, while most of them have very large anal scent-glands. The dorsal and lumbar vertebræ are thirteen and seven. The two sterno-mastoids are sometimes mesially fused, as in civets and genets; there is no occipital rhomboid; a short coraco-brachialis; a supinator longus; a large extensor ossis metacarpi pollicis into the radial sesamoid; the pronator quadratus is limited to the lower one-third of the forearm; the agitator caudæ is femoral in its insertion, and there is a fifth gluteus, a double sartorius, a bicipiti accessorius. The humerus has usually a supra-condyloid foramen. The genera are numerous, and may be arranged in three sub-families:—

1. *Cryptoproctinæ*, including one form Cryptoprocta, from Madagascar, a link to the true cats, but plantigrade, and possessing an os penis, webbed toes, retractile claws, large ears, and large scent-gland surrounding the anus.

2. *Ailuropoda*.—Civets and Paradoxures, with retractile claws, hair-clad toes united at base, short post-orbital processes, and soft skin. The genera included are Viverra, the civets and genets (with scent-glands between the anus and scrotum, as well as at the anus); Paradoxurus, the palm-cat, with prehensile tail of thirty-six vertebræ, and subplantigrade feet, naked perineum and partly naked tarsus. Galidia has also subplantigrade feet, and so has the short-tailed Cynogale. Arctictis, the Binturong, is arboreal, with pencil-tufted ears and a prehensile tail. Prionodon often loses its last molar tooth.

3. *Cynopoda*, with claws projecting, and not retractile; elongated toes, which are not united at the base, and are hair-clad. The orbital ring is nearly complete; the bulla tympani is somewhat pear-shaped, with its two chambers ranged fore and aft, and with a dilated anterior or true tympanic cavity; a concealed condyloid and a small, or deficient, glenoid foramen. Herpestes, the mongoose, or ichneumon, is digitigrade, and has no perineal glands, but the characteristic anal glands are present. Rhyzæna, the Suricate of S. Africa, is plantigrade, and (like Cynictis) has a closed orbital ring and a very prolonged auditory meatus fissured along its floor. Urva has a somewhat similar meatus, and its lateral toes are raised above the usual level. Crossarchus has no scrotum, and has a pentadactylous pes.

CHAPTER XXXVI.

Whales and Porpoises.

Order VII. *Cetacea.*—Fish-like, neckless carnivores, usually of large size, with no visible hind-limbs, a horizontally flattened tail, of two lateral lobes, and often a triangular dorsal fin. The fore-limbs are converted into paddles, in which the several digits are perfectly united under a smooth uniform skin. The skin is hairless, except in the fœtus; there is an abundant development of subcutaneous fat (blubber); and the epidermis is very thick and smooth. There are no traces of a nictitating membrane, of nails, nor of external ears; the two mammæ are placed beside the vulva in deep grooves, and the nostrils are on the upper surface of the head, far from the point of the snout.

The bones are hard, though spongy, and the long bones have no medullary canals. The stomach consists of several (4–7) compartments. There is no gall-bladder. The heads of the ribs and sides of the trunk vertebræ are covered by a remarkable system of arterial plexuses, and the placentation is diffuse.

The cervical vertebræ are seven, thin, flat, and often fused together. In the true whales the six foremost early unite by their bodies and arches, leaving slit-like interspaces for the nerves; the seventh may also unite, or its spine may form a joint with the spine of the sixth, or may ankylose therewith. In the rorquals union is slower, or may not take place. In many of the smaller cetaceans the atlas and axis unite, and often the two or three following vertebræ, but in the Beluga, Inia, Pontoporia, and Platanista the vertebræ remain separate.

Most of the cervical vertebræ have upper and lower transverse processes, forming a wide loop, and united at the tip, either by bone or cartilage. The odontoid process is small, but always represented; largest in Platanista. In

Physeter the atlas is free, and the other vertebræ ankylosed. The dorsal vertebræ are nine (Hyperoodon) to sixteen (Balænoptera), the lumbars three (Inia) to twenty-six (Delphinus), only distinguished from the caudals by the want of chevron bones. The neuro-central suture lies above the junction of the arch and the body. The vertebral epiphyses remain long separate. The vertebral arches articulate anteriorly by articular zygapophyses; posteriorly where these fail, they are replaced by articulating metapophyses. The hinder vertebræ have their transverse processes on the bodies, not on the arches (these correspond to the upper transverse processes of the cervical vertebræ); this seems not to be the case in Physeteridæ, wherein the lumbar transverse processes are in series with the lower cervical transverse processes. Anteriorly the transverse process is an outgrowth from the arch; medially it is derived partly from arch and body; posteriorly it arises from the body alone (*Flower*). There is no sacrum, but 16-32 caudal vertebræ, the hindmost of which have no arches and no processes; those in the tail fin are wider transversely, and flatter. The ribs are nine (Hyperoodon), ten (Ziphius), eleven (Physeter, Balænoptera rostrata), twelve (Phocæna), thirteen (Balæna mysticetus), fourteen (Megaptera, Kogia), fifteen (Balænoptera musculus), or sixteen (Balænoptera Sibbaldii). The vertebral ends are attached by their tubercles to the transverse processes of the vertebræ by ligaments, and, except in the Physeteridæ, the head of the first alone is usually elongated to touch the body of the vertebra in true whales; four or five of the foremost ribs thus articulate in the toothed whales. The first rib alone also is the only one which articulates with the sternum, in true whales; and sometimes, as in Balænoptera laticeps, it is double, having a cervical rib ankylosed to it. In the Physeteridæ the nine foremost have both heads and tubercles. The sternum is a very irregular-shaped bone, with a broad presternum ossified from one or two centres, followed by a mesosternum of two segments (Physeter), or of three, early consolidating, as in dolphins, or by a xiphoid cartilage, with no mesosternum, as in the whalebone whales.

The skull is often asymmetrical (except among the Mystacocetes, most so in Physeteridæ), and many of its bones unite with each other by the interlocking of long tongue-like lamellæ. There are long jaws; the frontal process of the maxilla is elongated, except in Balænidæ, and covers over the frontal bone. In Platanista the outer edge of the maxilla posteriorly is raised into a hood-like crest, which bends inwards, overhanging the anterior nares. Similar rough tuberous maxillary crests exist in Hyperoodon. The premaxillæ are long and very slender, forming only a very small part of the gape anteriorly, but stretching back to the anterior nares. The nasals are short solid wedges of bone, or else knobs articulating with, or ankylosed to the frontals. The mandibles are long, very dense, with a large internal

canal, whose lateral openings are funnel-shaped. It has no ascending ramus, a rudimental coronoid process; its condyle is directed backwards, and its symphysis is short in true whales, and ligamentous; longer, and ankylosed in the adult in toothed whales, longest in Pontoporia, where it stretches for half the length of the mandible. The lachrymal bone is absent in porpoises, large in Physeteroids, a small wedge-like bone in Balænoids. The jugal is small.

The brain-case is rounded, high, but short, with a broad base, with the foramen magnum looking backwards and a little upwards, bounded below and laterally by the two confluent, mainly ex-occipital condyles. The supra-occipital is large, and early unites with a large inter-parietal, which projects very far forwards, separating the parietals, and touching and partly separating even the frontal bones; the anterior margin of this bone, where it joins the frontal, rises into a transverse crest; this is large and high in Hyperoodon, and placed behind the anterior nares; in Physeter this crest is laterally confluent with maxillary crests, like those in Hyperoodon, and these three, being enormously enlarged, form the boundaries of a great concavity, whose mouth looks forwards, and in which, in the recent state, the spermaceti is found. The condyloid foramina are small, and placed far forwards. The basisphenoid is pierced by the carotid canal, and has a very shallow sella turcica, with rudimental clinoid processes. The optic nerves pass out in notches below the orbito-sphenoid; the superior maxillary nerve emerges through the sphenoidal fissure, the inferior maxillary through the large basicranial foramen lacerum medium; thus the alisphenoid is imperforate. The parietal bones are widely separated medially by the inter-parietal and supra-occipital, with which they both ankylose early. The lower angles form sometimes a partial boundary of the lacerated hole of the base of the skull. The frontals are large, overlapped by the maxillæ in the toothed whales, and with large supra-orbital plates (smallest in Platanista). The squamosal has a shallow glenoid fossa, a strong zygomatic arch, and is perfectly separate from the periotic, which early ankyloses with the tympanic, but is otherwise free from the other cranial bones, and does not project into the cranial cavity. There is a stout small tympano-hyal, a cartilaginous stylo- and epi-hyal, and a bony cerato-hyal attached to the broad flat basi-hyal, whose thyro-hyal cornua are generally stout, either ankylosed to the basi-hyal or free (Physeter).

The maxillo-turbinals are small, and the nasal fossæ smooth, with a rudimental olfactory organ, largest in the true whales. The mesethmoid has a large cribriform plate, flat, and with few holes in the toothed whales, but more hollowed, and with more perforations in the Mystacocetes. The nasal plate of the mesethmoid is large, and remains for the most part carti-

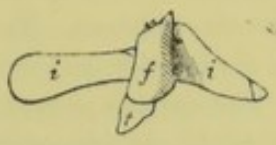
laginous; it fills up the large gutter-like space on the upper surface of the long vomer. The nasal passage is nearly vertical, and its anterior opening looks backwards and upwards in toothed whales, forwards in Mystacocetes. In the latter the vomer projects in the medial line of the palate, between the palate bones. The vascular and nervous foramina in the skull are of arge size, and often, as in the Physeters, of great length.

There is no clavicle, and the scapula is a very wide flat bone, triangular n outline, with a long, spur-like, and flattened acromion very close to the anterior edge; a very small supraspinous fossa, absent in Platanista, usually arranged as a partial groove along the anterior edge: there is a similarly spur-like coracoid, small in Balæna, absent in Megaptera. The glenoid cavity is the densest part of the bone, and its socket is deepened in the recent state by a glenoid ligament. The superscapula is cartilaginous and very large, wide in Balænoids, represented by a marginal strip of cartilage in Megaptera, while in Balænopterids it is principally developed at the posterior angle. The humerus is a short broad bone, with an epiphysis at one or both ends, one large tuberosity, and a head much larger than the glenoid cavity; there are two subequal distal facets for the forearm bones, and the elbow-joint has no synovial membrane, but the bones are united by fibrous tissue. The two forearm bones are parallel, and nearly equal; the ulna has a prominent olecranon process, and this in Balænoptera rostrata is capped by a large cartilaginous prominence. The radius widens to the manus, and is joined to the carpus also by fibrous tissue. The carpus consists of two rows of polygonal nodules of cartilage, with a varying number of ossific centres, which are usually comparatively late in appearing. In Orca they may remain gristly, even to a comparatively advanced stage. In Balæna three, in Balænoptera four or five, in Physeteroids six bony nodules develop, and sometimes, as in Beluga, a pisiform bone is also present. The metacarpals are five, and they and the phalanges are represented by cylindroidal rod-like ossifications in the continuous cartilaginous digits, which are placed close together within the common sheath of integument, and bound together to their tips by densely interwoven connective tissue; sometimes in Balænoptera the fifth metacarpal may be rudimental. The phalanges are variable in number—thus in Balæna the fingers have 1·4·5·4·3 respectively; in Balænoptera rostrata 4·7·6·3·1; in B. musculus 0·5·6·7·4; in Orca 2·6·4·3·2; in Pontoporia 0·6·6·3·2; in Globiocephalus 3·12–14·9·3·1; in Phocæna 2·10·7·3·1 or 2·8·7·3·2; in Physeter 1·5·5·4·3.

The rudimental hind-limbs are placed below the vertebral column anterior to the first chevron bone, and are, on each side, joined to the last lumbar vertebra by fibrous tissue and by an ischio-caudal muscle (porpoise).

They are slender, straight, or ∫-shaped bones, sixteen inches in length in a Balæna of sixty-four feet long, largest in the males, and often bilaterally unsymmetrical. To these are attached some fibres of the rectus abdominis muscle, and the crura penis or clitoridis, as well as the ischio-cavernosus and retractor penis muscles (*Van Beneden*), hence these bones are ischia, and they are developed from single ossific centres. Sometimes a small pyriform bone (fig. 39 *f*) is attached to the middle of the ischium by a ligament, and represents the femur; this is most distinct in Balæna, rudimental in Megaptera and Balænoptera musculus, absent in Balænoptera rostrata. *Professors Reinhardt* and *Struthers* describe a second terminal conical bone appended to the extremityof this in Balæna, representing a tibia (*t*). No femur nor tibia exists in the toothed whales.

Fig. 39.



Hind limb of Whalebone Whale, ¼ natural size: *i-i*, ischium; *f*, femur; *t*, tibia.

The muscular system in whales presents a well-marked panniculus, often both over- and underlaid by the layers of blubber, wide pectoral and latissimus dorsi muscles; a combined occipital trapezius, cleido-mastoid, and clavicular deltoid fused into a humero-mastoid muscle, and deriving its innervation from the spinal accessory nerve; a one-bellied omohyoid (sometimes absent); an acromio-trachelian; a single rhomboid, not stretching to the occiput, and two sets of enormous caudal muscles; levatores caudæ superiorly or dorsally, and depressores caudæ ventrally, nearly equal to each other, and inserted by strong rope-like tendons into the transverse processes of the caudal vertebræ; these enormous muscles are the active agents in locomotion.

The head has at its posterior part a series of muscles to move it, even though the neck is obsolete; these are splenii, complexi, trachelo-mastoids and small recti. The rudimental fore-limb has also a muscular system; the shoulder-joint, which has a capsular ligament and synovial membrane, is moved by several muscles; a rudimental supraspinatus, an infraspinatus, subscapularis, teres major, and coraco-brachialis brevis surround the shoulder; the latter has been once found with a split insertion in Balænoptera rostrata (*Perrin*). There is a triceps extensor of the forearm, but no biceps flexor, although there are rudiments even of digital muscles present in the Mystacocetes. In Balænoptera rostrata the flexor carpi radialis, flexor digitorum communis, palmaris longus (flexor sublimis digitorum of *Perrin*), flexor carpi ulnaris, and extensor digitorum are present. In Odontocetes finger muscles have only been described in Hyperoodon (*Struthers*).

The brain in whales is round, short, richly convoluted, but with shallow sulci, the cerebrum overlapping most of the cerebellum. There is a small

corpus callosum and small or rudimental olfactory nerves; the spinal cord is surrounded by vascular plexuses, and has a cervical and lumbar swelling, from the latter of which arise the densely clustered nerves, forming a cauda equina; the superior (sensory) roots of the nerves are smaller than the inferior, and the intercostal nerves for a short distance are surrounded by vascular plexuses. The superior branches of the lumbar nerves are as large as the inferior, and unite into recurrent longitudinal cords (*Cunningham*).

The heart is proportionally of large size; in one specimen of Balænoptera Sibbaldii, seventy-eight feet long, the aorta was three feet in internal circumference, and its wall was $1\frac{1}{2}$" thick; the aortic arch gives off either a right brachio-cephalic, left carotid, and left subclavian branches, or else a double innominate. In Globiocephalus the right brachio-cephalic gives off—first, a common trunk, which divides into posterior thoracic and cervico-occipital; secondly, carotid; thirdly, facial; fourthly, subclavian. The left brachio-cephalic gives off a similar set, with the exception of the left posterior thoracic, which arises as a special trunk. There are enormous vascular arterial plexuses filling the spinal canal, the lateral loops of the cervical vertebræ, covering the heads of the ribs, and even the fronts of the depressores caudæ; these act as reservoirs for oxygenated blood, as lymphatic follicular structures, or diminish the force of the flow of the blood; for this purpose also the arteries of the intestine are sometimes moniliform (*Turner*). The vena cava is not dilated, and there are abdominal venous retia mirabilia, and no valves in any of the veins. The lungs are large, not divided into lobes; the short trachea trifurcates, and there are large lymphatic glands at the median inferior diaphragmatic angle of each lung. The larynx has no vocal chords (or rudiments, *Murie*), and beneath the thyroid cartilage it is provided with a large air-sac, with strong muscular walls; this may act as an air reservoir, or may increase the force of expiration, or may be an organ of voice. The arytenoid cartilages are large, and, with the epiglottis, can be prolonged upwards into the nasal region of the pharynx, above the level of the opening of the mouth. A thyroid body is always present, and a thymus in the fœtus.

In connexion with these structures the mechanism of respiration can easily be understood. Whales rise to the surface at varying intervals, from half a minute to three minutes and a half,* and on reaching the surface, they, by a sudden expiratory effort, expel the air contained in their lungs.

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* It is not very easy accurately to time the rising of whales; but from a very large number of observations on Balænoptera rostrata, Delphinus tursio, and Globiocephalus, as well as on porpoises, I have never known a

This expiration is a sudden forcible effort, and produces a loud blowing sound, and with the air is expelled the fluids which accumulate in the nasal passages and nasal sacs; these are driven up in a shower of spray, and produce the appearance of "spouting," so long attributed erroneously to the vomiting by the nostrils of the water taken in by the mouth! The quantity of fluid spouted is proportionally larger in the bottlenoses than in the Balænopteræ. Having thus expired, the animal, while its head is over water, takes in a deep inspiration, and then sinks again. Sometimes the preliminary expiration begins to take place before the animal has risen quite to the surface. To provide for the increased efforts of respiration the diaphragm is thick, and has a very small tendon. The external nares or blow-holes are slit-like, sometimes with sacculi or pouches, and with pad-like fibro-cartilaginous borders, which are opened and closed by several planes of muscles.

The mouth is armed either with teeth or "whalebones." When teeth are present they are single-crowned, conical, and with one fang, never successional, and usually numerous. In Megaptera and the Baleen whale (not in Balænoptera) rudimentary teeth exist in the embryos, which never cut the gum, but become absorbed, and are followed by the development of whalebone. The nature of whalebone can be easily understood by imagining an enormous increase in the number and length of the epithelial processes and the transverse palatine ridges of ruminants. The mucous membrane of the palate is thickened laterally along the whole line of the jaw arches, and raised into successive transverse ridges, along each of which are lines of papillæ, which secrete enormously strong and large epithelial growths, the whalebone plates; these plates are arranged in a row, with their surfaces very close together, and their free edges downwards; each plate consists of a double row of strong hollow bristles, containing at their base elongated papillæ, and these are joined into a plate, except at their free edge, by an intermediate horny material, secreted by other papillæ on the transverse mucous ridge. In a small Balænoptera rostrata, fourteen feet long, there were 280 rows of these plates on each side. In Bal. Sibbaldii there were 370. Each row of plates consists of several blades, and as the free lower edges of these plates are formed by the projecting long bristles, these will thus form an exceedingly perfect straining apparatus. The outer edge of each plate is longer than its inner.

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whale to remain more than three minutes and a-half under water at a time; the larger forms, however, have the greatest capacity of staying under water—one large Megaptera I noted rising regularly every two minutes.

The uses of these baleen plates can be easily understood in the light of the nature of food and mode of feeding of these whales. Most of the larger whales feed on Clione and other pelagic molluscs, medusæ, cuttlefishes, smelts, &c.; these are taken into the mouth by the whale, and then, on closing the jaws, closing also the opening into the pharynx (which is narrow, bounded by a long thick velum with no uvula, and provided with a very strong sphincter muscle), and forcibly elevating the tongue to the palate, the entire contents of the mouth are pressed against the inner bristly border of the baleen plates, every particle of solid matter is retained, while the water is driven out, and the food matters thus collected are subsequently swallowed. The tongue is wide, scarcely at all free, covered by a thick epithelium, and with the whole floor of the mouth capable of considerable elevation and depression.

The salivary glands are rudimental or small, but in Balænoptera, Globiocephalus, Orca, and Lagenorhynchus there exist both parotid and submaxillary glands. The lower lip is very large and movable. The stomach is compound, and consists of three cavities (*Huxley*) in the porpoise, or four (*Murie*), as in Globiocephalus, or five (Balænoptera), or even seven, as in Hyperoodon; these are not arranged as in ruminants, nor is there any evidence of any ruminating process. The first stomach is a paunch, and has a thick epithelium; the digestive canal is about eight times the length of the body, and has no cæcum or a small simple one; there are many patches of glands, and the liver has no gall-bladder (*Williams* says a small one exists in Globiocephalus Chinensis). The kidneys are lobulated, and the testes are abdominal, with no seminal vesicles. The penis has no bone, and the uterus is bicornate, and the placentæ diffuse, with a large saccular allantoid. In a Balænoptera Sibbaldii, seventy-eight feet long, was found a mature fœtus nineteen feet six inches in length. Whales are usually uniparous, and the mammary glands in the specimen above referred to were over seven feet long, eight inches in breadth, and covered with a muscular expansion, which enabled the mother to ejaculate the milk into the infant's mouth.

The eye in whales is small, with only two lids, and a rudimentary lachrymal apparatus, no derivative nasal canal system, a sclerotic of enormous thickness posteriorly, a nearly spherical lens, a flat cornea, and a perfect set of muscles; there is a wide Eustachian tube, a large air-chamber, with membranous walls opening thereinto, and a cochlea of two coils.

Most whales are marine, but some are fluviatile. Inia and Pontoporia inhabit the S. American rivers, while Platanista lives in the Ganges.

Cetacea may be grouped in three sub-orders :—

Sub-order 1. *Zeuglodontia.*—Extinct, Miocene, mostly American whales,

with long slender snouts, long nasal bones, and two-rooted maxillary teeth, with serrated crowns, the pre-maxillary being conical; there are of these usually *i.* $\frac{3}{4}$, *p.* $\frac{1}{0}$, *m.* $\frac{6}{6}$; some of the teeth had vertical successors. The nasal opening was forward. Their cervical vertebræ were distinct, unankylosed, and they had a slight neck, and the elbow had probably a synovial membrane. These link the Whales and Carnivores.

Sub-order II. *Odontocete.*—Dolphins and porpoises, with simple conical teeth in either or both jaws, never successional; palate without baleen plates; blow-hole usually single, crescentic, concave forwards, with saccular dilatations of its cavity; sternum elongated; lachrymal bone small and distinct; mandibular rami with a more or less united symphysis. This includes four families:—

1. *Delphinidæ*, having teeth in both jaws along their whole extent, or for a considerable area, and ossified costal cartilages. This includes Phocæna, the porpoise, with a moderate dorsal fin; a rounded forehead, sloping uniformly to the mouth; a smooth premaxilla. The teeth may be on each side. Orca, the grampus, has larger simple teeth, $\frac{8}{8}$ – $\frac{8}{8}$ on each side; in Orca griseus the teeth are early lost. Beluga, the white fish, has no dorsal fin, and also loses its teeth early.

Globiocephalus, the black fish or pilot fish, has a rounded bulging forehead, falling nearly vertically to the mouth, and its pectoral fins are not lateral, but more ventrally placed. The premaxilla is expanded, and there are 12–14 teeth on each side of each jaw. Delphinus, the dolphin, has a beak-like snout, which has given rise to the name Bottlenose, as applied to these whales; they have $\frac{2}{2}\frac{1}{1}$–$\frac{2}{2}\frac{3}{3}$ teeth, and sometimes, as in D. rostratus have a long symphysis of the mandible. Inia, a freshwater Amazon form, has $\frac{2}{2}\frac{5}{8}$ teeth and a hair-beset beak. Pontoporia has $\frac{3}{3}\frac{2}{2}$ teeth on each side.

2. *Platanistidæ.*—Freshwater forms, with long skulls and with bony hood-like outgrowths of the maxillæ protecting the blow-holes, which are separate, linear, parallel. This includes the Gangetic Platanista.

3. *Monodontidæ.*—Narwhals, with, in the male, one long, tusk-like, spirally-marked, upper jaw tooth, usually on the left side, though occasionally on both. Germs of both exist, and in the female both remain rudimental. This tooth is a canine, which projects horizontally forwards, and may reach the length of six feet, or even more. The animal itself becomes 22–23 feet long.

4. *Hyperoodontidæ.*—Whales, with beak-like snout, and but one or two teeth in the lower jaw, and none in the upper; blow-hole crescentic, concave forwards; the teeth may be placed two at the anterior third and two at the point (Berardius), or there may be only two, and the vomer may

be small, forming less than one-third of the breadth of the face, and not reaching to the point of the beak (Dioplodon). In some of the other Ziphoid whales the vomer is usually elongated to the point of the snout, and expands between the premaxillæ (Petrorhynchus), or else it swells forwards between the generally unsymmetrical premaxillæ (Ziphius). Hyperoodon presents the peculiarly ridged maxillæ and cranium above described (p. 273), and in it the neck vertebræ are all ankylosed.

5. *Physeteridæ.*—Sperm whales, with very large heads, nearly one-third of the length of the body, and very obtuse anteriorly. The upper surface of the unsymmetrical skull has a deep concavity for the spermaceti (p. 273), which is semi-fluid during the life of the animal. The blow-holes are separate, longitudinal, unsymmetrical, directed forwards, and the rami of the lower jaw are united by a long symphysis, and are armed with a row of equal conical teeth. The upper jaw is toothless, the dorsal fin upright or rounded. These whales may attain the length of sixty feet, and the teeth may number $\frac{0}{20}$–$\frac{0}{25}$. From their intestinal glands they secrete ambergris. They resemble the ant-eaters in having the pterygoid bones confluent below the posterior nares.

Sub-order III. *Mystacocete.*—True whales, with baleen plates replacing the teeth; head large and broad; lower jaw with a small symphysis; the blow-holes separate, longitudinal; skull comparatively symmetrical; lachrymal bone small. There are two families included:—

1. *Balænidæ.*—Whalebone whales proper, the right whales of the fishers, with no ventral grooves on the skin, nor dorsal fin, wide pectoral paddles, a thick epidermis, and long baleen plates; neck vertebræ ankylosed. This includes the Balæna Mysticetus, with thirteen ribs; B. australis, with fifteen. B. Temminckii has a cervical rib ankylosed to the first dorsal rib, fifty-six vertebræ, and the hinder cervicals are free. The coracoid process is absent in B. australis.

2. *Balænopteridæ.*—Rorquals, with a dorsal fin, which may be broad, as in the long-handed Megaptera, whose fore-limbs are very long, and whose scapula has no acromion. In the other rorquals the dorsal fin is high, compressed, and the pectoral fins are moderate. The ventral surface of the fore part of the body is closely marked with longitudinal furrows. Balænoptera rostrata, the piked whale, has 11–12 pairs of ribs, and is rarely more than twenty feet long. B. musculus has been found 80–82 feet in length, and has 13–14 pairs of ribs, the first having a cervical rib ankylosed thereto.

CHAPTER XXXVII.

Hyrax and Elephants.

Order VIII. *Lamnunguia* (*Illiger*). — Small, hare-like, softly furred, short-eared, non-claviculate, plantigrade animals, with a short snout, a split upper lip, naked soles, short stumpy tail, toes joined together by skin and armed with flat nails (except the inner digit of the pes, which is clawed). The manus has four functional toes, the pes three.

The penis is pendulous, with no bone; there is no scrotum, and the testes are abdominal. There are large prostatic and Cowper's glands, four nguinal and two axillary teats, graceful limbs, a non-vascular amnion, and zonary placentation. The uterus is two-horned, the vulva and anus included in a common ridge of skin. Vertebræ are *c.* 7, *d.* 21–22, *l.* 8, *s.* 5–7, *c.* 5–10. The transverse process of the last lumbar articulates with the sacrum. The triangular scapula has no acromion, a coracoid, and a spine with retroverted edge. The straight humerus has no supra-condyloid foramen, but a supra-trochlear deficiency; the ulna is complete, separate; the pollex rudimental, with one phalanx (Hyrax Capensis), or only a metacarpal (Pseudohyrax). H. Capensis has a separate os centrale, but in Pseudohyrax this bone ankyloses with the trapezoid. The scaphoid and lunar are separate, the fifth digit has only two phalanges, and the axis of the third metacarpal bisects the os magnum and lunar bones. The femur has a third trochanteric ridge. The fibula is complete, thickest above, sometimes ankylosed to the tibia. The second toe has its ungual phalanx split nearly to its base, and the inner toe is clawed. The inner malleolus below touches a shelf-like process of the astragalus, which bone distally touches the cuboid. The skull is short, with complete or nearly complete orbits, the malar being large, stretching forwards and inwards to touch the imperforate lachrymal (which has an antorbital tubercle). It touches the post-orbital process, which is formed by the *parietal* and frontal bones; posteriorly the malar forms the outer part of the glenoid surface for the mandible. There is an alisphenoid canal, as in lemurs (to which the hind-

claw is also a likeness), and this bone has also foramina ovalia and rotunda. The nasals are wide behind, the pterygoids slender, and the palatines large, ending opposite the front of the last molars. There are pre- and post-tympanic processes, the latter shorter than the par-occipitals. The pre-maxillæ are large, and join the nasals. The tympanic is bullate; the periotic has a shallow floccular groove. The mandible has a solid symphysis, a small recurved coronoid, a transversely elongated condyle, a large vertical ramus, and a round angle. There is an inter-parietal bone; the tympanic and periotic are ankylosed, but separate from the squamosal. The basihyal is oval, with a median eminence and a hinder notch; the cerato-hyals have long internal processes meeting in the middle line; there are no epi- nor tympano-hyals, but small stylo-hyals and cartilaginous thyro-hyals, and the stylo-pharyngeus muscle arises from the paramastoid. The rectus abdominis has no lineæ transversæ; the clavicular deltoid and occipital trapezius are continuous, and inserted into the ulna. There is a sterno-scapular, a four-headed biceps, a coraco-brachialis (?), a dorsi-epitrochlear, and occipital rhomboid. The palmaris longus has a disc of cartilage in its insertion, from which a flexor brevis digitorum arises. There are pronators and supinators, but no indicator nor extensor longus pollicis. The part of obturator externus which arises within the obturator foramen, so common in ungulates, is here more distinctly separated; there is a long pubo-coccygeus and an ischio-coccygeus. The semi-membranosus and the condyloid part of the adductor magnus are inseparable, the origin of the common muscle being caudal as well as ischiatic. Tibialis anticus goes to the second metatarsal. The extensor digitorum longus arises from the femur, the peroneus longus passes outside (not below) the outer malleolus, the tendo Achillis passes into the plantar fascia, and there is a fibular soleus. The dentition is $i.\ \frac{1}{2}$ or $\frac{2}{2}$ (the outer upper early falls out), $c.\ \frac{0}{0}$, $p.\ \frac{4}{4}$, $m.\ \frac{3}{3}$. The lower incisors have long sockets, and are horizontal, pectinated, but more coarsely than those of Galeopithecus or Artibeus. There is a hard boss of fibro-cartilage under the mucous membrane, behind the upper incisors, on which the lower ones bite. The upper inner incisors are three-sided, prismatic, curved, with a layer of enamel anteriorly, and growing from a permanent pulp. The stomach has a median contraction, a large cardiac end, with a hard and thick epithelial lining and a smaller pyloric pouch. The intestine has one central cæcum, and two lateral blind pouches, the latter being the lowest down. The Eustachian tube has a saccular dilatation on the inner side of the bulla tympani. The bladder seems bicornate, as the ureters open at its fundus, not at its neck. There are vesiculæ seminales. The many-lobed liver has no gall-bladder. The aorta gives off an innominate (dividing into right subclavian and both carotids) and a left subclavian. There are two

genera—Hyrax, of S. Africa and Syria, the coney or Shaphan, and Pseudohyrax, of W. Africa.

Order IX. *Proboscidea* (*Illiger*).—Elephants, the largest of living land animals, are non-claviculate ungulates, with deciduate zonary placentation, short massive bodies, short necks, high heads, with the nostrils at the end of a long movable proboscis, which has medio-terminally a finger-like, prehensile tip. The skin is thick, in living forms sparsely hair-clad, with a large temporal gland between the eye and ear; the five toes are short, united, hoofed, placed in front of a flat palmar callosity, on which the weight of the body is supported. The legs are pillar-like, having the femur vertical when the animal stands. The tail is bristle-tipped, short. The dentition is *i.* $\frac{1}{0}$, *c.* $\frac{0}{0}$, *m.* $\frac{6}{6}$, the incisors being developed as tusks, which have had milk predecessors. These tusks are rootless, made of dentine and cement, sometimes (in a few fossil forms) with a strip of enamel, rodent-like. They may reach large sizes, seventy pounds weight each, and even more. There are no milk molars, and the adult molars each consist of a series of separate transverse enamel folds, arranged parallel to each other, having their central cavities filled with dentine, and their interspaces with cement; when the teeth wear with use, the summit of the fold rubs off, leaving the free edge of the folds to appear on the surface of the crown as a closed loop of enamel, with a centre of dentine, joined to its fellow-loops by cement. There are never more than three of the molars present on one side of the jaw at one time, and these succeed each other from behind forwards, and all but the penultimate are lost before the last cuts the gum.

The vertebræ are *c.* 7, *d.* 19–20, *l.* 3, *s.* 4, *c.* 31, with no chevron bones; the axis has a conical odontoid; the seventh has a long spine, imperforate transverse processes, and has on each side a facet for the first rib. The other cervicals are slightly opisthocœlous. The anterior dorsals have long spines, and the bodies of all the vertebræ are very much flattened; the ribs are broad, imbricating. The scapula has a wide posterior fossa and a metacromion. The humerus has no neck and a sharp supra-condyloid ridge externally, ending above in a spine. The forearm bones are separate, but fixed across each other, X-like, in a position of permanent pronation. The carpus has no os centrale, but the other bones are present, as are the five metacarpals and digits. The ilium is broad, flat. The femur has a short neck, no third trochanter, and no ligamentum teres. The great trochanter is small, the lesser scarcely visible. The tibia and fibula are separate. The hallux often has only one phalanx. The skull sutures are early obliterated, and the two surface tables separated by an enormously developed system of diploic air-cells, stretching through the frontal and parietal bones. The premaxillæ are large, with air cavities, and touching the short nasals. The anterior nares look upwards. The infra-orbital foramen is wide, the occiput vertical; the sphenoid has no clinoid processes. The malar forms the middle and hinder part of the slender zygoma, the front of which is formed by the maxilla. The maxillo-turbinals are rudimental. The lachrymal is small, imperforate, with a little spur. The slender pterygoids early join the sphenoids. The squamosals are large, the mastoid small, and there are no par-occipital nor post-glenoid processes. There is no foramen ovale, nor anterior condyloid hole, and the nerves pass as in Sirenia. The tympano-hyal ankyloses to the periotic, as does the bullate tympanum, which is grooved by the internal carotid artery. The thyro-hyal is long, ankylosed to the basi-hyal, and there are long stylo-hyals, with hinder processes. The trunk has two sets of muscles, intrinsic and extrinsic: the former are—1st, levatores, from the supra-nasal part of the frontal; 2nd, laterales, from the maxilla; 3rd, depressores, from the premaxillæ. The last-named are radiating fibres from the mucous membrane to the skin. The neck panniculus is ribbon-like, strong, and so are the abdomino-femoral and brachio-lateral parts of the panniculus, both of which are supplemented by strong layers and bands of striated, yellow, elastic tissue. The serratus magnus is enormous, the subscapularis thin. The latissimus dorsi is attached to the inferior angle of the scapula. There is a coraco-brachialis brevis and longus, an enormous biceps, with a second separate scapular, and two outer humeral heads. The flexor carpi radialis is inserted into two metacarpals. The palmaris longus is inserted into the pad of the palm. There are separate perforated, perforating, and polliceal flexors; a large anconeus; an

extensor minimi digiti to the fifth metacarpal. There is an extensor pollicis et indicis, an extensor ossis metacarpi pollicis, and two extensors carpi radialis. The ligamentum nuchæ is enormous; the occiput has a deep rough pit for it, divided into two parts by a sharp median vertical ridge. The mandible has a grooved, downward, prolonged symphysis. The tongue is smooth, fixed; the œsophagus and trachea closely united, the former with longitudinal and spiral striped fibres. The stomach is simple; the intestine 106–125 feet long, attached by a single continuous mesentery, with a wide cæcum, and a trilobed liver, with no gall-bladder, but an intra-duodenal, quadripartite, *diverticulum Vateri*. The triangular kidney has a closely adherent capsule, perforated by vessels from the extraperitoneal system, and is faintly divided into two, five, nine (Euelephas), or ten (Loxodon) lobes. The renal artery gives off the spermatic. There are no papillæ, nor is there a pelvis to the kidney, but the ureter is formed by the union of three, four, or five tubes. The bladder is small. The testes lie bound down by peritoneum immovably, below the kidneys, with the epididymis on the outer border, and a large plexus pampiniforme, which ends in the inferior vena cava. The vas deferens is convoluted, and there are appended four prostates, two on each side, and two Cowper's glands, which have special compressor muscles. The vesicula prostatica is small, and does not extend into a post-vesical peritoneal fold, as it does in ungulates (where the fold represents a true broad ligament). The long penis opens far forward, and has no bone, but an ischiatic levator muscle; there is an ischio-cavernosus also, and a bulbo-cavernosus muscle. The uterus is two-horned. The mammæ are two, pectoral, with many ducts in each nipple, as in Sirenia. The cerebrum is well convoluted, longer in Loxodon, and leaving the cerebellum quite uncovered. The eyes are small; the pinna large, flat. The trachea has 12 (–30 ?) rings, incomplete behind, each made of several (2–3) pieces, united by synovial joints. There is no third bronchus, and the lungs are long, oval, undivided, except that the right has a lobus azygos. The pericardium is attached to the diaphragm by yellow elastic tissue. The heart-apex is bifid, and there is no os cordis. There are two coronary veins, each with a valve, and two superior venæ cavæ, but no left vena azygos. The aorta gives off an innominate and a left subclavian; the former gives rise to the right subclavian, the two carotids, and sometimes a thyroidea ima. There may be one or two coronary arteries.

There are only two living genera—Euelephas, Indian, with five hoofs on the manus, and four on the pes; forehead concave; ears smaller; enamel ridges in the teeth parallel, with deep narrow interspaces. Loxodon, the African elephant, with four hoofs on the manus, three on the pes; convex forehead; large ears; moderate tusks in the female: teeth with lozenge-

shaped enamel folds, having shallow interspaces. The extinct forms are:—Elephas primigenius, with a thick woolly covering; Mastodon, with incisors in the mandible in young animals; molars with mammillary transverse ridges ununited with cement.

Dinotherium has large mandibular tusks, and is possibly a link binding these to the Sirenia, though considered by some as a marsupial (see p. 216). The internal ear is similar to that of Proboscideans (Claudius).

CHAPTER XXXVIII.

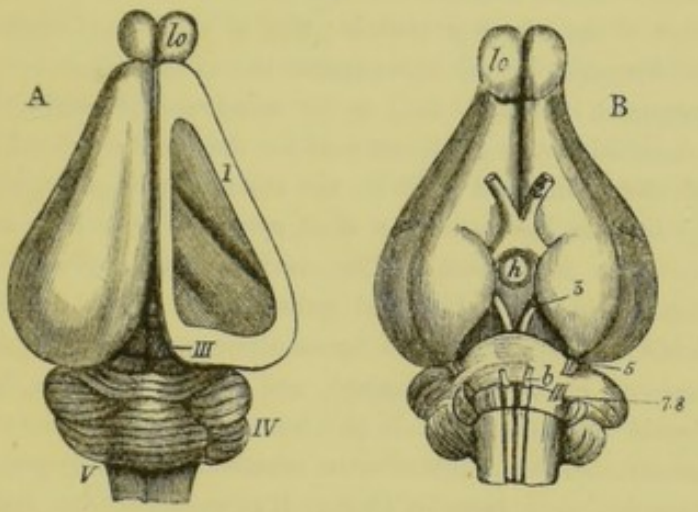
Gnawing Animals.

Order XII. *Rodentia* (*Vicq D'Azyr*).—Prolific, unguiculate vegetable-feeders, mostly of small size, and with teeth fitted for gnawing. Their placentation is discoidal, deciduate. The incisor teeth are $\frac{1}{1}$ or $\frac{2}{1}$, arcuated, concave backwards, like those of wombats; rootless and permanently growing, with a layer of enamel in front, backed by a column of dentine, so arranged that the more rapid wearing of the latter than of the former keeps the edge of the tooth permanently sharp and chisel-shaped. There are no canine teeth, and a long rounded diastema, along which the palatine and facial surfaces of the maxillæ are confluent. The long intestine has a cæcum (except in Myoxus). There are two superior venæ cavæ, right and left, always present, and vesiculæ seminales, large prostate and Cowper's glands, a long Weberian organ, and sometimes preputial glands, as in the beaver. The brain (fig. 39) is small, smooth or slightly convoluted; the cerebellum has small lateral lobes, and is usually uncovered. The orbits are incomplete, and the zygomatic arches are wide; the temporal fossæ small. The glenoid cavity is antero-posteriorly extended, and the condyle of the mandible is

also longitudinally elongated, so as to be capable of gliding fore and aft.

The enamel on the incisors is of a deep orange in Dipus, Castor, Dasyprocta, and Myopotamus; the upper incisors are longitudinally grooved in front in Orycteromys, Otomys, Meriones, Lagomys, Hydrochœrus, &c. The upper incisors form arcs of circles of lesser radius than the lower, hence the latter project in front of the former. In hares, &c., the enamel is traceable as a thin layer all round the incisor teeth.

Fig. 40.



Brain of rabbit: A, upper surface; B, lower surface; *lo*, olfactory lobe; I., cerebral hemisphere cut open, showing lateral ventricle; III., optic lobes; IV., cerebellum V., medulla oblongata; 2, optic nerve; 3, motor oculi nerve; 5, trifacial nerve *h*, hypophysis; 7,8, Portio dura and auditory nerve; *b*, sixth nerve.

The molar teeth are usually $\frac{3}{3}$, flat-topped, rarely tuberculate, usually consisting of transversely folded enamel ridges, and often growing from persistent pulps, as in Hydrochœrus; they may become rooted in the course of growth (Castor, Hystrix, Spalax, &c.), or else may have roots from their first appearance (Dipus, Mus. Sciurus). The premolars, when present, are similar, but smaller, and may be $\frac{1}{0}$–$\frac{1}{1}$–$\frac{2}{2}$ or $\frac{3}{3}$. The deciduous teeth may be shed or absorbed before birth.

The skull is generally long and flat above, with a vertical supra-occipital, often an inter-parietal; a bullate tympanic, sometimes tubular, and supplemented by a peri-otic excavation, the tympanic and peri-otic ankylosing together, but not to any other bone. The nasals are large, largest in Hystrix, smallest in Bathyergus, and they may early ankylose, as in Spalax. All the turbinals are large, as are the nasal cavities. The post-orbital process is small, largest in squirrels and hares, rudimental or absent

in some. The lachrymal has a small facial area, has its foramen always within the orbit, and only touches the jugal in Perognathus (and Geomys?). The premaxilla is large, and touches the frontal, which the maxilla never does. The maxilla is cribriform anteriorly in hares, and has often the roots of the incisor teeth elongated into it. In hares the optic foramina are confluent, so that there is an inter-orbital communication. The palate has large foramina, snd the zygoma is rarely narrow or absent, as in some Saccomyidæ. In Lophiomys a bony lamella extends out from the temporal crest, roofing it in, as in tortoises. The malar has often two large maxillary roots, between which and the maxilla there lies a sub-orbital fossa, occupied by a strong portion of the masseter muscle; this is often confounded with the infra-orbital foramen, but it is separated therefrom either by bone (Dipodidæ, Lagostomus, Octodon, &c.) or by membrane (Hystrix, Spalacopus, &c.) The mandible has a small coronoid for the small temporal muscle, but a rough and often elongated angle for the masseter and pterygoids.

The long scapula has usually a short spine, with a long metacromion process (except in the beaver). The clavicle may be always present, or may develop late in life (rabbit and guinea-pig), or may never develop at all (Hystricidæ). There may be a ligamentous omo-sternum (beaver), or a long cartilaginous element (porcupine), and a supra-trochlear, but rarely a supra-condyloid foramen exists in the humerus. The forearm bones are closely approximated, but allow of some rotation. There is generally an os centrale, a scapho-lunar bone in Castor, Hydrochœrus, &c., and an accessory radial sesamoid in the beaver. The pollex is slightly opposable in some squirrels, or may be absent (Hydrochœrus, Dactylomys). The symphysis pubis may be ligamentous and distensible (guinea-pig). The femur may have a third trochanter (hare, &c.), or an outer ridge (beaver), or may be smooth. The fibula is fused with the tibia below in hares, &c. The knee-joint has often ossifications in its semi-lunar cartilages. In jerboas the metatarsals early ankylose into a single bone, and there are three functional toes, the hallux and minimus being small or absent; the hallux is also absent in hares, and both it and the fifth in the capybara and agouti, in which the nails on these developed toes are hoof-like. In the beaver the fifth metatarsal ankyloses with the fourth, not with the cuboid.

The panniculus is only moderately developed. The ear muscles are continuous into a sheet in Xeros, and well-developed, the retrahens being continued to the middle line of the occiput in hares, jerboas, and squirrels, but *Schulze's* muscle is rarely present. The temporal muscle is small; the masseter large, consisting of two parts, in many a superficial or jugo-maxillary portion, and a deeper (mandibularis). A third part exists in agoutis, porcupines, capybaras, beavers, and pacas (mandibulo-maxillaris).

pterygoid muscles are well developed; the digastric has two bellies and a central tendon, except among the hares, in which the hinder portion is purely tendinous; the front bellies are fused in the rat and Capromys, having a central tendon crossing the median line above the basi-hyal; they are separate in Spalax and the marmot. The cleido-mastoid is separated from the sterno-mastoid in some, and there is a cleido-occipital muscle in the squirrel, beaver, Capromys, and some others. The omo-hyoid is absent in hares, guinea-pigs, porcupines, and Spalax; strongest in Capromys; it is present, but one-bellied, in others; the trachelo-acromial is often double, as in squirrels and hares, single in the jerboa, agouti, and porcupine, stretching up in the agouti to the bulla tympani, where the metacromion is small; its insertion is partly into an expansion over the shoulder, sometimes to the clavicle (agouti). Scalenus anticus may have a cranial origin (agouti), or be absent (Atherura, Cercolabes); the scalenes are inseparable in the jerboa. The trapezius is generally partly or entirely divided into superior and inferior portions, except in beaver, jerboa, and the squirrels; and in Capromys the trachelo-acromial, by projecting forwards, limits its scapular insertion. The rhomboid is occipito-cervical only in Dipus, but has a dorsal origin as well in the others. The occipital rhomboid is early separable in the hares, guinea-pigs, and squirrels. The dorsi-epitrochlearis is strong in climbers and runners, small in the swimming, burrowing, and leaping forms, but with a scapular origin in Spalax. Serratus posticus is a single muscle attached to the middle ribs—4–14 in Atherura, 3–9 in the guinea-pig. A sterno-trachelian muscle exists in Xeros; a small scapulo-clavicularis in hares, guinea-pigs, and mice; a true subclavius in the Paca, squirrels, and mice, but its insertion extends to the acromion in Spalax and beaver, and into the acromion and scapula alone in Dipus, Capromys, porcupines, &c. Separate sterno-scapular and subclavian muscles co-exist in the agouti and hares. The great pectoral is always joined to the latissimus dorsi by a muscular or tendinous sling. The supra- exceeds the infra-spinatus, except in burrowers; the teres minor is absent in Mus, Spalax, and Atherura, very small in Hystrix, rudimental in Cercolabes. A long coraco-brachialis exists in Spalax; a long and short in the beaver, Xeros, porcupines, marmot, and hamster; a middle and short form in the guinea-pig, agouti, hares, &c.; a middle and long in Capromys and Atherura. The biceps is a single glenoid ulnar bipenniform muscle, has a weak coracoid head in Cricetus, Capromys, and Xeros, and a radio-ulnar insertion in Atherura and Dipus. Brachiæus anticus is cleft in the hares, paca, guinea-pig, and agouti, into a long and short portion, both of which are humero-ulnar; the insertion is below (agouti) or above (cavy and hare) the biceps. The pronator teres does not extend much below the middle third of the radius. Anconeus internus is

present in all the forms which I have dissected, except in Dipus, and the pronator quadratus occupies three-fourths (agouti), half (Atherura and Paca), one-third (beaver, marmot), one-fourth (squirrel), one-fifth (Chinchilla), or the middle third of the arm (Dipus), or may be absent. Palmaris longus is not separable in porcupines, nor in Spalax; is large in the beaver; attached to a palmar ossicle in Dipus. The flexor digitorum sublimis may have a separate slip for the little finger (rabbit), or this slip may be absent. The flexor pollicis muscle is quite blended with the flexor profundus—at least at its tendinous portion—and the combined deep flexor has usually a condyloid head. Supinator longus is absent in hares, agouti, Spalax, Dipus, Pedetes, and Mus; present, but exceedingly feeble, in the beaver; rudimental in Atherura, but better developed in squirrels.

Extensor minimi digiti supplies the little digit only in beavers, marmots, jerboas, and mice; the fourth and fifth in Xeros, rabbit, cavy, and Spalax; the third (by a fascia), fourth and fifth in porcupines and squirrels. Flexor carpi ulnaris has no condyloid head in Spalax, cavy, or agouti; two ulnar heads in the marmot, but a condyloid head in hares; palmaris brevis is constant in all, and double in the paca and marmot. An extensor indicis exists in Cavia, Dipus, Sciurus, Cælogenys; an extensor pollicis et indicis in the rabbit, beaver and porcupines, but none in the rat nor Spalax. There is a double (trapezial and metacarpal) extensor ossis metacarpi pollicis in the beaver, and in the others the insertion of the single muscle is into either of the bones.

The rectus abdominis extends to the first rib, and has 5–7 inscriptions; there is no pyramidalis. The weak outer gluteus muscle is attached to the outside of the knee, and into a third trochanter; a separate agitator caudæ overlaps it in the beaver and marmot, but fuses with it in the others; there may be a gluteus quartus, and the small rotators are all developed. The quadratus femoris is very strong in Dipus, as in the kangaroos, and passes as far down as the junction of the upper and middle thirds of the femur. In the beaver and porcupine it has a caudo-femoral accessory slip prolonged down at its insertion to the femoral condyles; a ribbon-like caudo-tarsal slip (bicipiti accessorius) underlies the biceps hamstring in the beaver, Cynomys, and Lagostomus.

Sartorius is also variable, ending in a fibrous expansion in the middle of the thigh in Spalax, arising from the ilio-pectineal eminence in agouti, with a double origin (spine of the ilium and ilio-pectineal) in the hares, or from the middle of Poupart's ligament (Arctomys). The biceps flexor cruris has caudal and ischiatic organs in squirrels, Spalax, &c., or these parts may be separate (Atherura, Hystrix, Cavy). Semimembranosus has in the beavers and squirrels a caudal, as well as an ischiatic, head; and the same occurs

with the semitendinosus in squirrels, marmots, agoutis, beavers, and porcupines.

The psoas parvus is constant and largest in jerboas. The gastrocnemii have usually sesamoid bones in their heads, and the soleus often arises from the outer side of the head of the tibia. The tibialis posticus may unite with the tendon of the digital flexor, or it may be normal; the tibialis anticus may be double (Spalax), or may have a femoral and a tibial head and one tendon (agouti), or a tibial and a fibular organ (Arctomys), or it may be single (hares, squirrels), or with two tendons (Hystrix). There may be four peronei—long, short, fourth, and fifth, as in the hares; quinti is absent in the guinea-pig. The tibialis posticus may have an accessory muscle along its side, tibialis secundi. The extensor proprius hallucis is usually separate, but sends its tendon to the second toe; it is absent in hares.

The dorso-lumbar vertebræ are usually 19, but may range from 16 (Fiber, *d.* 13, *l.* 3) to 23 (Capromys, *d.* 17, *l.* 6), or 25 (Loncheres, *d.* 17, *l.* 8). There is 1 true, and 2–4 (Arctomys) pseudo-sacral vertebræ. The tail vertebræ range from 6–26 (Mus). The axis has a long odontoid and spine; the atlas in Capybara is pierced by the first and second pairs of cervical nerves, while the seventh is not pierced by the vertebral artery. The lumbar transverse processes are often very long, and point forwards.

The upper lip may be grooved (Saccomys), prolonged into a pointed snout (porcupines), or cleft; each half may send a process of hair-clad skin behind the incisors (Mus), or there may be a hairy patch on the inside of the cheeks (rabbit). There are large cheek pouches, often hairy within in Saccomyidæ and Cricetidæ, sometimes in the last-named reaching to the middle of the thorax, and acted on by muscles springing from the front of the lumbar vertebræ. The tongue has, in some, lateral foliated taste-organs, and one or two circumvallate papillæ. The œsophagus has a crop-like dilatation in dormice. The stomach may be simple, as in the rabbit, or divided into a cardiac and a pyloric pouch by a median constriction, and either of these may have cæca appended. In Lophiomys the pyloric cæcum, in Castor the cardiac, is glandular. In Arvicola there is a groove leading from the œsophagus to the pyloric sac; in others the cardiac sac is lined with squamous epithelium. The intestinal cæcum, absent in the dormouse, may be saccular (Mus, &c.), or long and spiral (Arvicola, hares, Anomalurus). There are often two anal glands, and the liver is usually five-lobed, with a large caudate, a bifid Spigelian lobe (except in Anomalurus), and a small right lateral lobe; in Capromys it is divided into numerous lobules, and the gall-bladder is absent in Mus, Cricetus, &c.; it lies in the umbilical fissure in Anomalurus. The duct of the large pancreas opens below the bile duct. The lungs are often multilobate (five, Arctomys, or six, Cricetus, on the

right side), and they may be unsymmetrical, the right larger than the left (Hystrix). There are large external and small internal jugular veins, and in the beavers the inferior vena cava is dilated above the liver. The aortic arch gives off branches, as in man. The vertebral arteries in hybernating species exceed largely the internal carotids (*Otto*).

The brain has a few convolutions in Hydrochœrus, usually one corpus mammillare, a large uncovered flocculus, and a large corpus trapezoideum and c. callosum. The sense-organs are variable, the eye being large in the hares, but subdermal in Spalax. In the former there is a third eyelid, with a triangular cartilage, and lubricated by a Harderian gland. The lachrymal duct has a small sac or none, and either a slit-like, crescentic orifice, or else two puncta lachrymalia. The external ear may be large and movable (Lepus), or none (Bathyergus). The cochlea may have three and a-half (Cavia) or five coils (Cœlogenys).

The ureters open near the fundus of the bladder in hares, and in many of the Muridæ the urethra pierces the clitoris in the female, as in Lemurs. The uterus may be double or bicornate; even the vagina may be double. The mammæ are two to four (guinea-pig, Microtus, &c.); five to eight (Agricola), ten (rabbit), fourteen (agouti), and they are abdominally placed, or pectoral, or lateral (Myopotamus). The testes are abdominal or inguinal, enlarging, and often descending periodically. The præputial glands are large in the beaver, four in number, and secrete the commercial substance castor. There is usually a penial bone, and the glans may be armed with recurved hooks (Cœlogenys).

This enormous order includes more than one half the known mammals, and they are distributed over the whole globe, the island of Madagascar only being almost without a rodent fauna.

The component mammals may be grouped into two sub-orders, according to the number of incisors in the upper jaw; those which retain two incisors on each side of the upper jaw forming the (smaller) group, Duplicidentata, while those which have but a single incisor on each side are named Simplicidentata.

Sub-order I. *Duplicidentati* (*Illiger*).—These are the most generalized of living rodents, which have an enamel layer continued, though thinly, around the incisors, and

which have a dental formula, *i.* $\frac{2}{1}$, the second pair being small, and outside the first; the brain-case is elongated; the alisphenoid canal absent; the optic foramina confluent; the fibula is ankylosed below to the tibia, and articulates with the calcaneum. There is a long sacculated cæcum, a hairy patch within the cheek, permanently external testes, and no vesicular glands.

The upper jaw at birth possesses a rudimental third incisor, which is soon lost. There is a carotid canal in the tympanic bone, and the malar process of the maxilla has but one root, the infra-orbital cavity being very small. The bony palate is a simple narrow bridge between the molar teeth, and deeply notched behind, the incisive foramina being heart-shaped, confluent in front.

Two families are included:—

1. *Lagomyidæ*, with *p.* $\frac{2}{2}$, molars $\frac{3}{3}$, rootless, with transverse enamel folds dividing them into lobes. The front of the maxilla has a single perforation. The jugal has its hinder angle prolonged to the ear meatus, and there is no median perforation in the basisphenoid, nor post-orbital processes on the frontal; the mandible has a tubercular coronoid process, and the clavicles are complete. This includes the tailless Lagomys, with rounded ears. The Pleistocene Titanomys had *p.* $\frac{1}{1}$.

2. *Leporidæ*.—Hares and rabbits, with short, recurved, bushy tails; long, large ears; long hind-limbs; clavicles imperfect; maxilla cribriform in front; basi-sphenoid with a median perforation, and separated from the vomer by a fissure; the frontals have large post-orbital processes, and the mandible has a lamellar coronoid. The dentition is *p.* $\frac{3}{2}$, *m.* $\frac{3}{3}$.

Sub-order II. *Simplicidentati* (*Lilljeborg*). — Rodents, with only one pair of incisors in the premaxilla, whose enamel is only developed on the anterior surface. The alisphenoid canal is present, and the incisive foramina are moderate, separate; the fibula does not articulate with the calcaneum, and the testes are usually abdominal, only periodically placed in a scrotum; vascular glands are present.

The large number of families included in this sub-order may be conveniently grouped into three sections.

§ 1. *Hystricomorpha* (*Brandt*).—Molar teeth, with folds or prisms, not with tubercles; premolars $\frac{1}{1}$; sub-orbital fossa large; zygomatic arch stout; post-orbital processes of the frontal absent, except in Chætomys; the under root of the zygoma is not a vertical flattened plate; the incisive holes are small, and there is an inter-pterygoid fissure; the angular portion of the mandible springs from the outer wall of the incisive alveolus, and the coronoid process is small. The fibula is not ankylosed, the upper lip rarely cleft, and the muffle clothed with short hairs.

Six families are included:—

1. *Caviidæ*.—American, with four digits on the manus, three on the pes, armed with hoof-like claws, keeled above; tail short or none; incisor teeth short, molars prismatic, rootless, divided into transverse lobes by folds; the upper row converge anteriorly, and the deciduous teeth are shed before birth. The upper lip is not cleft, and the clavicles are imperfect. The skull has long, curved, par-occipital processes, and the mandible, which is deeper at the angle than at the alveolar arch, has a well-marked masseteric ridge. This includes Cavia, the guinea-pig, with short limbs and ears; Hydrochœrus, the Capybara, the largest living rodent, about $2\frac{3}{4}'$ long, with webbed feet, and the palate produced behind the last molar (which is the largest); Dolichotis has long ears and limbs, and, like Cavia, a deeply emarginated palate posteriorly.

2. *Dinomyidæ*.—American, including one genus, Dinomys, with long bushy tails; cleft upper lip; claws as in last, but with a tetradactylous pes; optic foramina confluent; palate broad; clavicles imperfect, but with a broad manubrium; incisors broad; molars as in last family.

3. *Dasyproctidæ*.—American, with imperfect clavicles; moderate, slender limbs; manus with five, pes with five (Cœlogenys) or three toes (Dasyprocta); claws hoof-like; tail short or rudimentary; optic foramina separate; palate broad; milk teeth long retained; adult dentition with semi-rooted grinders and long incisors; masseteric ridge obsolete. Cœlogenys, the paca, has an enormously inflated and rough zygoma, whose cavity is lined with mucous membrane, and communicates with the mouth; the nerve has a separate canal; the malar is simple in Dasyprocta, the agouti.

4. *Chinchillidæ*.—American, with rootless molars, divided by transverse folds into continuous lamellæ, the lateral rows converging in front; the zygoma has no inferior process, and the jugal, which has no inferior angle, touches the lachrymal; the optic foramina are confluent, the clavicles perfect, the fore-limbs much smaller than the hind, the tail moderate, and the fur very soft. This includes the Chinchilla, which has enormous

auditory bullæ, that project upwards between the squamosal, supra-occipital, and inter-parietal bones; the manus has also five digits, while Lagidium has four on both manus and pes, and Lagostomus, the Viscacha, has four on the manus and three on the pes.

5. *Hystricidæ.*—Skull often smoothly ovate, its diplöe distended into air-cells; the face is short, and the malar has no lower angle; the molar teeth have both outer and inner enamel folds, and the hair is modified into quills or spines. The clavicle has a cartilaginous omo-sternum. This includes the porcupines of the Old World, which have semi-rooted imperfect clavicles and six mammæ. Hystrix, the common porcupine, has a short tail. Atherura, the African brush porcupine, has a longer, scaly, brush-tipped tail. The New-World porcupines have rooted molars, perfect clavicles, an unfurrowed upper lip, and the lachrymal bone is excluded from the lachrymal canal; the foot sole is tuberculated, but smooth, and the mammæ are four. The tail is prehensile in Cercolabes and Chætomys, in which the first digit of the pes is nailless, and two accessory ossicles support an inner plantar lobe. The tail is not prehensile in Erethizon.

6. *Octodontidæ.*—Jugal bone with an inferior angle; clavicles perfect; claws curved; molars with outer and inner enamel folds, without or with roots; incisive foramina long, extending into the maxillaries. In the African forms, Ctenodactylus and Pectinator, the claws of the two inner toes on the pes are covered by comb-like bristles, the premolars being absent in the first-named genus. A similar comb-organ exists in Ctenomys, from S. America, which has very simple enamel folds on its molar teeth. Habrocoma is tetradactylous, but has similar teeth. Myopotamus has a scaly tail, long paroccipital processes, and with all the toes of the pes webbed but the fifth. Loncheres and Echinomys have flattened spines mixed with the hairs. Dactylomys has a long scaly tail. In Aulacodus the outer digit of the tetradactylous pes is rudimental. Plagiodon has an obliquely diagonal pair of enamel folds in each molar tooth.

§ 2. *Myomorpha* (*Alston*).—Skull with no post-orbital processes on the frontal bone; a slender zygoma, in which the malar rarely extends far forward, and is supported by an extension of the zygomatic process of the maxilla. The foramina incisiva are long, and extend into the maxillaries; the outer walls of the pterygoid fossæ are usually obsolete, and the angular part of the mandible is continuous with the lower edge of the alveolus of the lower incisors. The tibia and fibula are completely ankylosed for their lower third in the adult; clavicles are perfect, except in Lophiomyidæ; premolars may or may not exist; the upper lip is usually cleft; the nostrils are curved, rounded above.

This includes six existing families :—

1. *Myoxidæ.*—Dormice. Old-World forms, with $p. \frac{1}{1}$, smaller than the molars, which are rooted, and with transverse enamel-folds. The frontals are contracted, clasped by the parietals, and the inter-parietal is broad, and touches the squamosals. Infra-orbital opening moderate, high, elongated in the root of the zygoma; the bullæ tympani are large; the mandible has a rounded angle and a long slender coronoid; the thumb is small, with a flattened nail; the pes is five-toed; the tail is as long as the body, and hairy; the cæcum absent. The dormouse, Myoxus, has a simple stomach, while in Muscardinus it is sacculated, with a thick-walled, cardiac, glandular appendage. Eliomys has a fontanelle in the angle of the mandible, while in Graphiurus the enamel ridges are nearly obsolete in the small teeth.

2. *Lophiomyidæ.*—One African genus, with no premolars; rooted and tuberculate molars; temporal fossæ covered (p. 287); skull granular; clavicles imperfect, although it is scandent in habit; cæcum small.

3. *Muridæ.*—Mice, with rudimental, small nail-bearing pollex; compressed incisors; contracted frontals; lower root of the zygomatic process of the maxilla flattened into a perpendicular plate; malar short, slender. This enormous and widely-distributed family includes ten sub-families, of which the foremost eight have rooted, the last two rootless, molars. The first, Sminthinæ, alone possess premolars, and have the infra-orbital hole larger than the anterior nares. This includes one N. European genus, Sminthus. In the Australian Hydromyinæ there are only $\frac{3}{2}$ molars, and the feet are webbed, the hind claws being much stronger than the fore. Platacanthomyinæ also include but one dormouse-like genus from India, Platacanthomys, with $\frac{3}{3}$ molars, with very small incisive holes, a hairy tail, and flattened spines mixed with the fur. Gerbillinæ, like the last, are Old-World forms, and have molars divided into transverse laminæ, narrow incisors, large tympanic bullæ, short fore- and long hind-limbs, long hairy tails. In Dasymys the lower root of the zygomatic process of the maxilla is hook-like; in Gerbillus the mandible has a rudimental coronoid process. The tail of Otomys is clad with hairs and scales. Phlæomyinæ are Indian forms, with broad incisors, molars like the last, large claws, and in Phlæomys a rudimental post-orbital process where the frontal joins the squamosal; the auditory bulla is small. Dendromyinæ include African forms, with tuberculated molars, small coronoid processes, long claws, and with the sub-orbital fossa not narrowing below. In Dendromys the fifth finger is as rudimental as the pollex, and bears a flat nail. Steatomys has this finger developed, and the pollex is wart-like. Lophuromys differs chiefly in having a clothing of fine flattened bristles. Cricetinæ, the hamster sub-family, consists of Old-World forms, with large internal cheek-pouches,

extending to the breast in Cricetus, tuberculate molars, cleft upper lip, a weak outer root of the zygoma, and an upturned angle to the mandible. The pouches stretch only to the ears in Saccostomus.

The true mice form the cosmopolitan sub-family Murinæ, and are known by having tuberculated molars; an infra-orbital opening wide above and narrowing below; long pterygoid fossæ; no cheek pouches (or rudiments in the American Hesperomys); a cleft upper lip, (except in Nesomys, in which the lip is only grooved, and in Holochilus, where it is partly cleft); moderate auditory bullæ; a moderately flattened, trigonal angle to the mandible; the tail is scaly, ringed, and usually naked; the skull has usually supra-orbital ridges; the pollex is represented by a wart, but is claw-bearing in Oxymycterus. Mus messorius has a body only two and a-half inches long. Mus musculus is the common mouse. Mus decumanus, the grey rat, which, starting from the shores of the Caspian about 1727, has overspread the globe, and in many parts of Great Britain has destroyed the native black rat, Mus rattus. Echinothrix has an enormously elongated face and spines in its fur. Pelomys has a rudimental fifth digit, with a flattened nail and a short first and fifth toe in its pes. Hapalotis, from Australia, has an obsolete coronoid process in its mandible, and has no supra-orbital ridges. The coronoid process is scarcely larger in the spiny Acomys, from Africa. In the American Reithrodon the pterygoid plates encroach on the posterior nares, and narrow them. Brachytarsomys has a very short tarsus, and Neotoma has its molars with angular open folds, never tuberculated, thu forming a link to the next sub-family.

Of the sub-families with rootless or only semi-rooted teeth, Arvicolinæ, the Voles, form the principal. They have molars composed of alternating, triangular prisms; the skull is much constricted in the frontal region, and there is a ridge at the front border of the squamosal; the tail is moderate, or short and hairy, not longer than the hind-foot in the lemming, Myodes; longer in Arvicola, scaly in Fiber, the Zibeth, in which the palate bones and the lower surface of the maxillaries are finely perforated. Siphneinæ, the last sub-family, has similar teeth, but has the hinder border of the palate deeply notched; the infra-orbital hole small and sub-triangular rudimentary outer ears and very short limbs and tail; the eyes are moderate in Ellobius; very small in Siphneus, from Siberia.

4. *Spalacidæ.*—Short-tailed or tailless Old-World forms, with rooted molars, which bear enamel folds, but no tubercles. The palate is narrow; the sub-orbital fossa narrow, with no perpendicular outer plate. They are mostly burrowing forms, with small outer ears or none; with eyes very small, or, as in Spalax, rudimentary, covered by skin; the limbs are short and stout, and the claws large; an inter-pterygoid fissure exists in Spalax,

Rhizomys, and Heterocephalus, and in these the angle of the jaw is continuous with the edge of incisor alveolus, as other Myomorphs, and none of them possess premolar teeth. In Bathyergus and Georhychus the angular part of the mandible arises from the side of the alveolus of the incisors, as in Hystricomorpha. In Heliophobius the mandible is similar, and the premolars are $\frac{2}{2}$, while in the other two genera they are $p.\ \frac{1}{1}$.

5. *Geomyidæ.*—American forms, with external, hair-lined cheek-pouches; an entire upper lip; wide sub-orbital fossæ; the auditory meatus is elongated, tubular; the jugal joins the lachrymal bone; the angle of the mandible is strongly twisted, and the squamosals are very large; they all have $p.\ \frac{1}{1}$. The mastoid does not appear on the upper wall of the skull in Geomys and Thomomys, which have broad incisors and large front claws. The incisors are narrow, and the mastoid appears widely on the surface in Perognathus, Heteromys, and Dipodomys. In the last-named the cervical vertebræ may be ankylosed; the molars are rootless, and the upper part of the zygoma is extended as a plate to touch the frontal bone, and the tympanic bulla is enormous. The extinct family, Theridomyidæ, is closely allied.

6. *Dipodidæ.*—Jerboas, with short pentadactylous hands and long three-, four-, or five-toed feet, with ankylosed metatarsals, except in Jaculus and Pedetes; skull with a high, short, and broad brain-case; a large sub-orbital fossa; the buccal surface of the maxilla finely perforated; a lachrymo-jugal suture; compressed incisor teeth and large mastoid process; the tail is long, and the cæcum very large. In the American Jaculus (Zapus of *Coues*) there is one premolar above, none below, and the metatarsals are separate; the pes five-toed, and a sparsely-haired tail. In Pedetes, the Cape jumping hare, there are $p.\ \frac{1}{1}$, and the molars are rootless, and the nails of the pes are hoof-like; the tail bushy throughout. In the true Jerboas the cervical vertebræ are more or less ankylosed, as are the metatarsals, which form a cannon bone; the molars are rooted, and the toes are either three (Dipus) or five, the two lateral being very short, not reaching the ground (Alactaga). There is one premolar above in both these genera; none in Platycercomys. In these the mandible has a fontanelle at its angle.

§ 3. *Sciuromorpha* (*Alston*).—Claviculate rodents, with the fibula always free and the angular portion of the mandible continuous with the lower edge of the incisor alveolus, not from its outer side. There is usually no sub-orbital fossa, occasionally a small one, and the jugal bone extends far forwards, and has not a long zygomatic process of the maxilla beneath it. The incisive foramina are confined to the premaxillæ, and there is no fissure from the bottom of the pterygoid fossa into the orbit (inter-pterygoid canal of *Waterhouse*), but the outer wall of the pterygoid fossa is obsolete. The mandible has a high-arched coronoid process.

This includes four living families:—

1. *Anomaluridæ.*—African, with *p.* $\frac{1}{1}$; molars not tuberculate, but with transverse enamel loops; no post-orbital processes; large, sub-ovate, sub-orbital fossæ, and palate deeply notched behind. There is a lateral patagium or flying membrane, stretching from carpus to thigh, supported on a cartilaginous process, which is attached to the olecranon process of the ulna; there are sixteen pairs of ribs and a long hairy tail, scaly below at its base.

2. *Sciuridæ.*—Squirrels, with *p.* $\frac{2}{1}$; molars tuberculate, rooted; skull broad in front, with post-orbital processes distinct, sub-orbital opening small; palate broad, flat; tail cylindrical, hairy; ribs twelve to thirteen pairs; the malar bone reaches to the glenoid cavity. This includes two sub-families:—

Sciurinæ.—True squirrels, with compressed incisors and long hairy tails. Tamias is a burrowing squirrel, and has cheek-pouches and a slender skull. Xeros has two, Sciurus three or four, pairs of mammæ, and both are arboreal. Pteromys, the flying squirrel, has a patagium from limb to limb (carpus to tarsus), having a cartilaginous style articulating with the carpus.

In the second sub-family, Arctomyinæ, the marmots, the incisors are not compressed, and the tail is short; the limbs never united by a patagium. There are large cheek-pouches in Spermophilus; small in Cynomys, the prairie dog; none or rudiments in Arctomys. The Miocene Ischyromys, with a sagittal crest and no post-orbital process, is closely allied.

3. *Haplodontidæ.*—One American genus, with *p.* $\frac{2}{1}$, molars rootless; skull depressed, frontly constricted, wide behind, with no post-orbital processes, twisted mandibular angles, small sub-orbital foramina; short, cylindrical, hairy tails.

4. *Castoridæ.*—Beavers. Skull massive, with no post-orbital process; small sub-orbital foramen, a sagittal crest, a rounded mandibular angle, *p.* $\frac{1}{1}$; molars rootless, with re-entering enamel folds; a groove on the under side of the basi-occipital; the carpus has an accessory ossicle, the second hinder toe has a double claw, and both manus and pes are pentadactylous. The cæcum is large; the stomach has a glandular appendage; there are scent-glands on each side of the prepuce and anus, and the tail is flat and scaly; the hind feet fully webbed. The beavers were formerly widely distributed in the N. temperate zone, but now are much more limited.

An extinct form, called Typotherium or Mesotherium, from the Pliocene of South America, forms a connecting link between the rodents and Lamnunguia, and thence unites these to Ungulata. As its rodent affinities are the strongest, *Alston* makes it the type of a third sub-order of Rodentia,

which he named *Hebetidentati*. In it the incisors are $\frac{2}{1}$, the second lower pair being very small, and placed rather behind the middle pair; their enamel is continuous all round. The premolars are $\frac{2}{1}$, molars are $\frac{3}{3}$, rootless, curved, with their concavity inwards (as in Toxodon). The mandibular condyle and glenoid cavity are transverse, and the fibula articulates with the calcaneum. The skull is massive, and the clavicles are perfect; the ischia articulating with two caudal vertebræ.

CHAPTER XXXIX.

Insect-eating Mammals and Bats.

Order XIII. *Insectivora* (*Cuvier*).—Plantigrade,* clavicu-late† disco-placentalians, mostly of small size, with all three kinds of teeth, but with the canines rarely (Centetes, Talpa) larger than the incisors, with hands and feet usually pendactylous and sharply clawed, but never with opposable digits. They have small, usually smooth brains, with an uncovered cerebellum; their incisors are more than two‡ in both jaws, and the molars are always rooted, with tubercled, enamel-coated crowns. They have simple stomachs, always a gall-bladder, abdominal or inguinal testes, large vesiculæ seminales, and bicornate uteri.

The dentition of the order is very variable, not only as to the number, but as to the forms of the teeth. The incisors are most commonly $\frac{3}{3}$, the inner pair being larger than the second pair above, but the second is often the larger below. Some of the incisors and the upper canine may have two

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* Rarely semi-plantigrade.

† Except Potamogale.

‡ Sorex has but one lower incisor.

fangs, as in Petrodromus, &c. The upper molars may have their normal four cusps (the antero-internal being joined by a ridge to the postero-external, or the two anterior may be joined together, and the two posterior transversely, as in Rhynchocyon, Macroscelides, &c.), and an outer cingulum. The outer cingulum itself may be developed, and may have four distinct cusps, as in Tupaia, Sorex, and Talpa. In Urotrichus the internal cingulum may have a cusp (as in the lemuroid Galeopithecus). In others the primary cusps may become diminished by the coalescence of the internal pair, which in Potamogale form but one tubercle. In the mole there is but one inner primary cusp, apparently the anterior. In the golden mole, Chrysochloris, the tooth is still farther reduced, so that there is but one inner and one outer tubercle, and a bilobed ridge, representing the cusps of the cingulum. The lower molars are less variable, and usually consist of two triangular prisms. *Mr. Mivart* calls attention to the remarkable parallelism in structure between the teeth of marsupials and those of Insectivores. The canine tooth is often with difficulty discriminable.

The skull has a small brain-case, and is usually long, conical, or pyramidal, broadest between the glenoid cavities, or posteriorly, with incomplete orbits, except in Tupaia. Ptilocercus has the orbits very nearly complete, while post-orbital processes are absent, except in these or in Rhynchocyon and Hylomys. The base of the skull is often in one plane. The supra-occipital is very large, and stretches far forwards in Sorex, and the zygomatic arch is deficient in Centetes, Ericulus, Echinops, Solenodon, Sorex, and Potamogale, the first-named genus having no malar bone. The zygoma, on the other hand, is well marked in Chrysochloris, and in Tupaia, Ptilocercus, and Hylomys there is a large hole in the malar bone. There are deficiencies in the palate in the hedgehog, mole, Myogale, Tupaia, Macroscelides, Petrodromus, and Solenodon, and the pterygoid fossa is usually absent, except in the hedgehog, desman, shrews, and banxrings. There is an alisphenoid canal in Centetes, Ericulus, Echinops, Solenodon, and Potamogale, and an external alisphenoid canal in Gymnura, Tupaia, Ptilocercus. The nasal bones early ankylose in Centetes, Ericulus, Echinops, Solenodon, and Potamogale. In these, Erinaceus, and Sorex there is no distinct carotid foramen. In Talpa the lachrymal foramen is well outside the orbit, while in Macroscelides, Rhynchocyon, and Petrodromus it is within the cavity; in the others it is marginal. A crest or process projects outwards in front of this foramen in Erinaceus, Gymnura, and Solenodon. The glenoid cavities have their inner ends on a plane anterior to their outer. The tympanic may be bullate, as in hedgehogs, or annular, and the symphysis of the mandible rarely ossifies.

The vertebræ are *d.-l.* 18–23, *s.* 3–5, *c.* 6–25. The clavicle has an epi-

coracoid joining it to the sternum in most, and the humerus has a supra-condyloid foramen, except in Erinaceus, Potamogale, and Sorex (murinus). There is a scapho-lunar bone in nearly all but shrews and Macroscelides, and nearly all but the shrews have an os intermedium. The symphysis pubis is small, or the pubes are mesially ununited. Macroscelides, Petrodomus, Ptilocercus, Tupaia, and Rhynchocyon are exceptional in having a well-marked, long symphysis. The tibia and fibula are ankylosed below, except in Tupaia, Centetes, Ericulus, and Solenodon. Salivary glands are large, and the stomach may have a cardiac pouch, as in the hedgehog.

The largest Insectivore living is the Desman, or the hedgehog; the smallest is the shrew, Crocidura etrusca, with a body and tail about $2\frac{1}{2}''$ long. The order is one of old date, the earliest known species being Spalacotherium, of the Purbeck beds. They are also widely distributed, but none are known from S. America or Australia. They have affinities to the Lemurs through Galeopithecus and Tupaia, to the rodents through the shrews, to the marsupials through Macroscelides, &c.

The following eight families are included:—

1. *Macroscelidæ*.—African, Jerboa-like forms, with long hind-legs, especially in the metatarsal region; large eyes; long, slender proboscis, concave transversely on its dorsum, naked at the tip; a cæcum; ankylosed tibia and fibula; also radius and ulna. The scapula has a long metacromion, and the pubes a long symphysis. The skull is contracted between the orbits, has no alisphenoid canal, but has carotid, post-glenoid, and sub-optic foramina, and may be inflated by air-chambers. The canine tooth is placed close to the premaxillary suture, and the vertebræ are thirteen dorsal, and six to eight lumbars, the latter with antero-posteriorly extended transverse processes, and no hyperapophyses. In Macroscelides the teeth are $i.\ \frac{3}{3}$, $c.\ \frac{1}{1}$ (the upper with two roots and two cusps), $p.\ \frac{3}{3}$ or $\frac{4}{4}$, $m.\ \frac{3}{3}$ or $\frac{3}{4}$. The cervical vertebræ have rudimental spines, while those of the dorsals are long. The humerus has an inter- as well as a supra-condyloid foramen; the femur has a third trochanter; par-occipital processes are absent, and the tympanic is bullate. Rhynchocyon has a sagittal crest on the skull, eight lumbar vertebræ, long cervical spines, a complete ulna, and a four-toed manus and pes; dentition $i.\ \frac{1}{3}$, $c.\ \frac{1}{1}$, $p.\ \frac{3}{3}$, $m.\ \frac{3}{3}$. Petrodromus has $i.\ \frac{3}{3}$, $c.\ \frac{1}{1}$, $p.\ \frac{3}{3}$, $m.\ \frac{3}{3}$, and a four-toed pes, but a five-toed manus.

2. *Tupaidæ.*—Banxrings are Asiatic and Malayan, squirrel-like forms, with long hair-clad tails, long pointed snouts, whose dorsum is convex transversely. The canine tooth is remote from the premaxilla, and is one-rooted; there are thirteen dorsal vertebræ, with no hypapophyses, seven lumbars, two sacrals, and twenty-five caudals. The scapula has a rudimental metacromion, the humerus a supra-condyloid foramen, and the femur a third trochanter, and the metatarsus scarcely exceeds the metacarpus in length; a cæcum is present. Tupaia has *i.* $\frac{2}{3}$, *c.* $\frac{1}{1}$, *p.* $\frac{3}{3}$, *m.* $\frac{3}{3}$, no par-occipital process, a supra-orbital foramen, and a long infra-orbital canal. Ptilocercus has a larger temporal fossa, a thickened hinder border to the palate, and a paramastoid process. Hylomys is short-tailed, with a long proboscis, and has only rudimental post-orbital processes, and *i.* $\frac{2}{3}$, *c.* $\frac{1}{1}$, *p.* $\frac{4}{4}$, *m.* $\frac{3}{3}$. In all the fur is soft, and the claws sharply curved.

3. *Erinaceidæ.*—Hedgehogs. Stout, spine-clad forms, with well-marked panniculus, with complete slender zygomata, a bullate tympanic bone, distinct eyes and ears, no cæcum, an open pubis, and ankylosed tibia and fibula. The pterygoid fossæ are large, and there is a transverse ridge across the back of the palate, and par-occipital and mastoid processes. There are fourteen to fifteen dorsal, five to six lumbar vertebræ, with small processes; the metacromion is long and pointed, the ulna is complete, and the metatarsus short. Gymnura has *i.* $\frac{2}{3}$, *c.* $\frac{1}{1}$, *p.* $\frac{4}{4}$, *m.* $\frac{3}{3}$; an external alisphenoid canal; an elongated skull, with an inter-orbital constriction; a long tail, five sacral vertebræ, and a back-prolonged tuber ischii. Erinaceus, the common hedgehog, has *i.* $\frac{2}{2}$, *c.* $\frac{1}{1}$, *p.* $\frac{3}{2}$, *m.* $\frac{3}{3}$. Some writers consider the canine to be the first premolar above, as it generally, but not always, has two roots; similarly the lower canine is often considered as an outer incisor. The milk teeth are *i.* $\frac{3}{3}$, *c.* $\frac{1}{1}$, *m.* $\frac{3}{1}$, and they are shed during the eighth week. The skull is constricted behind the orbits, which have no post-orbital processes. There is an excavation in the base of the skull continuous with the meso-pterygoid fossæ; a sagittal and a lambdoidal crest; a very large temporal fossa; no alisphenoid canal, nor distinct carotid foramen, but the oval and round sphenoidal holes are distinct, as is the sub-optic foramen, which opens from the orbit into the sinus of the presphenoid bone. The glenoid surface is flattened, and there is a transverse plate behind the posterior palatine ridge, continuous with the outer wall of the pterygoid fossa The cavity of the tympanum is large, and is bounded by the loosely-attached bullate tympanic, the squamosal, periotic, and ali-sphenoid bones, as well as by the basi-sphenoid internally. The angle of the mandible has a very slight inflection. The sacral vertebræ are three, the caudals twelve, and all have very short processes. The clavicles are long; the two scapular fossæ sub-equal; the pisiform elongated; the humerus was once in E. auritus

found to have a supra-condyloid foramen, but usually has only an inter-condyloid foramen. There is a ridge-like third trochanter, a small or open (in females) symphysis pubis, and the tuber ischii is not prolonged backwards. The dermal muscles are well marked, and the animal can roll himself into a ball, like the Armadillo Tolypeutes. For this purpose the panniculus forms a broad flat orbicularis muscle, which, beginning over the face and occiput, stretches laterally backwards on each side, to unite over the root of the tail. This muscle rolls the animal into a ball, but if opposed by the vertebral muscles erects the spines only. There are four accessory slips to the orbicular muscle: brachio-lateral, anterior and posterior; caudo-orbicular, and sterno-facial; and five, partly opposing, or radiating sets of fibres, such as occipito-frontal, occipito-orbicular, cervico-orbicular, dorso-orbicular, and auriculo-orbicular portions. The vertebral muscles are not very strong; the temporal is large; the palmaris longus rudimental or absent, but the short palmaris is large; the pronator teres and supinator longus are absent. There is a common extensor of the pollex, index, and medius, and the extensor minimi digiti supplies the fourth and fifth fingers; the flexors of the digits arise from the radius, ulna, coronoid, olecranon, and condyle, and form but one compound belly and tendon, from which slips pass to the four outer digits; the pollex is acted on by a small short flexor and an abductor. There are no lumbricales in the hand or foot, and the toes have each a long tendon, which has no accessorius. There is a tibialis posticus secundus lying internal to the normal tibialis, and attached to the inner cuneiform bone; the rectus abdominis has no perfect tendinous inscription. The abdomen is clothed below with stiff hairs, which abruptly change into spines along the lower edge of the orbicularis muscle. The snout is pointed, flexible; the tail hair-clad, short; the ears with rounded pinnæ, and the eyes small. The cochlea has but one turn and a-half. The brain is marked on the cerebrum by a faint longitudinal sulcus, and has large olfactory lobes and a short, thin corpus callosum. The short, thick, spinal cord ends medio-dorsally.

The intestine is about one-sixth the length of the body, and there is a large, irregularly-branched pancreas, as in Centetes; a liver, with a bifid spigelian; a large cystic lobe, and right and left lateral and accessory lobes. The right lung is four-lobed, the left bi- or tri-lobed; the diaphragm has a bone in its tendon near the aortic opening; the external jugular bone is continuous through the squamosal with the lateral sinus; the internal is small; the left precaval vein is present, and the aortic branches are innominate, left carotid and left subclavian; a branch of the internal carotid traverses the hollow of the stapes in the tympanic cavity, to form meningeal and ophthalmic branches. There are prostate and Cowper's glands, and a

wide uro-genital sinus, representing the prostatic part of the urethra and the sinus pocularis. The ovaries are in peritoneal sacs attached by serous bones to the posterior surface of the diaphragm, and the mammillæ are five on each side, ventro-lateral and axillary. The African E. Pruneri has a four-toed foot.

4. *Centetidæ.*—Tanrecs. Long-snouted, spiny, or bristle-clad forms, from Madagascar and the West Indies, with no bulla tympani, an imperforate small malar or none, and an incomplete or no zygoma; no cæcum, separate tibia and fibula; both paroccipital and mastoid processes; no separate carotid foramen, and the superior maxillary nerve traversing the foramen lacerum; no sub-optic foramen, nor pre-lachrymal ridge, nor outer ali-sphenoid canal, but a true ali-sphenoid canal. The metacromion is obtuse, and the pubic symphysis is small or none. The mandible has an inflexed angle in Centetes, which genus has a dental formula, *i.* $\frac{2}{3}$, *c.* $\frac{1}{1}$, *p.* $\frac{3}{3}$, *m.* $\frac{3}{3}$. It has no inter-orbital constriction. The canine has a simple crown and root, and is large, as in flesh-eaters; the summit of the lower fits into a fossa in the premaxilla. The vertebræ are *d.* 18, *l.* 5, *s.* 3, *c.* 10. The axis has an enormous spine, the other cervical spines are long, and the humerus has no inter-condyloid foramen. The femur is hollowed in front below, and has no third trochanter. Ericulus has *i.* $\frac{2}{2}$, smaller molars, and a separate scaphoid and lunar bones; the palate, which is perforated with many holes, projects behind the last molar, and there is no glenoid foramen, and the tibia and fibula do not ankylose below. The animal can roll itself into a ball, like the hedgehog; so also can Echinops, which has *p.* $\frac{2}{2}$, no inter-orbital constriction, and a short tail. Solenodon, on the other hand, has a long tail, and has an inter-orbital constriction. Its teeth are *i.* $\frac{2}{2}$, *c.* $\frac{1}{1}$, *p.* $\frac{4}{4}$, *m.* $\frac{3}{3}$. The canine has its crown in front of the premaxillary suture, and a scapho-lunar bone is present.

5. *Potamogalidæ* includes one genus of W. African non-claviculate forms, with *i.* $\frac{5}{3}$, *c.* $\frac{1}{1}$, *p.* $\frac{3}{3}$, *m.* $\frac{3}{3}$; no zygoma, nor pterygoid fossa; a glenoid and a sub-optic foramen, but no lachrymal foramen. The palatine surface of the maxillary is finely perforate. The par-occipitals extend horizontally backwards. They have a long tail, a complete distinct ulna, no os intermedium nor metacromion, distinct scaphoid and semilunar bones, and no cæcum. The nipples are two, abdominal.

6. *Chrysochloridæ.*—African, tailless, mole-like forms, with covered eyes, tetradactylous manus; skulls with complete zygomata, broad and high, narrowing rapidly forwards. The premaxillæ are produced forwards, as in Solenodon, and there are no mastoid nor par-occipital processes, pterygoid fossa, nor ali-sphenoid canals. The cranial bones ankylose early, and the mandible has a truncated ascending ramus. There are glenoid and carotid

foramina, and the foramen rotundum is confluent with the sphenoidal fissure. The teeth are *i.* $\frac{3}{3}$ (the first upper large, the first lower slender, and the second large, pointed), *c.* $\frac{1}{1}$, *p.* $\frac{3}{3}$, *m.* $\frac{3}{3}$. The vertebræ are *d.* 19–20, *l.* 3–4, *s.* 3–5, *c.* 5. The pre-sternum is keeled; the humerus moderately long; the scapula broad, with a high spine aud a blunt metacromion; the ulna is distinct, and there is an ossified tendon in the forearm, making functionally a third bone. The carpus has the scaphoid and semi-lunar bones separate; no os intermedium. The symphysis pubis is open, and the pedal digits have each only two phalanges (*Peters*). The cæcum is absent.

7. *Talpidæ.*—Moles. Burrowing forms, with cylindroid bodies, small heads, broad, tapering, but not high skulls, with small temporal fossæ and occipital bones inclined forwards. The zygomata are long, slender; the glenoid foramen is absent, and the ascending ramus of the mandible is not truncated; the lumbar vertebræ have hypapophysial ossicles beneath their interspaces; the sternum is keeled; the radius and ulna are distinct; the scapula long and narrow; an os intermedium is present, and the whole fore-limb is much larger than the hinder, and is placed far forwards; the symphysis pubis is open, and the pes is five-toed. The eyes and ears are invisible on the surface, and the skin has usually exceedingly minute eye-slits. Two sub-families are included:—

Talpinæ.—Moles, fitted for a purely subterranean life, with no pterygoid fossæ; an elongated presternum; short, broad clavicles, which are compound, in part coracoids, articulating in Talpa with the humerus, and with a prehumeral spur; no metacromion, no coracoid processes, and a sickle-shaped radial sesamoid in the carpus. This sub-family includes the mole, Talpa, with *i.* $\frac{3}{3}$, *c.* $\frac{1}{1}$, *p.* $\frac{4}{4}$, *m.* $\frac{3}{3}$. The incisors are very small; the upper canine long, two-fanged. The vertebræ are thirteen dorsal and five lumbar, with very short dorsal and cervical spines; sacral vertebræ five or six, and short tail of eleven vertebræ. The ungual phalanges in the hand are long and bifurcated, and the palms are turned backwards and outwards. The muscular system is extraordinarily strong. The trapezius is completely divided into upper and lower portions; there is a strong interscapular ligament, to which the rhomboid, mainly occipital, is attached; the subclavius and sterno-scapularis are both strong, distinct. The teres minor is small, teres major enormous, as are the great pectoral and latissimus dorsi. The abdominal cavity extends into the tail, and the urethra traverses the clitoris; the uterus is bicornate. The eye is small, with a nearly globular lens and a minute optic nerve. The semicircular canals of the ear project into the cranium. The symphysis pubis is open, the ilia very long, a third trochanter is developed, and a styloid sesamoid on the navicular bone.

Condylura, the star-nosed mole, has a star-like, cartilaginous process on its snout, and a tail of seventeen vertebræ, as long as the body. The lumbar vertebræ are seven, and the lower canine is larger than the incisors; otherwise the dentition is as in Talpa. Scapanus, also N. American, has an elongated proboscis, and Scalops has no lower canines, a marked inter-orbital constriction, and a naked tail of ten vertebræ.

Myogalinæ, the desmans, have pterygoid fossæ, a long coronoid process, no radial sesamoid in the carpus, and the first upper incisor is the longest. The outer ear, though not projecting, yet has a concha, and the eyes are small. The laterally compressed tail has a musk-gland at its root, and the toes are webbed, as their subterranean galleries open under water. Myogale has a dentition $i.\ \frac{3}{3}$, $c.\ \frac{1}{1}$, $p.\ \frac{4}{4}$, $m.\ \frac{3}{3}$, and its tail is nearly as long as the body. The cranial wall has a deficiency external to the ex-occipital, and the lachrymal foramen is very small; the vertebræ are *d.* 13. *l.* 6, *s.* 5, *c.* 26; the cervicals have no spines, except the axis; the humerus is elongated, and the scapula has a metacromion. The femur has a large third trochanter, and the pes is very much larger than the manus. Urotrichus, from Japan and N. America, has $i.\ \frac{2}{2}$, $c.\ \frac{1}{1}$, $p.\ \frac{4}{4}$, $m.\ \frac{3}{3}$, the canine being the smallest tooth in the upper jaw; the presternum is keeled more strongly than in Myogale, and the clavicles articulate with the humerus; the scapula is narrow, but has a metacromion; the snout is prolonged into a proboscis; the hands and feet are protected by horny plates.

8. *Soricidæ.*—Shrews. Mouse-like Insectivores, clothed with a soft short fur, with elongated snouts, ending in sharp points; small, but distinct, eyes and ears, the latter with a distinct pinna; hind feet at least nearly as large as fore, and the toes are claw-bearing, never webbed; the skin has odoriferous glands along the side, and the intestine has no cæcum; the skull has no pterygoid fossa, and the occiput slopes forwards; the zygoma also is absent. The inside of the ascending ramus of the mandible is excavated, and there is a ring-like tympanic and a large foramen lacerum medium in the base of the skull. The vertebræ are *d.* 13, *l.* 6, *s.* 4–5, *c.* 14–17. The sternum is not keeled, nor does the clavicle articulate with the humerus. The supra-spinous fossa has no prescapular wall, and the carpus has a scapho-lunar bone, no inter-medium, nor radial sesamoid. The pubes do not form a symphysis, and the femur has a third trochanter. The inner incisor teeth are often elongated; the molars are always $\frac{3}{3}$, and the canines, though indistinct, are $\frac{1}{1}$; there is always but one incisor and one premolar in the mandible, but the upper incisors and premolars are variable. Crocidura may have $i.\ \frac{3}{1}$, $p.\ \frac{2}{1}$, as in C. etrusca, the smallest known mammal, from South Europe, or $i.\ \frac{3}{1}$, $p.\ \frac{1}{1}$, or $i.\ \frac{2}{1}$, $p.\ \frac{1}{1}$, as in C. pulchella. Sorex and Crossopus have $i.\ \frac{4}{1}$, $p.\ \frac{2}{1}$.

Order XIV. *Chiroptera* (*Blumenbach*).*—These, the only truly flying mammals, are hot-blooded disco-placentalians, which have the bones of the fore-limb elongated, and supporting expansions of the integument which are capable of acting as perfect wings, not mere parachutes, like the so-called wings of Galeopithecus, Pteromys, Anomalurus, and Petaurus. The arm, forearm, and hand are all long; the humerus, always the strongest bone in the skeleton, may be as long as the whole body; the forearm consists of a strongly developed radius and a rudimental ulna, with no olecranon; the digits of the manus and their metacarpal bones are especially elongated and slender, united to their tips by the wing membrane, the thumb alone being free, and always claw-bearing, consisting of one or two phalanges. The fourth and fifth fingers have never more than two phalanges, and the middle finger is the longest. The clavicles are proportionally stronger than in any other animals, and the presternum is very wide, and it, as well as the meso-sternebers, usually develops a thin median crest on the ventral surface, for the attachment of the pectoral muscles. The symphysis pubis is narrow or open. The thigh-bone has no third trochanter, and the outer and inner trochanters are usually nearly equal. The legs have undergone an outward rotation through a large arc, so that the extensor aspect of the knee looks backwards and outwards, and the fibula is brought to the inner side of the leg, its upper extremity being in general deficient, or

* Since the printing of this chapter a Monograph on Bats has been published by *Dr. Dobson*, in which 400 species are described. In this work the insectivorous bats (Microcheiroptera) are divided into five families :— 1. Rhinolophidæ; 2. Nycteridæ; 3. Vespertilionidæ; 4. Emballonuridæ, including Nodiliones, Dicliduri, Molossinæ; 5. Phyllostomidæ.

represented by a fibrous band. The plantar surface of the foot is also directed forwards, and there is a spur (*calcar*) from the calcaneum to support the wing membrane, which stretches from the fore- to the hind-limb, and from thence to the tail.

The skulls are elongated, the mandible has an ankylosed symphysis, the brain is smooth, or nearly so, and the cerebellum uncovered. The dentition is variable, and singularly inconstant, but all the kinds of teeth are present, and the teeth are never more than *i.* $\frac{2}{3}$, *c.* $\frac{1}{1}$, *p.* $\frac{3}{3}$, *m.* $\frac{3}{3}$. The digestive canal is simple, with no cæcum, and there are two precaval veins; abdominal or inguinal testes, sometimes periodically descending into a perineal scrotum; a simple or bicornate uterus; vesiculæ seminales; a pendulous, often bone-bearing, penis, and two pectoral mammæ. The young are of large size at birth, and there is rarely more than one at a birth.

Bats have a fluttering, irregular, circling mode of flight, with a rapid beat of wing. They rarely fly high or rapidly. When at rest they hang, head downwards, suspended by the hook-like claws of the feet, or by the thumbs, and in this position they feed and suckle their young. On a plane surface they move awkwardly, with the wings folded against the side of the body, the pollex advanced and hooked into the floor by its claw, for the purpose of dragging on the body, while the hind-legs are directed backwards, with the knees bent backwards and upwards.

The hairs of bats are soft, and marked on the surface by imbricating whorls of variously-shaped scales, which are constant in their pattern and arrangement in each species. The scales may be in transverse series (Phyllostomidæ, Noctilionidæ, Molossidæ), or in oblique lines (Vespertilionidæ, Rhinolophidæ). The epidermis is dark-coloured, especially on the dorsal

surface; the dermis contains a great development of elastic tissue, and on its ventral surface are many large blood-vessels, with thick muscular coats, looped varicose capillaries, and small rhythmically contractile veins. There are also peculiar nerve-endings (*Schöbl*), to which is due the extreme sensitiveness of this surface, as proved by *Spallanzani*, who showed that blinded bats were able to avoid obstacles, without contact, in their locomotion. The different areas of the wing membrane, or patagium, have received different names—thus the portion which lies in front of the flexure of the elbow-joint, and which extends from the shoulder to the thumb-root, forming the anterior margin of the wing, is called the *pro-patagium;* the *plagio-patagium* is that portion which extends on each side from the extensor side of the arm and forearm to the lateral aspect of the body, thence to the extensor side of the femur and leg, as far as the ankle; its outward attachment is to the fifth finger, and its hinder border is free, crescentic, and thin. Between the hind-limbs is the *uro-patagium*, or inter-femoral membrane, and this fold includes the tail medially. The small fold between the calcar and the foot is called *epiblema;* the inter-digital membrane is called *dactylo-patagium*, and its parts are distinguished as follows:—that between the thumb-root and the index is the *dactylo-patagium brevis*, that between the index and middle is the *d. minus*, that between the middle and fourth is the *d. longus*, and that between the fourth and fifth is the *d. latus*. Dermal scent-glands occur on the front of the wing in Saccopteryx and Emballonura, or in the axilla of Chiromeles, &c.

The vertebral column is peculiar, in that it diminishes in the size of its components from the head, tailwards. The cervicals are the largest, broad and short, with slender neural arches and no spines, except on the axis, which often ankyloses to the third, and has a short odontoid. The atlas generally has a bony bridge arching over the vertebral artery. The dorso-lumbars are seventeen (either twelve to five or eleven to six), with a single curve, so acute at the lower point that the pelvis is turned, with its outlet looking forwards; hypapophyses are present in Scotophilus, Macroglossus, and Vampyrops, but the lumbar transverse processes are obsolete in all. The sacrum consists of two or three vertebræ, to which the proximal two or three caudals are ankylosed, and the caudals vary from two (Anura) to twenty-one.

The skull is variable in characters in the different sub-orders, and the bones coalesce at an early age, obliterating the sutures. The orbit is not separated from the temporal fossa, and there is rarely (except in Pteropus) any post-orbital process on the zygomatic arch which is slender, only absent in Phyllonycteris. The premaxilla is always small or rudimental, never ascending to the frontal, and the malar is always small, the principal

part of the zygoma consisting of the squamosal bone. The lachrymal foramen is outside the orbit, or absent, as in some of the Entomophagous forms. The tympanic bulla is thin, easily detached, never ankylosed, and the periotic is thin, often so translucent that the large two and a-half- or three-whorled cochlea can be seen clearly shining through its basilar surface; this is especially the case in Synotus and the vampyres. On their upper surfaces the periotics are deeply excavated for the flocculus. There is generally a sagittal and a lambdoidal crest; large nasals, which early unite medially; a wide basi-occipital, with an excavated basilar process, which has often a longitudinal median ridge.

The scapulæ are elongated antero-posteriorly, strongly ridged, with a short spine, a long thick hinder border, and a very large hooked coracoid process. The clavicles are very strong, arched, and often perforated by vessels on their hinder side. The humerus has a strong pectoral crest, a sharply-marked inner tuberosity, no supracondyloid, but occasionally an intercondyloid foramen, and there is often a sesamoid bone in the tendon of the triceps behind the elbow, above the rudimental olecranon; another minute sesamoid may exist in Pteropus, in front of the inner condyle. The ulna is generally deficient below. The carpal bones are six or seven in number; the cuneiform may be ankylosed to the lunar, or, more commonly, the scaphoid and lunar are united, and the cuneiform is sometimes also ankylosed thereto. There may be a palmar ossicle, as in Megaderma. The metacarpals are enormously elongated, except that of the thumb, and the phalanges of each digit are often ankylosed together at their joints; sometimes the index bears a small claw, as well as the pollex (Pteropus).

The ilium is narrow and elongated, ankylosed to the sacrum, and the ischium often articulates, and even ankyloses, to those caudal vertebræ which are ankylosed to the sacrum (pseudo-sacrals). The spine of the pubis is elongated, often forming a prominent spur, and in many of the Rhinolophidæ (Phyllorhina, Triænops, &c.) it is united by a bony bridge to the spine of the ilium, forming an arch over the femoral vessels. The straight femur is a small bone, with two sub-equal trochanters, and a narrow patellar fossa. The fibula is sometimes bowed inwards, as in Molossus; there is a very small calcaneum, and the five toes are equal, the outer (great toe) having but two phalanges.

The cutaneous muscles are numerous and strong. In the neck there are three radiating slips converging backwards to a tendon which extends along the front edge of the pro-patagium; there are also dorsi-patagial, coraco-, pubo-, femoro-, and ischio-cutaneous muscles. There is a strong occipito-polliceal muscle arising from the occiput, ending in a long elastic tendon, which is inserted into the base of the last joint of the thumb, often

with a second belly at its insertion ; this is a detached and modified occipital trapezius. There is a one-bellied depressor of the mandible (rarely with a tendinous inscription); a biventral omo-hyoid ; an enormous great pectoral, the largest muscle in the body; no lesser pectoral; a large subclavius, limited to the clavicle. The trapezius proper rarely rises above the first dorsal vertebra, nor are any of the muscles of the wing attached to the upper neck or head-bones; the proper spinal muscles are feebler than in any other group of mammals, and the levator anguli scapulæ does not rise above the fifth cervical vertebra, while a levator claviculæ comes from the fourth and fifth cervicals. The scapular deltoid lies transversely over the infra-spinous fossa, from whose margin it arises, and is covered by the acromial deltoid at its insertion ; the supra- and infra-spinatus are nearly equal in size, and the teres minor is very small, while the subscapularis is proportionally larger than in any other group of animals. The coraco-brachialis is very short, but always inserted below the latissimus dorsi, therefore represents a c. medius. The biceps has two heads, coracoid and glenoid, and is radial in its insertion, while the very small brachialis anticus is ulnar, and the triceps longus is often double. There is a feeble pronator teres, no p. quadratus, a supinator longus (except in some of the smaller forms), inserted into the upper portion of the radius. There is a palmaris longus, no flexor sublimis, but a flexor profundus, which is inserted into the pollex, medius, and annularis, or pollex, index, and medius, usually only into pollex and medius. The extensor ossis metacarpi pollicis has usually a sesamoid bone in its tendon ; there are two radial extensors of the carpus, and separate extensors of the pollex and index, rarely a common indicio-polliceal extensor, or both. The extensor digitorum communis sends no tendon to the index finger, and there are the usual small muscles for the pollex and little fingers. The recti abdominis in the females are widely apart below, and the diaphragmatic crura are large, as are the psoæ parvi muscles. There is no gluteus minimus ; a fourth gluteus ; a femoro-caudal ; a quadratus femoris ; an externally-placed iliacus muscle (owing to the extroversion of the ilium); a very large wide gracilis ; no biceps femoris, nor obturator internus ; a single extensor of the knee arising by two heads, one from the femur, and one from the ilium (representing the rectus). There is a rudimental popliteus, or none ; no sartorius, tensor vaginæ femoris, nor soleus, and a sesamoid bone in the outer head of the gastrocnemius. The foot, besides the ordinary muscles, possesses a levator and a depressor of the styliform calcar, and a very large transversus pedis. Many of these muscular characters show the affinities of this order to the next.

There are large salivary glands, a large thymus, and a fatty mass on the

nucha, filling up the suprascapular hollow, where there is no ligamentum nuchæ. The lungs are large, few-lobed; the heart large, usually giving off from its aortic arch a right innominate artery, a left carotid and left subclavian arteries, and the main limb arteries in the wing are sometimes broken up into longitudinal bundles of parallel vessels. The liver is few-lobed, with a gall-bladder; the stomach is simple, pyriform, or cylindroidal; in suctorial forms, like Desmodus, with a very long, narrow, cylindrical, and sacculated cardiac pouch, and a very short interval between the œsophageal and pyloric orifices. The intestine is short, longest in the fruit-eaters. The cerebrum has a superficial Sylvian and Rolandian fissure in Artibeus, and the pineal gland and quadrigeminal bodies are uncovered, as well as the cerebellum. The sense-organs, with the exception of the eyes, which are feeble, are well-marked, but vary in the different families.

Bats are widely distributed, but each species has, as a rule, a limited range. They are almost all nocturnal, and those that inhabit temperate climates hybernate, as do many of the other small mammals of such countries, such as the rodents and insectivores.

Chiroptera may be divided into two sub-orders :—

Sub-order I. *Frugivora* (*Wagner*), *Macrochiroptera* (*Dobson*).—Moderate or large-sized bats, for the most part with pointed snouts; small external ears, whose sides form a complete ring at the base; no nose appendages; molar teeth, each with a median longitudinal groove, a flat smooth crown, and a slightly-raised hinder point; premaxilla distinct, usually united to its fellow, as well as to the maxilla (except in Hypoderma, in which it is cartilaginous); frontal bones, with sharp post-orbital processes; lachrymal foramen always distinct, and the bony palate is continued behind the last molar, narrowing gradually. There is often an external ali-sphenoid canal, and an external pterygoid tubercle. The mandible has a very small post-angular process, or none; the paroccipital and mastoid processes are separate and small. The index finger

has three phalanges, the last bearing a claw (except in Eonycterus, Hypoderma, and Notopteris). The stomach is a simple sac, sometimes elongated at the pyloric end, the intestine five and a-half or six times the length of the body.

One family is included, Pteropidæ, which is Palæotropical, principally Malayan, in distribution. Pteropus includes the largest forms, the Kalongs and flying foxes of the islands of the Indian Ocean, some of which have an expanse of wing of five feet; they are tailless, and have a penial bone and a free thumb. Cynonycteris has no penial bone and a patagial fold, embracing the thumb; in these the dentition is $i.\ \frac{2}{2}$, $c.\ \frac{1}{1}$, $p.\ \frac{2}{3}$, $m.\ \frac{3}{3}$. Cynopterus and Pterocyon have $p.\ \frac{2}{3}$ and $m.\ \frac{2}{2}$, and Uronycteris, with the same dentition, has a long tail. Epomophorus has $p.\ \frac{2}{3}$ and $m.\ \frac{1}{2}$, and epaulettes of whitish hair. Megærops is tailless, and has prominent tubular nostrils. Macroglossus has a long vermiform tongue, weak slightly-elevated molars, and very long proboscis-like nostrils. Post-anal scent-glands exist in Eonycteris. Cephalotes and Harpyia, with tubular nostrils, have incisors $\frac{1}{0}$, possibly due to early shedding, as in the closely allied Hypoderma the teeth are at first $\frac{2}{2}$, but in the course of growth become reduced to $\frac{1}{1}$, and in old specimens to $\frac{1}{0}$. Macroglossus has often a parietal foramen, as has Cephalotes, and in both the paroccipital processes are rudimental.

Sub-order II. *Insectivora* (*Wagner*), *Microchiroptera* (*Dobson*).—A large assemblage of varying forms, which feed on animal food, worms, insects, blood, &c. They have shorter, wider skulls, with more dilated brain-case, shorter muzzle, rudimental or no post-orbital processes on the frontal, rarely long, as in Taphozous and Vespertilionina. The paroccipital processes are thin, lamellar, and united by a ridge to the mastoid process of the opisthotic. There is never an alisphenoid foramen, but a hamular spur on the pterygoid plate is present. The palate is suddenly constricted behind the last molar, but is often prolonged backwards for a short distance. The margins of the concha are not basally united, but begin separately, sometimes with separate outer and inner basal lobes.

The teeth are sharp; the molars with very sharply-pointed cusps, often joined by oblique ridges, so as to make W-like surfaces. The index finger never bears a claw.

Two tribes are included under this sub-order:—

Tribe 1. *Istiophora* (*Spix*).—All the forms herein included have remarkable leaf-like appendages on the nose, and for the support of these the nasal bones are widened and flattened, and the nasal portions of the maxillæ are dilated and hollowed into air-cells. In its simplest form, as in Anura, the appendage is a lancet-shaped acute leaf, dark in colour, and placed upright on the nose, with its surfaces directed dorsally and ventrally anterior, and below which the nostrils open. When more fully developed, there is a crescentic fold placed anteriorly in front of the nostrils, with sharp, and often waved and ridged borders, and with its convexity directed forwards). This is called the horse-shoe (*ferrum equinum*); in its concavity, between the ferrum equinum and upright leaf-like process, which is named *prosthema*, there is a third part, somewhat saddle-shaped, which is often elevated posteriorly into a prominence; this is known as the *sella*. The pyramidalis nasi muscle, which is present in all bats, is very large and strong in those bats provided with a well-marked horse-shoe, and is inserted into it and into the prosthema. There are also special lateral muscles, which can approximate the cornua of the horse-shoe to the base of the prosthema.

This tribe includes five families:—

1. *Desmodidæ*.—Sharp-toothed suctorial S. American bats, with no prosthema, no tail, and a shortened or no (Diphylla) uropatagium. The dentition is *i*. $\frac{3}{2}$ (in Diphylla the lower are pectinated, as in Galeopithecus and Hyrax), of which the two upper and outer very early fall out; *c*. $\frac{1}{1}$, very sharp; *p*. $\frac{1}{2}$; *m*. $\frac{1}{1}$; the back teeth form a longitudinal, cutting, wedge-shaped blade. The peculiarity of the stomach has been noticed before. Desmodus has strong, sharp-pointed upper and notched or bilobed lower incisors.

2. *Phyllostomidæ*.—Vampyres. Neotropical forms, with a distinct prosthema, often with no other part of the epirhinal apparatus. The ears are moderate, always separate, except in Macrotus, and with a tragus or separate upright cartilaginous lobe inside the helix. The canine teeth are sharp, triquetrous. There are three phalanges in the middle finger.

Three sub-families are included:—Stenoderminæ, in which the incisor teeth are small, persistent, but the upper and lower do not meet when the

mouth is closed. The molar teeth have square crowns, with sharp cusps not united, but with an elevated external cingulum forming a cutting edge. The face is often warty, and the tail entirely absent (Stenoderma, Artibeus, Vampyrops, Sturnira) or rudimental; the dentition is usually *i.* $\frac{2}{2}$ ($\frac{1}{2}$ in Sturnira), *c.* $\frac{1}{1}$, *p.* $\frac{1}{2}$ (Artibeus), $\frac{2}{2}$ (Platyrhinus, Sturnira, Brachyphyllia) or $\frac{1}{1}$, *m.* $\frac{3}{3}$. Glossophaginæ have the lower lip split, a long worm-like tongue and a long snout, small deciduous incisors, a small prosthema only, or even this may be rudimental (Phyllonycteris) on the nose. In these the outer cusps are joined by oblique ridges to four sharp points on the outer cingulum, forming a W, which is narrow. Some have *p.* $\frac{2}{3}$ (Monophyllus) or $\frac{3}{3}$ (Anura). Phyllonycteris has no zygoma. Vampyrinæ have large incisors, which meet when the mouth is closed, and the molars have W-like enamel ridges. The lower lip is not cleft. There is a ferrum equinum, as well as a prosthema (this is especially well-marked in Phyllostoma and Macrophyllum, but very distinct in Carollia, almost obsolete in Lophostoma and Lonchorhina). The tail is moderate, and included in the inter-femoral membrane, except its last joint in Macrotus, Macrophyllum, and Lonchorhina.

3. *Megadermidæ.*—Palæotropical forms, with very large ears, united together medially, each with a large-pointed tragus; the eyes are moderate. The prosthema is very large, with a middle vertical and two lateral flat portions, or rudimental, surrounding the slit-like nostrils, which can be closed at pleasure (Rhinopoma), or with two lateral separate portions (Nyctophilus); the horse-shoe is small, but its base is sometimes expanded to cover the upper lip (Lavia). There are often small post-orbital frontal processes. The incisors may be $\frac{0}{4}$ (Megaderma), $\frac{1}{2}$ (Antrozous), $\frac{1}{3}$ (Nyctophilus), $\frac{2}{3}$ (Nycteris), or $\frac{2}{4}$ (Rhinopoma). The premolars are $\frac{1}{1}$, $\frac{1}{2}$, or $\frac{2}{2}$, and the molars $\frac{3}{3}$, with W-shaped crests. The premaxillæ may be widely separated and cartilaginous (Megaderma), or fully developed, as in Rhinopoma, or separated by a median interspace, and the tail may be absent, or may end in a T-shaped bone (Nycteris), or in a simple point. The middle finger has one or two phalanges, and the index has a short phalanx (Megaderma), or none. The fibula is not ossified in Nycteris. The females of Megaderma have odour-secreting, pubic, wart-like glands.

4. *Rhinolophidæ.*—Small, Old World forms, with moderate, always separate ears, with no tragus. The horse-shoe and sella are always well marked, sometimes extremely complex in their arrangements; the former consists of two symmetrical lateral parts, whose hinder extremities externally are curiously hollowed into cells in Triænops, or marked by pores in other forms. The prosthema is narrow, mesial, sometimes hollowed at base.

The dentition is *i.* $\frac{1}{2}$, *c.* $\frac{1}{1}$, *p.* $\frac{2}{3}$ (Rhinolophus) or $\frac{2}{2}$. In Triænops the anterior upper premolar is outside the line of the teeth. The molars have W-like crowns, and there may be a sub-condyloid foramen in the mandible (Triænops). The manubrium sterni is very wide, and the sternal ends of the upper two or three pairs of ribs may be confluent. The humerus has a prolonged inner condyle, sometimes as a sharp inner spur (Triænops). The index finger is rudimental, with no separate phalanx. The pubic spine may be elongated (Rhinolophus), or may be joined to the ilium, as before described. The toes may be sub-equal, and with two phalanges, or unequal, and with three, except in the great toe, as in Rhinolophus. The fibula is complete. The skull has a flat wide base, with a very thin or perforate floor of the sella turcica; the cochlea is very large, and the post-orbital processes are absent, but the zygoma is vertically thickened a little in front of its hinder end. The premaxillæ are rudimental, attached to the nasal cartilages; infra-orbital foramen is large, often bridged over by an obliquely ascending bony lamella. The palatine surface is concave; the anterior condyloid foramen small, or confluent with the jugular; the carotid foramen is absent, as is the post-glenoid (except in Triænops); the mandible has a long post-angular process, and a sharp, though not much elevated, coronoid. The par-occipital process is slender (Triænops) or blunt, separate, though close to the mastoid process of the opisthotic. The genera are Rhinolophus, Phyllorhina, Cælops, and Triænops. Cælops has a rudimental tail and a lobed ferrum equinum. The eyes in all are exceedingly small. In some species of Phyllorhina there is an eversible fat-secreting sac behind the prosthema, armed at its fundus with a pencil of stiff hairs.

5. *Mormopidæ.*—Neotropical, mostly West Indian, passage-forms to the next family, having rudimental nasal appendages in the form of dermal folds; the nostrils are in front of the muzzle, and open by simple apertures near the edge of the upper lip. There are W-like crowns to the molar teeth, and $\frac{2}{3}$ incisors. There are erect skin-folds on the chin. The patagium may be attached along the medio-dorsal line (Pteronotus), or laterally as usual, and the inter-femoral membrane is large.

Tribe 2. *Gymnorhina* (*Wagner*).—Bats, with no leaf-like appendages on the nose, and with nostrils opening by simple crescentic or circular apertures, with W-like crowns on the molar teeth, and with ears always provided with a tragus. Three families are included:—

6. *Noctilionidæ.*—Having the tail shorter than the inter-femoral membrane, and with its end free; the thumb has its base included in the patagium; the middle finger has three (Mystacina) or two phalanges, and the frontal has long post-orbital processes in Taphozous. Emballonura has

a scent-gland at its elbow; the incisors are $\frac{2}{1}$ (Noctilio), $\frac{2}{2}$ (the upper very early falling out, as in Taphozous), or $\frac{2}{3}$, as in Diclidurus and Emballonura; the *p.* $\frac{2}{2}$, *m.* $\frac{3}{3}$. Some species of Taphozous have deep, gular, odour-secreting pouches in the males, and all the forms, except Noctilio and Mystacina, have the first phalanx of the middle finger folded when in rest on the dorsal surface of the metacarpal bone, as in Molossidæ; in Mystacina it is folded on the ventral surface of the metacarpal. The frontal is concave in Taphozous, Coleura, and Diclidurus.

7. *Molossidæ.*—This family, as described by *Peters*, consists of stout little bats, with short legs and thick tails, projecting from the inter-femoral membrane. The fibula is perfect, nearly as thick as the tibia. In Chiromeles the hallux is opposable, and has a flat nail. Thoracic and gular glandular pouches exist in this genus and in Dysopes. The first toe is thicker than the others, or the first and fifth. These bats have also thick upper lips, flat heads, long narrow wings, and the first phalanx of the middle finger is short. In Chiromeles and Molossus the upper incisors are strong, and placed close together; in Nyctinomus the premaxillæ are separate, or joined by cartilage. The tragus in Molossus is very small, but is much more distinct in Nyctinomus. In one species *Mr. Swinhoe* states that the animal can protrude its eye almost out of its socket, and retract it again at pleasure.

8. *Vespertilionidæ.*—Small sharp-snouted bats, with long tails, entirely included in the angularly-prolonged inter-femoral membrane. The premaxillæ are usually medially separated, and the middle finger has only two phalanges, except in Thyroptera tricolor. Two sub-families are included:—Vespertilioninæ consist of those bats which have *i.* $\frac{2}{3}$, and have post-orbital processes on the frontal bones. This includes the common British long-eared bat, Plecotus, whose large ears are united together medially, and which has *p.* $\frac{2}{2}$, *m.* $\frac{3}{3}$. Synotus, the barbastelle, has also large ears, whose outer angles are prolonged in front of the eyes. The other forms have smaller separate ears. The toes have only two phalanges in Thyroptera. The premaxillæ are united medially by cartilage in Natalus, by bone in Furipterus. The premaxilla is extended forwards, bringing the incisors in the line with the molars in Kerivoula. Our smaller common bats belong to the genera Vesperugo, Scotophilus, and Vespertilio. The last-named has crescentic simple nostrils, and the outer margin of the ear ends opposite the base of the tragus, while the two other genera have the outer edge of the ear extending towards the angle of the mouth. In Vesperugo the teeth are *i.* $\frac{2}{3}$, *p.* $\frac{2}{2}$ or $\frac{1}{1}$, while in Scotophilus they are *i.* $\frac{1}{3}$, *p.* $\frac{1}{2}$. Miniopterus has a greatly elevated crown, raised above the face line. In some species of

Vesperugo (sub-g. Glischropus) the base of the thumb and sole of the feet are occupied with fleshy pads. Nycticejinæ have $\frac{1}{3}$ incisors and no post-orbital processes, and are Asiatic (Nycticejus), American (Atalapha), or African (Otonycterus). The last-named has very large united ears.*

CHAPTER XL.

Apes and Monkeys.

Order XV. *Primates* (*Linnæus p.*)—Disco-placentalian, claviculate mammals, with a flat nail on the hallux, which is generally opposable, and in the vast majority the other digits are also armed with flat nails, and the pollex is either rudimental or opposable. The brain is rounded and proportionally large, the olfactory bulb being much reduced, and overlapped by the cerebrum. The dentition is *i.* $\frac{2}{2}$, *c.* $\frac{1}{1}$, *p.* $\frac{2}{2}$ or $\frac{3}{3}$ (in Arctopitheci and Platyrhines), *m.* $\frac{3}{3}$ ($\frac{2}{2}$ in Arctopitheci). The orbits are surrounded by a complete bony ring, and are usually more or less closed externally, and directed forwards, their axes being parallel, and the lachrymal foramen is placed within the edge. The face is comparatively hairless, except about the mouth in males. The base of the skull is shorter, and the facial angle larger than in other mammals (*Camper's* facial angle is the angle included between two lines drawn, one from the auditory meatus to the lower edge of the ala

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* The Plecotine genus Corinorhinus has two lateral rounded eminences, posterior and external to the nostrils, overlapping them, forming a kind of foreshadowing of a sella, while the confluence below of the ali-nasal cartilages appears to represent an inchoate ferrum equinum.

nasi, the other from the forehead to the ala nasi). The symphysis of the lower jaw early ankyloses. The carpus has an os centrale (except in man, gorilla, and chimpanzee), the scaphoid and lunar are always separate, and the trapezium is always present and well marked. The femur has no third trochanter, but has a round ligament, and does not give origin to the extensor muscles of the toes. The tibia and fibula are always separate. The uterus is single, simple; the mammæ two, pectoral; the aorta gives off a right brachio-cephalic, a left carotid, and a left subclavian artery. There is only one (right) superior vena cava, a simple stomach (except in Semnopithecus), a moderate intestine, and a small cæcum.

The basi-cranial axis is much shorter than the cranial cavity, and the foramen magnum is on the under surface of the skull, so that a portion of the weight is behind the cranio-spinal joint; hence the ligamentum nuchæ is weak. The radius and ulna are fully developed, capable of free pronation and supination, and always provided with a long and short supinator, and a round and a square pronator. The cerebrum has an opercular lobe, a calcarine sulcus, and a posterior horn to the lateral ventricle; it overlaps the cerebellum completely. There is an imperforate clitoris, a very small umbilical vesicle and allantois; the testes are in a scrotum, and have an epididymis; there is a small vesicula prostatica, and there is one pair of Cowper's glands and of vesicula seminales. The soft palate has usually a uvula, the larynx has vocal chords, and the right lung never has a lobus azygos. The left superior vena cava is represented by a vestigial fold of the pericardium (*Marshall*), and there is a crescentic valve (greater Eustachian) guarding the opening of the inferior vena cava into the right auricle.

They all have a flexor biceps cubiti muscle, and a middle form of the coraco-brachialis. The rectus femoris is partly separate from the rest of the quadriceps extensor, and the biceps femoris has often a femoral head.

The liver has rarely more than five lobes, and always possesses a gall-bladder. The right and left lungs have three or four and two lobes respectively.

Four sub-orders are herein included:—

Sub-order I. *Arctopitheci* (*Geoffroy*).—The Oustitis, or

Marmosets, are squirrel-like, gregarious, arboreal, South American monkeys, with long, furred, but not prehensile tails, large hair-clad ears, and broad septum between the wide nostrils. The fur is silky and thick; the skull small, smooth, elongated, with the foramen magnum placed farther back than in the true monkeys; the frontal bone is flat and broad, the brain-case is rounded, and the orbits are not closely approximated. The pollex is not opposable. The foot has a long sole, short toes, and the hallux is small, and all the digits, except the last-named, are armed with hooked claws or claw-like nails. The fore-limbs are shorter than the hinder. The dentition is *i.* $\frac{2}{2}$, *c.* $\frac{1}{1}$, *p.* $\frac{3}{3}$, *m.* $\frac{2}{2}$, and the grinders have sharp cusps.

The skull has feeble supra-orbital ridges, long styloid processes, and an auditory bulla; the spheno-maxillary fissure is nearly closed by bone, and the squama occipitis is horizontal. The vertebræ are *c.* 7, *d.* 12, *l.* 7, *s.* 3, *c.* 30, with the tenth as an anticlinal vertebra. The humerus has no supra-condyloid foramen.

There is an occipital rhomboid; a dorsi-epitrochlearis; a two-headed biceps; a middle coraco-brachialis; a common flexor muscle for all the digits, that for the pollex being placed on the radial side; an extensor pollicis et indicis; an extensor minimi digiti sending off slips to the third, fourth, and fifth fingers. There are proper short muscles of the pollex and index, and a complete set of interossei. The semitendinosus has a tendinous inscription, and the gluteus maximus is small. The soleus has no tibial head; the flexor longus digitorum and flexor hallucis tendons are slightly united—the former supplies the second and fifth toes, while the latter only supplies the third and fourth. The hallux is flexed by the musculus accessorius, aided by a small slip from the flexor digitorum longus. There are four peronei, longus, brevis, quinti digiti, and quarti digiti, and the flexor brevis digitorum supplies perforated tendons to the four outer toes, those of the three outermost arising from the deep tendons, along with the lumbricales, while the innermost comes from the calcaneum. The hallux has a feeble adductor, a flexor brevis, and an abductor. In visceral anatomy they show few peculiarities. The brain has long smooth hemispheres, marked only with Sylvian, calcarine, and

Rolandian (absent, according to *Bischof*) fissures (fig. 41), the internal perpendicular fissure being absent; a posterior cornu of the lateral ventricle, a thick septum lucidum, and a hippocampus minor (this projection into the posterior cornua, of which the importance has been greatly overrated, is nothing but the internal projection of the calcarine sulcus). The flocculus is large, as is the middle lobe of the cerebellum.

The larynx is provided with a median pouch in Midas rosalia. The umbilical vesicle is distinguishable at a late period of gestation, and there are two umbilical veins, which unite below the liver.

There is one family and one genus included, Hapale, in some of whose species (Sub-genus Midas) the incisors are in a straight line, and project forwards, like the incisors of lemurs. Some of them have pencils of hairs projecting from the ears.

Sub-order II. *Platyrrhini* (*Geoffroy*).—American monkeys, with *p.* $\frac{3}{3}$ and *m.* $\frac{3}{3}$. The cusps of the molars are joined by ridges, and there is a diastema in the upper series for the lower canines. The nostrils are lateral in the snout, on account of the breadth of the nasal septum. The tympanic bone is annular, with a wide mouth and no bony meatus. The external ears are rounded and bare. The fingers all bear flat nails, and the hallux is opposable. They have usually small pollices, which are like the other fingers, and in progression they are quadrupedal, and plantigrade when on a flat surface. The tails are long, often prehensile, and the skulls generally high, rounded, and smooth. There are never cheek-pouches nor gluteal callosities present.

The vertebræ are variable, the atlas has often a prominent hypapophysis, and the spines have often back-directed hypapophyses, as in Mycetes. The dorsal vertebræ are twelve to fifteen; the lumbars three to six. They have a slight lumbar straightening of the dorsal curve. The sacrals are three true, and the caudal vertebræ are twenty-four to thirty-three, with chevron bones in Ateles and in a few others. The ribs are twelve to fifteen pairs, and the breast-bone has often two epi-coracoid processes bearing the clavicles. The scapula is transversely elongate, ridged below. The clavicle is arched. The humerus has often a supra-condyloid foramen (except in Mycetes and

Ateles), and its head looks backwards. The thumb has one small phalanx in Ateles, two in all others, and the hallux is much shorter than the other toes. The tubera ischii are everted, small, and smooth. The femur has a sesamoid on each condyle. The tibia is platycnemic. The hind-limb is longer than the fore-limb, except in Ateles.

The skull is variable in the different genera. The supra-occipital is sometimes thrown very far back, so as to lie horizontally (Chrysothrix); the floccular fossa is well marked; the tentorium is ossified, and a short spheno-parietal suture is usually present; the mastoid process is absent. The frontals early coalesce in Pithecia, and have a median crest. The orbits are enormous in Nyctipithecus, and sometimes the septum between them is membranous (Chrysothrix); the outer wall is often nearly complete; the sphenomaxillary fissure is either obliterated, or converted into a foramen. The stylo-hyal is not ossified, and the basi-hyal is wide, concave behind. The rami of the mandibles are wide and deep at the angles, and the incisor teeth are sometimes approximated and lemur-like. The premaxillo-maxillary suture early disappears. The muscular system of the tail in Ateles and the other prehensile-tailed genera is complex, and the long tendons of the extensor and flexor muscles of the tail are inserted into the developed processes of all the caudal vertebræ. The pectoral muscles are often complex.

The rudimental thumb of Ateles has its four short muscles, but the flexor digitorum sends no tendon to it. In Cebus, Chrysothrix, and Lagothrix the polliceal flexor tendon arises from the common flexor and from its radial side, as in lower forms. The flexor hallucis supplies the second, third, and fourth toes, and partly the first, while the flexor digitorum longus supplies the first and fifth. In all, the short muscles of the hallux are well developed.

The stomach is rounded, simple; the intestine moderate; the cæcum large, but with no appendix. The liver with a large caudate lobe (Pithecia), and with a prominent Spigelian. The lungs are two- or three- (left), or four-lobed (right). The laryngeal ventricles are sometimes very large, as in Mycetes, in which there are also additional sacculi between the arytenoids and the glottis. In other genera these cavities are small, but there is a large median laryngeal pouch. In Ateles this is developed between the first ring of the trachea and the cricoid cartilage, while in Mycetes the body of the os hyoides is dilated into a large, thin-walled, bony sac, which is lined by mucous membrane, and opens into the larynx below the epiglottis, which is very large; the thyro- and cerato-hyals are very small, and the thyroid cartilage is much larger proportionally than in man; the cricoid is elliptical. The arytenoids are small, with a fibro-cartilaginous prominence replacing the cuneiform

cartilages, and above them is a fibro-cartilaginous mass, in which are combined the cuneiform and cornicular cartilages: this narrows the glottis. The kidneys have generally one papilla each; the bladder is pyriform. The tunica vaginalis is a short diverticulum from the abdominal cavity, not shut off from the peritoneum; the penis has a button-like glans, and there is an elongated clitoris, wide Fallopian tubes, and an elongated uterus.

In the development of the teeth the canines appear before the last molars. The brain is nearly smooth in Nyctipithecus, having only the primary fissures developed. In Pithecia the Rolandian fissure appears, though feebly. In Mycetes there are also developed the parallel fissures, anterior and posterior. In Cebus the brain is well convoluted, and has a trace of the anterior lateral fissure and of the outer frontal convolution, both of which are absent in Chrysothrix. In Ateles the external perpendicular fissure is nearly closed, owing to the development of annectent gyri. The cerebral hemispheres always overlap the cerebellum, either barely, as in Mycetes, or else they may project so far back as to extend for one-sixth behind the hinder edge of the latter, as in Chrysothrix. In all the corpus callosum is short, the posterior cornu of the ventricle is well marked, and the lateral lobes of the cerebellum are small, overlapped by the large middle lobe, while the flocculi are large, and corpora trapezoidea are well marked.

The Platyrrhines form one family, whose component genera may be divided into three sub-families:—

1. *Aneturæ.*—Monkeys with long, but not prehensile tails, which are fully hair-clad, the vertebræ tapering to the end. This includes Pithecia, whose males bear long beards, and whose incisors often converge, and are directed forwards.

Nyctipithecus is remarkable for the enormous eyes, wide orbits, slender malars, thin nasal septum, and carnivorous habit. Callithrix have small canine teeth, pyramidal skulls, high mandibular rami, and compressed vertical incisors. Chrysothrix, the squirrel monkey, has the peculiar backward elongation of the occiput already referred to, and has its tentorial plane horizontal; its tail is scarcely prehensile, and the glans penis is rounded.

2. *Cebinæ.*—Monkeys with prehensile tails, completely hair-clad, whose terminal vertebræ are expanded laterally. These are the Capuchins of Brazil.

3. *Gymnuræ.*—Monkeys with prehensile tails, which are naked on their under surface and sensitive; the terminal caudal vertebræ expanded. These are the spider monkeys and howling apes. The former, Ateles, have rudimental thumbs, with one small (Ateles) or two phalanges,* often not visibly

* To the form with two phalanges *Spix* gives the name Brachyteles!

projecting as separate digits; the nails are convex, thick, and the tail very long. The tentorium is ossified, and there is an oblique ridge on the crowns of the upper molars from the antero-external to the postero-internal cusp. Lagothrix has a distinct thumb, a round beardless head, but has no dilatation of the hyoid bone.

Mycetes, the howling monkey, whose voice can be heard at enormous distances, has the peculiar arrangement of larynx before described, and has mandibular angles of unusual depth, in order to protect the organ of voice. The pollex is slender, and reaches to the second joint of the index.

The fossil Protopithecus, from Brazil, is a synthetic Platyrrhine tyde.

Sub-order III. *Catarrhinæ.*—Old World monkeys and apes, with *p.* $\frac{2}{2}$, *m.* $\frac{3}{3}$. The canines are large, and the anterior lower premolar has a pointed crown and a sharp front edge, which works against the hinder edge of the upper canine. The cusps of the molars are united by ridges, and there is a diastema between the upper outer incisors and the upper canines. The nostrils are close together, the septum being narrowed, and the nasal bones early coalesce. The tympanic bone has a long tubular meatus and no bulla. The tail may be rudimental, short or long, but is never prehensile, and the proportions of the limbs alter little after birth. The brain has usually four annectent gyri, a lesser hippocampus, and collateral eminences.

The catarrhine monkeys make one family, which may be divided into two sub-families, as proposed by *Geoffroy St. Hilaire.*

1. *Cynopitheci.*—Quadrupedal forms, with prominent muzzles, cheek-pouches, and with large naked callosities on the flattened tubera ischii. The larynx has usually a median sac expanding over the front of the throat, at least in males. The extremities are moderate, the hind-limbs larger than the fore, and the progression is plantigrade and quadrupedal on a plane surface.

The inner lower incisors are equal to or larger than the outer, and the cusps of the molars are united by transverse ridges. The permanent canine is cut before the last molar, and the wisdom tooth, or last molar, is usually a large tooth. The middle cervical vertebræ have short and simple spines; and the atlas has narrow transverse processes. The dorso-lumbar vertebræ are usually nineteen, of which eleven to thirteen bear ribs, and the tenth is the anticlinal. The mammillary and accessory processes are large, and may articulate on the lower dorsal and upper lumbar vertebræ. The lumbar transverse processes are lower than in man, and their tips usually point forwards. The spinal column has a single dorso-lumbar concavity directed forwards, and the lumbo-sacral angle is very obtuse. The sacrum is elongated, of three or four vertebræ; the caudals are three to thirty-one; when numerous, the foremost have chevron bones. The pre-sternum is broad; the meso-sternum long, compressed, of three to five separate sternebers, and the xiphi-sternum is small, narrow. The scapula is wider and shorter than in man; its pre-axial edge equalling its glenoid margin, but the post-scapula exceeds the pre-scapula; the clavicle is slender; the humeral head is about one-fourth of a sphere; its shaft is convex forwards, and the bicipital groove looks inward. The olecranon process is elongated above the sigmoid notch. The radial head is in advance of the ulna, and the neck lies close to the ulna. There is never a supra-condyloid, rarely an inter-condyloid foramen. The manus is long and narrow, the os centrale constant, the pisiform elongated, and a radial sesamoid is present. The ulna articulates with the cuneiform, and sometimes with the pisiform, and the pollex is short, opposable, or rudimentary (Colobus).

The ilia are long, narrow, and hollowed externally; their sacral surface rising above the sacro-iliac synchondrosis, and their crests advanced to the transverse process of the sixth lumbar vertebra. The ischia are elongated backwards in the line of the axis of the ilium, and the tuberosities are widely everted, having flat rough surfaces for the dermal callosities. The ramus of the pubis is at right angles to the ischio-iliac axis, and the symphysis pubis is long, the arch small, and the cavity of the pelvis deep and narrow. The long bones of the hind-limb exceed those of the fore-limb; the femur has a ligamentum teres and a narrow trochlea, usually a fabella on its outer condyle; the tibia has a flat skin, and the fibula is strong; the tarsus is less than half the length of the foot, and the plantar surface does not form an arched sole; the heel is flattened transversely, and the upper articular face of the astragalus is directed inwards; the ento-cuneiform has a vertically concave facet for the navicular, and articulates by a saddle-shaped surface with the metatarsal of the hallux. The hallux is thus divergent and powerfully apposable; its tip reaches usually to the middle of the first phalanx of the second toe.

The skull has supra-orbital, temporal, and occipital crests in adult males; a minute bony tympano-hyal, a cartilaginous stylo-hyal, a rudimental par-occipital, and no mastoid process, no ali-sphenoid canal, nor spheno-parietal suture. There is a post-glenoid process, often a glenoid foramen. The olfactory fossa is narrow and deep; the floccular, hollow on the periotic, is also large; the orbital plates of the frontal unite mesially between the mesethmoid and the presphenoid. The foramen magnum looks downwards, and sometimes backwards, and the basi-cranial axis forms more than five-eighths of the length of the cranial cavity. The palate is long, narrow, and its sides are parallel. The nasal bones are flat, and early ankylose. The pre-maxilla is always conspicuous on the face, and bounds the anterior nares; its suture with the maxilla, as well as the pre-basi-sphenoid suture, remains distinct until the period of the second dentition. The foramen ovale is a notch, and is completed by the periotic bone.

They possess a trachelo-acromial muscle, a gluteus quartus, a dorsi-epitrochlearis, an abductor of the fifth metatarsal, a psoas parvus, peroneus quinti digiti, no extensor of the first phalanx of the pollex nor peroneus tertius, no femoral head for the biceps, nor tibial head of soleus. The tibialis anticus is usually split, and sends a slip to the ento-cuneiform, as well as to the first metatarsal. There is a flexor accessorius, and the flexor brevis digitorum partly arises from the fascial extension of the plantaris tendon; the pedal interossei are arranged as in the hand, acting around the middle digit as an axis. The transversalis pedis has two heads only (from the second and third metatarsals). The extensor minimi digiti in the hand sends tendons to the fourth and fifth fingers, and the extensor indicis to the second and third. The extensor ossis metacarpi pollicis is split, and sends tendons to the trapezium and to the first phalanx of the pollex. The flexor pollicis tendon is an offshoot from the common flexor, and sometimes is absent. The great pectoral muscle is bilaminar; the lesser is inserted into the semi-vagina of the shoulder-joint. There is always an occipital rhomboid, often a short coraco-brachialis; the levator anguli scapulæ and serratus magnus are fused, and the brachialis anticus is chiefly external to the deltoid. The platysma resembles that of man. The compressor nasi in all is represented by loose cellular tissue. The sterno-mastoid is much smaller than the cleido-mastoid, and the omo-hyoid is feeble. The anterior belly of the digastric is usually split, and the lower part is prolonged from side to side medially.

The stomach has a wide cardiac and a narrow pyloric end. In Semnopithecus and Colobus it has three compartments, a smooth-walled cardiac pouch; a wide sacculated middle part, into which a groove leads from the œsophagus, and a narrow pyloric portion, at first sacculated, but becoming

tubular towards the duodenum. The cæcum is small, with indistinct valves, except among the baboons and Semnopitheci, and no vermiform appendix; the valvulæ conniventes in the jejunum are feeble or none. The liver may have no lateral lobe (Semnopithecus), or this portion may be small (Colobus) or moderate. The caudate lobe is sometimes large and prominent. The kidney is smooth, with one papilla; there is a penial fibro-cartilage or bone and two retractores penis muscles. The placenta is often bi-lobed or oval. The heart is rounded, with short annular tips; the aortic arch gives off a common innominate artery (from which the carotids and right subclavians arise) and a left subclavian. The larynx has a median air-sac, larger in males than in females, which in Semnopithecus extends even to the arm-pits, in Cynocephalus to the top of the sternum; this is absent in Macacus radiatus and Cercopithecus mona. The laryngeal ventricles are small; the left lung has two, the right four lobes.

The brain has an external perpendicular fissure. The corpora mammillaria are usually fused, and the occipital lobes of the cerebrum always overlap the cerebellum.

The Cynoid Catarrhine monkeys inhabit the tropical and sub-tropical regions of Asia and Africa and the Malayan Islands.

The most elongated muzzles are to be found among the baboons (Cynocephalus), which are for the most part short-tailed, and have very large canines. An allied form, with a rudimental tail of three vertebræ Cynopithecus, is found in Celebes.

Papio, the mandrill, from W. Africa, has a peculiarly-grooved blue face, red nostrils, and a white beard.

Inuus, the Barbary ape, has no projecting tail, and only four caudal vertebræ, the two foremost of which represent the pseudo-sacrals of man. Macacus, with a short tail and short nasal bones, is entirely Asiatic in distribution. These, like all the long-muzzled forms, have strong anterior tubercles to the cervical transverse processes.

All the foregoing forms have an additional (fifth) cusp on the lower hindmost molar tooth. Cercocebus, the mangabey, from Africa, which has a long tail and a much less prominent muzzle, has also five tubercles on its last lower molar.

Cercopithecus, the long-tailed African monkeys, have the first molar teeth directed backwards. They have usually a very thin inter-orbital septum.

Colobus, also African, is characterised by the rudimental condition of the thumb, which has only a very small first phalanx (or none in C. verus), and, like the Asiatic genus Semnopithecus, they have compound stomachs. Semnopithecus has also large approximated orbits, small but functional thumbs, no cheek-pouches, a small laryngeal sac, and a fifth tubercle on

the last molar. Presbytes has also a compound stomach, but has no cheek-pouches, nor has it a fifth tubercle on its last molar. Nasalis has also no cheek-pouches, a fifth tubercle, and a very prominent nose; in both these the thumb is much stronger and more actively functional than in any of the foregoing.

Many fossil Quadrumana have been met with. The Miocene Dryopithecus combines the characters of a Cynomorph with those of a Gibbon, while its canine is Anthropoid in position. Mesopithecus had the limbs of a Macaque and the teeth of Semnopithecus. Pliopithecus, from the Miocene, was allied to Colobus. Eopithecus, from the Suffolk Eocene, was probably more closely allied to the Macaques.

2. *Anthropomorpha* (*Linnæus*).—This sub-family consists of climbing, semi-erect animals, which use their fore-limbs (which are larger than the hinder) partly in progression; having a completely hair-clad body, no cheek-pouches, and a rudimental tail of four or five small vertebræ, which have only traces of the caudal muscles. They have smaller median than lateral incisors in the lower jaw, and the middle molars are provided with four cusps and an oblique ridge.

The dorso-lumbar vertebræ do not exceed eighteen, and there is no anticlinal vertebra. The lumbar mammillary processes are small, not interlocking nor articulating together. The humeral head is more than one-fourth of a sphere, and is not directed backwards, but upwards and inwards. The olecranon process is not prolonged beyond the trochlear fossa, and the forearm bones are capable of complete pronation and supination. There are five sacral and pseudo-sacral vertebræ ankylosed. The cranial cavity is more than once and a-half the length of the basi-cranial axis, and there is no alisphenoid canal. The placenta is rounded, and the funis is lateral; there is an os penis and a vermiform appendix to the cæcum, rudimental in Gibbons. They have all a facial premaxilla and a post-glenoid process. In muscular characters they for the most part resemble the Cynomorphs. The pedal flexors have a musculus accessorius from the os calcis, into which bone the plantaris is inserted. The front of the ento-cuneiform bone is convex, and the first metatarsal is inclined inwards, and the entire foot is directed inwards when the animal stands erect. There is a comparatively straight spine, with a very slight or no lumbar convexity forwards.

Hylobates, the Gibbons, are natives of the Malay Archipelago, and have

callosities on the buttocks, like the Cynomorphs. They have flat nails on the pollex and hallux, and also on the other digits. The arms are very long in Hylobates—longer than the vertebral column. The hands exceed the foot, and the forearm the arm in length. The squama occipitis is nearly vertical, and there is a spheno-parietal suture. The frontals separate the ethmoid from the presphenoid by a median bridge of union within the cranium. The sternum is broad; the ribs twelve (H. leuciscus), thirteen (H. agilis), or fourteen (H. Lar. and syndactylus). The last lumbar transverse process is not broad, and is free from the ilium, and the dorso-lumbars are eighteen. The carpus has an os centrale, as in the Cynomorphs, and the trapezium has a globular facet for the well-marked pollex. The permanent canine is cut after the last molar. The chin sometimes projects (H. syndactyla). There is a small weak flexor accessorius pedis, combined adductor hallucis and transversalis pedis, digital extensors as in Cynomorphs, and a gluteus quartus. In H. leuciscus the short head of the biceps is attached to the great pectoral (*Vrolik*), and in all the kidney has one papilla. The eyes are large, in lateral orbits, and the skull is small and round. H. syndactylus, the Siamang, has a large laryngeal sac, a uvula, and the second and third toes are united. The hallux is very long. There are eight species.

Pithecus, the orang utang of Sumatra and Borneo, averages about four feet five inches to five feet two inches in height, has arms considerably longer than the vertebral column, and the lower limbs are 2′ 10″ long. The shoulders are about two feet six inches in breadth. The forearm is to the humerus as 97 : 100; the wrist is opposite the knee-joint; the pollex and hallux are short, the latter with no nail, and often with but one phalanx; the other phalanges are often curved. The dorsal vertebræ are twelve, the lumbars five; the sternum has twin centres of ossification in each sterneber; the basi-hyal is small, not much hollowed, and the stylo-hyal is sometimes ossified; there is a prespheno-ethmoid suture, the frontals not being medially coalescent, and there is a spheno-parietal suture. The supra-orbital ridges are not prominent. The nasals early ankylose. The scapula is not unlike that of man, the clavicle is straight, the carpus has an os centrale, and the femur has no ligamentum teres binding it to the acetabulum; the pelvis is long. The tarsus is to the whole length of the foot as 10 : 35, and the hallux as 1 : 4. The clavicular and sternal great pectorals are separate (*Sandifort*). The flexor accessorius is weak, and the transversalis pedis is absent; the pollex and hallux have no long flexor tendons, and the flexor hallucis arises from the outer condyle of the femur. The great pectoral is tripartite, and the flexor digitorum longus pedis supplies the second and fifth toes, while the flexor hallucis supplies the third and fourth toes; there is a separate opponens hallucis muscle.

The brain is about twenty-four to twenty-six cubic inches in bulk, about sixteen ounces in weight, and in shape is not unlike the human. It has an occipito-temporal sulcus. The tongue papillæ circumvallatæ are arranged in a V; there is no uvula. The larynx has large lateral laryngeal ventricles, which communicate, and extend down to the sternum. The cuneiform cartilages are large and curved, and the epiglottis has a broad point. The stomach has a globular cardiac and an elongated pyloric region. The kidney has but one papilla. The penis has a cylindrical glans.

Troglodytes, the chimpanzee, from tropical W. Africa, reaches the height of five feet or four feet six inches, has shorter arms, a long head, and equal arm and forearm. The shoulders are about two feet four inches in breadth, the fingers reaching to the middle of the tibia. It can easily stand erect, and has nails on the thumb and great toe. The hair is coarse, straight, and black, or dark-brown. The lower limbs are 2′ 1″ long. There are thirteen dorsal and four lumbar vertebræ, the latter showing a slight forward convexity, and the last lumbar vertebra has a wide flat process, which occasionally joins the ilium. The skull has a lambdoidal crest, but no sagittal ridge. There are large frontal sinuses in the male, which form a prominent supra-orbital ridge. The jaws are smaller relatively, in proportion to skull, than in the allied forms, and the premaxillo-maxillary suture disappears before the second dentition. There is no spheno-parietal suture, but an ethmo-presphenoidal union, and a small os planum, which does not articulate with the lachrymal. The scapula is elongated, with an oblique spine and a rounded inferior angle.

The carpus has no os centrale, the trapezium has a convex facet for the first metacarpal, and the pollex is a little more than one-third the length of the manus. The pelvis is slightly wider than that of the orang, and has an iliac fossa on each side. The pubic symphysis is long, and the ilium and pubis unite early. The tarsus is to the foot as 10 : 24, and the hallux to the foot as 5 : 12.

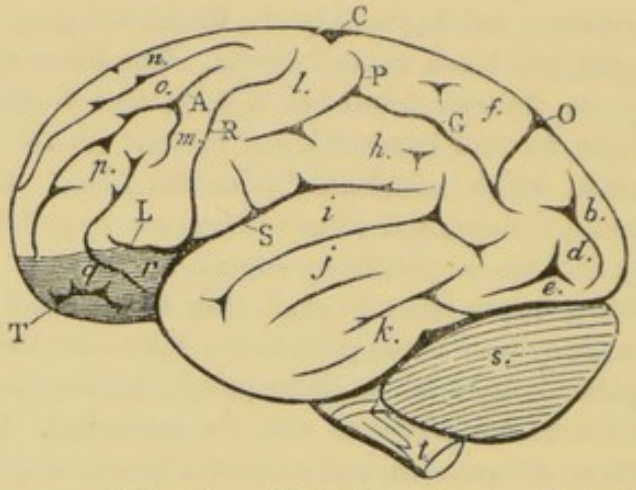
The foot has a double tibialis anticus, a weak flexor accessorius, and the flexor brevis digitorum pedis partly arises from the surface of the deep flexor, and the pedal interossei are arranged like those of the hand; the flexor hallucis longus supplies the first, third, and fourth toes, and is joined by a cross-band to the flexor digitorum, which supplies the second and fifth toes. The pronator teres has usually no coronoid origin, nor has the flexor digitorum sublimis a radial origin.

The flexor digitorum profundus manus supplies a fine filamentary tendon to the pollex, and the extensor digitorum ulnaris supplies only the fifth digit, while the indicator only supplies the index.

The serratus magnus is separate from the levator anguli scapulæ, as in all

the Anthropoids. The lesser pectoral is either inserted into the semi-vagina or into the coracoid process. The supra-spinatus is to the infra-spinatus as 10 : 15. The gluteus maximus is three-fifths the size of the g. medius and pyriformis. The flexors of the knee are to the extensors as 150 : 100. The last lower molar tooth has four tubercles and a hinder talon, and the diastema is very short. The nasal bones unite medially at about two years of age. The brain is about twenty-six to twenty-seven cubic inches in size, and about eighteen ounces in weight, and its gyri are simpler than in man. The external perpendicular sulcus is large. The cerebellum is one-sixth the size of the cerebrum. *Vrolik* notices that the inner branch of the spinal

Fig. 41.



Brain of Chimpanzee—Side View: S, Sylvian fissure; R, Rolandian fissure; C, Calloso-marginal fissure; A, anterior parallel fissure; P, posterior parallel fissure; O, internal perpendicular fissure; L, anterior lateral fissure; T, triradiate sulcus; G, meso-parietal fissure; *b*, internal occipital gyrus; *d*, middle occipital gyrus; *e*, external occipital gyrus; *f*, præcuneus; *h*, lobulus tuberis; *i*, superior spheno-temporal gyrus; *j*, middle spheno-temporal gyrus; *k*, internal spheno-parietal gyrus; *l*, ascending parietal gyrus; *m*, ascending frontal gyrus; *n*, internal frontal; *o*, middle frontal; *p*, external frontal convolution; *q*, supra-orbital gyri; *r*, front edge of opercular lobe; *s*, cerebellum; *t*, medulla oblongata.

accessory does not join the vagus, but goes separately to the larynx. I did not observe this in one chimpanzee. The tongue has its circumvallate papillæ arranged in a T-like form, and there is no uvula. The kidney has several papillæ. The larynx has smaller lateral sacs than in the orang-utang; there is a median hyo-thyroid sac, and the arytenoid cartilages are small; the epiglottis has a blunt tip, aud the cuneiform cartilages are large. The ears have a wide flattened pinna, with a wide helicoid and shallow scaphoid fossæ and a short lobe.

Gorilla, the last genus, is also West African, and is the largest of the Anthropoids. Its stature varies from five feet six inches to four feet ten

inches, and the shoulders are about two feet eight inches in breadth. It has shorter arms (3′ 6″), the elbows only reaching the lowest ribs, and the wrists to the tuber ischii, the fingers to the knee. The humerus is to the forearm as 100 : 78; the pes is to the manus as 16 : 21. The hallux and pollex both bear nails. The lower limb is about 2′ 7″ long, or to the tip of the middle toe 3′ 5″. The spinal curvatures are like those of man, but the cervical spines are all long. The dorsal vertebræ are thirteen, the lumbars four. The skull is long, has large sagittal and lambdoidal crests, and very large frontal sinuses. The jaws are enormously strong, and the frontal bones meet between the ethmoid and presphenoid. There is a spheno-parietal suture.

The nasal bones are slightly prominent, and the alar cartilages of the nose are thicker, wider, and flatter than in man. The ear is well-formed. The carpus has no os centrale; the trapezium has a saddle-shaped metacarpal facet, as in man. The heel is longer, stronger, and broader than in the others, and inclines inwards. The pollex has no flexor muscle, but may have a tendon, with no muscular fibres attached thereto. The first phalanges of the three middle toes are colligate. The tarsus is to the foot as 23 : 10, and the hallux as 1 : 2. There is a very small trachelo-acromial muscle inserted into the clavicle, a very short occipital origin of the trapezius, no occipital rhomboid, and, as in the others, there is a very feeble dorsi-epitrochlear. The lesser pectoral is inserted into the coracoid process and fascia below it; the infra-spinatus is nearly double the supra-spinatus. The pronator radii teres has sometimes a coronoid head, and the flexor digitorum sublimis had a radial origin. The extensor indicis goes only to the index finger. The gluteus maximus is equal in size to the combined gluteus medius and pyriformis, which are inseparable. The extensors of the knee are to the flexors as 100 : 97. The soleus had only a trace of a tibial head, and the peroneus tertius is absent. The last lower molar has three tubercles externally and two inner tubercles, as well as a hinder talon. There is no uvula, and the tongue circumvallate papillæ form a V. The laryngeal pouches are smaller than in the chimpanzee, and the kidneys have several papillæ. The brain is generally about thirty to thirty-five cubic inches in volume, about twenty-four ounces in weight, and its convolutions are like those of the chimpanzee. There are molar mucous glands in the mouth, and a muscular band accompanies the ligamentum pterygo-spinosum.

CHAPTER XLI.

Man.

Sub-order IV. *Anthropidæ* (*Huxley*).—This subdivision includes man, who, although distinguished from the foregoing by characters of psychical endowment, differing in kind, as well as in degree, from anything exhibited in the rest of the animal kingdom, yet structurally is closely related to the organisms of the last order, differing therefrom chiefly in adaptive characters. His fore-limbs are suited solely for prehension, and the hinder solely for progression, the hallux and its metatarsal being nearly parallel to the other toes. The surface is only covered with a rudimental hair-clothing, except in tracts such as the head, supercilia, axilla, pubes, and in the male over the mandible and upper lip.

The vertebræ are *c.* 7, *d.* 12, *l.* 5, *s.* 5, *c.* 4, and their surface epiphyses are mere marginal rings. The adult spine has four curves, cervical and lumbar convex forwards, dorsal and sacral concave forwards. The sacrum is at least as broad as long. The shaft of the humerus is longer than either of the forearm bones,* and the wide short manus has no radial sesamoid, nor separate os centrale; the phalanges are straight, not more than six times as long as their median breadth, and the end of the thumb reaches to the middle of the first phalanx of the index. The ilia are wide, concave inwards, with a marginal S-shaped crest; the symphysis is pubic, short; the ischiatic tuber-

* It is said to be shorter or equal among the Aymaras (?)

osities are everted, and the pelvic cavity is broader than long; so is its anterior outlet. The femur is the longest bone in the body, and has a keel posteriorly, the linea aspera. The ankles are large; the inner descends lower behind than in front, but the outer is lower than the inner. The tibia is long, with a sharp anterior crest. The tarsus is longer than the metatarsus, and this than the phalanges, but the whole foot is very short in comparison with the length of the leg. The calcaneum is thick at its tuberosity, and has two plantar tubercles; the pre-ento-cuneiform facet is flat, and the tibial surface of the astragalus looks upwards. There is a perfectly separate flexor pollicis longus muscle. The gluteus maximus is in man at least one and a-half times the size of the gluteus medius, and the hip adductors are larger, while the hip extensors are proportionally smaller than in any other of the Primates.

The skull has enormous anterior and middle fossæ, which mask the development of the brow ridges; its capacity is over forty cubic inches, and its cavity more than two and a-quarter times the length of the basi-cranial axis. The teeth are as in the Catarrhinæ, but there is no diastema, and the small permanent canine is cut before the second true molar. The mandible has a true chin process. The brain is very large, the cerebellum being about one-eighth of the cerebrum, and the whole weighs normally over forty ounces. The gyri are complex, a little unsymmetrical, and the occipito-temporal fissure is filled up by bridging convolutions, of which there are five.

The skin ranges in colour from white to jet black, but in infants of the darkest races it is always much lighter at birth. The colour depends on pigment granules in the deepest cells of the cuticle. The fœtus about its sixth month is clothed with a rudimental coating of short deciduous hairs,

which in direction agree with those of Catarrhines. In the adult the beard hairs are the strongest, and average about 0·135 mm. in diameter; the fine body hairs are often only ·005 mm. As a rule, fair hair is more slender than dark, in the proportion of ·05 to ·07. In general the only regions perfectly free from hairs are the surface of the eyelids, prolabia, glans penis and prepuce, the palms of the hands, and soles of the feet. In the same area the usual proportional number of hairs in Europeans are:—occiput, 225; forehead, 211; chin, 39; leg, 26; forearm, 23; back of hand, 19; thigh, 13. Among other races the development of hair varies. Thus beards are rare among most of the Turanian and American races, and some negroes have very scanty body hairs. The Ainos, of the Japanese Archipelago, the Mallicolese, and the natives of Tanna, are supposed to be the most hirsute race in the world. In some races, as in Negroes, from the curved direction of the mouths of the hair follicles, the hair is closely curled, and appears to grow in tufts.

The middle cervical vertebræ have usually short bifid spines, but the last has a very long spine: the last lumbar is a transition or lumbo-sacral vertebra, with a thick spine. In the fœtus the dorso-lumbar region has very little curvature, but the adult curves begin to show themselves at a very early age in the child, and the sacro-vertebral angle is prominent, even at an early period of childhood. The costo-vertebral joint in man is above the neuro-central suture; the first rib has flat surfaces directed vertically upwards and downwards. The axis of the ilium is vertical, and anterior to the line of the centre of gravity. The adult hind-limb is five times the length of the fœtal. The thigh-bone is much longer and larger than any bone in the body, or proportionally than it is in any other animal; it has an elongated and oblique neck, whose angle varies with age and sex. The linea aspera, or rough muscular ridge, is narrower and sharper than in other animals, and the axis of the bone can be brought into and even behind the axis of the vertebral column; similarly the leg can be absolutely brought to a right line with the thigh. The foot is plantigrade, and rests on three portions—the ball of the great toe, the fifth metatarsal, and the calcaneum; the axis of the first being the main axis of the foot.

The occipital condyles are placed farther forward on the base of the skull than in the Anthropoids, and the cranio-facial angle ranges from 90° to 120°. The cranium at birth is half the size it attains in the adult, and is two-ninths the length of the body. The face is deeper and shorter than in any of the Catarrhines. The temporal and occipital crests are faint lines on the general convexity of the skull, and the paroccipital is a small jugular process. The complexly toothed sutures often contain detached (*Wormian*) ossicles, and the mastoid processes are large and pneumatic, communicating

with the tympanic cavities. The orbital plates of the frontal are nearly flat, and do not meet medially between the mesethmoid and the presphenoid. The ethmoidal ossa plana are nearly parallel, and the maxillo-premaxillary suture is invisible on the face, as the front of the maxilla covers the entire face of the premaxilla, and unites mesially with its fellow, but the suture may remain traceable on the palate. The mesethmoid is ossified above, projecting beyond the cribriform plate as a crista galli. The maxillo-palatine suture is transverse, and there is an anterior nasal spine where the maxillæ meet medially in front. There is no ali-sphenoid foramen, nor glenoidal hole, but a small post-glenoid process.

The clavicle is the first bone to ossify, and bony growth extends into the meso-scapular cartilage externally, but the pre-coracoid forms an epiphysis at its sternal end, endosteally ossifying at fifteen to eighteen years, and joining the shaft before twenty. The omo-sternum becomes an inter-articular fibro-cartilage between it and the sternum. The scapula is broad, with a large coracoid and a wide post-scapula. The head of the humerus is one-third of a sphere, of about 33 mm. radius. The olecranon ends at the upper edge of its articular surface. The wide short manus has an ulnar, but no radial sesamoid, nor os centrale. The phalanges are straight, not longer than six times their median breadth. The adult hind-limb is five times, the adult fore-limb is three and a-half times, the length of these limbs at birth.

The acromio-trachelian, dorsi-epitrochlear, occipital rhomboid, and brachio-laterales muscles only appear as very rare anomalies, and are not normally present, even in rudiment. There is always a separate long flexor muscle for the pollex, and an extensor of its first phalanx (not present in any other mammal). There is a coronoid head for the pronator radii teres, a radial head for the flexor digitorum sublimis, a tibial origin for the soleus, a single tibialis anticus, and a femoral head for the biceps flexor cruris. The psoas parvus and pyramidalis abdominis muscles are oftener absent than present (1 : 10 and 1 : 2 respectively). The gluteus quartus is rarely separate, but the pyriformis is always distinct from the gluteus medius. The flexors and extensors of the knee are tolerably equal, and there is a pre-malleolar third peroneus muscle from the lower third of the fibula to the fifth metatarsal; this peroneus tertius does not exist in any other mammal.

The flexor digitorum brevis arises from the calcaneum, not from the deep tendons. The foot interossei act from the middle of the second digit, not the third; hence the plantar are adductors of the third, fourth and fifth toes respectively, while two of the dorsal inter-ossei are attached to the second, one to the third, and one to the fourth toe.

The middle point of the body in the fœtus is at the umbilicus; in the adult male it is at the lower one-tenth of the abdominal linea alba.

The brain is very large. That of the European male averages about 46·8 ounces; of the Mongol, 46·6; of the Negro, 44·0; of the American Indian, 44·7; of the Australian, 41; of Bushman, 38; of the Tasmanian (now extinct), 42; of the Malay, 44 ounces. There is, however, a considerable variety observable in these weights: thus of a small series of Chinese brains the males averaged 50·45, the females 45·55, and in a number of Pelew Islanders the average was 49·37, while in one set of English brains the weight was 48·146.

The gyri are complex, and a little unsymmetrical. The occipito-temporal fissure is filled. The convolutions of the temporal and frontal lobe are proportionally large, and the Sylvian fissure is interrupted behind. The spinal cord in the adult ends at the second lumbar vertebra.

The penis has no bone and a triangularly ovate glans. There is a somewhat flask-like vesicula prostatica, and the prostate gland surrounds the urethra.

There is one species of man, including several races, varying in complexion, form, and many other respects. Some of the most important of these race-characters are derived from the shapes of the skull. If the length of the cranium be taken as a unit, the breadth may vary proportionally from 0·99 to 0·62, this proportion being called the cephalic index. Skulls above ·80 are brachycephalic, those below it are dolichocephalic.

To intermediate forms the following names are given:—Brachistocephalic (index from ·85 upwards), Eurycephalic (from ·85 to ·83), Mecocephalic (from ·74 to ·71), Mecistocephalic (from ·71 downwards). The observed limits have been ·97 and ·62.

Other skull forms, though scarcely ever constant as race characters, are the following:—Cymbocephalic, elongated and laterally compressed, often keeled above, as among the Eskimos; when exaggerated this is called Scaphocephalus, and is medially carinate, exceedingly long and beaked fore and aft, co-existing often with a closed sagittal suture. Klinocephalic skulls are saddle-shaped, with a median transverse depression. Cylindrocephalic and trigonocephalic skulls are of the shapes indicated by their names. Plagiocephalic crania are laterally unsymmetrical or oblique. Microcephalic skulls may have a capacity as low as 65·6 *c. i.*, while Macrocephalic crania may rise to a capacity of 121·6 *c. i.* Acrocephalic or Hypselocephalic skulls are those where the altitudinal index (height : length) exceeds the latitudinal (breadth : length), while Tapeinocephalic, including those of the lowest races, are the reverse.

When the cranio-facial angle (or that between the facial axis and the

basi-cranial) is comparatively small (87°–100°) the face is said to be orthognathic; when the angle is greater (100°–120°) the jaws project, and the face is said to be prognathous, as in Negroes. Prognathism, however, may depend on any one of three conditions—1, Disproportionate size of the facial bones (Macrognathism); 2, Obliquity of the facial axis and projection of the maxillæ (true or maxillary Prognathism); or, 3, Simple obliquity and projection of the upper alveolar arches (alveolar Prognathism). Two groups of brachy- and dolicho-cephali must be distinguished—the one in which the skull is well filled (Crania latiores of *Cleland*); the other in which it is ill-filled, falling in between the prominent points (Stenocephalic, Angustiores). Prognathism, elongation of the basi-cranial axis, Tapeinocephaly, absence or diminution in length of the spheno-parietal suture, and diminution in length of the pre-auricular portion of the skull, are signs of degradation (*Rolleston*). The opposite conditions are associated with superiority.

Other important characters to be noticed in the skeletons of different races of men are the various inter-membral indices, or relative lengths of different parts. These are shown in the following Tables:—

I. *Inter-membral Index—Length of Humerus and Radius, that of Femur and Tibia being* 100.

Irishmen,	69·60	Australians,	69·00
Negroes,	68·77	Bushmen,	·87
Europeans, average,	69·73		

II. *Humero-radial Index—Length of Radius, that of Humerus being* 100.

Irishmen,	73·95	Negroes,	79·40
Australians,	74·00	Gorilla,	78·50
Chimpanzee,	90·20	Orangs,	95·70

III. *Femoro-tibial Index—Length of Tibia, the Femur being* 100.

Irishmen,	84·0	Average European,	81·6–85
Negroes,	88·2	Australians,	82·0
Gorillas,	82·2	Chimpanzees,	83·0
Orangs,	86·2	Bushmen,	78·0

IV. *Femoro-humeral Index—Length of Humerus, the Femur being* 100.

Irishmen,	70·2	Negroes,	70·7
Australians,	70·6	Chimpanzees,	95·5
Gorillas,	112·2	Orangs,	129·1

V. *Radial Length compared with that of Tibia and Femur* = 100.

Irishmen, . . .	29·60	Average Europeans, .	29·55
Negroes, . . .	30·38	Australians, . . .	29·10

VI. *Humeral Length compared with that of Tibia and Femur* = 100.

Irishmen, . . .	29·60	Average Europeans, .	40·11
Negroes, . . .	38·20	Australian, . . .	39·3

VII. *The Stature being* 100, *the following are the relations thereto of the parts of the Skeleton.*

	Australians.	Europeans.	Negroes.	Bushmen.
Humerus and radius, .	35·4	33·68	34·70	35·1
Femur and tibia, . .	51·5	49·60	50·65	51·2
Radius, . . .	15·1	14·15	15·19	15·3

	Australians.	Europeans.	Negroes.	Bushmen.
Humerus, . . .	20·3	19·50	19·50	20·0
Tibia, ...	22·6	22·18	23·25	23·8
Femur, ...	28·6	27·51	27·42	27·7

The whole arm (minus the hand) in man is to the spine as 79 : 100; in the gorilla, 92 : 100; in the chimpanzee as 96 : 100; in the orang as 112 : 100. The leg (minus the foot) is to the spine in man as 113 : 100; in the gorilla as 96; in the chimpanzee as 90; and in the orang as 88. The length of the trunk (clavicle to perineum) is to the whole stature as 35·4 : 100 in man. In the gorilla it is 44 : 100.

There are many variable structures in the human body, such as the convolutions of the frontal and occipital lobes of the brain; the folds of peritoneum; the arrangements of the portions of the intestinal canal; the blood-vessels and certain of the muscles, such as the biceps, palmaris longus, omo-hyoid, digastric, pectorals, coraco-brachialis, pyramidalis abdominis, psoas parvus, &c. Certain relative proportions are likewise variable,

as the relative lengths of the ring and index fingers in the hand, and of the first and second toes in the foot. Certain bones are liable to variations, such as the sphenoid, malar, and lachrymal. The femur also often varies in the degree of the development of its carina, and the tibia may depart from its usual triangularity in section, and become platycnemic, having only two angles, instead of three.

The following parts and structures, not normal constituents of the human body, may be occasionally present:—A lobus azygos for the right lung, a laryngeal sacculus, an œsophageal pouch, an intestinal diverticulum (the modified end of the duct of the umbilical vesicle), a ligamentum conjugale costarum, a right aortic arch, a secondary spleen.

Among muscles the following, found in lower animals as normal constituents, have been found occasionally in man:—Panniculus carnosus developed as sternal rectus, &c., levator claviculæ, trachelo-acromial, occipital rhomboid, dorsi-epitrochlearis, anconeus internus, coraco-brachialis brevis, peroneus quinti digiti.

Of bony structures the supra-condyloid process of the humerus, a basi-occipital (medial) condyle, the pterygoid bridge (ossification of Civinini's ligament, a cervical or a first lumbar rib, inter-nasal bones (*Mayer*); sesamoid bones in the outer head of the gastrocnemius, in the popliteus, in the tibialis posticus and peroneus longus tendons, &c., are also found.

The following rudimental organs are found in man:—The plica semilunaris and lachrymal caruncle (rudiments of the third eyelid and gland), *Woolner's* tip in the ear, the processus gracilis of the malleus, the vestigial fold of the pericardium, the trace of the left superior vena cava (*Marshall*), &c. The pedunculated hydatid (representing the upper end of *Müller's* duct), the epoophoron (*Wolffian* body) in the female; the sinus pocularis (urethral end of *Müllerian* duct) in the male, and among muscles the conchal and nasal fasciculi, the sacro-coccygeus and extensor coccygis muscles, &c.

The adult human body shows the remains of the following provisional organs:—The urachus, or pedicle of the allantois; the cord-like remains of the allantoic, or umbilical arteries; umbilical vein; omphalo-meseraic vessels; foramen ovale cordis; ductus arteriosus; ductus venosus.

The following points are of morphological and zoological value in the development of man:—The period of gestation is about 280 days, and the child at birth weighs about $6\frac{1}{2}$ (female) or $7\frac{1}{2}$ lbs. (male). It measures about $16\frac{1}{2}$ inches (female) to 18 inches (male), and has a brain capacity of 350 cubic centimetres (female) to 400 (male). The brain grows rapidly being 540 (m.) to 510 (f.) at two months, 900 (m.) to 850 (f.) at one year, 1360 (m.) to 1250 (f.) at ten years, and 1500 (m.) to 1320 (f.) at adult age. The various parts of the cerebrum are to each other in the adult as follows—Frontal

lobe, 41·4 per cent.; parietal, 13·7 per cent.; opercular, 7·2 per cent.; temporal, 20·4 per cent.; occipital, 17·3 per cent. The circumference of the head at birth is 14½ inches, at twenty months is 19½ inches, at 14 years 20⅔ inches, and at adult age 22 inches. The frontal sinuses develop at thirteen, the maxillary antrum has commenced to develop at birth. The clavicle begins to ossify at the fifth week of fœtal life, the lower jaw at the beginning of the sixth, the shaft of the thigh-bone a few days later. The elements of the temporal bone unite at two years of age. The four occipital segments unite at six. Ossification is completed in the thigh-bone at twenty-one, when the lower epiphysis joins the shaft, and the sphenoid joins the occipital a little later.

Male and female skeletons may be differentiated thus:—The skulls of females are lower proportionally, smaller in capacity, rounder, smoother, with weaker crests and with small air-spaces, like the frontal sinuses or mastoid cells. The forearm forms a more oblique lateral angle with the humerus at the elbow, salient inwards, the lumbar curve is proportionally greater in the female, and the pelvis is wider.

When from compression and curvature of the hair follicle the hair appears elliptical or irregular in section, and crisp and woolly, the condition is called Ulotrichism, as in Negroes. The opposite, or straight-haired condition, is called Leiotrichism. The condition of the hair is said to vary in persons of the same race, but of different complexion; thus *Pruner Bey* found that the hair of Irish blondes was oval, that of Irish brunettes was round in section; but this is liable to great variety. As a rule, the hair of aboriginal races is irregular in section.

The development of superficial hair is very variable—thus some races are quite or nearly hairless; others, like the Mallicolese and natives of Tanna, are hairy all over.

Ulotrichous races vary from olive to black in colour. They are mostly prognathous, with dark brown or black irides, with a longer forearm and leg proportionally than in the Leiotrichs, and the females have projecting nymphæ, and are often steatopygous. The mental process of the mandible is small, the cervical spines often non-bifurcate. The nasal bones are early confluent, and very little arched, and the skulls are mostly dolichocephalic. These woolly-haired races have very little facial hair.

The races herein included are the Negroes, Bushmen, Hottentots, of Africa; the Negritos, of the Melanesian Archipelago; the Semangs, of Malaya; the Andamanese (who are brachycephalic).

In these races there is often a considerable disproportion in size between the sexes—thus the male Andamanese average about 64 inches in height, the females 59. This is noticeable in other races—thus the male Javanese

measures 5′ 6″, the females 4′ 9½″; the male Australian 5′ 6″, the females 4′ 11″.

The Leiotrichi are more numerous, and are divisible into several groups, which are not very clearly marked off from each other. The most clearly defined group we may call Australioid. They are dark, with wavy hair, usually not very abundant, and irregularly circular in section. The skulls are dolichocephalic, prognathous, with small or no frontal sinuses, a small spheno-parietal suture. The pre-auricular skull area is shorter than in other races, the cranial capacity is small, and the last molar teeth are large. The last lumbar and first sacral vertebræ are often ankylosed, and the male pelvis is transversely narrowed.

The races which belong to this group are the Australians, the Veddahs of Ceylon, Lepchas of Sikkim, Khonds, Yenadies, Iroolers, and other aboriginal tribes of India, the Guanches of Teneriffe, possibly the ancient Egyptians. In some of these races, as in the Queenslanders, the children are almost white when born. In others, as in the Guanches, there is in the humerus often a supra-condyloid foramen.

The second, or Turanian, group are for the most part yellowish brown, or tawny coloured, with straight long hair on the head, and very little on the face. The skulls are acrocephalic or brachycephalic, rarely long, as in the Western Eskimos, Tschutches, and Ainos. The faces are mostly prognathous, with oblique eyes, often strong tegumentary folds across the inner canthus (called epicanthus).

The Chinese, Birmans, Tartars, Polynesians, Malays, Eskimos, Americans, Ugrians, Lapps, Eskaldunes, &c., are examples.

The third, or Iranian group, including the Shemitic and Indo-Germanic races, are for the most part Orthognathous, with pale skins and copious facial hair. They are usually dolichocephalic, and may be either fair-haired, with blue irides, as among the Xanthochroic Sclavs, Teutons, and fair Celts, or dark-haired, with brown irides (Melanochroic), as among the Iberians, dark Celts, Persians, and most of the Shemitic races. *Professor Huxley* has surmised these to be mixed Australioids and Iranians. The Xanthochroi are usually larger in stature, and more frequently brachycephalic, while the Melanochroi are smaller and more dolichocephalic.

Traces of fossil man are comparatively infrequent, except in the most recent deposits. The oldest traces hitherto recorded are those of Pliocene age described by *Desnoyers* and *Capellini*, unless the Miocene traces recorded by *Bourgeois* of Thenay be confirmed. The oldest traces hitherto found have been of a dolichocephalic, robust, small race, with platycephalic heads, very small chins, and large orbits. In Western Europe these were followed by a second, taller, dolichocephalic race, with large skulls, distinct

chins, wide cheek-bones, bowed ulnæ, grooved fibulæ, and platycnemic tibiæ.

A third, distinct, and later pre-historic race of brachycephali had short heads, a lower stature, and occasionally inter-condyloid foramina.

In the later ages, when mankind used smooth stone weapons (Neolithic, as distinguished from the rougher stone weapons of the older, or Palæolithic Age), there were two races in Britain—one the older Melanochroic, possibly ancestral to the black Celts; another Xanthochroic, possibly Cimbric in origin. The remains of the former are found in the Long Barrows; of the latter in the Round Barrows.

Modern changes are said to be taking place in the human race in several respects. The alveolar arches in civilized races are said to be shortening, and in some places there is a rapidly increasing tendency to Myopia (short-sightedness).

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THE END.