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OF THE
VERTEBRATE
ANIMALS

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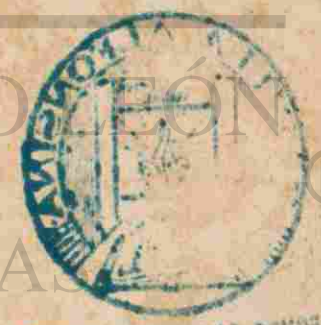

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MEMBER OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND.

NEW YORK:
J. S. REDFIELD, CLINTON HALL.
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1845.

ADVERTISEMENT.

THE want of some good elementary work in our own language, at least of one that, within a small compass and reasonable price, should express the amount of our knowledge upon the Anatomy of the several classes of Vertebrate Animals, was the chief inducement to my undertaking the translation of the present work, in the selection of which I was encouraged by the very favorable light in which Dr. RUDOLPH WAGNER had been already made known to the Medical Profession through his "Elements of Physiology," so ably edited by Dr. WILLIS. The thorough practical knowledge which he possesses of his subject, combined with the clearness and brevity of his style, render indeed his works the very best introductions that are extant to the sciences of Physiology and Comparative Anatomy.

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to clothe it in an English dress, an attempt in which I trust my labors may not be wholly without success.

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ALFRED TULK.

London, 1845.

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ELEMENTS

OF

COMPARATIVE ANATOMY.

VERTEBRATE ANIMALS.

CLASS I.—MAMMALIA.*

TEGUMENTARY SYSTEM.

The *Integument* of the Mammalia resembles in many respects that of Man, the chief differences between them occurring in the epidermis and its horny appendages. The fatty tissue beneath the skin is often developed to a surprising degree, and the corium is very thick, as appears in all large animals, such as the Elephant, Rhinoceros, and other Pachydermata. Various kinds of pigment

* Frequent reference being made throughout the text to the several Orders of Mammalia, a tabular view of the arrangement of that Class is subjoined.

Class MAMMALIA.

Order I.—Quadrumana.—Ex. *Chimpanzee, Lemur.*

II.—Cheiroptera.—Ex. *Bat.*

III. Carnivora. { Insectivora.—Ex. *Hedgehog, Mole, Shrew.* / Feræ.—Ex. *Bear, Weasel, Cat.* / Pinnipedia.—Ex. *Seal, Morse.*

IV. Marsupiata. { M. Carnivora.—Ex. *Opossum.* / M. Frugivora.—Ex. *Kangaroo.*

V. Rodentia.—Ex. *Squirrel, Rat, Beaver.*

VI. Edentata. { E. Tardigrada.—Ex. *Sloth.* / E. Ordinaria.—Ex. *Armadillo, Ant-eater, Pangolin.* / E. Monotremata.—Ex. *Ornithorynchus, Echidna.*

VII. Pachydermata.—Ex. *Elephant, Rhinoceros, Hog.*

VIII. Solidungula.—Ex. *Horse.*

IX. Ruminantia.—Ex. *Camel, Giraffe, Ox, Sheep.*

X. Cetacea. { C. Herbivora.—Ex. *Dugong.* / C. Ordinaria.—Ex. *Whale, Porpoise.*

are frequently found in the epidermis, corium, and Malpighian layer. The Cetacea approach the fishes in the texture of their corium, which is composed of an interlacement of very loose fibres, the intervals between which are filled with fluid fat. The pigmentary layer in this order is remarkably dense, often several lines in thickness, and lies directly beneath a thin, usually smooth and hairless epidermis. The layers of the epidermis frequently attain a considerable thickness, and form what are called callosities. In many of the Rodentia and Carnivora, and in the Camels, these callosities are developed into thick pads under the feet; in the Apes they form the cushions upon the buttocks. In the huge Pachydermata a similar structure prevails in connexion with the whole epidermis. True scales are met with in the tail of many animals, as in the Beaver. A horny tissue, consisting of coarse fibres, is exhibited in the structure of nails and claws, but more especially in that of hoofs and horns. Thus the horn of the Rhinoceros consists of corneous fibres, like bristles, which have coalesced so as to form a hollow cone; the individual fibres, however, have a fine cellular texture like hairs.

The most common of the horny covering of the Mammalia occurs in the form of *hairs*. A distinction of these can be made, as in the feathers of birds, into woolly hairs corresponding to *down*, and ordinary hair or *fur*. The first are very soft and slender, frequently curled, and are situated next the skin. The second kind are longer, stiffer, usually running to a fine point, and may be developed into bristles, vibrissæ, and spines. The spinous hairs are mixed with the others; they are coarser, more rigid, and generally slender at the base, bulge out externally. The fine silken sort of hairs are the connecting link with wool. The roots, follicles, and stems of hairs, have the same structure in the mammiferous class of animals as in Man. The follicles of the hairs are, however, very large in the vibrissæ of the upper lip and corners of the mouth in some Mammalia, as the Seal, where they receive nervous twigs of considerable size.

The minute structure of hair presents great differences, according to the class, order, genus, and species, to which the animal belongs. In different parts of the body even the hairs have not the same structure. They consist, as in Man, of cells, and are invested by a thin cellular layer of epithelium. As a general rule, we can distinguish a cortical and a medullary substance, which exhibit differences in the color, thickness, form, and size of their cells

The two are often very distinct, so that, as in the spines of the hedgehog, a canal is found internally, separated by transverse partitions into cellular intervals. Sometimes, on the contrary, particularly in the cervine Ruminantia (the Roe), the cortical substance appears entirely wanting, and the hair is made up throughout of coarser cells. The cortical substance is generally coarser and harder than the medullary, but frequently passes insensibly into it. The latter is in many cases wanting, as almost always in the hair of the human head, where epithelium and cortical substance are alone found, while in other situations, as upon the chin, the eyelashes, eyebrows, nose, axillæ, and pubis, the hairs possess a medullary centre. Most hairs are not round, but compressed upon one or two sides, so as to present a transversely oval section (Dasyprocta), or one that is kidney-shaped (Giraffa), or that is quadrangular (Histrix Javan.), or irregularly angular (Auchenia Llama).

The hairs upon their external surface are for the most part smooth and even, as in Man, or they exhibit slight lateral projections, as in the Squirrel, or they are knotty, as in the Bear, or provided with pointed processes like the teeth of a saw, which in some cases (Mygale) stand out only upon one side, in others (Pteropus) upon both, or they are furnished with thorn-shaped processes, as in the Cheiroptera. They are rarely found channelled, as is the case in the two-toed Sloth, by rounded longitudinal ridges and intervening grooves. The gray and grayish-white hairs of such animals as the Mole and Mouse, exhibit a variegated appearance, like the down of Birds. They are annulated with black at regular intervals, where the hair is either transparent, or else surrounded by more delicately marked rings. The spines of the Hedgehog and Porcupine do not essentially differ in structure from hair, they only seem to contain more of the same materials. Their epithelium is very much developed, and the cortical substance consists of small, elongated cells, and is of a horny consistency. The medullary tube is very spacious, and contains two kinds of cells. In the different species of the genus Erinaceus, we perceive differences in the form and size of these internal cells. In bristles, *e. g.* of the Hog, there is found a very small compressed medullary tube, and in the cortical substance a very ample cellular structure. In the several orders of Mammalia, very great differences occur, so that they can scarcely be said to have anything in common. Thus all the Apes have three substances, which vary much, however, in their relative preportions. In the Carnivora the cortical substance appears always to predomi-

nate very much over the medullary, while in the Antilopes, Musk-deer, and Goats, among the Ruminantia, the very large celled medullary substance is developed almost to the exclusion of the cortical part. The greatest and most remarkable peculiarities both of the whole internal and external structure occur in the Edentata, as has been already mentioned, *e. g.* in Bradypus didactylus. In Myrmecophaga jubata we find very greatly elongated cortical cells, and the epithelial layer of an exceedingly compact texture. In the Ornithorynchus, the spiny hairs have a broad rudder-shaped end; they are somewhat serrated, inferiorly near to the bulb, but at the apex quite entire. Still more remarkable are the fir-cone shaped scales of the Pangolin, and the coat of mail of the Armadillo. Here indeed true tegumentary bones occur, as in the Chelonia and many Fishes.

The cetacea are an exception to the rest of the Mammalia as regards their outer coverings, since their skin is destitute of hair; yet in the Whales there are short bristles growing from the integument of the upper and lower lip. The epidermis and its lower layers (Malpighian rete) are very thick, and provided with numerous pigmentary cells. The corium consists of layers of white, tough fibres, which form a network having a large quantity of fat interposed between them, while the fatty tissue in the interior of the body, as around the kidneys, where it is very much developed in other animals, is wanting. The papillary bodies are greatly developed.

Sudoriparous glands occur in the integument of many animals, though they have been hitherto most closely investigated in the domestic kinds. They are everywhere distributed in the integument of the Horse, which perspires profusely and from every part; they are generally largest in the skin of the sexual organs. They are no less numerous, though much smaller, in horned cattle; more conspicuous in the Sheep and Pig. The small sudoriparous glands of the Dog and Cat are with difficulty detected; it is only in the skin of the nose, and especially in that of the elastic foot-pads, that they are manifestly larger.

OSSEOUS SYSTEM.

The type in the Skeleton of the mammiferous animal is that of the Vertebrata generally, and of Man in particular. It nevertheless presents remarkable varieties of form in the class, which, however, are all easily understood, when they are regarded either as modifications of the human skeleton, or are viewed in relation with the element in which the animals live. The Cetacea and Edentata are farthest removed from the human type, then the Cheiroptera, Ruminantia, Pachydermata, Marsupiata, and some Insectivora, still less the Rodentia and Carnivora, and least of all the Quadrumana. According as the animals live in water and move by swimming, or inhabit cavities dug in the earth, or are organized for running or flying, or can use the extremities for seizing and tearing, will the skeleton be modified throughout, and the extremities, along with the bony arches which support them, be lengthened, shortened, or otherwise altered, until at length a very evident relationship is established with Fishes, Amphibia, and Birds.

The *Cranium* of the Mammalia, as regards the number and arrangement of its individual bones, agrees in all points with that of Man, and possesses certain peculiarities which distinguish it from the two next classes of Birds and Amphibia. The lower jaw always articulates by a single more or less convex condyle, with the skull; and the intermediate bone, called os quadratum, which is present in the other Vertebrata, is here absent. The facial bones are immovably connected to each other, while those of the cranium form a rounded skull, which is developed in an inverse ratio to the former. The sutures of the bones of the skull generally remain visible throughout life, though with age, and in particular orders, they exhibit a tendency to become obliterated. The *occipital* bone is constantly, as in Man, articulated by means of two condyles with the atlas, and is divided in the embryo into a basilar, two condyloid, and a posterior portion, all of which remain permanently detached in the lower classes of Vertebrata. The foramen magnum is usually situated quite at the back part of the skull, and in a position more or less perpendicular. It is only among a few of the Apes, and especially the young animals, that it approaches the horizontal direction which it has in Man, by being advanced more toward the sinciput. It is frequently small, and more or less triangular or quadrangular, as in the Pachydermata, sometimes, as

in the Cheiroptera, it is remarkably large. Near to, or immediately above it, there occasionally occur, as in Phoca, small persistent fontanelles. The *sphenoid* bone coalesces with the occipital at an early period, has a pair of great wings, much smaller however than in Man, while the lesser wings are often very conspicuous. The pterygoid processes of the sphenoid sometimes remain separated throughout life (Monotremata). In some Cetacea, and in Myrmecophega, they coalesce with the surface of the palatal bones. The *temporal* bone has a tympanic attached to the petrous portion, either by suture or ligament. This bony piece exhibits great differences in the several orders. In the Cetacea it is large, harder than ivory, and completely detached from the temporal. In some Apes and Makis, but especially in the Carnivora, as the Cat, and in many Rodentia, as in Dipus, it presents the form of a large, thin walled, bony ampulla. The squamous portion is for the most part low and depressed, and the mastoid process is generally very slightly developed, and is wanting in many Edentata, Pachydermata, and Cetacea. The styloid process is usually a separate ossicle, which, as regards its development, belongs rather to the lingual bones; in Man it coalesces at a late period with the temporal bone. The temporal bone consists originally in the fœtus of four pieces—the squamous, the tympanic, the petrous, and mastoid portions. The *parietal* bones are usually small and insignificant, flat, and united together at an early period in many orders, as in the Solidungula, Ruminantia, most of the Rodentia, the Carnivora, and in Manatus halicore. Between them and the expanded portion of the occipital there is developed a small ossicle, which, in Man and the Apes, coalesces at an early stage of fœtal existence with that bone. The *interparietal* is met with in many Rodentia, Marsupiata, and in Hyrax, and sometimes, though then as an abnormal production, in Man. The *frontal* bone is but slightly arched, and consists originally of two lateral portions, which in Man coalesce at an early period, but not unfrequently remain distinct. In the Apes, Cherioptera, Rhinoceros, and Elephant, we meet with only a single frontal bone, which, in the horned animals, is provided with large bony processes.

The *nasal* bones, as a rule, are double, as in Man, and mostly very long. They are very small in the Apes, where they are not unfrequently joined into a single small bone, as in the Orang-utang, and many other genera, though not in all, *e. g.* most of the American species; the same arrangement occurs abnormally in some races

of Man, as the Bushmen-Hottentots. The nasal bones are very long and conspicuous in the Solidungula and Ruminantia, and of remarkable length in the Porcupine. The Cetacea, as the Narwhal, have a pair of very small, rounded, and somewhat asymmetrical nasal bones, situated far back. The *lacrymal* bone appears to be very rarely wanting, as in the Seal and Walrus, or to become confluent with adjacent bones, as in the Ornithorynchus and Echidna. It exists only as a small imperforate plate in Manatus and Halicore, while in the rest of the Cetacea it is merely an appendage of the frontal bone. In the Solidungula and Ruminantia it is very large, and is frequently, as in the Stags, provided with a deep pit or groove for the reception of the sebaceous sacs. The *malar* bone is very seldom wanting, as in Manis; but it is very small, thin, and flattened in the ordinary Cetacea. In Myrmecophaga it presents the form of a small thin scale, which is, as in the Tardigrada and in Centetes, not united by a complete zygomatic arch with the temporal bone. In the Sloths it gives off both above and below a free and pointed process of considerable size. In the Carnivora it is very much developed, and forms a very strong arch, convex externally. Its frontal process seldom reaches the bone of that name, and it is only in the Solidungula, Ruminantia, and Makis, that the union takes place between them so as to complete the ring of the orbit externally. It is only in the Apes that an inner plate is developed like that of Man, which circumscribes completely the orbit and zygomatic groove. The *palatal* bones are small in Man and in the Apes, and most conspicuous in the Carnivora. The *vomer* is generally present, and is sometimes, especially in the Cetacea and Ruminantia, a perpendicular plate of considerable size. Numerous differences are exhibited by the *superior* and *intermaxillary* bones. The *intermaxillary*, which, in Man, is found only in the earliest fœtal period, occurs in all the Mammalia, and supports the incisive teeth, except when it is devoid of teeth, as in the Ruminantia. It is, therefore, particularly conspicuous in animals provided with large incisors, as in the Rodentia and the Elephant, where it extends far backward, abutting against the nasal bones and vomer, and more rarely still against the frontal or the malar and lacrymal bones. It is very seldom, as in the Ornithorynchus and Unau (two-toed Sloth), divided again upon each side into two portions. In many Cheiroptera the intermaxillaries are separated by a remarkable interval in the middle from each other, as in the malformation called cleft palate in Man. The *lower jaw* consists in the Apes,

Cheiroptera, Solidungula, and Pachydermata, and some few genera from the other orders, of a single piece, as in Man, both halves having become united in the median line at an early period before or after birth. In other animals both the halves remain permanently separated, and are held together only by ligamentous fibres. The lower jaw is in its simplest condition in Balæna, where it resembles a rounded arched rib. In the Dolphin it is somewhat deeper, and provided with a small coronoid process. The ascending ramus of the jaw, which is more or less conspicuous in the higher orders of Mammalia, is frequently altogether wanting, as in Orycteropus. The Carnivora have a strong and broad, the Ruminantia, as the Camel, a long and small, coronoid process. The lower border of the symphysis is in Man alone curved forward and upward, in all the Apes it slopes downward and backward. Many Mammalia, such as the Carnivora and Rodentia, have a process directed backward from the angle of the jaw, a structure which is very generally met with in Birds. The form of the articulating condyle is subject to great diversities, which usually characterize entire orders. Thus it is very small, and plays freely in all directions within a shallow glenoid cavity in the Ruminantia; it is much elongated transversely, and locked in a deep cavity of a corresponding form in the Carnivora so as to admit of no lateral motion; it is lengthened out from back to front, and chiefly moveable in this direction in the Rodentia.

Viewed as a whole, the form of the skull departs most from that of Man in the lowest orders. Thus in the Cetacea the jaws are generally lengthened out in the shape of a snout; and the cranial bones are united merely by squamous sutures. A want of lateral symmetry occurs also in this order. In the Physeter the right nasal orifice is much the larger, the nasal partition is pushed to the left side, and the nasal bones lie rather behind than by the side of each other. In the Dolphin this asymmetrical condition is extended to other bones, namely, the intermaxillaries. In the Narwhal the lower jaw itself is asymmetrical, the left half like the corresponding half of the upper jaw being the larger and broader. The skull of the Monotremata (Ornithorynchus, Echidna) is very bird-like through the early coalescence of its bones, and the snout-shaped jaws. In the higher orders the facial and maxillary bones constantly retreat farther backward. In the Horse the facial is four times larger than the cranial portion of the skull, a proportion exactly the reverse of that of Man. The depressions within the

cranial cavity for the lodgement of the cerebrum and cerebellum are in many Mammalia, *e. g.* the Dolphin, Horse, Seal, Cat, &c., separated by a bony tentorium prolonged inward from the posterior part of the parietal bones. A bony falx, as in the Ornithorynchus is seldom met with. The openings for the nerves exhibit various relations, those which are separated in Man sometimes coalescing into single apertures, others, on the contrary, remaining distinct, as the foramina incisiva. These intermaxillary apertures are particularly large in the Ruminantia, the Ornithorynchus, &c., but small in the Apes, and completely absent in the Cetacea.

The comparison of the form of the skull of the higher Apes with that of Man is a subject of much interest. Young Orang-utangs and Chimpanzees, like all young animals, have a very rounded form of skull; and owing to the slight development of the jaws, the relation of the cranial to the facial portion approximates more closely to that of the human subject; but, as they grow up, very strong muscular ridges are developed from the skull, and the proportion of these parts then becomes equal. The cranium of a full grown Orang-utang nearly equals that of Man in size, but the capacity of its cavity is considerably less. The skull of the Chimpanzee ranks next to the human cranium, and there are even forms of the latter, as of persons born deficient in brain and intellect, which sink to the same proportions as those of the Chimpanzee. The distinguishing osteological characters in the skull of the Orangs (S. satyrus and troglodytes) from that of Man are as follows: There is a remarkable interval between the canine and incisor teeth in the upper, and between the canine and molar teeth in the lower jaw; the original development of the intermaxillaries is much more conspicuous, and the foramina incisiva are removed farther back from the incisor teeth; the foramen magnum, which in Man falls immediately behind a median line drawn transversely across the base of the skull, lies much further back and is more slanting; the articulating condyles of the occipital are smaller; the petrous bone and the jaws are much more strongly developed; the nasal bones are flattened and blended together; the mastoid and styloid processes of the temporal, and the crista galli of the ethmoid are wanting.

The *Vertebral Column* exhibits great constancy in the number of vertebræ in its cervical region. There are most generally seven; Manatus and Rytina have six, the three-toed Sloth has nine cervical vertebræ, both of these being very rare exceptions. The cervical

vertebræ are generally broad and shallow, very long in some Ruminantia, as the Giraffe, very short, thin, lamellated, and partly anchylosed together by their bodies and arches, in the Cetacea, as the Dolphin and Whale. A fusion and partial anchylosis occur also in some Edentata, *e. g*, the Armadilloes, Dasypus, and Chlamyphorus. The atlas is often very large, and the second cervical vertebra has very generally a processus dentatus. The average number of the dorsal vertebræ is, as in Man, 12. Most Apes have from 12 to 14; the Cheiroptera most frequently 11; the Carnivora usually 13; the Ruminantia, Edentata, and Pachydermata 15 to 20; the Cetacea, 11 to 18; the greatest number, 23, occurs in the two-toed Sloth. The spinous processes are for the most part straight and frequently very long, as in the Solipedia, Ruminantia, Pachydermata, for the attachment of the ligamentum nuchæ, and form what is called the withers. In the higher Apes they stand obliquely, as in Man, and cover each other like tiles. They are seldom wanting as, in Cheiroptera and some Insectivora. The lumbar vertebræ are generally the largest, and in a few instances have inferior spinous processes, *e. g*. the Hare. Their number is from 3 to 7; seldom more. The Anthropoid Apes have mostly 4, the rest of the Mammalia usually more than 5; the smallest number is 2 (Myrmecophaga didactyla), the highest 9 (Loris). In the Solidungula, more rarely in the Pachydermata and Ruminantia, the transverse processes of the most inferior lumbar vertebræ are united by ligaments or blended together, a condition which sometimes occurs abnormally in Man. The *sacrum*, as a rule, is very narrow, straight, and composed of from 2 to 5 vertebræ united together; the Monotremata, the Loris, and most of the Marsupiata, have only 2, the Mole has 6. It consists in the Orangs of 4 united vertebræ (in most other Apes of 3), and is in them broad like the human sacrum, and slightly concave. In the Ornithorynchus, the sacral vertebræ, remain permanently separated. The sacrum is exceedingly broad and anchylosed inferiorly to the pelvis in Dasypus. Caudal vertebræ are very generally present, but, as in Man, they are reduced in some of the higher Apes to 4 or 5 aborted vertebræ. They are usually very numerous—20 or 30, and in some Edentata even 40, and beyond that number. The first caudal vertebræ are very similar in form to true vertebræ; they have the usual processes, and very generally inferior spinous processes also. Toward the end of the tail they always dwindle gradually in size, lose their processes, and become simple ossicles, resembling the phalanges of the

fingers. A universal characteristic of the vertebræ of a mammiferous animal is this: the anterior and posterior surfaces of their bodies are either flat or slightly concave, and collected together by ligament. It is rare for the cervical vertebræ to have, as in the Horse, an articulating cavity posteriorly, and in front a very convex head.

The *Ribs* correspond in number with that of the dorsal vertebræ. They are for the most part long, flat, and sometimes very broad from before backward, as in some Edentata, *e. g*. Myrmecophaga didactyla, where they are in contact in that direction, and even overlap each other like tiles, so as to form a kind of coat of mail; occasionally, however, they are very small and rounded, as in Manatus. The ribs are mostly connected, as in Man, with two vertebræ, and their transverse processes; in the Monotremata, however, they articulate only with the vertebral bodies. In the Cetacea the posterior ribs hang down from the transverse processes alone. In front, the ribs are furnished with their costal cartilages, which in some orders, as the Edentata (also in the Cheiroptera and Cetacea), have a great tendency to become soon converted into bone, and thus into a series of sternal ribs, as is constantly the case in birds. The number of true ribs (those which are attached to the sternum) is usually greater than that of the false, though the Cetacea have far more of the latter; the Whales have in fact only one or two true ribs. The Seals, on the contrary, have the greatest number of true ribs. In the Monotremata, the anterior rib-bones are attached by distinct capsular joints to the sternum, and the last costal cartilages are expanded into broad thin plates.

The *Sternum* is very generally divided into three portions, the middle one of which, or the body, in place of being represented by a single piece, as in the adult human subject, usually consists of as many pieces as there are true ribs present. In most cases even in the Cetacea, the sternum is broad and compressed from before backward, but more rarely in the lateral direction; it is very short in the Cetacea, very long in the Carnivora and Edentata. The manubrium sterni presents considerable differences, but generally receives the clavicles, when present, and the first two ribs. It is very broad and conspicuous in the Edentata, and in the Cheiroptera and Monotremata is prolonged into a transverse process, so that it has the form of a T. In the Cheiroptera, the Armadilloes, and the Mole, there is a crest upon the antero-inferior surface of the manubrium for the attachment of the large and powerfully developed pec-

toral muscle. In the Elephant and Horse, the whole sternum is very much compressed latterly. The ensiform process is frequently short and pointed, sometimes, however, it is very long, and expanded behind into a thin cartilaginous disc, as in Myrmecophaga, Dasypus, Manis, and some Rodentia; in some Edentata it extends nearly to the pelvis. In the Ant-eaters the anomaly is exhibited of the costal cartilages passing between two portions of the sternum so as to meet and become united from opposite sides. In the Monotremata the manubrium and body of the sternum are united by a capsular articulation. Many of the pieces of the body of the sternum frequently coalesce, as in the Horse and Elephant.

The *Scapular Arch* presents very many differences. A *Scapula* is generally present; it is very broad even in the Cetacea, and has for the most part a spine, though that may be but slightly developed, as well as a coracoid process. The latter, which is wanting in Phoca, is very long, on the contrary, in the Cheiroptera. The scapula is remarkably long and narrow in the Mole, and its form is similar though of smaller proportion in the other Insectivora, as Sorex. It is small also in the Ruminantia, throughout which order the acromion is wanting along with the clavicles. In many Rodentia a hook-shaped process arises from the spine posteriorly, as in Lepus. The broadest and most peculiar shaped scapula is seen in the Edentata. In the Cheiroptera its form approximates the human, frequently more so than that of the Apes, where it is, as in the Chimpanzee, longer, and the neck, as in the Orang-utang, usually very broad.

The *Clavicle* is completely wanting in the Cetacea, Ruminantia, Solidungula, Pachydermata, and some of the Rodentia and Carnivora, as Phoca, Ursus, Nasua; it is found very small, flat, and simply imbedded in the flesh in the Dog and Hyena, but larger in the Badger, Otter, and Cat, where it is represented by a sickle-shaped rib-like bone. It is present in the Marsupiata and Insectivora. Among the latter the Mole has a very remarkably formed, short, quadrangular clavicle provided with a joint for articulation with the humerus. In some Rodentia it is small, connected merely with the sternum, and does not extend as far as the scapula. In the Cheiroptera it is very large and strongly arched. In the Quadrumana it agrees for the most part in form with that of Man, though it is proportionately thicker and stronger, as in the Orangs.

The *Humerus* is in general a rounded and long bony tube, but exhibits most remarkable differences. In swimming and fossorial

animals it is very short, as in the true Cetacea, and in many of the digging and aquatic Mammalia. On this account it frequently obtains quite a peculiar breadth, being provided with singular processes or inequalities of surface for the attachment of muscles, as in the Mole and Monotremata. It is on the other hand longest and thinnest in the Cheiroptera, and in all the Apes, especially the Gibbons, Orang-utang, &c. It is much longer in the very anthropoid Chimpanzee, than in Man. The inferior articulating extremity is formed into one or two pulley-like surfaces for connexion with the bones of the fore-arm. The olecranal fossa is perforated in different Apes, Carnivora, and Rodentia. There occurs also frequently in these orders, as also in many Edentata and Marsupiata, an opening in the internal condyle for the passage of the median nerve and brachial artery. The structure of the scapular and humeral bones in the Monotremata—Ornithorynchus, and Echidna, is of a very opposite character, the scapular arch in them being arranged according to the type of the Saurians. The scapula is long and sabre-shaped, and, with a peculiar piece situated more inferiorly, and connected with the sternum, which corresponds completely with the coraco-clavicular bone in Birds, forms an articulating cavity for the humerus. The thin anterior clavicle, corresponding to the furcular bone, unites with that of the opposite side, and is firmly supported by the anterior border of the T-shaped manubrium sterni. Beside these, there lies upon each side a peculiar quadrangular bone between the manubrium and the coracoid, which reminds us of a similar structure in the Lizards.

Still greater differences are met with in the bones of the *Fore-arm* and *Hand*, especially the latter. The element in which the animals live, whether air or water, upon or beneath the surface of the earth, has a special influence upon these parts, which are further modified by particular wants and modes of existence. In general, we find two bones in the fore-arm, which admit of a greater degree of rotation in the Quadrumana, the Carnivora, and Marsupiata, than in the remaining classes. This motion is however less even in the higher Apes, than in Man, and pronation and supination are much more limited. The ulna is constantly longer than the radius, and provided with an olecranon of variable size, which is all but absent in the true Cetacea, where the two short bones of the fore-arm lie immovably behind each other, and are very flat like the whole extremity, which is constructed after the fashion of a fin. Even in the Rodentia and Insectivora, the radius which

lies anteriorly is very slightly moveable. In the Mole it gives off superiorly and anteriorly a free hook-shaped process. In the Edentata in particular, the ulna is very long, and its large olecranon often provided with hook-shaped processes. In the Seals both bones of the fore-arm, as well as the humerus, are bent in a peculiar manner in the form of an S. In those herbivorous quadrupeds which are organized for rapid motion, both bones lie behind each other, are immoveably united, and more or less anchylosed. The latter is the case in some Pachydermata, such as Dycotyles and Hippopotamus, but not in the Elephant. In the Horse the ulna has an olecranon of considerable size, but which soon becomes thinner and blends with the very upper portion of the radius, far from its inferior extremity, so that the latter bone is the main support of the leg. The construction is similar in the Cheiroptera, where the perfectly rudimentary, short and spine-shaped ulna frequently has appended to it a discoid olecranon, comparable to a patella, as in Pteropus, Nycteris, Rhinolophus, &c.

The *Carpus* always consists of several small variously shaped bones ranged in a double row, the number of which varies between 5 and 11; very frequently there are 8, as in Man, or 7, 9, or 10, as in the Apes. The first or posterior row exhibits in the Rodentia, Carnivora, and Marsupiata a tendency to a reduction of the number (4), by the first two bones uniting so as to form a scapholunar bone, as in the Hedgehog, while the anterior row is increased to 5, by the interposition of an additional ossicle between the scaphoid, os magnum, and cuneiform bones. The pisiform bone is frequently of considerable size, and serves as a point of attachment to a flexor muscle of the hand. The Whales have only from 3 to 5 dice-shaped carpal bones lying between thick tendons and masses of ligament. In the very broad hand of the Mole, there is superadded to its internal border an 11th very large and sickle-shaped bone.

The *Metacarpus* consists for the most part of five elongated bones, which dwindle down to four and three in the Rhinoceros, and in the Ruminantia and the Horse to a single bone, though in the latter animal there are two shorter styloid appendages, which are the rudiments of two of the lateral metacarpal bones. Five fingers are usually met with, whereof the thumb is frequently rudimentary, and consists only of a single small bone, which is also occasionally wanting. The Ruminantia have generally two fingers; the hinder claws, however, and their small phalangeal bones,

are to be viewed as farther rudiments of phalanges. The number of phalanges in a finger is seldom diminished to two (which is the usual number in the thumb), or increased to 6 or 11 in the longest finger, as in the Cetacea, where the Whale has 5 to 6, and there are even more in the Dolphin. In the Solidungula, and also in the Ruminantia, the posterior phalanx of the finger is called the fetlock, the middle the coronary, and the anterior which supports the nail or hoof, the coffin bone.

Between the metacarpus and the first row of phalanges are situated very generally certain sesamoid bones, called in the Horse splint-bones. Others also lie between the first and second row of phalanges, but are often wanting. Sesamoid bones lie between the nail bones and middle phalanges, and are called in the Horse, Ruminantia, and Pachydermata, shuttle-bones. Where only one toe is present, as in the Horse, the shuttle is single, but the splint-bone double. The Edentata, *e. g.* Dasypus, Myrmecophaga, exhibit most extraordinary proportions in the relative size of their different fingers. In the Sloths the metacarpal bones are united together posteriorly, and also with the front row of phalangeal bones. The fingers of the Apes even of the higher species are distinguished from those of Man by their length and slenderness, and the greater shortness of the thumb, so that a perfect hand is found only in the human subject, theirs being more adapted for clasping trees in the act of climbing. As a rule in the Cheiroptera, the thumb only is free, and supports a claw, though this is the case sometimes with the index finger; the remaining slender, wire-like metacarpal and phalangeal bones lie within the alary membrane.

The *Pelvis* of the Mammalia is never so broad as in the human subject, and its lateral walls are always smaller, flatter, and longer. The iliac bones are broadest and most depressed in the Tardigrada, the higher Apes, and the Elephant. In the rest of the Apes, the Makis, and Carnivora, the iliac bones are much smaller and longer, and the pelvis, owing to the backward recession of the pubic articulation, are very oblique and narrow. The pelvis is much elongated in the Cheiroptera, and especially in many of the Insectivora, where it is either connected only at the pubic articulation by a small ligament, or, as in the Mole and Shrew, is open in the form of a gap. In many Cheiroptera it is completely open like that of the Bird. The pubic articulation is frequently very deep; it is formed also by the ischia, and is very often converted into bone. In the Armadilloes, as Dasypus, the ischia with the pubis are very broad,

and united to 7 or 8 sacral vertebræ. In the Apes with tuberosities, the ischia are broad and flat inferiorly, as if cut off. The spine of the ischium occurs only in the Apes. On the other hand, in some Cheiroptera and Edentata, the spines of the ischia coalesce posteriorly, or with the sacral and caudal bones, so that the sciatic notch is always converted into a true foramen. The foramen ovale is often very large, and occasionally, as in Phoca, the two bones enclosing it are very much elongated. The acetabulum has almost always a bottom, and frequently a depression for the insertion of the ligamentum teres, which latter is, however, completely wanting even in the higher Apes. The acetabulum is very seldom perforated, as in Echidna (and in all Birds). In the Ai, which has such an unseemly gait, the acetabulum is very small and shallow. From the anterior or upper border of the pubic bones there frequently arises a pointed spine-shaped eminence (*eminantia ilio-pectinea*), which is the first indication of a marsupial bone, *e. g.* in Vespertilio spectrum. In the Monotremata and Marsupiata there is constantly placed in the same situation the marsupial bone, an elongated cylindrical and triangular bone, the free point of which is directed forward. It may be regarded as formed by a partial ossification of the fibres of the external sheath of the abdominal muscles. The pelvic bones are very simple in the Cetacea, and appear sometimes to be entirely wanting, as in Manatus. In the Dolphins they consist of two simple elongated bones lying near the anal and generative organs, which converge together from opposite sides, or else, as in many Whales, are connected by a transverse piece, this rudimentary form of pelvis frequently resembling the hyoid bone of Man; in the Dugong a small V-shaped bone is the representative of the pelvis.

The *Posterior Extremities* exhibit a great general resemblance to the anterior. The *femur* preserves the human type in the different orders more than the humerus. The trochanter major is often very large, and extends beyond the head of the bone; the internal trochanter is occasionally wanting, and in a number of animals, *e. g.* Castor, Dasypus, Equus, but in the Rhinoceros especially, we meet besides with a strong process more or less in the middle, resembling a third trochanter. In the Cheiroptera the head of the straight femur lies in a peculiar manner between the two trochanters, which are of equal height. The femur is short in the Solipedia and Ruminantia, and particularly so in the Seals. In the leg, the *tibia* is always the principal bone and the main support of the femur. The

fibula presents many varieties, and is often very rudimentary. The two bones lie near to each other, but distinct in the Apes, Carnivora, and Marsupiata. The fibula is generally very strong and thick in the Edentata, especially the Monotremata, where it far exceeds the tibia in length, by a strong process projecting from it superiorly. In Orycteropus it has coalesced with the tibia superiorly; in the Sloths it reaches beyond the tibia inferiorly, and forms an articulating surface for the astragalus. In the Rodentia, *e. g.* Dipus, but especially in the Insectivora, as Talpa, Sorex, the fibula is indicated below by a distinct line marking where it has coalesced, frequently beyond its lower half, with the tibia, while a complete space remains between the two bones above. In most Cheiroptera, the fibula is reduced to a thin fibro-cartilage, which most frequently does not reach the end of the tibia. In the Horse it exists merely as a short, slender, style-shaped appendage of the tibia. It is for the most part rudimentary in the Ruminantia, where it is represented by a small quadrangular bone, lying inferiorly against the outer side of the end of the tibia. A *patella* is very generally met with, and is perhaps only wanting in some Marsupiata. It is particularly large in the Edentata and Pachydermata, and small in the Apes. The average number of the bones of the *tarsus* is seven, as in Man, in the higher orders of Quadrumana, Carnivora, and Marsupiata. The smallest number is found in the Ruminantia; which, as a rule, have five, the astragalus and scaphoid having coalesced: the Giraffe has only a single scaphoid, and altogether but four tarsal bones. The Camels and Solidungula have six (there being two scaphoids); the Edentata have mostly seven or eight. In the Ai the Anterior bones of the tarsus have coalesced mutually, and with the metacarpal bones. In the Cheiroptera the os calcis supports a long slender thread-like bone, like a spur, which bounds the alary membrane posteriorly. The os calcis has generally a long process in the Mammalia for the attachment of the tendo-Achillis; and there is frequently developed in the substance of the latter behind this bone a sesamoid ossicle, or kind of petalla, to the calcaneum. The *metatarsus* is very similar to the metacarpus, consisting in the Ruminantia of a single bone, divided, however, internally into two cavities, and having, as in the metacarpus, its original separation marked out by an external elongated longitudinal ridge; there are also, as appears especially in several Cervine animals, two style-shaped bones loosely connected with the metatarsal bone inferiorly, and which support the phalanges of the spur or dew-claws. The

metatarsal bones of the principal toes in the leaping animals are long, and partly united together, *e. g.* in the Kangaroo, Pedetes, Dipus, where three toes have only a single metatarsal of remarkable length terminating in three articular heads. The single metatarsal of the Solidungula has only a single articular head, but two style-shaped and very slender adjacent bones. Most of the remaining orders have the number of toes from 3 to 4; the Quadrumana, Cheiroptera, and most Carnivora, have 5. The number of toes is the same as the fingers, only the great toe corresponding to the thumb is frequently rudimentary, and has only one joint, or is wanting altogether, while the remaining toes have generally three phalanges each. In the Apes the metatarsal and phalangeal bones are much slenderer than in Man.

MUSCULAR SYSTEM.

The several orders and genera of Mammalia present the greatest diversities in reference to the muscles of the extremities. In the greater number of cases, especially as regards the higher orders, the muscular system may be referred to the human type. While, however, the thin flat muscles which lie beneath, and serve to corrugate the integument, are very slightly developed in Man, and are limited to particular situations (M. frontales, occipitales, platysma-myoides, &c.), they occur in the Mammalia as muscular layers spreading over the whole face, shoulder, and abdomen. In many cases they coalesce more or less together, and in those animals particularly which can roll themselves up in a ball, they form a very large thick fleshy lamina, which can be drawn like a cap over the whole back, sides, and part of the extremities, *e. g.* in the Porcupine and Hedgehog, in which last the tegumentary muscle is short, hood-shaped, very thick, and separable into two layers.

The muscular system of the Apes, even of the highest, exhibits many departures from that of Man. The muscles of the extremities are arranged according to a more analogous type. The individual mobility of the fingers is much more limited in them than in Man, and this is particularly the case with the thumb. The short extensor of the thumb is wanting; the flexor brevis is blended with the adductor; the flexor longus pollicis is not a distinct muscle, but only a tendon of the flexor digitorum communis profundus; the extensor longus pollicis forms a common muscle with that of the index and middle fingers. The want of a distinct extensor proprius digiti indicis is the more remarkable, as, through this, the Apes are deprived of the power of mimicking the action of pointing, and the index must always in their case be extended along with the rest of the fingers. The foot of the Apes is, as regards its muscular movements, more like the hand; its interossei muscles are arranged like those of the same name in the human hand, and enable the toes to spread and approximate, in their chief movement, the act of climbing. There is found further, in the foot of the Apes, an abductor longus pollicis and minimi digiti. Other arrangements of the muscular system in the Apes depend upon their incapability of maintaining the erect posture. Certain flexor muscles of the legs, as the biceps, sartorius, gracilis, semitendinosus, are invariably inserted very low down into the leg, so that the knee always appears bent in front, and the limb can not be completely extended. The rotator muscles of the femur, such as those of the buttocks, are much more feebly developed in the Apes, than in Man. The abdominal muscles are, on the contrary, much stronger in the Apes, in order to sustain more easily the weight of the viscera, in progressing upon all fours, and the femoral and inguinal rings have much wider openings. The scapula of the Apes has much stronger and more powerful muscles than that of Man, to prevent its luxation; and it is furnished with a peculiar protractor muscle, which is wanting in Man. The cervical muscles are in like manner much stronger, and implanted higher up upon the cranium, to prevent the head sinking downward. The latissimus dorsi gives off a singular muscular slip, which is attached by tendon to the olecranon process, and is especially developed in the long-armed Apes, where it serves to sling the whole arm very rapidly and powerfully forward, a movement which is of the greatest importance for dexterously grasping remote branches while in the act of climbing. The tailed Apes, those even provided with a short stump, *e. g.* Inuus ecaudatus, have a caudal muscle very highly developed, and divided into many bundles, which act as elevators, lateralizers, and depressors of the tail. In the prehensile-tailed Apes, the tail serves even as a fifth hand, and the flexor muscles are hence very much developed. In Man the facial muscles are much more separated, and subdivided into a greater number of fasciculi than in the Apes, whence arises that manifold power of expression, which serves as a reflex of the internal workings of the mind. The Apes have only a pair of strong muscular masses which surround the

mouth, and either close or protrude that part, enabling them to expose the teeth and make other grimaces.

In the Cheiroptera, the anterior extremities are modified to serve as instruments of flight. The great pectoral muscle is therefore largely developed, as in Birds, and attached to the ridge upon the manubrium sterni. It is divided into three portions. The subclavius muscle is also very strong. Two strong flexors and extensors of the fore-arm are met with, the first of which has a particularly long tendon; the pronators and supinators are however very rudimentary, and assist only in flexion and extension. The extensor and flexor muscles of the hand have very long tendons, and work rather as abductors and adductors. The anterior alary expansion is provided, as in Birds, with a peculiar stretcher.

The muscular system of the face of the Elephant is very strongly developed; those muscles, such as the levator labii superioris, zygomaticus, which act as elevators of the heavy proboscis, being very large. The M. orbicularis oris passes also superiorly over the mouth to the base of the trunk.

Throughout the several orders, the muscular system is accommodated to the form of the skeleton, and the general economy of the animal. In the Carnivora the masseter and temporal muscles are enormously developed, and form a large fleshy cushion filling up the whole of the interval between the strong zygomatic arch and the skull, upon the upper surface of which they coalesce. The muscles of the back, especially those of the nape of the neck, are very strong in those animals which have to support a large head, which in many cases is provided with horns and antlers. They arise here from the withers, or the very long spinous processes of the anterior dorsal vertebræ, and from the ligamentum nuchæ, which is attached to the back part of the skull. In the Giraffe this ligament arises as far back as the sacral vertebræ. In those hoofed animals which are organized for rapid motion, and provided also with a long and heavy trunk, the extensors of the extremities are developed to a much greater extent than their opponent flexors, and have long tendons with short muscular bellies arising from them, as is the case in the extremities of Birds.

The muscular system of the Cetacea, from their partial want or imperfect development of extremities, presents a remarkable simplicity of structure and arrangement as compared with its high condition in the Apes. The whole conformation of the skeleton and

of the muscles is like that of Fishes, and is so disposed that these animals may overcome in the easiest manner the resistance of the water in swimming. Their movements through this element, which are performed with extraordinary force and rapidity, are effected chiefly or exclusively by means of the tail. For this purpose very strong and powerful muscles are situated upon the upper and under surface of the vertebral column, and are inserted by long tendons into the horizontal caudal fin, with which these animals can give the most tremendous blows. On account of the smallness and anchylosis of the cervical vertebræ, and the immobility of the head, the muscles of the neck and its nape are but slightly separated. All the muscles, which in the other Mammalia are destined for the movement of the fore-arm, hand, and fingers, are wanting in their rudder-like extremities, while, on the other hand, the muscles of the scapula and humerus are nearly all present, but under peculiar modifications. The whole arm of the Cetacea can indeed be only moved as a fin, and in other respects the anterior extremities seem but to serve the purpose of preserving the equilibrium of the body. The dorsal fin of the Dolphins and Rorqual consists of an elastic fibrous expansion, without muscles. A considerable tegumentary muscle lies beneath the fatty layer of the skin of the back, and a smaller one, intersected by tendinous fibres, upon the belly.

In all Mammalia, without exception, a complete diaphragm exists as in Man, which is wanting or only imperfectly developed in the remaining Vertebrata. It separates completely the thoracic and abdominal cavities, but exhibits many differences of arrangement in the several families. There frequently occur in this muscle regular ossifications—in its tendinous parts in the Camel, in the fleshy portions in the Hedgehog. In the Cetacea the tendinous parts are given off from a very muscular diaphragm, which has such an oblique direction, that the thoracic cavity gains a greater extent upon the vertebral column posteriorly than anteriorly.

The other modification of the muscular system, such as those in the fossorial animals, *e. g.* the Mole, and in the Marsupiata and Monotremata, where the pyramidal muscles are particularly developed, and act as protractors of the marsupial bones, can not be further adverted to in this place.

NERVOUS SYSTEM.

The coverings of the brain and spinal-cord agree in general, in so far as the arachnoid and pia mater with its net-work of vessels are concerned, with those of Man. The dura mater usually forms a falx, which extends deeply between the hemispheres. As a general rule, the tentorium cerebelli is present, but the falx minor is nearly always wanting, on account of the large vermiform lobe of the cerebellum projecting beyond its hemispheres. The tentorium is in many Mammalia supported by a bony plate springing from the internal surface of the skull, and is particularly strong in the Cat, and other Feræ, but feeble in the Horse, Dolphin, and some of the Apes. An osseous plate is seldom found in the falx, as in many Birds; but it occurs in the Ornithorynchus. Between the laminæ of the dura mater are found the venous sinuses.

The spinal cord of the Mammalia extends considerably lower than in Man; as a rule, it reaches as far as the sacrum, though in the Cetacea it appears to terminate higher up. The nerves themselves of the Cauda equina pass out through the openings of the most complete of the caudal vertebræ. Of the two enlargements upon the cord, the posterior is wanting where there is imperfect development of the hinder extremities, as in the Cetacea; and sometimes the two enlargements coalesce so as to form a single one of very considerable size. The central canal which is present in the fœtus of Man (perhaps also in the adult) appears in very many of the Mammalia to exist during their whole life; at all events, the fourth ventricle is more or less deeply prolonged into the spinal marrow. The brain is developed in the lowest degree, and is truly bird-like in the Ornithorynchus, where the pons is very small, and there is only a rudiment of the corpus callosum present, as in the Marsupiata, while the hemispheres of the cerebellum appear more as appendages, or lateral extensions, of the very greatly developed vermiform lobe; the corpora quadrigemina form only a pair of ganglia, the posterior pair being scarcely visible; the optic thalami coalesce in the middle by a very strong commissura mollis, and the hemispheres are without convolutions. In the Rodentia, Marsupiata, and Edentata, the vermiform portion of the cerebellum is so considerable, that the hemispheres appear to recede very much; they are already more developed in the Ruminantia and Pachydermata, and are still more highly organized in the Carnivora, the Dolphin and most Apes. It is in this order of progression also that the number of lamellæ and lobuli of the cerebellum are developed, and that the ramifications of the arbor vitæ and the corpora rhomboidea within the olivary bodies, which form indistinct external projections, become manifest. Above all we meet with a pons Varolii, the size of which increases in the order above given. One peculiar organ of the Mammalia, which does not occur in Man, is the part called trapezium, a quadrangular elevated layer of transverse medullary fibres, which lies close behind the pons near to the pyramidal bodies, and abuts against the origin of the auditory and facial nerves. The corpora quadrigemina are usually very conspicuous, and very frequently provided with an internal cavity; they lie partly, as in the Marsupiata, the Edentata, the Cheiroptera, and most Rodentia, perfectly free, and are not reached by the hemispheres; they are smallest in the Apes. In the Carnivora, the posterior pair is as a rule the largest, in the Ruminantia and Solipedia, the anterior. The thalami optici increase in size inversely, in the ascending series of animals. The corpus striatum is conspicuous, especially in the lower orders, and between it and the optic thalamus there very generally occurs the broad and often band-shaped stria cornea.

In the cerebrum are found nearly all the parts of the human brain repeated with certain modifications. The corpus callosum is very rudimentary in the Marsupiata, and generally diminutive in the Rodentia, Edentata, and Cheiroptera, where it extends but a very little distance posteriorly. The corpora albicantia form as a rule only a single mass, though sometimes, as in the higher Apes, they are separated; indications of their division are also found in the Dog and other Carnivora. The pineal gland is always present, varying in form and size, and, in those animals which have the corpora quadrigemina uncovered, lies also for the most part freely exposed, as, for example, in many of the Rodentia and Edentata. The pituitary gland is of very considerable size, and situated upon a slender infundibulum. The hemispheres exhibit the greatest number of differences. The posterior lobes are either all but wanting, or so very much shortened, that the cerebellum remains quite uncovered, as in the Marsupiata, Rodentia, Edentata, and Cheiroptera. The hemispheres are moreover quite flat, or have only a very few shallow depressions, as in Lepus and Cavia; in the Insectivora also, as Sorex, Talpa, Erinaceus, they are often altogether without sulci, and in the Carnivora they frequently exhibit nothing more than a few

shallow grooves. In the small Monkeys with claws, as Midas, they are nearly quite flat. In the Dog, the Otter, and the Seal, among the Carnivora, the convolutions are far more numerous than in the Feline tribes, as is the case also in the Horse and the Ruminant. The Elephant is remarkable for a well-developed cerebrum, provided with numerous deep furrows. In the ordinary Apes the furrows are fewer in number than in the last-named orders, and are deficient in symmetry upon the two sides. The grooves are still more numerous in the brain of the Dolphin, which is so remarkable for its rounded form. The ventricles and choroid plexuses resemble those of Man; yet it is usually only the anterior and middle or descending cornu of the lateral ventricle which is developed, the posterior occurring in those orders only where the posterior cerebral lobes are present. The lesser pes hippocampi is almost always wanting, while the cornu Ammonis with the corpus fimbriatum is usually found very large, *e. g.* in the Rodentia. In like manner the fornix and septum lucidum are met with. The concretions of the pineal body are wanting. The lateral ventricles communicate in those orders which are furnished with conspicuous mammillary processes or ganglia for the olfactory nerves, namely, in the Rodentia, Ruminantia, Pachydermata, Edentata, Marsupiata, and Feræ. These ganglia form triangular, obtuse projections beneath the anterior lobes of the cerebrum.

The brain of the highest Apes, as the Orang-utang and Chimpanzee, approximates more to that of the human subject; it differs however in the very inferior proportional development of its hemispheres (the convolutions of which are at the same time more numerous and asymmetrical than in the rest of the Apes), as opposed to the cerebellum, which is still however covered by the posterior lobes of the cerebrum in old animals, as in Apes generally, *e. g.* Celeus capucinus. The digital impressions upon the cornu Ammonis occur only in the higher Apes. The brain of the Chimpanzee is more anthropoid than that of the Asiatic Orang-utang.

The nerves arise and are distributed after the human type, from which the olfactory pair exhibit the most departures. They are probably entirely wanting in the Cetacea, as the Dolphin, or are present only as very fine thread-like rudiments. In other animals they form, on the contrary, large hollow clavate organs, provided with numerous ganglia, which proceed from the mammillary processes. They are smaller and correspond with the human form in the Apes. The animals which have very small rudimentary eyes,

such as the Mole, have very delicate optic nerves. The fifth pair is frequently very much developed; the infra-orbital branch in particular is often of remarkable size, particularly in those animals that are provided with a snout, or with large vibrissæ upon the upper lip, to the follicles of which, it gives considerable branches.

ORGANS OF THE SENSES.

Organs of Vision.

It is only in the Apes that the eye is situated, as in Man, in a complete bony cavity closed both from without and within; in all the rest of the Mammalia, and also in the Makis, the orbital and zygomatic spaces blend upon the sides of the skull. Both spaces are nevertheless separated by a peculiar membrane, which is called the orbital membrane, and was formerly regarded incorrectly as muscular; it arises from the periosteum, lines the orbits funnel-wise, and consists partly of elastic tissue. It seems to act as an antagonist to the retractor muscle of the globe of the eye, protruding or pushing the eyeball forward so soon as the action of that muscle ceases.

In other respects the Mammalia in general exhibit the greatest conformity in the structure of the eye with that of Man. Yet there are some species among the Insectivora and Rodentia, for example the Talpa cæca, Spalax typhlus, Chrysocloris, living under ground, in which the eye is very rudimentary, and nearly closed by the skin, so that they possess an extremely imperfect sense of vision. The globe of the eye is here very small, but appears to contain all its principal parts. In the Mammalia the transverse diameter of the eyeball is generally the largest, as in the Whale, the Walrus, and the Seal; the sclerotic is of enormous thickness in the Whales, and in the Ornithorynchus it is enclosed by a bony plate. In the Apes and in Man the longitudinal axis of the eye exceeds the transverse in diameter. The cornea is flat in the aquatic Mammalia. Between the sclerotic and choroid lies as usual the pigmentary layer. In addition to this there occurs in many Mammalia a membrane composed of an interlacement of delicate fibres, and having a metallic brilliancy, called the tapetum. In the Ruminantia, Solidungula and Pachydermata, it has a variegated lustre of blended green and

blue; in the Carnivora and Whales a silvery or mother-of-pearl tint. The form of the pupil varies frequently in one and the same genus; thus the Wolf and Dog have a round, the Fox a perpendicular slit-shaped pupil. In the Solidungula and Ruminantia there project from the uvea upon the border of the pupil, tuft-shaped flakes of pigment, called the racemiform or sponge-like bodies.

The lens is, in some Rodentia, but particularly in aquatic animals, such as the Cetacea and Seals, very convex and spherical. The macula lutea of the retina appears, with the exception of the Apes, to occur only in the human subject. The number and mode of attachment of the muscles of the eye are the same as in Man. The tendon, however, of the superior oblique appears to be wanting to the Cetacea. With the exception of the Apes, all the Mammalia appear also to have an additional muscle, the suspensory or retractor. This is a quadrifid muscle embracing the optic nerve, the portions of which sometimes coalesce, as in the Ruminantia, into a single infundibuliform muscle. It is fixed to the sclerotic behind the cornea.

The eyebrows and eyelashes occur only in a few Mammalia, the latter being wanting in the smaller kinds. The eyelids have the usual cartilages and muscles, and the lower lid is moveable. The third eyelid, called also the haw or nictitating membrane, has a single triangular cartilage, and is met with in nearly all the Mammalia, with the exception of the true Cetacea; it contains muscular fibres, and is drawn like a curtain over the front of the eye, so soon as the retractor muscle acts upon the latter. The Apes have, like Man, no haw, but only a rudiment of it, the plica semilunaris, in the inner angle of the eye. In the Ornithorynchus, and Echidna, the eye is closed by a single circular eyelid, with a small round opening in it. Meibomian glands and a caruncula lacrymalis are frequently present; the last, however, is wanting where the haw is much developed. The lacrymal gland with its apparatus appears to be wanting only in the Cetacea; it is often very large, and in addition to it, there is found in all animals provided with a third eyelid, as the Hare, the Harderian gland (which occurs generally in Birds) well developed, two or three ducts from it opening beneath a fold of the inner surface of that lid. The mechanism for moving the nictitating membrane is not the same as in Birds. It seems to be drawn forward the more the retractor muscle acts, when the eye by being pulled back presses within the orbit against the posterior termination of the cartilage of the nictitating membrane,

and at the same time favors the escape of the secretion from the Harderian gland.

Organ of Hearing.

The most important part of the organ of Hearing, the labyrinth, exhibits throughout the Mammalia in general a complete agreement with the human structure. It is completely imbedded in the dense osseous substance of the temporal bone, and in the fœtus only is surrounded by loose bony tissue. The direction of the semicircular canals and the vestibule are in their number and situation, their histological elements, and otolithic concretions, with slight variations, similar to those of the human subject. In some instances, as in the Ornithorynchus and the Mole, where the semicircular canals are very large, they project internally into the cranial cavity. Recent accurate investigations concerning the labyrinth show also that in the individual genera and orders of Mammalia a number of minor but very interesting differences occur. The least variations occur in the vestibule of the labyrinth (which is, however, all but wanting in the Whales); the greatest in the semicircular canals. In the Cats, the Cheiroptera, and Viverridæ, these canals form the segment of a circle, in the Horse they exhibit a parabolic curve, in the Camels, Goats, and in Myrmecophaga jubata, they form a portion of an ellipse, frequently also of a spiral, as in the Antilopes and some Edentata. In the Whales they are very small, smaller than in the Field-mouse, and form a segment of a circle of scarcely 90°. The Dromedary has the largest canals, and next to them, some Seals. In many, though not in all of the Mammalia, the canals open by five orifices into the vestibule. The ampullæ also in size and situation present numerous differences; there are nearly always, however, three ampullæ present, but only two in the Sloths, none being met with upon the external canal. Of all the parts of the labyrinth, the cochlea varies most, namely, in the number of its coils. In the Whales and Dolphins, it has only $1\frac{1}{2}$ turns, though it is very large, being thus in remarkable contrast with the small canals; in Delphinus delphis it is larger than in the largest terrestrial mammal, and the spires lie upon one level. In the Hedgehog also the small cochlea makes only $1\frac{1}{2}$ turns, but is more conical; in the Seals, 2 coils are met with, as likewise in the Chamois. Most Ruminantia, the Horse, and many of the Edentata, have not quite $2\frac{1}{2}$ coils, which is the case too in Man, in the Apes, and Cheiroptera.

Bears, Cats, Dogs, and probably the Carnivora in general, have three complete coils; the Pig, the Squirrel, and other Rodentia, have nearly 4; in Cælogenys Paca nearly 5 turns are met with; in the Ornithorynchus and Echidna, on the contrary, the cochlea has only a half coil, and rather represents a semilunar cone, comparable to the cochlea of a Bird; it has, however, a modiolus and two scalæ. The size and form of the two fenestræ vary remarkably; in the Seal, for example, the foramen rotundum is three times larger than the f. ovale. The tympanic cavity offers in the class Mammalia the greatest differences of all. In Man, and in the Apes, it is completely concealed in the petrous bone; in the remaining orders, on the contrary, we find a peculiar tympanic bone which exhibits great diversities in the several orders. In the Cetacea it is large, and hard as ivory, remains completely separated from the much smaller petrous bone, and like it, is only united by ligament to the skull. In the Ruminantia, the tympanum is angular and irregular, in the Ox very cellular, and the Sheep and Goat spacious and devoid of cells. The Horse and Pig have a cellular tympanum. In many Rodentia and Carnivora, where it usually swells out into a bony bulla (very large in Dipus), the tympanum remains at least a very long time separated, or is united by means of a suture, which sometimes disappears at a later period; externally there is often appended or united to the tympanum a bony tympanic ring, which is not always complete above. The tympanic cavity extends occasionally into the other cavities of adjacent bones, *e. g.* in the Sloth, into the zygomatic arch. The membrana tympani is (except in the Cetacea) drawn in a somewhat funnel-shape inward, lies sometimes, as in the Mole, nearly horizontal, or approximates that position, as in many Carnivora and Edentata, while elsewhere it stands more perpendicularly, as in Man. The Eustachian tube is partly bony, partly cartilaginous, and always opens by a peculiar orifice behind the nasal passages within the fauces. In the Horse and Ass the Eustachian tube, upon either side, is always united with a membranous oviform purse or air-sac, which lies within the fauces, beneath the occipital bone, and is formed of mucous membrane, the sacs of either side being contiguous. The three auditory ossicles can in general be distinguished, namely, the malleus, the incus, with the os orbiculare and the stapes, and although their forms undergo considerable changes, we frequently recognise in them the human type, as in the Apes of the Old World. In those of the New World their form varies more; the opening into the stapes for

example, being very small. The three ossicles can still be recognised in the Rodentia, *e. g.* the Squirrel. The handle of the malleus is especially subject to variation; in the Carnivora it is very long, in the Sloth broad with a projecting ridge; in the Rodentia it is frequently formed like the blade of a knife. In Chrysocloris a peculiar clavate bone is found lying between the malleus and incus. Small animals not unfrequently possess very clumsily shaped ossicles, as is the case in a remarkable degree in the malleus of the Hedgehog. The stapes exhibits very interesting modifications of form. Without bearing any relation to the position of the animal in the system, it presents, for example, in the higher Apes, the Elephant, Mole, Hedgehog, Ox, only slight variations from the human form, its opening being larger or smaller, its branches equal or unequal. In some Rodentia and Insectivora, as in the Squirrel, the Marmot, the Mole, a branch of the carotid, namely, the trunk of the arteria opthalmica and maxillaris, and in Cheiroptera, the art. meningea media, pass through the stapes and the tympanic cavity; the artery between the branches of the stapes is surrounded by a bony tube which serves as a kind of bolt (pessulus) upon which the stapes rides, and is thus prevented from entering too far into the very large foramen ovale. In the Seal and other animals the branches of the stapes are very thick, and the opening therefore very small; the latter indeed disappears completely in the Walrus, the Dolphin and the Whale. Imperforate and rod-shaped, the stapes of the Ornithorynchus resembles the columella of Birds, and a similar transition of form is shown in the Sloth and Kangaroo, and, as appears from recent researches, in the Marsupiata generally. The muscles of the ossicles appear to be always two in number, as in Man, the tensor tympani and stapedius. In the Horse and Ox, there is frequently found a sesamoid bone in the stapedius muscle. The cells which in Man are found in the Mastoid process of the temporal bone, are present also in the Apes, but they frequently disappear along with that process, which is often represented by an apophysis of the occipital bone; in some instances, however, small cells extend also into the squamous and even the jugal portions of the temporal.

External to the membrana tympani there lies in nearly all the Mammalia, excepting the Cetacea, the bony meatus, which differs in length, width, and direction. Attached to it is a trumpet-shaped cartilage, the concha of the ear, which is wanting only in a few Mammalia, namely, such as live in water or under the earth, as in

the Cetacea, the Walrus, many Seals, the Mole, Ornithorynchus and Pangolins. The ears are, on the contrary, in the African Elephant, very large pendulous flaps; they are much smaller in the Asiatic species; they are largest of all in many Cheiroptera, *e. g.* Plecotus auritus, where they are nearly as long as the body, and the tragus also is greatly developed, exhibiting manifold forms throughout this order, in which the ears are very membranous. Hanging ears appear to occur in the Dogs, Pigs, and Goats, only when domesticated. In Man the cartilage of the ear consists only of one piece, while in most Mammalia three can be distinguished. The concha is the largest cartilage, and trumpet-shaped. Above the anterior part of the convex surface of the concha lies the cartilago scutiformis, which merely serves as a surface of attachment to several muscles, but does not contribute to the formation of the concha. The cartilago annularis lies over the external auditory meatus in the lower curve of the concha, to which it is united by ligament, and completes the meatus. While in Man the muscles of the external ear are only feebly developed, and that organ can be but slightly moved, very numerous muscles turn the ear of the Mammalia in all directions. In the Horse there are enumerated seventeen separate muscles, of which the depressor, adductor, and rotator, are in particular wanting in man. In many diving animals peculiar valve-shaped projections are found, by which the external meatus is closed and protected against the entrance of water; thus, for example, the narrow tortuous meatus of the Ornithorynchus has a valve externally, and in the Water-shrew the antitragus can close the external meatus at will. The external meatus is lined with a delicate skin, and contains the secretory sacs of the cerumen, which are not even wanting in the Cetacea. This last-named order presents further peculiarities, which here require notice. The tympanic cavity exhibits a very peculiar formation in the large sinuses, which are appended to it, and penetrate partly into bony cavities, which have been regarded as receptacles for large blood-vessels, but are in truth auditory sinuses, which extend partly into the cranial bones, and, partly enclosed by a peculiar smooth and shining membrane, stretch over them. The completely membranous and never cartilaginous Eustachian tube extends from a large membranous sinus, with which the bony tympanic cavity is continuous, inward and upward, to open upon the external side, very high up in the bony nasal cavity. The internal lining of this tube forms several crescentic valves, which can not however completely close its cavity. Of the three ossicles, that which corresponds to the malleus is nearly triangular, departing very much from its usual form, and being provided with a long pointed process. The stapes has only a very fine opening, or is solid. The external meatus is not formed of bone, and is excessively narrow and tortuous. The external opening of the ear is so small, that it is scarcely visible.

Organs of Smell.

All Mammalia, with the exception of the Cetacea, have an ethmoid bone, often of great breadth, the cribriform plate perforated with numerous holes, and the ethmoidal labyrinth well developed. In the Apes the ethmoid is narrower than in Man, the crista galli is wanting (even in the Orang-utang), and it exhibits few openings. It is larger and very much perforated in the Pachydermata, the Ruminantia, and especialiy in the Carnivora. Of the three turbinated bones, the inferior is in particular frequently developed to a surprising degree, and consists of a pair of much convoluted laminæ, as in the Ruminantia, some Rodentia and Pachydermata. Other Rodentia, as the Hare, Beaver, Squirrel, have more the complex structure of the Carnivora, in which the nasal cavity, though spacious in animals generally, is the largest of all. The turbinated bone is here divided into a number of jagged lateral laminæ, so that, on a transverse section, it seems like a branching tree. The nasal sinuses are generally present, but exhibit great differences in the separate orders and genera, and are least developed in the Rodentia and Cetacea. The frontal sinuses are sometimes remarkably large, the wide intercommunicating bony cells penetrating even into the temporal and occipital bones, while in many animals, as the Marten, the Badger, the Rhinoceros, they are entirely wanting. In the Ruminantia they enter the frontal prominences upon which the horns are situated. The superior maxillary cavities are small in the Apes, and disappear entirely in the Carnivora, Edentata, and Rodentia; in the Pachydermata they are of moderate size; they are very large in the Horse, and in the Ruminantia. The sphenoidal sinus is enormously developed in the Elephant, and extends even into the alary processes of that bone; yet the frontal sinuses are here wanting. The nose is formed, as in Man, partly of cartilage; its muscles are often powerfully developed, and there is a special dilator. There is found very generally also, as in Birds, a peculiar nasal gland, which is, however,

frequently wanting; it always lies upon the external wall of the nasal cavity, and where there is an antrum, it is contained within the cavity, and its duct terminates at the anterior extremity of the inferior meatus. In animals provided with a snout, the nasal cartilages are lengthened out to a tube, which is covered with muscles that move it in many directions. Frequently, as in the Hog and the Mole, there lies near to the root and in the substance of the snout a peculiar bone. Internally the snout is divided into a double tube, and the whole structure is particularly remarkable in the Elephant, where it forms that highly developed organ of touch and prehension, the proboscis, which is lined internally with a dry epithelium; its two tubes are contracted in the vicinity of the intermaxillary bones, by which the ingress of water when sucked up is prevented; it consists of very numerous longitudinally arranged muscular bundles, with tendinous contracted portions, which, when they act, shorten the proboscis, while their antagonists are transverse or oblique bundles, imbedded in a net-work of adipose tissue. In all, there are reckoned about 30,000 to 40,000 bundles. Special elevators and depressors arise from the frontal and superior maxillary bones. In the Mole, there lie upon each side of the snout four muscles, which arise from the upper jaw, and are attached by their tendons to the nasal tube, like ropes to a mast. In many Cheiroptera, as Rhinolophus, Phyllostoma, peculiar appendages, partly cartilaginous, partly membranous, and of very singular forms, are developed upon the nose. Diving animals have occasionally valves by which the nasal passages can be closed internally, as in the Ornithorynchus, where the small round nasal openings lie at the base of the snout. The seals have an annular sphincter muscle round the nostrils. In the male of Phoca cristata, the Cystophora borealis, the nose is not developed into a snout, but presents itself as a large musculo-membranous bag, into which the animal can introduce air.

The nose of the Cetacea departs from the type of the rest of the Mammalia, and is developed into the blowing canal, while it takes a perpendicular direction, and terminates superiorly in front of the fore-head, as the blow-hole. The bony nasal cavity is therefore extremely simple. It consists, for example, in the Dolphin and in the Narwhal, of a simple smooth bony canal upon either side, without sinuses or turbinated bones. The nasal or spouting opening is single in the Spermaceti Whale, the Narwhal and the Dolphin; the Whales (Balæna) have two nasal openings, and

true ethmoidal cells appear to be met with here, which are wanting in the rest of the typical Whales.

In the Dolphins, the spouting apparatus has been accurately described. Behind the velum palati the inferior part of the nasal canal, which is here single, can be shut off from the pharynx by a strong circular muscle (Musc. pharyngo-palatinus v. constrictor isthmi faucium superior). Further, superiorly above and behind the bony palate, the nasal canal is as usual divided by a septum, and each of the two passages thus formed receives the Eustachian tube of its side, and terminates, as the external nasal aperture, upon the skull in front of the forehead. The blowing apparatus with its peculiar cavities here lies upon the bones. The nasal canal passes immediately into two anterior and two posterior cavities, lying one over the other; the covering of these is formed by a couple of projecting folds or valves, one arising from the anterior, one from the posterior wall, and which leave between them a narrow transverse fold. Above the valves there lies a simple flask-shaped cavity, the neck of which passes into the external blow-hole, which communicates upon either side in front and externally with the double capacious and rounded spouting sacs, each of which presents upon its basis strong parallel rib-shaped elevations (plications of its fibrous coat); all the parts of this external apparatus are lined with a hard, dry epithelium, and are formed of a thin fibrous tissue. The whole apparatus is surrounded by muscles which lie beneath the integument and fat, and form several layers which probably dilate the blow-hole.

Organs of Taste.

The tongue in the Mammalia, as in Man, serves as an instrument of taste; in relation, however, to size, form, structure, and development of epithelium, degree of mobility, &c., it exhibits great differences. In the true Cetacea it is but slightly moveable, flat, depressed, smooth and without gustatory papillæ; this is the case also in the Dugong and Sea-cow (Manatus). In many Edentata, *e. g.* Myrmecophaga, Manis, and such like, it is very long and vermiform, smooth and viscous. In the Ornithorynchus it is covered in front with large, hard, horny spines, behind with soft villi; in the Cats among the Carnivora, with very pointed horny spines, capable of tearing; among the Cheiroptera, at least in Pteropus, partly with similar trident-shaped corneous spines, as sheaths to the papillæ. Most animals have a soft tongue covered with papillæ, of which

the papillæ vallatæ, in number, position, and size, are subject to the greatest variations. In the Apes the tongue is most like the human organ; they have from 3—4—7 cup-shaped papillæ (p. circumvallatæ) ranged in the form of a triangle, or the letter Y; there are found mostly but 2 or 3, as in the Cheiroptera, in the Horse, Dog, and other Carnivora; sometimes, however, 10 or more occur. Great and interesting varieties are here exhibited, which have not been followed out so closely as they deserve, since they certainly stand in connexion with the sense of taste, and it is in the papillæ vallatæ that the glosso-pharyngeal nerve ramifies in particular. Further examples of such varieties may be here adduced. While in Hyæna striata, and Viverra zibetha, there are only two such papillæ upon the root of the tongue, and in the Cats, eight disposed in two rows, *e. g.* the Lyon and Lynx; there are found in Ursus arctos as many as 20 arranged in an arciform manner in two rows, the posterior of which is formed of smaller papillæ; 15 in one row are found in Ursus Americanus. Among the Rodentia, Dasyprocta Aguti has a pair of peculiarly large, much elongated papillæ. The Goat has 30, 15 upon each side, forming two rows; the Stag has 20 similarly disposed papillæ. The 10 to 12 papillæ vallatæ in the Camel, in which the papillæ filiformes also are very long and thick at their roots, are very singularly formed, being large and unequally notched like molar-teeth, and surrounded by a deep fossa. There rarely lies beneath the tongue a second accessory organ, as in the Bear, or sometimes even a third.

In addition to the tongue there occur in the Mammalia very peculiar organs, probably connected indirectly with the nutritive instincts, and thus with the sense of taste, and which combine the nasal with the oral cavity. These are the Stenonian ducts and Jacobson's organs, so called after their discoverers. The latter sometimes occur when the first are wanting; though the reverse is more frequently the case. The ducts of Steno are those canals, nearly filled with dense cellular tissue, lined with mucous membrane, and frequently surrounded by cartilaginous sheaths, which lie near to each other, separated by a partition in the intermaxillary bone, behind the incisive teeth; in the skeleton they pass out by the foramina incisiva, which coalesce in Man into a common hole. The naso-palatine nerve of Scarpa enters here, and ramifies upon the nasal septum and mucous membrane of the palate. The Jacobsonian organ is particularly developed in the Ruminantia, as in the Stag and Ox, where the trumpet-shaped tubes are above four inches long, and extend anteriorly over the Stenonian canals, to the posterior border of the vomer. The Carnivora and Rodentia have in part only the Stenonian canals, while even these are wanting in the Horse.

Organs of Touch.

The tips of the fingers are alone specially constructed as organs of touch in Man; still, many Apes, as Cebus Azaræ, possess a fine tactile sense in these parts. In the rest of the Mammalia, the upper lip, the nose, and snout, especially the bristles or vibrissæ seated upon the upper lip and at the angles of the mouth, the follicles of which often receive very large twigs from the infra-orbital branch of the fifth pair, serve chiefly as organs of touch. In the common Otter the vibrissæ of the angle of the mouth receive twigs from the alveolar branch of the third division of the fifth pair, and in the Seals, the numerous ramifications of the infra-orbital form an areolar plexus, before they enter the follices of the hairs of the beard.

DIGESTIVE SYSTEM.

The organs of mastication, namely, the *Teeth*, present in the Mammalia remarkable differences in number, form, and structure, which stand in such close relation with the whole economy, mode of life and form of the animal, that its place in the system can, as a rule, be determined from a few fragments of the teeth. In some genera of the lowest orders, *e. g.* Manis, Myrmecophaga, and Echidna, the teeth are completely wanting. In others, as in the Whales, their place is occupied by mere horny laminæ, called whale-bone. The teeth occur invariably only in the intermaxillary upper and lower jaw-bones, and are generally implanted in sockets. As a rule, there are two sets of teeth, which succeed each other, the milk teeth and the permanent teeth, and these, as in Man, are divided into molar, canine, and incisor teeth, the first of these being the most universally present. Three kinds of teeth may be distinguished, 1st, Simple teeth, *dentes simplices*, in which the crown, as in man, is simply covered over with enamel. This is the case in the higher orders, the Apes, the Cheiroptera, Carnivora, Marsupiata, and many Rodentia, viz., the Mice, Marmots, &c. 2d, Enamel-folded teeth, *dentes complicati*, where the enamel is inflected into the dental substance, a form met with in many Rodentia, as Myoxus, Castor, and

Hystrix. 3d, Compound teeth, *dentes compositi*, in which each molar tooth consists of separate laminæ covered with enamel, and united by means of a softer intervening substance, called crusta, petrosa, or cementum. This structure is most clearly and strikingly displayed in the large molars of the elephant, but it occurs also in the Horse, the Ruminantia, and many Rodentia, as the Hare, the Field-mouse (Arvicola), and the Guinea-pig.

The diversities in the form and arrangement of the teeth are so great, that scarcely anything general can be said about them. It is the special province of zoology to set forth these specialities, and we shall therefore here give only a few of the prominent examples. Thus in the Narwhal a very peculiar formation and asymmetrical arrangement of the teeth occurs. There is usually found only upon one side of the upper jaw a very long spear-shaped projecting tusk, while that of the other side remains quite rudimentary, and is probably a mere deciduous tooth; the rest of the teeth are wanting. Hyperoodon has only some small teeth in the lower jaw. The Dolphins have a great many, often 200, mostly pointed teeth, in both jaws. The graminivorous Cetacea, Halicore and Manatus, have merely molar teeth with flat crowns; in the first the incisor teeth in the upper jaw are developed into long deflexed tusks. In the Ruminantia generally the superior incisor teeth are wanting in the intermaxillary bone, which in the Camels only supports a pair of incisors resembling canines. The canine teeth, with the exception of the Musk-deer and the Camel, are also wanting in the Ruminantia. In the Horse the males only have canines, but here also they are frequently undeveloped. Among the Pachydermata the canines are wanting in the Rhinoceros, in the Hyrax, which has rodent-shaped incisors, and in the Elephant, in which incisor teeth are also wanting in the lower jaw, while those in the intermaxillary project as long tusks. The Ornithorynchus has, upon the whole, above and below, four singular horny molar teeth. The incisors are wanting in all the Edentata, Dasypus sexcinctus only having two upper ones; the canines also are wanting in nearly all, and the molar teeth easily fall out. The Rodentia always have two long chisel-shaped incisors, covered only upon their anterior surface with enamel, continually growing from behind, and implanted in very long deep maxillary sockets; behind the superior pair in Lepus and Lagomys two lesser ones are found. The canines are here wanting without any exception, and we therefore meet with a great interval between the incisor and molar teeth. The herbivorous

Marsupiata approximate the Rodentia in the absence of canine teeth, and in having sometimes, as in Phascolomys, two incisors both above and below. The carnivorous Marsupiata, as Didelphis, correspond in the structure of their teeth with the Carnivora, whose molars are always furnished with more or less pointed, and frequently, as in Phoca, many jagged crowns. The more purely carnivorous the animal, and the more it feeds upon living prey, the less numerous are the molars, one of which, the largest, constitutes what is called the carnivorous tooth. The canines here become large tusks or fangs. The Cats serve as an example, in which, through the prodigious development of the canines, conspicuous intervals arise in the dental series. The Walrus has also very large canines (tusks). The Cheiroptera and insectivorous Feræ, as the Hedgehog and Mole, have broader molars, but with very pointed serræ; they are similar also in the Lemurs, the Makis and Loris; in the Cheiroptera the superior incisors are very small, and easily fall out. Among the Apes, those of the Old World have the same number of molars as Man (20); those of the New World have 24. They never however stand in old animals (even in the Orang-utang and Chimpanzee) in an uninterrupted row, but there are always, on account of the enormous development of the canines, conspicuous spaces in front of the molar teeth. In Man alone the teeth stand in one continuous unbroken row, and it seldom happens, save in the Negro races, that small intervals remain between the incisor and canine teeth of the upper jaw. It is only in an extinct race of Pachydermata, Anoplotherium, that all the teeth form an unbroken series, as in Man.

As concerns the microscopic structure of the teeth, their tubuli and enamel, &c., we are hardly prepared at present to offer any generalizations, and recourse must be had therefore to the most recent works of micrographers upon this subject. The manifold external forms and arrangements of the teeth are figured in zoological books.

The form of the *Lips* is very various. Thus many Ruminantia, like the Ox, or the Sea-cow (Manati), have a thick, moist, hairless upper lip, while in the Ornithorynchus hard horny kind of lips, shaped like the bill of a duck, occur. Many genera possess what are called cheek-pouches, that is, purse-shaped sacs, usually internal, seldom external, when they are always small, as in Cælogenys and Askomys. The Apes of the Old World, with the exception of the highest genera, have mostly small cheek-pouches; as likewise some

Cheiroptera. They are very large in the Hamster and other Rodentia, where they extend deeply down the neck, and are compressed by peculiar tegumentary muscles which arise from the spinous processes of the vertebræ, being detached from the trapezius muscle. The cavity of the mouth is usually smooth internally; sometimes, however, as in the Ruminantia, it is beset with hard tubercles, which are very hard and horny on the palate of Echidna. The palate is frequently provided with deep transverse furrows and projecting elevations. Some Rodentia, such as the Beaver and Hare, have a spot upon the inner surface of the cheek beset with hairs. The velum palati is more or less scooped out into a semilunar form; the uvula is wanting in nearly all animals, even in the Makis; and in the Apes where it occurs, it is smaller than in Man. In the Elephant the velum palati is very long; as also in the Cetacea, where it is drawn very far back. The mucous glands are more or less developed; in the zygomatic groove in the cheek, they not unfrequently form a ragged conglomerate gland (glandula buccalis), with several excretory ducts, which sometimes extends even into the orbit and zygomatic fossa. The tonsils are generally met with; they are largest in rapacious and carnivorous animals, as in the Bears and Cats; they are, on the contrary, very small in the Mustelidæ; in the Rodentia they are most feebly developed, and exhibit in general great diversities in the several orders. In the Apes even they are different. In the Lion and some other Cats, each tonsil forms a sac, in which the fluid secreted accumulates. A peculiar formation occurs in the Camel; there is here found a singular development of the velum palati, which is called the bursa faucium, as a moveable duplication of the velum containing many glands, which occurs in its full development only in the male, and in the rutting season swells out so much as to protrude from between the teeth.

The *Tongue* has already been considered as the organ of taste. In some animals, as the Dog and Cat, there is found in its middle line covered by flesh a band-shaped fibro-cartilage, called the worm. The lingual or hyoid bone is generally present, but exhibits very diversified forms. It is in its simplest condition in the scaly animals, as the Manis, where it forms only a slender arch, and exhibits no traces of peculiar cornua. It is of considerable size, and provided with two cornua in the Ornithorynchus and Echidna; in the latter the posterior cornu consists of three pieces. In the Cetacea, as the Dolphin, the body of the lingual bone is flat, and there are

two pairs of tolerably conspicuous cornua. In the Ruminantia, the body represents a small bow, and the anterior cornua are united with a very long styloid process, a peculiar bone in itself. The structure in the Horse is similar, only the body is larger, and the anterior cornua consist of single pieces; in both orders, as in the Pachydermata, the posterior cornua are anchylosed to the body, and very short, as in the Elephant and Rhinoceros especially. The posterior cornua are generally the longest in the Rodentia, and particularly in the Marsupiata, among which they are least in Didelphis, and their pieces are elongated and slender, as is also the case in the Carnivora. In most Apes the anterior cornua are elongated, or as long as the posterior, and simple. In the Orangs the anterior cornua are small, as in Man, in whom they are very small, and far surpassed in size by the posterior pair. In the howling Apes (Mycetes), the body is expanded into a very large, thin-walled, bony bladder, in which the voice formed in the windpipe resounds, and is thus rendered so remarkably loud.

The manducatory, lingual, and hyoid muscles present themselves generally in the Mammalia, as in Man, with, however, a number of minor differences. Thus it is only in the higher orders that the digastric muscle is truly double-bellied, and is, even in the Apes, not generally perforated by the stylo-hyoideus. The omo-hyoideus is very frequently wanting, next to it, the stylo-glossus, and stylo-hyoideus. As a rule, there is developed a peculiar masto-hyoid muscle, which draws the styloid bones powerfully backward.

The *Œsophagus* is short and very wide in the Cetacea, so also in the Carnivora and Makis. It is otherwise, as a rule, long and narrow, and in many Rodentia, as the Hamster, passes far beyond the slit in the diaphragm. It has frequently a thick epithelium, and its inner surface is longitudinally plicated, but it is rarely, as in Didelphis, provided at its inferior extremity with valvular spiral folds: as a rule, it passes to the stomach without any valve. In the Horse, however, there is developed a more or less large sickle-shaped fold, which can close the cardia, and prevent the return of food, so that the Horse can not vomit.

The *Stomach* exhibits remarkable diversities. In the greater number of Mammalia it is simple, as in Man and in most Apes, where it is, however, mostly rounder than in Man, and in the Makis, has a considerable cœcal dilatation. The slender Apes (Semnopithecus) form a striking exception; here the left half forms a large cavity many times constricted, while the right is long, narrow,

and intestiniform, and puckered up by a pair of strong muscular bands, like the human colon. In Mycetes, also, at least in several species, the stomach is divided into two portions by a constriction. The stomach is always simple, and mostly very rounded (as in the Cats), in the Carnivora and Cheiroptera, least of all in the true insectivorous Bats, and in the insectivora among the Feræ, *e. g.* Centenes. In many of the Vampires it is elongated and conical, with a small cardiac cœcum. In the fructivorus Cheiroptera (Pteropus) the stomach is very long, and intestiniform with a very considerable cœcum, and has a transverse position, while in the Walrus the very much elongated stomach is without a cœcal pouch, and lies perpendicularly within the abdomen. Very many differences are exhibited by the Rodentia, among which indeed most of the genera have a simple cylindrical stomach, with a tolerably large cœcum. The stomach, however, is frequently, even when it has no visible, or but an insignificant constriction externally, divided within into two very distinct portions, as in Meriones. In the cardiac half the epithelium is continued from the œsophagus, while the pyloric is thickly beset with glands, and coated over with a soft mucous membrane; in the Beaver it has a very dense glandular layer. Frequently as in the Hamster, the division into two halves is very striking externally. There is seldom found a long glandular proventriculus, separated, as in Birds, by a constriction from the wide muscular stomach, as in the Red-dormouse (Myoxus avellanarius), but not in M. glis and nitela. In the Lemming, and in most of the Musk-rats (Hypudæus. s. Arvicola), the second or pyloric division itself is divided again into several (3) sacs or portions. The stomach is simple in most Edentata (even in the Ornithorynchus), and almost without a cœcum. The squamigerous Edentata (Manis) have a thick glandular layer in the left portion. Among the Marsupiata the stomach is simple in the carnivorous kinds; in the Kangaroo it divides into a left, middle, and right portion, and is very intestiniform. Also in the Pachydermata there occurs a complex stomach, as in the Peccari, while in the Elephant and Rhinoceros it is simple, and double in the Tapir and Hyrax. In the Horse, the stomach is simple externally; the œsophagus, however, enters the middle of the lesser curvature, and the cardiac and pyloric portions are differently constructed. The sloth has a twisted intestiniform, subdivided stomach; and in the Manati and Dugong the stomach has even two pedunculated cœcal pouches in the middle.

Still more peculiar is the stomach of the Ruminantia, in which order

it first merits the special name of a *Compound stomach*, from its being divided into four different cavities. The Sheep will serve best as a type of this structure, which, however, does not differ essentially in the Ox, Goat, &c. The first stomach is called the *paunch* (*rumen* s. *ingluvies*); it is the largest, situated most to the left side, and usually projects below into a pair of blind appendages; its inner surface presents very prominent, conical, and hard papillæ. The second stomach, the *honey-comb* (*reticulum* s. *ollula*) lies more in front, above and to the right of the paunch, is small and round, and has a similar hard epithelium upon the mucous membrane, the projecting folds of which unite to form hexagonal cells, which are beset with small pointed warts. The third, likewise small, placed more superiorly, and to the right behind the liver, is called the *psalterium* or *many plies* (*omasus*), the internal lining membrane of which forms numerous deep folds, lying upon each other like the leaves of a book, and beset with small hard tubercles. To this succeeds the fourth stomach, named *rennet* (*abomasus*), of larger size than the two preceding, elongated, and terminating in the duodenum, and provided with a velvety mucous membrane disposed in several longitudinal folds. The œsophagus enters to the right far into the paunch, but in such a manner, that what is called the œsophageal groove passes at the same time through the honey-comb into the third stomach, or many-plies. This groove consists of two longitudinal ridges of muscle and mucous membrane, which commence from the paunch as thin folds, and form in the reticulum two thicker lips, having between them a groove, which, by the approximation of its edges, can be converted into a canal. The food first reaches the paunch by the usual route, and is then regurgitated bit by bit from it back again through the reticulum into the gullet, and so into the mouth, where having been rechewed, it is swallowed and conveyed within the closed groove, between the folds of the psalterium, whence it advances into the fourth stomach. Fluids are conveyed directly through the œsophageal groove into the rennet. In the Camel and Llama the construction is essentially the same, but with some modifications. The paunch, and also the reticulum, have here a great number of peculiar shaped cells; the psalterium is very small, and nearly free from folds, and the rennet intestiniform. The cells are indicated externally as bladder-like elevations, arranged in groups. In the Cetacea (and what is remarkable, in the carnivorous kinds) compound stomachs also occur, the structure of which is best known in the Dolphins. Four stomachs are found; the first, lying to the

right, has the largest circumference, corresponds with the paunch, and is very much corrugated internally. The second is smaller, and communicates with the very extremity of the œsophagus by a large round opening. The third stomach is the smallest, while the fourth, next in size to the first, is intestiniform, very long and curved; and opens by a very small pyloric orifice into the intestine.

The *Intestinal canal* is in general portioned off by means of a valve into an anterior longer small intestine, and a posterior shorter or large intestine. In the genuine Cetacea (not in Manatus and Halicore) no limitation is found between small and large intestine, and the cœcum is wanting, as also in the Cheiroptera, many Carnivora (*e. g.* Ursus, Mustela), and in the Insectivora, while it is very seldom wanting in the Rodentia. The cœcum, elsewhere pretty generally present, is very short in the rest of the Carnivora, namely, in the Cats; it is conspicuous in the Ruminantia, still more so in the Horse, and especially in most of the Rodentia, *e. g.* Mus Cricetus, Cavia, Castor, and Lagomys, where it exceeds the stomach many times in size—in the Hare from 8 to 10 times. There rarely occur, as in most Birds, two small cœca, *e. g.* in Myrmecophaga and Hyrax. A vermiform appendix occurs in the Orangs and Gibbons, and rarely here and there throughout the other orders, as in Lagomys. In the Cetacea the duodenum commences by a bladder-like enlargement, which was once falsely regarded as a portion of the stomach. The clusters of Peyer's glands are, as a rule, considerably developed. The mesentery is usually longer than in Man, even in the Apes. A small and large omentum, traversed by elegantly disposed streaks of fat (as in the Otter), is regularly present. The insertion of the great omentum departs most from that of the human adult, and resembles more that of the fœtus. Frequently, as in the Rodentia, lumbar omenta occur, which penetrate partly into the inguinal canal, and are to be regarded as elongations of the peritoneal or vaginal coat of the testicle. In the female (as the Rat), the lumbar omenta are elongations of the round ligaments of the uterus. In the Ruminantia the great omentum forms a veil over the compound stomach; in the Carnivora it lies around the intestines. The intestinal villi are exceedingly large in the Rhinoceros, and very conspicuous in the Rodentia, and also in the Makis; they are larger in the Apes than in Man, and small in the Ruminantia. The length of the intestinal canal is most considerable in the latter, and is in proportion to the length of the body as 15 or 20 to 1; in

the Sheep even as 28 to 1; in most Carnivora, it is as 4 to 1; and in the Cheiroptera, as 3 to 1. Many animals, as the Cetacea, the Ornithorynchus, and the Mole, seem to have mere longitudinal folds upon the mucous membrane, but no villi.

Of the *Salivary glands* the three pairs of the human subject are generally present, yet they are wanting completely in the Cetacea. The Dugong (Halicore) alone has a very large parotid, which on the other hand is wanting along with the sublingual gland in the Seals. These glands are also partly wanting in the Monotremata. In general the salivary glands are largely developed in the Ruminantia, Pachydermata, and Rodentia, moderately so in the Quadrumana, and less in the Carnivora. In many Carnivora, as in the Dog, and in many Rodentia, as the Squirrel, and also in the Makis, the submaxillary glands are larger than, frequently as large again as the parotids. This is especially the case in the Beaver, where the two coalesce posteriorly in the nape of the neck, and form a large mass. The Edentata, also, especially the Kangaroo and Opossum, as likewise the Cheiroptera, have large salivary glands, with the exception of the sublingual, which, in the last-named order, is very slightly developed; in the Dog and Cat it is also very small. The submaxillary gland is very large in Myrmecophaga and Orycteropus.

The *Liver* of the Mammalia is fashioned after the human type; it is usually divided into two principal lobes, and is frequently more deeply bisected. In the Cetacea its two lateral lobes are very feebly indicated; in the Ruminantia there is found a third smaller lobe. The liver is three-lobed in the Hog and some Rodentia; most of the Rodentia, Marsupiata, and Apes, have, however, from 4 to 6, the Carnivora still more, 6 to 8 lobes, as the Dog, Cat, and Bear. The liver of the Orang is like that of Man.

The *Gall-bladder* is usually present, though it is also frequently wanting, as, for example, in the true Cetacea, many Ruminantia (Camel, Goat), the Horse, and most Pachydermata (though not in the Hog), and several of the Rodentia, as the Hamster, the Mouse, and in the Sloth among the Edentata. A biliary duct always passes to the intestine, into which, or into the gall-bladder, the excretory ducts of the liver pour their secretion. The pancreatic duct often joins just before it enters the intestine the termination of the biliary duct, which is in this situation frequently expanded in the shape of a bladder, as in the Elephant, the Kangaroo, the Otter, the Seal, &c. A remarkable peculiarity is possessed by the Orycteropus, in which two separate gall-bladders occur, united by a common peritoneal

covering; each of these is continued into a tortuous cystic duct, which unites with three ducts from the liver into a common excretory canal.

The *Spleen* is always present, but varies in form and size in the several orders. Thus it is, in general, elongated and small in the Ruminantia, Carnivora, and Makis; short, broad, and flat, in the Apes; largest, in relation to the liver, in Man. The Cetacea here also exhibit a striking anomaly, the Dolphins having from 5 to 6 lesser spleens, lying near to the larger one, which is always proportionally but slightly developed. In Man also there occurs in rare cases an abnormal subdivision of this organ.

The *Pancreas* is, for the most part, formed of two, and rarely of three, principal lobes. It has one or two excretory ducts, which last number occurs also not unfrequently in Man. When it is simple, as in all the Apes, the Ruminantia, and most Carnivora and Rodentia, it usually falls, as has been mentioned above, into the biliary duct, but if a second one is present, as in the Horse, Hog, Otter, and Beaver, it enters by itself farther behind into the duodenum.

ORGANS OF CIRCULATION.

The *Heart* consists, as in Man and Birds, of two perfectly distinct auriculo-ventricular chambers. It is surrounded by a pericardium, the lower part of which is not generally united with the diaphragm, as is the case in Man and the Orang, and is frequently, as in the Hedgehog, remarkably thin and delicate. The form of the heart is, in general, more rounded and not so elongated as in Man. In the Cetacea it is very broad and flat. In the herbivorous Cetacea (Halicore and Manatus) the heart is cleft in a peculiar manner, the division into two ventricles being indicated externally by a deep fissure in its apex. The foramen ovale is, as in Man, always closed, and only open as an accidental abnormal condition. The internal arrangement of the muscles and valves exhibits several trifling varieties; thus the Eustachian valve is wanting in many genera, while on the contrary in the Elephant it is very large and spirally twisted. In the Ornithorynchus the fleshy condition of the valves (valv. tricuspidales) in the right heart reminds us of that in Birds. In some herbivorous Mammalia, as in the Ox, Sheep, Hog, and Goat, there is found as a normal formation, in the septum ventriculorum, below the origin of the aorta, a cruciform

ossification called the bone of the heart. The heart lies, for the most part, in the median line, parallel with the sternum, rarely having its apex, as in Man, directed to the left, though this is the case in the Apes, the Sloth, and the Mole, and also in a less degree in some other animals, as the Seal.

The *Aorta* gives off first from its root the two coronary arteries, rarely only a single one, as in the Elephant. The origin of the vessels from the arch of the aorta exhibits, as is well known, frequent varieties in Man, several of which occur as normal states in the genera and orders of Mammalia. In the Horse and the Ruminantia the aorta divides at once at its origin into an anterior trunk, or arteria innominata, which gives off both carotid and subclavian arteries, and a posterior trunk for the thoracic and abdominal aorta. In most of the Carnivora, Rodentia, Marsupiata, and in the Hog, Ant-eater and Pangolin, the left subclavian artery is distinct from the innominata, and proceeds by itself from the arch. In the Dolphin and Cheiroptera, at least in Vespertilio murinus, two arteriæ innominatæ arise, and give off each a carotid and subclavian upon either side. The human arrangement, namely, with three main trunks, of which the innominata gives off the right common carotid and subclavian arteries, occurs partly in the Apes, Carnivora, some Rodentia and most Edentata. It is very rarely, as in the Elephant, that both the carotids are given off from a single common trunk, situated in the middle between the two subclavian arteries. Sometimes, as in some diving animals, as the Seals and Narwhal, the aorta forms near to its exit from the heart a sac-like expansion. The subdivisions of the arterial system exhibit a host of minor differences, which can not be entered upon further here. It is only worthy of remark, that in some animals, as the Sloth and Loris, which are remarkable for the slowness of their movements, that the arteries of the arm and leg divide at the commencement of the extremities into several (3) main trunks, two of which ramify again into a number of finer anastomosing filaments (retia mirabilia), which wind around the middle branch. Large arterial retia mirabilia occur within the skull of the Ruminantia, and are situated within the cavernous sinus, and extend even to the vertebral artery. The Cetacea have many arterial plexuses in different situations—in connexion with the intercostal and thoracic arteries in the cavity of the thorax, and upon both sides of the vertebral column from the psoas muscle to the neck.

The *Pulmonary artery*, in its mode of origin and the number of its

valves, agrees for the most part with that of Man, though there sometimes occurs, as in the aorta, a sacciform expansion of its commencement, *e. g.* in the Narwhal, and in a less degree in many of the Dolphins also. The number of pulmonary veins varies considerably, and there frequently occur upon one side a greater number than upon the other (3+2), a circumstance chiefly occasioned by the number of the lobes of the lung.

Valves occur in the *Veins* of the body, and frequently, even as in the Ox, in the portal veins, where they are wanting in Man. The trunk of the superior vena cava is very frequently double, in individual animals from all the orders, as in the common Bat, Hedgehog, Squirrel, Ornithorynchus, Elephant; as a rule, however, it is single, as in the Apes, Ruminantia, most Carnivora, &c. The inferior vena cava is commonly dilated in diving animals, previous to entering the heart, and while yet within the liver, as in the Seals; in a less degree also in the Dolphin and Otter, still less so in the Beaver and Ornithorynchus; in these it forms a true sinus, like that of Fishes. This large size of the veins, in relation to that of the arteries, exerts unquestionably an important influence upon the circulation and the process of diving; and the discovery is a remarkable one, of a peculiar annular muscle, about an inch in breadth, which is met with in the Seals on the trunk of the inferior vena cava, above the diaphragm and venous sac, and which can cut off the return of blood to the heart. In the Cetacea remarkably developed venous plexuses occur; one of these lies, *e. g.* in the canal formed by the inferior spinous processes of the tail; another much more conspicuous (*plexus iliacus*) lies between the psoas muscle and the peritoneum.

The *absorbent vessels* exhibit in general the same conditions as in Man, in reference to the chyliferous ducts. The lymphatic glands of the mesentery are usually less numerous, and more blended together, than in Man. They sometimes form only a single mass lying at the root of the mesentery, called the *Pancreas Asellii* (as in the Dog and the Carnivora generally), near to which, however, some smaller lymphatic glands usually occur. This mesenteric gland is most conspicuous in the Cetacea, where the lymphatic vessels are very much developed.

The *Blood* of Mammalia very uniformly presents small, round, disc-shaped corpuscles, very similar to, but mostly somewhat smaller than in Man; this is especially the case in the Ruminantia. The largest animals, as the Elephant, have still very small corpuscles. In the Apes they appear of the same size as in Man. There is a remarkable exception to the form of these corpuscles in the Camels and Llamas, where they are somewhat elliptical.

ORGANS OF VOICE AND RESPIRATION.

The larynx, trachea, and lungs, in the Mammalia, are fashioned after the type of the same organs in Man. In the larynx the same cartilages are met with as in Man, though the relations of their separate parts are frequently changed. In the Cetacea the larynx is very small, especially the thyroid and cricoid cartilages; on the contrary, the arytenoid cartilages and the epiglottis are very long, and reach as far as into the nasal cavity. The thyroid cartilage is very anomalous in form, and there are no chordæ vocales, since neither the Dolphins nor Whales have been heard to utter any sound. In the Pachydermata also the larynx is small, especially its arytenoid cartilages. The thyroid cartilage is long and deep, but narrow in the Ruminantia, and for the most part also in the Edentata. The Rodentia have a conspicuous larynx, and in the Carnivora especially, the cricoid cartilage is very large, often three times greater than the thyroid. The Cheiroptera are distinguished by their very small epiglottis. The lateral ventricles of the larynx, and with them the anterior chordæ vocales, are frequently wanting, as in the Ox, Sheep, Musk-deer, Armadillo, and Pangolin. In several Mammalia, as in the Apes (but not the Makis), and many Carnivora (*e. g.* Ursus, Canis), the two cuneiform or Wrisbergian cartilages (*cartilagines cuneiformes*), which lie in the fold of membrane between the arytenoid cartilages and the epiglottis, are considerably developed, while in man they are wanting, or very minute. Peculiar sesamoid cartilages rest, in some Mammalia, as the Ornithorynchus, the genera Mustela, Didelphis, &c., upon the posterior border of the arytenoid cartilages. There occurs a smaller azygos interarticular cartilage (*c. interarticularis*) in many Mammalia, as the Hedgehog (where it is very conspicuous), and also in the Hog, Dog, &c., situated in the middle between the two arytenoid cartilages upon the upper border of the cricoid. The human larynx is distinguished from that of the Apes, in particular by the greater shallowness of the thyroid cartilage, the greater development of the arytenoids, the lesser size of the lateral ventricles, the absence or slight development of the Wrisbergian cartilages, and the greater degree of hardness and frequent ossification of the carti-

lages, especially in the male sex, as well as by a greater sexual difference, the female larynx being softer in its cartilages, smaller, and less prominent.

Singular varieties have still to be mentioned in the structure of the larynx in some Mammalia, namely, among the Apes. In the Sapajous the cavity of the larynx above the inferior chordæ vocales is lengthened out into a bent tube, the anterior wall of which is formed by the thyroid cartilage, the superior by the epiglottis, the posterior and inferior wall again by the adjacent prominences of the cuneiform cartilages. Still more striking is the arrangement in the Howling Apes, where membranes, bones, and cartilages, both of the larynx and os hyoides concur to form the lateral laryngeal sacs or apparatus of resonance, by which the volume of their voice is prodigiously increased. Even in the Orang-utang and Chimpanzee the lateral ventricles of the laryngeal cavity are lengthened out into membranous sacs, which extend forward beneath the body of the hyoid bone. Similar sacs also occur in other Apes, as in the common Inuus ecaudatus, where there is, however, only one which opens by a small simple orifice beneath the epiglottis above the lateral ventricles. There is a remarkable valve, found hitherto only in the Marmots, which, directed downward, can fill up and close the whole breadth of the larynx.

There is very generally situated upon and beneath the larynx in the Mammalia a *Thyroid gland*. It consists in a great number of two completely separated lateral lobes, and, as a rule, is double. In many Apes both lobes are more separated than in Man, but usually united by a ligament. Both halves of the gland lie very far apart in the Otter, where they are situated upon the sides of the larynx, and are in contact with the sub-maxillary glands. In the Cetacea, on the contrary, the flat or heart-shaped thyroid gland is not separated into two lobes, and lies transversely over the trachea.

The *Trachea* in the Cetacea is extremely short, on account of the shortness of the neck, and, at the same time, very wide; the cartilaginous rings are very closely approximated together, and in the Whales not closed anteriorly, so that here it is membranous. In the herbivorous Cetacea it is not divided into separate rings or arches, but is wound about by a spiral band of cartilage. In the Horse and some Ruminantia it consists of complete rings, while in a large number of animals it is perfectly membranous behind, as appears to be particularly the case in the Rodentia. The number of rings varies remarkably, and is determined by the length of the

trachea and neck. While the Cetacea have only from 7 to 12, the Carnivora have mostly from 30 to 40, and even more rings; there occur from 60 to 100 in the Ruminantia, and in the Camels even 110 rings; their number varies, however, in individuals of the same species. In Man we find from 17 to 20 imperfect rings. The trachea is almost always straight, *i. e.*, it passes without any contortions to the lungs; in the Sloth (Bradypus tridactylus) alone, it makes, as in many Birds, a bend forward and downward before dividing into the bronchi. The trachei usually divides, as in Man, into two main bronchial trunks; occasionally, however, as in the Ruminantia and the Hog, it divides into three, which is also the case in the true Cetacea. The third supernumerary bronchus is always smaller, arises anteriorly, and passes to the right lung. The bronchial rings are in one case to be traced, quite complete, far into the lung, in others they soon disappear.

The *Lungs* are sometimes quite simple and undivided upon each side, as in the Horse, Elephant, and Rhinoceros. The number of the lobes, is, however, commonly greater than in Man, four or even five (as in Hamster and Marmot) being found upon the right, two to three upon the left. The right lung is usually larger, sometimes double the size of the left, as in the Musk-deer. The lungs of all Mammalia, as in Man, have terminal cells which are situated at the extremities of the bronchi, and appear to be in the whole class nearly of the same size—from $\frac{1}{6}$th to $\frac{1}{20}$th of a line.

The Mammalia, like Man, have a *Thymus gland*, which is formed toward the end of fœtal existence, and attains its greatest development during the period of lactation; it afterward usually disappears by degrees, though sometimes it is persistent. It lies in the antero-superior part of the cavity of the chest, usually consists of two main lobes, and agrees in structure with that of the human thymus. All diving animals, the Beaver, Seal, Otter, and Cetacea, exhibit a very large thymus gland which exists throughout life, and which frequently extends from the thoracic cavity, along the trachea, up both sides of the neck, as is the case in the Ruminantia.

URINARY ORGANS.

In the internal structure of the *Kidneys*, in reference to their vascular system, their Malpighian bodies, the infundibuliform structure of the urinary canals, &c., the Mammalia agree with Man. The kidneys in most of the Carnivora are much rounded; in the

Dugong, on the contrary, they are greatly elongated; occasionally they appear incompletely lobed (in many Cats and Weasels), as in the newly-born infant. In some animals, particularly those that live in water, each kidney is divided into several, often into many lobuli. In the Ox, there are found 20 free, rounded lobuli, about 12 in the Otter, and from 40 to 50 in the Bear. The kidney is divided into from 70 to 100 or more lobules in the Seals, and its surface has in consequence a tessellated aspect. In the true Cetacea the kidneys have a racemiform appearance; in the Dolphins 200 separate lobules can be counted. Each lobule is provided with a papilla, and there is here found no pelvis, but an excretory duct proceeds from each lobule, so that the ureter is composed of branched tubes, like the ducts of other glands. Most of the remaining animals, namely, all Apes, even the Orangs, most Rodentia, Carnivora, and Edentata, have only a single papilla, into which all the renal tubuli open. The *urinary bladder* is particularly large in the Herbivora (as in the Horse), smaller, rounded and muscular in the Carnivora, thick-walled, elongated, and very small in the Cetacea, whore the ureters also are exceedingly short.

The *Renal capsules* are generally present, and always larger in the fœtal than in the adult animal. They are flat, and like those of Man, in the Quadrumana; very large in most Rodentia, and very small in the Cetacea, even in their fœtus.

SPECIAL SECRETING ORGANS.

Besides the organs of secretion which are necessary for the general animal economy, there occur in separate families, genera and species, particular secretions, which always serve a special purpose in connexion with the peculiar structure and mode of life of the animal to which they belong.

Thus several of the *Sebaceous follicles of the skin* are developed in many animals into compound follicles and true glands, which secrete a strong smelling sebaceous or unctuous fluid.

A group of such sebaceous sacs lies in the Stags and Antilopes in a cavity of the lacrymal bone beneath the eye, which secrete what are called the "tears of the Stag."

The peculiar smell which emanates from the Cheiroptera depends, for the most part, upon a considerable flat and yellow colored gland, which in Vespertilio murinus, noctula, &c., lies upon both sides of the upper jaw, between the eye and nose. Similar, only

less developed, sacs are found in some other animals, *e. g.*, Arctomys, Lutra, &c.

In the Shrew-mice, at least the larger species, there occurs upon the side of the body, opposite to the anterior feet, a layer of glands, which secrete a fetid fluid.

In the genera nearly allied to the Shrew-mice, namely, Myogale, and Macroscelides, a layer of separate cœcal sacs, or pyriform pouches, lies upon the under side of the tail. The secretion of these glands is very strong in Moschus.

In the Peccari (Dicotyles torquatus) there lies upon the back in the crupper a gland opening externally, and giving exit to a strong smelling secretion; it consists of a sac with thick walls, into which blind cells open. A glandular organ, probably similar, has been recently found in the Stag, surrounding the eight basal caudal vertebræ.

A considerable gland, 6 to 8 inches broad, lies, in the Elephant, beneath the integument in the neighborhood of the temple. It opens by a narrow excretory duct between the ear and eye, and secretes in the male, during the rutting season, an adhesive fetid moisture.

In the Carnivora and Rodentia, *Anal sacs* or *glands* are very frequently found; and their secretion appears always to possess a strong odor. Such simple sacs, consisting of many coats, and covered with a muscular layer to press out their contents, are found in Mustela, Lutra, Arctomys, Dasyprocta, &c.; in the Civet (Viverra zibetha), and in the Beaver, they are provided with thick glandular walls. In the Hyæna there is only a single pouch which opens by a transverse slit above the anus; it contains, however, several conspicuous sacs, which consist of blind follicles grouped together like a bunch of grapes.

The peculiar *Preputial glands*, which frequently occur, as in some Rodentia and Carnivora, near to the anal sacs, appear to be less generally distributed. Conspicuous but simple sacs are found in the preputium in Mus, Cricetus and Lepus. In the Beaver and Civet they are found along with the anal sacs, and yield the castoreum and civet-musk. The sacs in the Civet are double, but enclosed in a common pouch, which opens between the anus and sexual organs. Small follicles are situated in its thick walls. Such sacs are also met with in the Ruminantia, namely, the Antilopes. The most remarkable instance, however, occurs in the Musk-deer, where the musk pouch is an organ of secretion opening into the prepuce, though

it lies as a simple azygos pouch, provided internally with small depressions, between the umbilicus and the glans penis.

In many Ruminantia, such as the Sheep, Doe, Elk, and Reindeer, we frequently find over the hoofs, both in the fore and hind feet, or only in the one set, a membranous pouch of considerable size, beset with follicles, which secrete a fatty odorous substance, which is poured out upon the anterior surface of the hoof above its cleft.

A most peculiar gland, probably a *Poison gland* (and in this case it would be, as such, the only example in a mammiferous animal), occurs in the male Ornithorynchus. It is a considerable triangular gland, which lies upon the outer side of the leg. A long excretory duct runs beneath the integument to the inner side of the heel as far as the astragalus, where it forms a sacculate dilatation at the base of the horny spur, and opens at length by a canal traversing the latter to its apex.

SEXUAL ORGANS.

The sexual organs of the Mammalia and the organs of lactation, which must be here considered also, differ very much from those of the other Vertebrata. They repeat with certain modifications the human type of formation.

The *Ovaries* are, as a rule, rounded or oviform bodies, as in Man, in which are imbedded in a more or less dense fibrous stroma the Graafian follicles. In each of the latter there lies one small ovule (very rarely two), scarcely visible by the naked eye, which includes a germinal vesicle with a single germinal spot. If the stroma is in small quantity, the follicles frequently appear pedunculated, and thus the ovarium obtains a more clustered appearance, as is the case in the Mole and Ornithorynchus.

The *Fallopian tubes* or *Oviducts* usually commence, as in Man, by a free opening into the abdominal cavity, and are usually surrounded by a puckered border of folds, forming what are called the fimbriæ. In many Carnivora, *e. g.* Canis, Felis, Phocha, Mustela, Lutra, the peritoneal covering of the oviducts is continued to the ovary, which it loosely invests, after the manner of the testicle, with a kind of tunica vaginalis. In some animals, as the Dog and Cat, a small opening remains in this sac, communicating with the abdominal cavity; in others the sac is completely closed, and in these last,

what is called extra-uterine or abdominal pregnancy, which sometimes occurs in the human subject, can not take place.

The *Uterus* exhibits great varieties. It is Simple, *uterus simplex*, and of a triangular, oval, or round form, according with the human type, while the two oviducts enter its cavity at right angles upon either side of the fundus. This is the case principally in the Apes and Cheiroptera. The uterus is Two-horned, *uterus bicornis*, in the Ruminantia, Pachydermata, Solipedia, and Cetacea, and in a less degree also in the Makis. The body is here prolonged into a pair of thick and crooked cornua, which pass into the very narrow and much-contorted Fallopian tubes. The uterus is called Divided, *uterus divisus*, where it has only a very short body, as in most Carnivora, Edentata, and most Rodentia, which speedily divides both externally and internally, and is continuous with the straight or slightly twisted oviducts. The uterus is actually Double, *uterus duplex* s. *biforis*, in some of the Edentata, and in most Rodentia, as the Mouse and Hare. Each Fallopian tube passes above into an intestiniform uterus, which has two completely distinct openings lying near to each other within the vagina. The structure is still more anomalous in the Ornithorynchus; the oviducts are here not completely separated, but each has inferiorly an expansion, like the oviducts of Birds, and opens by itself into the cloaca; between the two apertures lies that of the urinary bladder.

The uterus of the Marsupiata is very peculiar, and exhibits in the several genera varieties which, however, are not very remarkable, so that its structure in the Kangaroo may serve as an example. The oviducts are at their abdominal extremity surrounded with a folded crown of fimbriæ, and each, very delicate at its commencement, expands into an elongated uterus, in which the small embryos are developed, and attached by a short umbilical cord. Both uteri open into the vagina, which is likewise double, and very peculiarly formed, as it frequently forms a cœcal sac, which is often divided by a septum, into the commencement of which the uteri open. From this arise superiorly the vaginal canals, two handle-shaped and intestiniform membranous tubes, frequently contorted, which coalesce in front of the external sexual opening, or kind of cloaca. Through these the small and still imperfectly developed fœtus unquestionably reaches the exterior, and is conveyed by a process not yet known into the pouch.

The *Vagina* of the Mammalia seldom presents transverse rugæ, but usually slight longitudinal folds. At its termination, frequently

also in its middle, but rarely posteriorly, there is often found, as in the Horse, the Ruminantia, Carnivora, and Apes, a fold or septum, in one case strong, in another merely rudimentary, which corresponds to the hymen of the human female, but is never so peculiarly developed as in the latter.

The *Clitoris* appears to be generally present, and occurs also in the Monotremata and Cetacea. It is usually situated far forward, consists of cellular tissue, and is provided with a glans, and prepuce. It is very much developed in the Rodentia, Carnivora, and Apes, and in them contains not unfrequently a cartilage or bone analogous to that of the penis. Thus there is found a small bone in the domestic Cat, which is larger in other species of the Feline race, and in the Otter, Bear, Marmot, &c., but is apparently frequently wanting in the Apes. A clitoris, on the contrary, of unusual size occurs in the Spider-monkeys (Ateles), being from two to three inches long, and provided with a glans and conspicuous prepuce, upon the under surface of which a groove runs from the orifice of the bladder, along which the urine flows. In the Marsupiata, the clitoris is split like the glans of the male, and there project from it two folds forming a groove for the passage of the urine, or, as in the Lemming, the Makis, and Loris, the clitoris is actually perforated, and thus attains the highest grade of analogy with the male penis. The spongy bodies and arteriæ helicinæ are frequently wanting, and the body is filled with fat, so that even in the Spider-monkeys, it is probably incapable of erection. The preputial glands of the clitoris are occasionally very much developed; and in some Carnivora, Marsupiata, Ruminantia, and Rodentia, we also find at the base of the clitoris more or less distinctly developed Cowper's glands, which have been lately proved to exist in the human female. The nymphæ or internal labia are wanting; the external labia are but slightly developed, and consist only of a pair of hairless projections, which bound a mostly rounded vaginal orifice; the mons veneris is wanting. In some Mammalia, namely, the Horse and Ruminantia, we find upon either side of that of the urethra the two orifices of what are called the vaginal canals, which run between the muscular and mucous membrane to the broad ligaments of the uterus, but are sometimes entirely closed; they may probably be regarded as the remains of the excretory ducts of the Wolffian bodies or false kidneys in the fœtus, and thus as a kind of persistent arrest of formation.

The *Mammary glands*, which occur in all the Mammalia, are to

be viewed as accessories of the sexual organs. The number, position, and external form of the mammæ are very different in the several orders; it is the special province of Zoology to describe more minutely these diversities. Frequently, as in the Hedgehog, Dog, Hare, and other rodent and carnivorous animals, there occur from 10 to 12 mammæ; the number, however, varies between 2 and 12. It is only in the higher orders, as in the Apes and Cheiroptera, though also in the herbivorous Cetacea, that the mammæ are present two in number, as in Man, and situated upon the breast. In the rest of the Cetacea, indeed, and in the Solipedia, there are found only two mammæ, but they lie far back, near to the anus or the sexual organs. The Pachydermata and Ruminants have mostly from 2 to 4 upon the belly. In the Carnivora and Rodentia, the number varies from 4 to 12, and they then lie in two adjacent rows, upon the belly, extending from the breast to the perineum. The number of the lactic glands, which are frequently blended together, is indicated externally by that of the nipples; these have a soft cuticular covering, are perforated by the excretory ducts of the glands, and differ in number and arrangement. In the Cow, the ducts pass into a large simple sinus, which has only a single papillary opening; the structure is similar in the Whale and Dolphin. In the Rabbit and Cat we find 5 small openings, and ten in the Dog, while in Man from 15 to 20 occur. The nipples are seldom completely wanting, as they are in the Monotremata, where the young can only suck, by making a kind of fold of the skin upon the breast by means of their snout. In this order, however, as in the Cetacea, a peculiar tegumentary muscle occurs, which can compress the gland, and so spurt, as it were, the milk into the young one's mouth. The same arrangement occurs also in the Marsupiata, so that the fluid necessary for their nourishment can be supplied to the small and imperfectly developed embryos which hang on to the elongated nipples. The mamma appears in general to be a conglomerate gland with arborescently divided excretory ducts, which terminate in clusters of small bladders like bunches of grapes. An exception, however, to this is presented by the Monotremata. Thus in the Ornithorynchus each mammary gland consists of a mass of cœca of considerable size, and varying in length, and either single or divided at their extremities, which converge toward the nippleless external openings.

In the Marsupiata a peculiar external organ of generation occurs. There is found, namely, in front of the pelvis, supported by a pair of peculiar bones, a sac or pouch (in many genera, *e. g.* in Didelphis,

only a pair of lateral tegumentary folds), within which are situated the mammæ and nipples, to which the still slightly developed embryos attach themselves, and are there completely formed. The pouch is a duplicature of the external integument, which posteriorly and superiorly stands in connexion with the tendon of the external oblique muscle of the abdomen. The muscle of the mammary gland, already mentioned (*compressor mammæ*), is situated upon the external oblique muscle, arises from the posterior part of the pelvis, becomes broader anteriorly, and divides into two slips, between which the nipples are enclosed. The number of the latter is greater in the carnivorous than in the herbivorous Marsupiata.

The *Male* sexual organs, like the female, exhibit considerable diversities in the several orders. The *Testicles*, as in Man, are oval or rounded, and sometimes much elongated and thin or slender, as in the Cetacea. They have a tunica vaginalis, but are seldom situated, as in Man, in a scrotum separated by a partition, this being the case only in the Apes, several Carnivora, the Ruminantia, and the Horse. The scrotum usually stands in communication with the abdominal cavity through an open inguinal canal. In many insectivorous Carnivora and in most Rodentia, the scrotum is all but wanting, and the testicles lie in the perineum, as in the Beaver, or within the abdominal cavity, as in Sorex, Erinaceus, Talpa, Myoxus, and many others, while in other genera and in the Cheiroptera the testicles, during the rut at least, glide back into the belly. In the Cetacea and Monotremata, as also in some Pachydermata, *e. g.* the Elephant, and indeed, in many Rodentia, the testicles are situated permanently in the abdomen, upon either side of the rectum, and are there retained in their place by a mesentery similar to the broad ligaments of the uterus. The internal structural arrangement of the testicle is essentially the same as in Man; the delicate seminiferous tubes uniting into the seminal duct form an epidydymis. In many animals a portion of the tunica albuginea is given off as a strip of various form, which sends laterally ray-shaped fibres between the lobules of the seminal vessels; this structure is known by the name of Corpus Highmori, and is particularly distinct in the Ruminantia, and also in the Horse and Dog. At the spot where the vasa deferentia unite, before the commencement of the urethra, they form not unfrequently an expansion like the uterus, or a kind of sinus, which is perhaps to be viewed as a remnant of the sinus urogenitalis in the fœtus.

The testes secrete a white *Semen*, the moving elements of which,

called seminal animalcules or spermatozoa, are formed indeed after a common type, but exhibit numerous shades of difference in the several species. They have always, however, like those of the human subject, a small, thick, more or less clavate, shovel or even sickle-shaped head, from which extends a long and very slender tail.

The *Vesiculæ seminales*, which are probably to be regarded less as receptacles for the semen than as organs of secretion, since they not unfrequently have thick glandular walls, exhibit great diversities. In the Apes they are commonly more tortuous and divided, than in Man. In the Makis they form a large cœcum with a simple cavity, and appear to be similar in most Cheiroptera. In the Carnivora, the Marsupiata, the Monotremata and Cetacea, they would appear to be wanting, if an expansion which frequently occurs of the vas deferens be not taken for them. In the Horse three vesiculæ seminales are found; in the Hare there is only a single, large, glandular bladder present; they are very large, and provided with lateral lobes, in the Hog; those of the Ruminantia are similar and large. In the Elephant the very large vesiculæ seminales appear to be compressed by a special muscle. There frequently occur dilatations of the vasa deferentia, which may be regarded as vesiculæ seminales, as in Dipus.

The *Prostate gland* presents remarkable diversities. In the Apes it resembles for the most part that of Man, though in a less developed condition. In the Cheiroptera it is divided into lesser lobules. It is distinct and cylindriform in most Carnivora; it is frequently, however, but slightly developed, as in the Otter. In the Horse the gland has two cornua, and consists of large sacs; in the Ruminantia and in the Hog it is represented by a very thin glandular layer; in the Cetacea it forms a single large mass, which surrounds the urethra in the form of a ring. The greatest development of the prostate is exhibited by many Rodentia and Insectivora. Thus there is found in the hybernating Dormice (Myoxus for example), a tuft of cœcal tubes, or a rounded sac, as in Sorex, or a large knotty tuft of glands, as in Talpa, Castor, Cricetus. In Dipus, near a pair of large simple cœcal tubes of unequal size, there is found a pair of lesser lobed glands. Its development is perhaps greatest among our indigenous animals in the Hedge-hog, where the posterior pair always consists of six lobes, with very long contorted, cœcal vessels, united by cellular tissue, the anterior pair being represented by a tuft of divided cœcal canals. The Elephant has also two pairs of divided vesiculæ seminales, and among the Ro-

dentia there are animals, as the Rat, in which there are as many as three pairs of prostate glands.

Cowper's glands likewise exhibit remarkable complexities; and perhaps in no part of the anatomy of the Mammalia does greater variety prevail. As a rule, allied genera have them formed alike, while in one and the same order great diversities occur. In the Apes these glands are mostly larger than in Man; in the Cheiroptera and Carnivora they are often very conspicuous, as in Sorex, Hyæna, Viverra, and also in the herbivorous Marsupiata; they are, on the contrary, very small in the Dog, Cat, and Fox. They are very much developed in many Rodentia, as Myoxus and Castor, and in the Hog, Elephant, and Camel. In Dipus they form a pair of distinct sacs, and in the Hedge-hog they are long, and contorted. In the Hedge-hog, the Mole, and Insectivora generally, they are most conspicuous, and form at times large flat lobed glands, composed of tufts of delicate cœcal tubes.

The *Penis* of the male also exhibits exceedingly great diversities It is only in the Apes and Cheiroptera that it hangs down freely, as in Man, from the pubic arch. In the Cats and many Rodentia it is directed backward. In the Marsupiata the opening of the prepuce is even surrounded by the sphincter ani muscle, and in the Beaver it is so drawn back that the entrance into it nearly resembles a vagina. These relations are occasioned by the prepuce or bag of the penis commonly investing the organ in such a way, that in its usual position the penis is retracted within it as in a sheath. This vagina-shaped prepuce opens for the most part behind the umbilicus, and when the penis is long, it lies within the sheath with either a simple or double S-shaped curve; this is the case to a very great degree in the Elephant. In the Hog there lies internally, upon each side of the prepuce, a small folded cœcal pouch, which is apt to retain some of the urine as it escapes, and in which calculi easily form. Animals having the penis directed backward micturate also in that direction, but during copulation, when it is erected, the penis stands forward. The suspensory ligament arising from the pubic arch is in man and most Mammalia feebly developed; but in large animals, as the Pachydermata and Solipedia, it is very strong and remarkable, in order to support the great weight of the penis. In the orders just mentioned, as also in most Ruminantia and Carnivora, the prepuce is drawn back from over the penis by a pair of retractor muscles, which arise from the abdomino-tegumentary muscles; while by another pair of retractors arising from the first caudal vertebræ

and the sphincter ani, the penis is withdrawn into the prepuce. There usually occurs, as in man, a corpus spongiosum, perforated by a single urethral canal, and two corpora cavernosa divided by a septum. This last is frequently wanting in the Ruminantia and Cetacea. In the Kangaroo the corpora cavernosa of the penis and urethra are blended, and it is here, as in the Marsupiata generally, that the penis is bifid at the end, corresponding with the double vagina of the female; the urethra opens in the angle of the fissure, though each apex of the divided glans is perforated by an opening for the semen. In the Monotremata also, the penis is perforated by an urethra, though the seminal canal is, at least in the Ornithorynchus, separated from the urethra, and gives off two lateral canals for each half of the glans, which open upon the spines of the latter, by four fine canals.

There is scarcely an organ throughout the class Mammalia, with the exception of the teeth, which in the orders, genera, and even species, exhibits such great and striking varieties as the *Glans of the penis*. In some animals, as the Ruminantia, the Hog, and some of the Carnivora, it might almost be said to be wanting; for the slightly developed spongy body of the urethra running to a thin point anteriorly, the extremity of the urethra or penis can only be improperly called a glans. It is seldom soft and spongy, as in Man, but is often covered with hard and pointed epithelial structures. In some Apes it is mushroom-shaped, even somewhat split, and occasionally provided with horny spines, which are also found in the Cheiroptera. In the Shrews the glans is hard, horny, and tubercular, and it is similar in the Hedgehog, being here divided into three lamelliform lobes; in the Hyæna it is a broad knob; in the Bear and Dog it is elongated and club-shaped, but smooth; while in the Cat it is beset with spines directed backward; it is deeply slit in the Marsupiata, and furnished in the Guinea-pig with scales and two horny hooks, and in Dipus with two long soft spines; in the Hare it is small, thin, and pointed; in Dasyprocta it supports serrato-dentated plates; in Castor it is provided with rough tubercles, in the Hamsters with hairs, in Phascolomys, &c., with spines. In the Horse it is bulbous anteriorly, and has a groove inferiorly, where the urethra terminates, and posteriorly a ridge; in the Rhinoceros it is bell or mushroom-shaped, with a pedicle; in Delphinus delphis it is tongue-shaped, and in the rest of the Cetacea for the most part acutely conical; in the Ornithorynchus its form is particularly singular; it is very large, four-sided, divided into two halves, and thickly beset with

spines; in Echidna it is divided into four rounded, perforated extremities, beset with small tubercles.

The *Bone of the penis*, which principally belongs to the glans, is met with in many animals, namely, in the Apes, Cheiroptera, Carnivora (even in the Seal and Walrus), many Rodentia, and some Cetacea, as in the Whales (though its existence has been disputed by other writers), but not in the Pachydermata and Ruminantia. In Man, to wit, in the Negro race, where the penis is very largely developed, there frequently occurs a small prismatic cartilage from one to two lines in length, as a rudiment of this bone. The bone usually arises at the end of the fibrous septum, and advances toward the glans, the tendinous fibres of the septum being attached internally to its periosteum. Among the Apes, where the bone of the penis is often very large, it appears to be entirely wanting in the Orangs. In the Fox and in the Dog-kind it is large, and hollowed out inferiorly in the form of a groove; it is very small and thin in the Cat, curved in the shape of a hook anteriorly in Mustela, and bent in the form of the letter S in the Rackoon; it is terminated anteriorly by two rounded bodies in the Otter, has a small but broad shovel-shaped extremity in the Squirrel, and is deeply slit in the Marsupiata. This bone serves obviously to increase the rigidity of the penis during the act of copulation, which, as is known, is in many animals a painful operation. The penis has the usual muscles (*m. m. ischio-cavernosi and bulbo-cavernosi*), and in many animals where the penis is situated in the direction backward, there is found a pair of muscles often thick-bellied (*m. pubo-cavernosi*) arising from the pubis, the tendons of which are attached to the dorsum of the penis, and seem to be instrumental, during copulation, in giving the penis an anterior direction.

The same diversity, which is observed in the Mammalia in reference to the form of the internal and external sexual organs, is met with in the fœtal envelopes, *e. g.* in the allantois, the umbilical vesicle and placenta. The latter exhibits great diversities, which are frequently characteristic of whole genera and families. Thus, the true Carnivora, such as the Cats, Dogs, Seals, &c., have a girdle or band-shaped placenta, so that the membranes of the ovum are free at both of its ends or poles. On the border of this annular placenta, there often appear, as in the Dog, beautiful green pigmentary deposites. In the Ruminantia the placenta is divided into a great number of distinct round or button-shaped cotyledons, which are distributed over the whole ovum

and uterus, being separated by considerable intervals. In many Rodentia, a single rounded placenta is indeed present, but it is divided into several lobes, as occurs occasionally also in Man. In the Apes the placenta consists of two adjacent divisions. In the Hog the whole surface of the chorion performs the function of a placenta. There is no vestige of a placenta in the Marsupiata, which is probably the case also in the Monotremata.

In Birds and Amphibia, there is found what is called the cloaca, or the termination in a common opening of the urinary and sexual organs. In the Mammalia this structure occurs only in the Marsupiata and Monotremata. The closest relation of the cloaca to that of Birds is presented by the latter order, where it is provided, as in them, with powerful muscles.

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II. Passerinæ. { Ex. All true *singing Birds* and those which, having no song, yet possess a complicated inferior larynx, as the *Sparrow, Rook, Shrike, &c.*

III. Scansores. { Ex. *Woodpecker, Cuckoo, Parrot, Toucan,* with those genera which, though related by external characters to the singing Birds, are devoid of a muscular vocal apparatus, viz., *Alcedo, Upupa, Merops, Cypselus, Trochilus, &c.*, and constitute the subdivision Picariæ.

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structures beneath. Occasionally the feathers assume a hair-like character, as upon the eyelids and base of the bill, *e. g.* in the Raven. It is very rarely that true hairs resembling bristles are met with, as upon the neck of the Turkey.

The epidermic plant-like horny structures of Birds, the Feathers, are divided into Down-feathers and Contour or Quill-feathers. The first are delicately soft and flexible, mostly of a gray or grayish-yellow color, and lie beneath obscured by the quill-feathers. There are feathers which are entirely downy, but each quill-feather, even the large primaries of the wing, has some strips of down at its commencement. The feathers of the neck and trunk form in most Birds circumscribed patches (*pterylæ*), which are distinctly defined by means either of intervals naked or beset with down.

In a perfectly formed Feather, the following parts may be distinguished. 1st. The stem (*scapus*), which forms the principal part of the feather; it is cylindrical or fusiform, and is prolonged inferiorly into the transparent hollow part, the quill (*calamus*), by which it is attached to the skin. Within the quill is found what is called the pith, which consists of membranous cones arranged one upon the other. Externally, where the vane or beard of the feather commences, the stem becomes medullary, and is then called the Shaft (*rachis*). This shaft, over the back of which the quill is continued as a horny investment, is almost always quadrangular, and rarely quite flat, as in Aptenodytes. The inferior surface of the shaft, namely, that which is turned toward the body of the bird, is hollowed out into a groove, and is depressed at the commencement of the quill into an umbilical fossa, near or from which the accessory plume (*hyporhachis*) arises. This resembles the main shaft, in giving off a bilinear series of barbs, and the two together form an apparently double feather. It is wanting in the primary feathers of the wing and tail. It frequently supports merely downy barbs, as in the Gallinæ, and is occasionally reduced to a single barb, or is wanting altogether, as in the Owls, many Picariæ (Alcedo, Upupa), and Ducks, &c. From either side of the main and accessory plumes arise the Barbs which form the vane (*vexillum*) of the feather. They are small lancet-shaped lamellæ, varying in form, length, and thickness, in different Birds. In like manner, from either side of the barbs, proceed the Barbules (*radii*), which are much more numerous and complex in their structure than the barbs. Occasionally, like as in a tripinnate leaf, the barbules are provided again with smaller accessory barbules, constituting a third series. The barbules are

called, in accordance with their form and function, either *cilia* or *hamuli*. The former, where they occur, as in the feathers of the Goose, are the most numerous of all the parts of the feather, and proceed with the hooklets only from the foremost series of barbs; they are situated only upon the upper edge of the barb, and stand either in a double or only a single row. In the barbs of downy feathers small nodules appear to supply the place of the cilia. The cilia, like the hooklets, can only be seen with a magnifying power. The hooklets form likewise lateral processes of the barbs, but are found only upon their anterior series and upon the inferior side of each barb. They differ from the cilia by the hook-shaped curve of their extremities, the hooklets of an anterior series of barbs catching upon those of the one behind it, so that in this way the barbs are held fast. This arrangement is of importance for the flight of the bird, as by means of it the barbs of the feather are prevented from being torn asunder by the air, which would necessarily injure the power of flight.

The *Contour-feathers* are, as a rule, formed in the manner above stated, and have a perfectly-formed and stiff shaft. Their structure is most complete in the primaries of the wing, and the remigial feathers of the tail. The cilia and hooklets, however, are occasionally wanting, as in the Ostrich and Nandou (Rhea); and in other birds, as in the Cassowary, the barbs are absent. At the extremity of the bristles at the angle of the mouth, and upon the chin, and the eyelashes, the barbs are also wanting, or there is found only a membranous projection in place of a vane. The remarkably long spurs of the wing in the Indian Cassowary are shafts without any barbs.

The *Down-feathers* pass occasionally into quill-feathers; although they mostly lie concealed, yet they frequently form large freely exposed masses, as upon the neck of many of the Vultures. A down-feather frequently stands in the middle between four quill-feathers, and forms with them a quincunctial figure. The true down feathers exhibit an articulated structure, and appear like so many cones inserted in each other, and exhibit under the microscope, when they are of a gray color, a particolored appearance like that of the gray hairs of the Mouse, &c. The broader nodules are black, the intervals between them transparent and colorless. The down-feathers of nestling and young birds have very delicate barbs, and none, or only very small, nodose dilatations.

The *Plume-feathers* (filo-plumæ) differ very strikingly from the

two kinds already named, by a very slender stiff stem and a marrowless, transparent, very slender shaft, with very fine round barbs, not provided with ciliary, nor connected by hook-shaped, barbules. The barbs are occasionally entirely wanting and then these feathers resemble hairs. They occur in all birds, but are often easily overlooked; they are always associated with the quill-feathers, so that upon the head, neck, and trunk, one or two filamentary feathers stand quite near to each of the quill-feathers, and appear to proceed along with them from the same tegumentary capsule. It is more rare to find, as in the Herons and birds of the duck-kind, several, even so many as ten, filamentary feathers near to each quill-feather.

OSSEOUS SYSTEM.

The Skeleton of Birds presents a remarkable contrast to that of the other Vertebrata, while, at the same time, nearly all its forms throughout the class are characterized by a great uniformity.

One special peculiarity is met with in the internal structure of the bones, which are more or less hollow internally, devoid of marrow, and permeated by air. For the latter purpose many of them are provided with openings, which stand in relation to certain air-cells of the body (which will be described in treating of the respiratory organs), and are filled from them with air. As a general rule, the capacity and extent of these openings throughout the skeleton depends upon the size of the bird, and its powers of flight. Small, though very rapidly flying birds, have few hollow bones; in large and very high flying species, they are, on the other hand, most numerous. In many Birds, all or nearly all the bones are solid. In several of the bones, there is a predominant tendency over others to this hollow structure, as is found most frequently the case in the humerus, cranium, and sternum, but more rarely in the femur, and very rarely in the bones situated below the elbow and knee-joints. The bones are filled through one or many openings, which occupy different situations, according to the genera and species. Thus the small Passerine birds, many small Grallæ and Palmipedes, as the Snipes, Terns, Moor-hens, &c., have no bones for the reception of air, except some of the cranial, which are always filled with air from the nose. The most complete want of pneumatic permeability in the bones is at present to be observed in the Apteryx of New Zealand, a bird belonging to the order Brevipennes, and which is destitute also of air-cells. In some of the larger Passerine birds, as

the Crows, Shrikes, the humerus is the least hollow. The femur is far more generally filled with medullary tissue, but in the Diurnal birds of Prey it is permeated by air as well as the sternum, vertebræ, ribs, and pelvic bones. In the Owls, the femora of which contain marrow, the cranium is very much elevated by the large and wide air-cells of the diplöe. In the Pelicans very many of the bones receive air. The air openings are developed to the greatest extent, however, in the genus Buceros, where, in addition to the cranial and Maxillary bones, the cervical vertebræ, the pelvis, the caudal vertebræ (but not the sternum and ribs), and all the bones of the extremities, even to the phalanges and toes, are permeated with air. As regards their situation, the air-openings are frequently characteristic of different genera. Thus, *e. g.* in the Vulture and Falcon, the air opening in the femur is placed anteriorly and superiorly beneath its head, as is also the case in the Stork and Picariæ, but in the Ostrich, the Blackbird, and Thrush, it is situated posteriorly; in Buceros melanoleucos there are two pneumatic openings, one superiorly and in front of the femur, the second inferiorly and posteriorly. The Ostrich has the humerus permeable to the air; in the Cassowary, however, it is full of marrow, which is the case also in most of the Scansores, Gallinæ, Grallæ, and Palmipedes. In the Pelican, the Peacock, Bustard, this bone is again found permeable to air. In young birds those bones which at a later period admit air, are filled with marrow, which first of all becomes gradually absorbed. Those bones in the birds' skeleton which convey air differ at the first glance from the rest by their greater whiteness, and more compact cancellated structure; they contain also more earthy constituents.

The *Cranium* of Birds is peculiar in the early union of its separate bones and the complete obliteration of their connecting sutures, so that a complete bony case is formed, which encloses the brain and leaves free only the occipital foramen and the openings for the exit of the nerves. In very young birds, however, the several bones and their sutures may be distinguished. The *occipital* bone consists, as in most Amphibia, of four primary elements, the body, the two condyloid, and the superior occipital. The articulating condyle consists of a single round tubercle. The foramen magnum is sometimes perpendicular, as in the Gallinæ, Grallæ, and Palmipedes, *e. g.* the Goose, but more frequently horizontal, in which case the posterior part of the skull projects in a vaulted form behind it, as in the Rapaces and Passeres, the Woodpeckers, and many of the Grallatorial birds. In the Snipe especially it lies very

far forward and horizontal, so that the cranium is very much rounded. In the Rapaces, Passeres, and Scansores, as also in many of the Grallæ and Brevipennes, the cranium exhibits, particularly upon its back part, very smooth convexities, and is devoid of those singular muscular ridges which occasionally, as in the Gulls and Herons, form high ridges corresponding in situation with the direction of the lamboidal suture, and to which the muscles of the neck are attached. Young birds have a rounder form of skull than adults. There is found not unfrequently situated above the foramen magnum, and chiefly in the superior portion of the occipital bone, a considerable opening or fontanelle, filled up only by ligaments, *e. g.* in many Grallæ and Palmipedes, as the Goose, Duck, Crane, Snipe, Flamingo, Spoonbill, and Ibis, while this structure is often wanting in very closely-allied genera. In the Cormorant (Carbo), at least in the larger species of that genus, there is situated loosely upon the posterior surface of the occipital bone, to which it is attached merely by ligament, a long pyramidal and accessory bone, directed straight backward. In the *sphenoid* bone we distinguish a mostly narrow body (spine-shaped anteriorly) directed forward, as also the alæ majores, which confluent with it at an early period, are perforated by the openings for the fifth pair of nerves, and give off in the direction outward and downward a peculiar hook-shaped process, or postero-superior jugal process. This process is occasionally very strongly hook-shaped, as in Buceros. It coalesces occasionally, as in the Gallinæ, with an inferior process of the same name, coming from the temporal bone, so that an aperture is thus formed between them. In the Parrots it is developed to the greatest degree, and projects far forward, so that in many of the species it coalesces with the lacrymal bone, and forms an arch beneath the orbits; this occurs also in Scolopax rusticola. A peculiar pair of distinct and mostly narrow style-shaped bones converging together anteriorly, which articulate in front with the palate bones, behind with the ossa quadrata, and often, by means of a third joint in the middle, with the body of the sphenoid, may be regarded as the inferior wings of that bone. These inferior wings, called by other writers *ossa communicantia*, exhibit in other respects many diversities. They are short and thick in the Gallinæ, most frequently long and style-shaped, as in the Rapaces, and Passeres, and most of the Grallæ, Palmipedes, and Picariæ. In the Woodpeckers they support superiorly a free process. Their third broad articulation provided with a smooth cartilage occurs, *e. g.* in

the Owls, the Pigeons, Snipes, Goatsuckers, and birds of the Duck kind, and contributes to the movement of the superior maxillary arch. The *temporal* bone consists of a cranial portion which encloses the organ of hearing, and is formed by the early coalescence of the petrous, squamous, and mastoid portions; the squamous frequently gives off an inferior spine-shaped zygomatic process, not connected, however, with the jugal bone; the mastoid process is but slighty developed, and there is moreover an articular portion, the *tympanic* or *os quadratum*. This bone, which is free, and wanting in the Mammalia, occurs constantly in the other Vertebrata, where it often consists of several portions; it very generally projects superiorly into two processes, the posterior one of which, the largest, articulates by a rounded head with the cranium, while the anterior remains free. Inferiorly it articulates with the lower jaw, inferiorly and externally with the jugal bone, inferiorly and posteriorly with the lower wings of the sphenoid. Laterally, and in the direction inward, the os quadratum gives off a peculiar tympanic process, which helps to form the posterior wall of the tympanic cavity, and partakes in the movement of the upper jaw. This process exhibits no inconsiderable differences in the several orders. The *parietal* bone, originally consisting of two halves, abuts anteriorly against the frontal, which is also double in early life. The latter has often concave depressions or deep grooves, as in the Gulls and many other Aquatic birds, for the reception of the nasal glands, which here lie upon the edge of the orbital cavity. The *ethmoid* is occasionally present only as a single perpendicular plate, which, with the sphenoid, forms either the closed or more or less perforated partition of the orbits. This partition is frequently, in nearly allied birds, completely bony, as in the Stork, or very perforated and membranous, as in the Heron. The ethmoid, however, frequently exhibits traces of lateral portions, as in the Passeres, *e. g.* Corvus, the Rapaces, and many Scansores, where they are more strongly developed, and abut against the lacrymal bone.

As regards the *Facial bones*, an *intermaxillary* bone of mostly large size and single (rarely, as in the Gallinæ and Snipes, of small or minute size), forms the principal part of the upper bill, and exhibits great diversities of form. Superiorly and posteriorly it is slit for the reception of the nasal cavities, and sends usually a long, narrow, flattened process between the nasal bones. In the Parrots the intermaxillary bone is merely united by ligament to the skull, and is therefore very moveable, while in other cases the union is

usually effected by means of a bony suture. The *superior maxillaries*, which are generally small, and removed quite to the sides of the upper mandible, are united posteriorly by a slender flattened jugal process to the bone of that name, so as to form a jugal arch. The *nasal* bones are flat and mostly of considerable size, lie in front of the frontals, and give off frequently two processes directed forward, as in the Gallinæ, where they are very deeply excavated so as to present the form of an arch. By means of this excavation in the bones, the nasal foramina coalesce posteriorly. Near to and externally to the nasal and frontal bones, upon the anterior edge of the orbital cavity, are situated the *lacrymal* bones, for the most part separate, and exhibiting great varieties in their degree of development, but which are, as a rule, however, very large, and project inferiorly into a hook-shaped process. In the Woodpeckers and Parrots they are very firmly blended with the skull; they are very small in the Gallinæ, while, on the contrary, in the Spoon-bill, Albatross, and other birds, they abut against the jugal arch, and are united to it by a ligament which is frequently ossified. In the Parrots and Snipes the lacrymal bone forms a ring around the orbit after it has united with the jugal process of the sphenoid bone. The lacrymal bone is very much developed in the Diurnal birds of Prey, where it helps to form the roof of the orbit, and supports externally the os superciliare, which occurs even in the Ostriches. The *palatal* bones exhibit important diversities. They are in general two elongated slender bones, which are moveably united, partly together, and partly with the sphenoid (rarely by means of a suture), but are firmly anchylosed in front with the superior maxillary bones. They are flat, broad, and horizontal, in the Birds of Prey; particularly broad in Caprimulgus; narrow and not united in the Passeres, with but few exceptions, such as Loxia coccothraustes, where they are placed vertically, as in the Parrots; they are very narrow, especially in front, in the Gallinæ; wedge-shaped and hollowed out into the form of a groove in many Grallæ and Palmipedes, as the Storks and Herons, and anchylosed so as to form a short tube along with the vomer in Buceros; in the Goose they are perpendicular, and so also in the Parrots, where however they consist of much broader laminæ, with a strong free process given off posteriorly and inferiorly; in the Brevipennes they are anchylosed by suture with the Sphenoid. Between them lies the *vomer*, which is wanting in the Parrots and Gallinæ, but which is most strongly developed in the Palmipedes, and is generally represented by a

perpendicular bony plate. The *jugal* bone, which is throughout the class very long, slender, and flattened, consists of two pieces, and is united posteriorly to the os quadratum by fibro-cartilage, anteriorly with the jugal process of the superior maxillary by suture, forming nearly always a straight bridge of bone parallel with the lower jaw. It is only in the Goatsucker (Caprimulgus) that the jugal bone is arched in the direction outward to conform with the similarly projecting posterior piece of the lower jaw. In other instances the zygomatic arch is very short and strong, as in Buceros, or very slender, as in the Snipes.

The *Lower Jaw* consists of a single anterior and five pairs of posterior pieces, perfectly analogous to those in the lower jaw of the Amphibia. They soon, however, coalesce, the anterior pretty firmly, the posterior pieces completely. Instead of the articulating condyle, there is found, as in all the Vertebrata below the Mammalia, an articulating cavity for the reception of the os quadratum, and which gives off internally and superiorly a kind of coronoid process, and in the direction backward a frequently long and very much developed process, as is seen particularly in the Gallinæ, *e. g.* the Grouse. Minor differences also frequently occur; thus in Cypselus the lower jaw is in the form of a very narrow and slender arch, while in the Parrots it is formed of deep perpendicular bony walls; in both the processes are wanting. In the Crow and most Passeres the posterior half of the lower jaw is perforated by a large opening. It is remarkable that in birds the whole apparatus of the superior maxilla (supporting the upper Mandible) admits generally of a slight, occasionally even a considerable degree of motion, in the direction upward and forward, which is effected by the moveable connexion posteriorly of the palatal, sphenoid, jugal, and quadratal bones.

The different portions of the *Vertebral Column* in birds exhibit several peculiar and remarkable arrangements. The number of the vertebræ not only varies very considerably in the orders, but also among the genera and species, and even in individuals of the same species; the Swan, for example, has generally 23, but frequently also 24, cervical vertebræ. The relative numbers of the vertebræ are, however, in general more constant than in the Amphibia. The cervical vertebræ are always more numerous than in the Mammalia; as a rule, there are from 11—12 (rarely only 9 or 10), as in most Rapaces, Passeres, and Scansores birds; 13—15 in the Gallinæ, 16—19 in the long-necked Grallæ and Palmipedes, as in the Stork, Crane, Heron, and also in the Ostrich and Cassowary; 23—24, as in

the Swan, being the highest number. The atlas is depressed and ring-shaped, and generally articulates by its capsular surface with the single condyle of the occipital bone, so that the head can be freely rotated in a circle upon this joint, and directed completely backward. In the Ostrich and Penguin a pair of smaller lateral articulating surfaces are met with, which are directly confluent with the central articulating cavity of the atlas, and receive two corresponding divisions of the tubercle of the occiput, formed by the lateral portions of that bone. The second cervical vertebra is deeper, and has a processus dentatus; its body is united to the atlas by a single synovial capsule; an annular and a straight check ligament are met with binding the processus dentatus to the atlas and tubercle of the occipital bone. In Buceros the two superior cervical vertebræ are blendid together and united into one. The rest of the cervical vertebræ have oblique, transverse, and slightly-developed spinous processes, namely, upon the middle part of the neck, and the most posterior have also occasionally inferior spinous processes. The transverse processes are very thick and strong, and have a double root, so that they form a ring, and in the entire skeleton an interrupted canal, within which the vertebral vessels and the cervical portion of the sympathetic nerve are lodged. The bodies of these vertebræ are very moveable upon each other, concave on their superior surface, convex posteriorly, and are united by free capsular ligaments, with only very thin intervening cartilages. The superior can be moved usually more freely in the direction forward, the middle more backward, and the inferior again forward, whence is produced the peculiar sigmoid curve of the neck which is visible in the skeletons of most Birds. The spinal canal is of various form and width in the several divisions of the cervical vertebræ, a condition which, in long-necked Birds, has especial reference to the great degree of mobility in the neck; the roots of the spinous processes are also united, for greater security during the numerous movements of the vertebræ, by elastic ligaments, an arrangement which, along with the preceding one, is plainly for the purpose of protecting the spinal cord during the extensive inflections of the neck. The number of dorsal vertebræ is in general less, and subject to fewer varieties; there are mostly found from 7—9, rarely 10, as in the Ostrich, Cassowary, Goose, and still more rarely 11, as in the Swan and some Ducks. They are but slightly moveable, and are often, especially the hindermost, completely anchylosed together and to the sacrum. This normal state of anchylosis, like that of the sacral vertebræ, was

here necessary, from the posterior extremities being brought behind the centre of gravity of the body. With this view the superior spinous processes are not unfrequently blended together so as to form a continuous ridge, and in the Flamingo, even the second to the fifth dorsal vertebræ are completely fused together, and their transverse and spinous processes have coalesced into a single plate of bone. The bodies relatively to those of the cervical vertebræ are short, and more or less strongly compressed laterally, in the Penguins being quite crest-shaped, while on the contrary they are very broad in the Ostrich. The anterior usually support strong elongated, and, as in Eudytes and other birds, disjoined inferior spinous processes for the attachment of the recti antici majores muscles. The lumbar vertebræ are anchylosed with the sacrum and pelvis to form a single lumbo-sacral bone. The portions however which belong to the several bodies can be more or less clearly distinguished. The lumbo-sacral bone is mostly composed of from 9 to 10, or even more, as 15 vertebræ (many Grallatorial and several Gallinaceous birds), rarely of 17 (as in the Ostrich), or 19 (Cassowary). The caudal series of vertebræ exhibits slight differences; the vertebræ are here very moveable and few in number, and have for the most part considerable transverse and superior, as frequently also inferior spinous, processes. They are hollow even to the last, and form the canal for the spinal marrow. The last caudal vertebra is always of a peculiar shape, and has mostly a strong share-shaped spinous process arising from it, upon which the remigial feathers of the tail are supported. This process is absent however in birds which have a rudimentary tail, as the Struthionidæ and Penguins; on the contrary, in some of the Scansorial birds where the tail serves as an instrument of support in the act of climbing, as in the Woodpeckers and Tree-creepers, the body of the last caudal vertebra is very broad, and supports a peculiar flattened and concave plate.

The number of the *Ribs* varies in accordance with that of the dorsal vertebræ. They always articulate by means of a small head with the body of a single vertebra near to its anterior border, and with the corresponding transverse process by their tubercle. Anteriorly there are situated mostly two, rarely, as in the Cassowary, four false ribs, generally small, and running to a point, which do not reach the sternum. The succeeding true ribs are always laterally compressed and very flat, with the exception of the last rib and the one before it; from about their middle there proceeds a strong and elongated process, which is very seldom moveably united to the rib, as in the

Cassowary, and which directed backward rests upon the rib immediately behind that from which it springs. These processes are rarely wanting entirely, or so slightly developed, as in the Emeu of New Holland, that they can scarcely be perceived. The last, also the second, as in the Ostrich, but more rarely the three last ribs, as in Rhea, do not reach the sternum, and correspond thus with the false ribs in the human subject. The true ribs are united to the sternum by peculiar long bones corresponding to the cartilages of the ribs. These, called sterno-costal bones, are moveably articulated both with the ribs and the lateral borders of the sternum, and are united at both ends by capsular ligaments.

The *Sternum* is, of all the bones in Birds, that which exhibits the most numerous and striking variations, being formed upon a very special and definite type, which departs widely from that of the rest of the Vertebrata. It is in general of considerable breadth, and of an elongated quadrangular form, and upon its anterior surface there is found arising from the median line a very strongly developed crest or keel, which is wanting only in the Brevipennes or Struthious birds, and which serves for the attachment of the great pectoral muscle. The development of this crest generally stands in direct relation with the powers of flight of the Bird, and it is accordingly most large and projecting in the Humming-birds, which though the smallest in size, are the most rapid flyers. High-flying Birds, such as the typical Birds of Prey, have a broader sternum, the posterior margin of which is uninterrupted by notches, as in birds of feeble flight. Anteriorly, the sternum is united with the coracoid bones, upon either side by a pair of very elongated articulating surfaces. Between them is usually situated a single median and often small process, while a similar one projects upon either side from the outer edge of the coracoid articulation. The greatest number of varieties are met with in the posterior border of the sternum, and which are frequently employed as characteristics of whole families and genera. There occur here one or several notches (*excisuræ obturatoriæ*) closed only by tendinous membrane, which are either bounded by long narrow abdominal processes externally, or constitute true openings. As regards the diversities which the sternum presents in the several orders, it is short and broad, almost entirely flat or slightly concave in the Brevipennes, with two short abdominal processes in the Ostrich and in the Apteryx, in which last it is perforated in the middle by two openings; in the Cassowary it is somewhat roof-shaped. Next to the Humming-birds, the keel is

strongest in the Pigeons, Swifts (Cypselus), and the Pratincoles (Glareola). The keel is very broad in the Crane, from its being hollowed out to receive a convolution of the trachea. The anterior median process is mostly furcate in the Passerine birds and also in the Parrots, but it is small and undivided in the Rapaces. The sternum is without any openings upon its posterior edge in Trochilus, Cypselus, and the Brevipennes. A pair of slight notches is found in Carbo, Caprimulgus, Podiceps. The Diurnal birds of Prey have simply a pair of round openings, which in old individuals occasionally disappear. Most Parrots and the Picariæ have similar openings, but a sternum of smaller size. The Passeres have a pair of simple but often deep incisures, which are still more strongly developed in many Grallæ and Palmipedes. In the Owls there are two small notches and processes upon either side of the middle of the posterior border, as also in many Scansores and Picariæ, and many of the Grallæ and Palmipedes, where they are often larger. The Gallinæ have four very deep notches, especially the internal pair, and very long abdominal processes, so that their sternum contains the least extent of bone. In the Pigeons the sternum is similar in character, though the external notch is larger. In the Divers (Colymbus) the middle posterior portion of the sternum is very long.

The *Scapular Arch* of birds consists of a narrow, somewhat curved, and long scapula, which covers the ribs posteriorly from above, and is united anteriorly by fibro-cartilage with the coracoid bone. The latter, which has been called also the posterior clavicular bone, but which is regarded by some anatomists as an increased development of the coracoid process of the scapula, becomes broader inferiorly toward the sternum, and is united to the anterior edge of that bone by a tense capsular ligament. There is found very generally a second anterior V-shaped clavicular bone, commonly called the "merry-thought" bone (*furcula*), the prongs of which converging downward and backward, are, with scarcely any exception, blended together, and frequently project into a process, which is united by ligament to the anterior apex of the sternal keel; more rarely a joint is formed in this situation which subsequently becomes obliterated by the formation of bony tissue. All these bones exhibit, with the exception of the Struthious birds, no very remarkable differences. In the Penguin, however, the scapula is very straight, and unusually broad at its posterior extremity; in the Woodpeckers it is bent behind in the form of a hook. The furcula is, in the Diurnal birds of Prey, very much divaricated,

in other words, strongly arched, its branches standing wide apart from each other; in the Owls the branches are thinner, and the whole furcula more V-shaped; this being the case in a still greater degree in the Gallinæ, where the process at the angle of union of the branches is of very considerable size. In the Cuckoo the furcula articulates with the keel of the sternum; in the Stork and Heron these parts are firmly united by syndesmosis, and in the Crane by actual coalition. In some Owls, Parrots, and in the Rhamphastidiæ, the two branches are not united, and in some New Holland Parrots (Pezoporus) the furcula is either entirely wanting, or in a very rudimentary condition. The Brevipennes present peculiar modifications of the scapular arch, for in them the scapula is very narrow and small, the furcula is wanting or coalesces with the coracoid bones, which in the Ostrich are each perforated by a single large opening, and in the Cassowary are represented by narrow bony plates. In the Emeu a rudiment of the furcula is always present, and appears in the Indian Cassowary as a mere hook-shaped process. The furcula is entirely wanting in the Apteryx.

The *Humerus* articulates by its broad head with the shoulder-joint, to which it is attached by a loose capsular ligament and several strong fibrous bands; this articulating surface is commonly formed by the coracoid bone and scapula. The humerus is in many of those small birds which are considered powerful fliers, as the Swift (Cypselus), Humming-bird, very short and broad, provided with processes, and in some degree resembles the scapula of the Mole. In the Penguin it is, in common with all the bones of the arm, quite thin and flattened; it is very large in the great Birds of Prey, as Gypaëtus, in the Ostrich at least it is much longer than the bones of the fore-arm, but is small and rudimentary in the Emeu. The two bones of the fore-arm are generally the longest in large Birds of powerful flight. The ulna, which is of considerable size and thickness, has usually a short olecranon at its proximal extremity, while near to and in front of it lies the far more slender radius. To these bones succeed two short bones, particularly large in the Penguin, very rarely wanting, as in the Emeu and Apteryx, and which represent the bones of the carpus. The metacarpus is always composed of a single bone, which consists however primarily in nearly all birds of two distinct pieces, which at a later period in their existence blend so completely together at their extremities, that a large elongated space is left between them. The principal bone is that which, corresponding in position to the radius, is turned

mostly directly forward, and forms the metacarpal bone of the middle finger; the smaller bone directed backward supports on its apex the little finger, while at the base and from the radial side of the middle metacarpal, a strong process is met with, which supports the thumb, and forms the rudiment also of its carpal bone. The thumb itself mostly consists of an elongated phalanx of considerable size, which supports the spurious alule or winglet; not unfrequently, however, as in the Ostrich, the Duck, and Swift, it supports a terminal phalanx provided with a horny covering. The thumb is wanting in the Penguin. The middle finger is the longest, and consists for the most part of two, more rarely, as in many Palmipedes, the Ostrich, and Emeu, of three joints; in the last-named bird a strong nail is met with upon the distal phalanx; the first phalanx is a tolerably broad bone. The little finger has in all cases probably only one phalanx. In this manner the hand of the Bird, without overstraining the homologies of its constituent parts, may be readily compared with that of the Mammalia. In some Birds which are possessed of great powers of flight, *e. g.* Cypselus and the Humming-bird, the portion which forms the hand is the largest in the whole skeleton of the arm. In the Penguin, also, the case is very similar, only the bones here are all situated in a rudimentary wing which has been converted into a paddle, and are therefore completely flattened, reminding us of the like condition of the anterior extremities in the Dolphin. In the Apteryx the hand is still more simple than in cases where it exhibits only a single three-jointed digit, for there a solitary phalanx, provided with a claw, is supported by the small metacarpal bone, and forms what is called the spur of the wing. The horny spur in Palamedea, Parra, Charadrius spinosus, and other birds, is firmly implanted upon a long process of the rudimentary metacarpal bone of the thumb.

As regards the movement of the anterior extremities in the bird, the arm is found placed in the position of pronation, and the hand is not capable of true flexion and extension, but merely of abduction and adduction, so that the rowing movement of the wings through the air in flight may be performed in the most efficient manner. The curves also of the articulating surface of the distal end of the humerus, upon which the radius and ulna move, are so differently arranged, that the two bones of the fore-arm, if flexed and extended upon each other in the longitudinal direction, would be inevitably dislocated. The radius acts in flexion by being pushed forward upon the corresponding small bone of the carpus, by which move-

ment the hand becomes more strongly bent, or drawn much more toward the fore-arm. A peculiar arrangement of ligaments gives to the arm the necessary degree of security during these complicated movements.

The *Pelvis* of Birds is completely closed posteriorly through the union into one of the mostly elongated iliac bones with the lumbo-sacral bone, but open in front, through the very general want of union of the pubic bones. The iliac bones are also frequently anchylosed to the last ribs and the dorsal vertebræ. The ischium is a small perpendicular plate of bone extending in the direction downward, and united to the iliac bones, so that the ischiatic notch is converted into a large foramen situated behind the acetabulum. The pubic bones are very thin, narrow, and rib-like, run parallel with the lower border of the ischia, and are usually united with them over a greater or lesser interval by a narrow ligament, so that between the two, as in most Passeres and Palmipedes, an often small but occasionally double obturator foramen is left. Frequently, as in the Birds of Prey, this pubo-ischiadic symphysis is ossified, so that both bones are united by a broad bridge; in other birds, on the contrary, as the Stork and Ibis, the two bones are not immediately in contact, but separated by a tendinous membrane. A part of the pubis however extends beyond this symphysis; the extremities of the pubis usually diverge strongly, as in many Grallæ and Palmipedes, but they are often expanded and converge considerably, as in the Diurnal birds of Prey, the Swan, and the Diving birds. A true pubic symphysis occurs however in the Ostrich, in which bird alone the pelvis is therefore closed in front. The acetabulum for articulation with the head of the thigh-bone, is always completely perforated, the bottom of its cavity internally being merely closed by ligament. Lesser peculiarities are exhibited in the conformation of the pelvis by the different orders. In the Penguin however a singular anomaly occurs, namely, that the hip-bones are not anchylosed to the vertebral column, but are rendered to a certain degree moveable by ligamentous union; a condition of parts which must tend to increase the waddling unsteady gait of this bird upon its hinder extremities, placed, as they are, so far back beneath the body.

The *Femur* is constantly smaller than the bones below it which constitute the leg, and is easily distinguished from that of the Mammalia by a groove upon the tuberosity of its external condyle, which is converted into a pulley for receiving the articulating head of the fibula. Upon its head there is a groove for the insertion of

a very strong ligamentum teres. The *Tibia* is always a strong and very elongated bone, and is characterized in particular by a bony bridge which proceeds obliquely from its lower end to the external maleolus, and beneath which the tendon of the extensor communis digitorum passes. Superiorly the tibia is prolonged into a crest-shaped process projecting in the direction upward and forward, above or behind which there lies, as in Aptenodytes, an often large and misshapen patella. In some Palmipedes (Podiceps, Eudytes), this process of the tibia is long, conical, and terminates in a point, and in the latter genus where the patella is wanting, it exceeds even the femur in length. In Podiceps a smaller, similarly formed patella lies behind the process. In the Ostrich two patellæ constantly occur, situated one above the other. The *Fibula* is always very slender, applies itself inferiorly to the tibia, to which it is partly united, and is frequently continued below into a mere fibro-cartilage. The metatarsal or tarso-metatarsal bone very strikingly reminds us through its simple condition of an analogous structure in the Ruminantia and Solipedia. It is strong and of very great length, projecting inferiorly into three trochlear heads for the three toes, and is frequently present, especially in the Wading-birds, as the principal bone of the leg exceeding remarkably the bones above it in length; toward its distal extremity a very small adjacent bone is found provided with an articulating head for the great toe when that is present; it is fixed to the tarso-metatarsal only by a ligament. In the Penguin the latter bone is unusually short and broad, and partitioned by deep longitudinal grooves and interspaces, so that its original division into three metatarsal bones becomes thereby indicated. most birds have four toes, and in that case the large, posterior or inner toe has constantly two, the next to it, three, the middle and longest four, and the external toe five, phalanges. When the great toe is wanting, the remaining digits preserve generally the above number of phalanges, though several departures from this rule occur, as in Caprimulgus, where the external toe has four joints, while in Cypselus all the toes, with the exception of the great toe, have three.

In Birds there occur more generally than in the other classes of Vertebrate animals, regular ossifications or sesamoid bones in several of the ligaments and muscular tendons, the presence and functional conditions of which frequently characterize whole families and orders. Thus in most birds the lower jaw obtains its supply of air from the tympanic cavity by a membranous tube, which, placed

close behind the os quadratum, passes internally thence into the pneumatic opening in the posterior part of the lower jaw. Now in the Passerine birds this tube is very generally surrounded by a bony sheath (*siphonium Nitzch*), which is absent in the remaining orders; in the larger species, such as Corvus, which are provided with a muscular vocal apparatus, this sheath of bone is very large and conspicuous. Another ossicle which constantly occurs in the Rapaces, Passeres, and Scansores, is called the humero-capsular, from its being situated within the articulating capsule of the shoulder, where it plays by means of a surface invested with cartilage upon the upper part of the head of the humerus. Frequently among the Passeres, as in Cypselus, a kind of patella is found in the tendon of the long extensor of the arm, behind the olecranon; it is even double in Aptenodytes, where two large patelliform bones are met with. Two other sesamoid bones (*epicarpium* and *hypocarpium*) are situated on the carpus, which serves as a point of attachment to the primaries of the wing. Two ossicles (*ossa palato mandibularia*) are occasionally situated upon the upper edge of the lower jaw, as in Fulica. In the ligament which passes from the jugal bone to the lower jaw, one or two ossicles are situated in many birds. Some others occur also in the lower extremities, as in many Mammalia.

MUSCULAR SYSTEM.

The muscles of Birds exhibit in general, in conformity with the whole organization of this class, fewer diversities of importance than those in the Mammalia and Amphibia. The muscles of most Birds are remarkable for their deep red color and the density of their texture. In the herbivorous birds the muscles are of a paler color, and softer, and their intervening cellular tissue contains a greater quantity of fat, so that the flesh is also more palatable as an article of food. The mechanical arrangement and position of the muscles is specially adapted to the performance of the function of flight; the fleshy parts of the muscles, or their bellies, are very short and thick, and concentrated upon the trunk, so as not to encumber the limbs, the muscles of which lie as much as possible upon the body, and are extended into long tendons, which exhibit a peculiar disposition, especially in the posterior extremities, to become ossified to a considerable extent.

The tegumentary muscles which contract the skin are very extensively developed in the present class, as also the muscles which bristle up the feathers upon the neck and head particularly of those birds, where they arise in tufts. In the Gallinæ a peculiar tegumentary muscle supports the crop as it hangs down in the neck. The strongest tegumentary muscles occur in the Apteryx, in which several distinct layers and fasciculi may be distinguished; a provision very necessary to this bird, which scratches deep in the earth, and must therefore shake its feathers with considerable force to dislodge the dirt from them. In addition to these muscles in birds, there are strips appropriated to the feathers, which becoming detached from the tegumentary muscles, form a sheath around the quill part of each feather where it projects into the skin. They are wanting generally to the down-feathers, and are in the others easily overlooked on account of their small size in most birds. In the larger birds, however, as some of the Palmipedes, *e. g.* the Pelican, Goose, and Duck, they are very much developed, each feather receiving four, more rarely five, small muscular fasciculi, which can move the feather in all directions, so that in Sula and Anas, where about 3,000 quill-feathers are reckoned upon the body, the number of these muscles amounts to 12,000. The muscles of the great primaries of the wing are the largest. No muscles are found upon the face of birds, the greatest part of which is covered by horny substance. The temporal, masseteric and pterygoid muscles, as well as the depressor of the lower mandible, are strongly developed, and so arranged, that in acting, they effect at the same time the movement of the upper maxillary arch and tympanic bones. It is rare for an asymmetrical disposition of these muscles to occur, as in the singular cross-bill of the Loxia curvirostra, in which the muscles of the jaws are more strongly developed upon one side than the other, but always upon that toward which the apex of the lower jaw is turned up in a state of rest.

As might be anticipated from the great degree of motion and flexibility of the neck, and the consequent freedom with which the head can be turned in all directions, the muscles of the neck and its nape exhibit numerous subdivisions, and are powerfully developed. The neck, especially when long, can be contorted like the body of a serpent in the most varied manner, a condition which was essential to birds, from their jaws having to serve principally as instruments of prehension. The fixed and partly anchylosed condition of the vertebræ of the trunk afford a strong immoveable point of attachment to part of the cervical muscles; while the muscles of

the dorsal and lumbar region are, on the contrary, less distinct and much more feebly developed.

The muscles which correspond to the *rectus capitis anticus major et minor lateralis*, *trachelo-mastoideus*, *complexus*, *biventer cervicis* (the last, however, being wanting in the Herons), are very large and powerful.

From the tail serving in Birds, as a very moveable rudder to steer their course through the air, the muscles which are found upon the caudal portion of the vertebral column are very strong and distinct, and arise from the pelvic and lumbo-sacral bones, which afford them a fixed point of attachment. By these muscles the tail itself is elevated, depressed, and lateralized, and by means of other very powerful fasciculi, which are attached to the proximal ends of the remigial feathers, these also can be expanded or approximated.

A great portion of those muscles which lie immediately upon the trunk, namely, the costal and abdominal muscles (*m. m. intercostales externi et interni*, *serratus anticus major*, *latissimus dorsi*, *m. rectus externus*, *internus transversus abdominis*), are but slightly developed, and of a very flattened form. The abdominal muscles, which, though broad and weak are however constantly present, form only a thin covering over the viscera, which are protected for the greatest extent by the large and expanded sternum; they have no transverse tendinous intersections, but are united in the middle by a broad white line (*linea alba*). The rectus muscle of the abdomen frequently does not pass to the pubis, but blends with its fellow of the opposite side in the sphincter of the anus.

The diaphragm, which is most developed in the Ostrich, is represented by small muscular fasciculi, which usually arise by digitations from the four middle sternal ribs, and are attached to a thin tendinous aponeurosis, which is spread over the inner and inferior surface of the lungs.

The pectoral muscles are enormously developed, more especially the *pectoralis major*, the fleshy mass of which in certain instances weighs as much as all the rest of the muscles put together. It arises from the keel and posterior and external part of the lower surface of the sternum, and from the furcular bones, and is inserted into the humerus, and serves to depress forcibly the latter bone, so as to produce the downward stroke of the wing in flight. Beneath it there lies a second muscle or *pectoralis minor*, and beneath that again a third. In the Ostrich the origin of the pectoralis major is

limited to a smaller proportional extent, namely, about one eighth of the anterior and outer part of the sternum; it is inserted by a feeble tendon into the crest of the humerus, which it moves in the direction forward. In the Penguin and some other Palmipedes the second pectoral muscle is actually the largest and strongest of the three, and extends over the whole length of the sternum; the *pectoralis tertius* s. *coraco-brachialis inferior* is here, also (and particularly in the Gallinæ), strongly developed; it acts likewise as a depressor of the humerus, and thus these muscles become in birds which, like the Penguin, use their wings only as fins, no less important agents in the performance of that function, than in the ordinary one of flight. The muscles of the shoulder are more feebly developed; the *deltoid* is divided into several portions; the rest may be easily distinguished as the analogues of the *trapezius*, *rhomboideus*, *supra spinatus*, *infra-spinatus* and *subscapularis* of the human subject. The extensors of the alary membrane (*m. m. extensores plicæ alaris anterioris*) present a peculiar structure; they consist of several short muscular bellies, which arise from the furcular, coracoid and humeral bones, and give off long slender tendons, one of which, composed partly of elastic tissue, runs along the free anterior border of the aponeurotic expansion of the wing, and is inserted into that portion of it which covers the radial side of the carpal bones. A similar tendon, only feebler and shorter, lies in the posterior part of the alary expansion (*m. tensor plicæ alaris posterioris*), and is given off by a muscle arising from the ribs; it is inserted by an aponeurosis into the fascia of the fore-arm.

Birds have in general two flexor muscles of the fore-arm, of which the biceps is strongly developed, and a single extensor; they have also pronators and supinators, but their action is limited to inflexion and extension of the fore-arm. Long narrow-bellied muscles with thin tendons are also met with, which adduct and abduct the hand, as well as move the phalanges of the digits; they have received the names of *m. m. extensores et flexores carpi* s. *metacarpi radiales et ulnares* (*longus et brevis*), *m. m. extensores*, *flexores*, *abductores*, *adductores pollicis et digiti medii*, &c. The last muscles act only as extensors and abductors.

The muscles of the pelvis are very slightly developed, and there are none which might correspond to the psoas, obturator externus and quadratus lumborum muscles; the other muscles here situated may be compared with the *iliacus*, *obturator internus* and *pectinæus*. In the posterior extremities, from their having to support the entire

weight of the body, the extensors obtain a manifest preponderance of size over their opponent flexors, and all take their origin high up upon the pelvis. Two glutæi muscles (*m. glutæus major et minor*) may be distinguished, the first of these being of tolerably large size, and filling up the external concave surface of the ilium; there frequently occurs also a third glutæus muscle. Of the *gemelli* muscles the superior one is present. The adductor and flexor muscles, viz., the *rectus femoris*, the *sartorius* which is often wanting *e. g.* in the Herons, the *m. gracilis*, *biceps femoris* and also the *tensor vaginæ*, admit of being readily referred to their respective analogues in Man.

Such is also the case with the remaining flexor and extensor muscles of the leg and toes, in which a *gastrocnemius*, *tibialis anticus*, *peronæus*, *flexor digitorum longus perforatus et perforans*, can be distinguished, along with special adductors and abductors of the toes. The fleshy portions of all these muscles are situated high up, arising from the proximal end of the tibia, or even from the femur, and are continued over the rest of the leg, in the form of very long tendons. They exhibit modifications in the foot according as the great toe is present or absent, or there is a fifth toe developed, or in relation to the whole foot, as it may be adapted either for swimming or climbing, &c.

The methods by which the actions of swimming and flying are performed are subjects belonging rather to the physiology and natural history of birds, and can not therefore be further inquired into in the present work.

NERVOUS SYSTEM.

The same coverings or membranes can be distinguished in the Brain of birds as are met with in that of the human subject. The dura mater, which is of a tough consistence, gives off a feebly developed falx, prolonged from a bony ridge upon the internal surface of the cranial cavity, between the two cerebral hemispheres. A strong fold of this membrane forms also a tentorium between the cerebrum and cerebellum; and the vascular plexuses of the pia mater are remarkably developed.

The *Hemispheres* form a pair of nervous masses usually of the shape which their name implies, but which are, in some cases, as in the Grallæ, Palmipedes, and also in the Parrots, more elongated longitudinally, than laterally expanded, as in the Birds of

Prey, while they present in the Pigeons and Passeres a tolerably uniform and rounded aspect. Their surface is either quite smooth, or exhibits only simple inflexions, or several shallow depressions, as in the Parrots. They appear to terminate abruptly behind, so as to leave the small cerebellum completely uncovered. The cerebellum, as it is called, would seem to correspond rather with the vermiform process of that organ in the Mammalia, here increased in size, and its hemispheres, to a pair of lateral projections or appendages of the same. This process is divided into a considerable number of lamellæ (20 to 30), which vary in different genera. A longitudinal section exposes in its interior the arbor vitæ, the ramifications of which vary numerically according to the genera, they being 9 in Lanius, 11 in the Falcon; the corpora dentata cerebelli are, however, wanting. There is no distinct connecting commissure to the lateral lobes, or pons, its place being supplied only by some transversal medullary fibres. The corpora quadrigemina are represented by a single pair of convex eminences, presenting externally no indications of a further division, and which, placed tolerably apart from each other, are interposed between the cerebral hemispheres and cerebellum. They are composed externally of white or medullary substance, but have internally a large nucleus of gray matter, enclosing a small cavity or ventricle. The thalami optici of smaller size are partly united with these bigeminal bodies, and partly lodged within the hemispheres of the cerebrum. The corpora striata form a pair of large ganglia. Superiorly and posteriorly, in the angle between the cerebellum and its two hemispheres, the pineal gland is situated as a tongue-shaped lobule, in general placed quite superficially, though its position in the Owls is deeper. It is easily removed along with the dura mater in stripping off that membrane. The pituitary body lies in a depression of the sella turcica of the sphenoid bone, and is of considerable size. Of the commissures, the great or corpus callosum is extremely short and small, and the part corresponding with the fornix is in an equally rudimentary condition. These parts have in fact all but coalesced with the anterior commissure, from which a radiated expansion of medullary fibres may be seen, upon drawing the hemispheres asunder, to be prolonged into their substance. Several streaks of gray and white matter lying further back behind this, correspond to the commissura mollis and posterior, which overlie the large valvula cerebelli. The ventricles of the brain are essentially the same as in the Mammalia, only the lateral ventricles have

coalesced into one with the third ventricle, and are prolonged forward into the olfactory ganglia or mammillary processes, as in most of the Mammalia. The fourth ventricle communicates as a narrow slit with the stem of the arbor vitæ, and in the direction forward with the aqueduct of Sylvius.

The *Spinal Cord* is connected to the brain through the intervention of a well-developed medulla oblongata; it is cylindrical throughout, has an anterior and posterior fissure, and a narrow central canal which extends throughout its entire length. There is a swelling upon the anterior extremity of the cord corresponding with the origin of the brachial plexus of nerves; another of larger size is situated within the lumbo-sacral bone, and accords with the origin of the nerves to the posterior extremities, while at its commencement the lateral columns of the spinal marrow diverge so much as to form a kind of groove, termed from its figure the rhomboidal sinus, and which, communicating with the median canal of the cord, is covered by a very soft gelatinous transparent substance, consisting of an assemblage of delicate white cells permeated by blood-vessels. The spinal cord then becomes narrower and is prolonged into the canals of the caudal vertebræ.

The twelve cerebral pairs of nerves in the class of Birds can be readily referred to their types in the human subject. The nerves of smell take their origin from a special swelling or olfactory ganglion. The optic nerves are always of very large size and cylindrical, and form a complete union or chiasma, which consists in general of eight nervous fibrils, that decussate each other. The fifth pair is very conspicuous, and the larger or sensitive root has a Gasserian ganglion upon it. Its first or ophthalmic division combines with a branch from the oculo-motor, or third pair of nerves, to form a large ciliary ganglion, from which is given off directly the ciliary nerve supplying minute filaments to the iris. No connexion of this nerve with the sympathetic has been observed; a fact which is the more interesting, from the relation which it probably bears to the voluntary power possessed by Birds over the movements of their iris. From the ophthalmic division of the fifth a branch proceeds also to the Harderian gland, another to the nasal organs, while a third ramifies upon the beak, so that this nerve is more extensively distributed than in the Mammalia. The second division or superior maxillary nerve is particularly large in the Ducks and Geese, and ramifies in the upper mandible beneath its marginal lamellæ and the mucous lining of the palate; branches also arise from it to

supply the eyelids and lacrymal gland. The course of the inferior maxillary or third branch of the fifth is very simple, entering the canal of the lower jaw, and ramifying, as may be most distinctly seen in the Duck, beneath the horny texture of the mandible; it gives off no gustatory branch to the tongue. The small root of the trigeminal nerve passes over the ganglion, and distributes twigs, as in the Mammalia, to the manducatory and hyoid muscles. The third, fourth, and sixth nerves correspond with those of the Mammalia, and supply the muscles of the eye; their mode of origin from the brain is the same as in Man, and their cerebral roots admit of being easily traced. The large muscles of the nictitating membrane are supplied in birds by nerves from the sixth pair, or abducens. The seventh pair, or portio dura, is, as might be premised from the absence of facial muscles, only feebly developed, and as usual united with the portio mollis or auditory nerve. The eighth, or glosso-pharyngeal, is more remarkable, and differs in several important relations from the same nerve in Man and the Mammalia. It is more intimately united than in them both in its origin and course with the nervus vagus, and gives off, in common with the latter, several branches to the pharynx and upper part of the larynx, parts which in the Mammalia are supplied from the nervus vagus only. The most important branch however of the eighth is the largest, which is distributed to the tongue, and may be traced in birds of a delicate sense of taste into the papillæ of that organ, serving unquestionably in such cases to the exercise of the gustatory function. At all events, this nerve, as well as the vagus, is of a mixed character, being both motor and sensitive. The vagus gives branches to the muscles of the tongue, descends the neck by the side of the jugular vein, and forms plexuses, from which branches proceed to the pharynx, lungs, stomach, and proventriculus, while recurrent branches are distributed to the muscles of the inferior larnyx. The nervus accessorius soon unites within the cranium with the vagus. The hypoglossal nerve, or ninth pair, arises by two roots, and gives branches to the muscles of the tongue, which are particularly developed in the Woodpeckers, and others of large size, to the sterno-tracheal muscles.

The brachial plexus is formed in birds by the two last cervical and two first dorsal nerves. The nerves of the lower extremity proceed from an anterior and posterior plexus, that of the lumbo-sacral nerves forming the ischiatic nerve. The number of spinal nerves generally corresponds with that of the vertebræ.

Communications may be traced between the cranial portion of the *Sympathetic system* and most of the cerebral nerves. The superior cervical ganglion is of considerable size. The remainder of the main trunk of the sympathetic then enters the uppermost cervicle vertebræ by the canal formed by their double transverse processes, communicates with the corresponding spinal nerves in that situation, and forms ganglia upon the vertebral vessels. It next issues from this canal, and is continued over the brachial plexus, to which other ganglia developed in its course are very firmly attached, and at length enters the thoracic cavity, where it becomes of very large size and forms a ganglion in front of the head of each rib; two nervous filaments from each ganglion, one passing above, the other below the neck of the rib, serve to bring into communication contiguous ganglia. The branches from the thoracic ganglia give off the splanchnic nerve, which forms an aganglionic cæliac plexus accompanying the gastric and intestinal arteries, but passing chiefly to the muscular parietes of the gizzard and to the liver. The nerve is then prolonged to the caudal vertebræ, where it terminates in a series of small ganglia.

ORGANS OF THE SENSES.

Organs of Vision.

All Birds, without exception, are provided with a perfect and well-developed visual apparatus. The eyes are always of great size, being largest and most prominent in the Owls, flattened and smallest relatively to the size of the head in the Natatores. They are but slightly moveable, and are situated in orbitar cavities circumscribed superiorly and laterally by bone, which are separated in the cranium from each other by a thin osseous plate, frequently perforated to such an extent as to leave only an intervening membranous partition. The globe of the eye, the form and component parts of which may be recognised upon a perpendicular section, is convex posteriorly, more flattened in front, or, as in the Owls, elongated into a round cylinder, and in such cases provided with a very prominent cornea. The very dense and tough sclerotic coat is supported by a series of bony plates interposed between its two fibrous layers, and united so as to form a continuous circular chaplet embracing the posterior part of the eyeball as far forward as the margin of the cornea; their number consists mostly of 12—15, and they partially

overlap each other so as to admit of a slight degree of motion. These osseous plates are most largely developed in the Owls, as the horned species or Hibous, where they form a cup-shaped ring of remarkable depth, and are usually as long as they are broad. The cornea is in general highly convex, to the greatest degree in the Birds of Prey, and least in the Natatores. The anterior chamber of the eye is very large, and contains an abundant quantity of aqueous humor, so that the iris is very far removed from the cornea. The choroid is provided upon both its surfaces, especially the internal or retinad, with a dense and black layer of pigment. It is attached in front and externally to the sclerotica by a dense white ciliary ligament or zone, from which fasciculi proceed to the iris and largely plicated ciliary processes. These fasciculi, like the fibres of the iris, exhibit under the microscope the transverse striæ so characteristic of voluntary muscular tissue. Between the folds of the ciliary ligament is situated the canal of Fontana. The iris presents numerous shades of color, but is never of a metallic hue; the yellow color of the iris, *e. g.* in the Owls, being due to the presence of distinct racemoid follicles or cells which contain a fluid fat. The pupil, which can be voluntarily contracted and dilated by the movements of the iris, is always round. The optic nerve perforates the posterior part of the globe of the eye by a slightly excentric elongated fissure. The retina presents a well-developed papillary or nervous layer, and the vitreous humor, which is in considerable quantity, exists in a semi-fluid condition. The variously-shaped but never spherical lens is generally more convex upon its posterior surface.

A peculiar mechanism is met with in the eye of birds, which has been called the *pecten* or *marsupium*. This organ, which is more or less quadrangular, and varies in length and breadth, consists of a plicated membrane invested like the choroid (from which it is a production corresponding in structure) with a layer of black pigment, and projects forward from the fissure of entrance of the optic nerve into the vitreous humor, frequently, though not always, reaching as far forward through the apex of its longest fold, as the posterior surface of the capsule of the lens. It is very richly supplied with blood, by an arterial plexus given off from a ramuscule of the ophthalmic artery, which corresponds to the arteria centralis retinæ. The form and number of the plications of the marsupium vary remarkably in the several genera and species, and even in individuals of the latter. In the Ostrich and Casso-

wary the folds are acutely angular like those of a fan, though in other cases they are generally rounded off. Nocturnal birds have in general the fewest number of folds, *e. g.* the Owls from 5 to 6, the Goatsuckers 5. In the greater proportion of birds from 14 to 15 occur. The folds are most numerous in the Passeres, where they amount from 16 to 18, and 22, or even 28, as in Corvus. In Diurnal birds of Prey, there are from 14 to 16; in the Gallinæ 16 to 18, and in most Palmipedes only 9 to 12. The pecten in the Ostrich is provided with 15 or 16, in the Cassowary with 4 or 5, and with 18 folds in the Humming-bird.

The function of the marsupium is unknown. It can not in any way contribute, as has been suggested by some anatomists, by the alternate contraction and dilatation of an erectile tissue to alter and adjust the focal distance of the lens within the eye; this power, which is possessed to a considerable extent by birds, being probably effected by the conjoined action of the muscular and very mobile structures of the iris and ciliary ligament, by which the position of the lens may be shifted. The whole form of the eyeball is very admirably adapted for the exercise of this function, through the large size of its anterior chamber, and the quantity of aqueous humor contained therein.

A remarkable exception to the great uniformity of structure which the eye exhibits throughout the present class, is furnished by that singular bird of New Zealand, the Apteryx australis. The marsupium is here entirely wanting (and so far as is known this is the only instance of the absence of that organ among Birds), a condition which may be probably associated with the perfectly nocturnal habits of this species, and its limited range of locomotion. The optic nerve enters the eye by a small round opening, and the globe of the eye is in proportion to that of other birds of very small dimensions; the lens also is small, and very convex.

The eye of Birds is moved by four recti and two oblique muscles; the trochlea or pulley for the tendon of the superior oblique muscle is however wanting, and all the muscles are proportionally very short. All birds have three eyelids; a superior which is the shortest; an inferior the largest and most moveable palpebra, provided with a tarsal cartilage, and a third situated in the anterior angle of the eye, which is very moveable, and called the nictitating membrane. The orbicularis palpebrarum muscle, which is most strongly developed in the Apteryx, is inserted into the tarsal cartilage, and when it acts draws the lower eyelid in the direction upward. The

levator palpebræ superioris arises from the roof of the orbit, and is inserted near the external canthus of the lid. Both the upper and lower eyelids are provided with short feather-like bristles, as eyelashes. The nictitating membrane can be swept by a very peculiar mechanism over the whole anterior surface of the eye. The muscular structures by which this is effected may be best studied in the eye of the Owl. A very broad, flat, thin, and quadrate muscle (*m. quadratus memb. nictitantis*) is situated upon the back part of the globe of the eye, and arises from the superior and posterior margins of the sclerotica. Its fibres descend toward the entrance of the optic nerve, and terminate in a free concave tendinous canal. A second muscle (*m. pyramidalis memb. nictitantis*) has a short narrow belly which arises from the inner or nasal aspect of the eyeball, and gives off a long slender tendon, which, as it turns round the optic nerve, passes through the canal formed by the tendon of the quadratus, and is inserted into the lower margin of the third eyelid, which by the contraction of this muscle is drawn like a curtain in front of the globe of the eye. In the Owls a small ossicle (*ossiculum tuberculare*) is situated upon the inferior surface of the bony ring of the sclerotica, to support the long tendon of the pyramidalis muscle.

Birds have very generally a *lacrymal gland* situated in the posterior angle of the eye, two excretory ducts, and a membranous lacrymal canal leading into the nasal passages. The *Harderian gland*, which has been already alluded to (p. 26) as occurring in many Mammalia, is much more largely developed in Birds than the lacrymal gland, and especially in the order Palmipedes, as the Goose and Pelican. It is situated upon the anterior or internal angle of the eye, and through an excretory duct which opens upon the inner surface of the nictitating membrane, pours out a viscid secretion to moisten and lubricate the latter.

Organs of Hearing.

The Organs of Hearing in Birds admit of being easily demonstrated, from the very superficial position which the labyrinth occupies in relation to the bones of the cranium.

An external ear or auricle is wanting, and it is only a few species, such as the Owls, which have a large membranous crescentic fold or auditory conch, provided with tufts of short feathers, and which can be used as a valve. The largest ear-conch is met with among our indigenous Owls in the long-tufted Hibou (strix otus).

The external auditory meatus is short, and completely formed by bone posteriorly, where it forms a conchiform expansion. The membrana tympani large and consisting of several lamellæ, is directed obliquely backward and inward, and differs in form from that of the Mammalia, by being stretched so as to be convex or infundibuliform externally toward the meatus, instead of internally, as in the human subject. The tympanic cavity is spacious and irregular, and receives the orifices of the two mostly osseous Eustachian canals which nearly coalesce together at their faucial extremity into a common opening. Other small apertures conduct from this cavity into the osseous cells of the surrounding bones, which correspond to the cells of the mastoid process, and occasionally extend over the whole cranium. The walls of the tympanic cavity are not truly closed, but communicate directly with all the cranial bones, and even with the os quadratum.

A veritable chain of auditory ossicles may be distinguished, one of which is style-shaped and bony, while the two others remain in a cartilaginous condition. The external of these cartilages, corresponding to the malleus, is mostly of a triangular shape, perforate, and provided frequently with a long process, abuts against the membrana tympani. The second internal but smaller cartilage may be frequently detached from the malleus, which it serves to unite with the stapes or columella; it may be regarded as the rudiment of the incus. The principal bone is the long styliform analogue of the stapes, the *columella* or *bacillus;* its base expands into a broad oval plate which is lodged in the foramen ovale, and through this the sonorous impressions are transmitted to the aqueous fluid of the labyrinth. More frequently the columella is found to be broader inferiorly, and by being provided with two crura, to assume its characteristic stirrup-like figure, as is the case in the Pelican, Raven, &c., where it resembles the stapes of many of the Mammalia, *e. g.* the Kangaroo.

Only a single muscle can be detected for moving the auditory ossicles; this would seem to correspond to the laxator rather than the tensor tympani, the nominally implied action of the latter muscle upon the membrana tympani being usually effected by the elasticity of the malleal cartilage. The muscle in question arises from the posterior part of the tympanic cavity, and is inserted into the malleal cartilage, expanding also in a tendinous manner upon the membrana tympani.

The Labyrinth consists of very compact bony parietes, but is

surrounded by a very loose osseous tissue, so that it may be readily exposed for examination. The vestibule is very small, while on the other hand the semicircular canals are large and vary in size; being slender, elevated and broad in the Rapacious and Passerine birds, but depressed and thick in most of the Grallæ, Palmipedes, and Gallinæ. The vertical canal from the depth of its arc is apparent at once within the cranial cavity, without any previous preparation, and is directed inward and forward. The two others, which are directed externally and posteriorly, cross each other completely; the external or horizontal canal being the smallest. In the direction forward there projects a slightly-curved osseous cone, with the concavity directed downward, inward, and somewhat backward, which represents the cochlea, although it is not spirally twisted like that organ. The foramen rotundum, which is small and closed by a kind of secondary tympanic membrane, is here met with, and serves to bring the cochlea and vestibule into functional communication with each other. The foramen ovale is in Birds also round, but larger than the f. rotundum, and is closed by the basi-opercular plate of the columella.

A mucous membrane is found lining the bony labyrinth; the tubes of the semicircular canals dilate into ampullæ, the external of which is the least developed, while the anterior and posterior are supported by a cruciform septum, and it is upon the bulging prominence of this septum that the auditory nerve expands. These dilatations are visible at once upon opening the cavity of the labyrinth. The cochlea contains internally, as in the squamigerous Amphibia, two curved cartilaginous lamellæ of a triangular form, united by a delicate membrane; upon this lies another plicated and very highly vascular membrane, which gives off a sacciform expansion, called the Utricle (*lagena*), into the round terminal dilatation of the conical cochlea. One of these cartilaginous lamellæ (the vestibular) is fringed with dentoid processes, the number of which differs in the several genera. The other or tympanic cartilage is situated in the direction backward, and faces the foramen rotundum. A branch of the auditory nerve enters the cochlea upon the external side of one of these cartilages, expands and perforates it by numerous filaments, which are distributed upon the membrane connecting the two cartilages, and analogous to that covering the lamina spiralis in the higher animals; a branch is also given to the utricle. In the membranous sac of the vestibule, which is double, being divided by a thin septum, pulverulent masses of crystallized phosphate of lime

(otoliths) are found, as in Man and Mammalia. The diversities presented by the auditory apparatus in the several orders and genera can not be entered upon in a work like the present. The Struthious birds appear to agree essentially with the other members of the class in their organs of hearing, only their conical cochlea is the smallest in size in proportion to the other parts.

Organs of Smell.

The ethmoid bone in Birds forms an osseous plate of considerable size (frequently interrupted by an aperture closed with membrane), which is interposed between the orbitar cavities, and presents generally rudiments of lateral parts. This bony septum is completed in front by cartilage. The nasal cavity is remarkably large; a proper external moveable nose is, however, wanting, and the nostrils are situated upon the upper mandible near to the base of the bill, being wide and distinctly visible; but in rare instances, as in the Booby (Sula alba), they are so narrow that they have been erroneously believed to be wanting altogether. Cartilaginous but immoveable nasal alæ are for the most part present, and occasionally, as in the Albatross, Petrel, and Puffin, elongated into a tube which may be regarded as an external nasal organ. The nostrils vary in form and size, and are frequently, as in the Raven, protected with feather-like bristles. The two nostrils are separated from each other by a septum, which is wanting however in many birds, *e. g.* the Gallinazo (Cathartes), so that they intercommunicate from either side. The posterior nasal orifices (*choanæ*) are two long narrow fissures frequently coalescing into one, at the commencement of which in the palate are usually found some epithelial papillæ. Within each nasal cavity are situated three cartilaginous, rarely partly ossified, turbinated bones; the superior of these is formed by a simple spheroidal or bell-shaped inflexion of the lateral cartilaginous parietes of the nasal cavity; the inferior frequently consists of a small curved plate provided with lateral projections, which adheres to the septum narium and is often largely developed, as in the Snipe, where it is represented by a falciform lamina. The middle one, which is the largest in size, is to be regarded as a true turbinated bone, being constantly a perfectly convoluted cartilagino-membranous plate varying in its degree of development. Among birds of the Duck kind, its convolution makes two and a half turns, in the Gallinæ only one and a half; accessory nasal cavities or sinuses are

rarely met with, though in Anas clangula true frontal sinuses are found extending over the whole upper part of the cranium. The nasal cavities are lined by a very vascular mucous membrane. The olfactory nerve ramifies in a radiated manner upon the septum narium and superior turbinated bone only, the two inferior ossa turbinata receiving filaments from the fifth pair.

A peculiar *Nasal Gland* for lubricating the surface of the pituitary membrane of the nose is very generally found, being rarely wanting, as in the Pigeon, Cuckoo, and Woodcock, and is often very largely developed. It exhibits very great diversities throughout the orders and genera; in many Birds, as the Palmipedes, *e. g.* Eudytes, Alca, Diomedea, and in Charadrius, it lies in a deep cœcal depression upon the frontal bone, which is narrower and flatter in the Gulls and Puffins. The gland is of a crescentic shape in most Birds, as the Passeres, Gallinæ, Owls, many of the Grallæ and Palmipedes, and situated in depressions above the obtuse supra-orbital ridge; in the Bustard it is placed near to the superior turbinated bone; in the Rapacious and some of the Wading-birds, as the Heron, it is lodged in the upper part of the orbit, but very rarely, as in the Woodpeckers, in its lower part beneath the eyeball. The two nasal glands often form, as in Charadrius, large cushions upon the forehead, and in these cases the excretory duct perforates the groove of the frontal bone anteriorly, and is continued onward upon the external wall of the nasal cavity. The Ostriches have a nasal gland, but only slightly developed.

Organs of Taste.

Covered for the most part by a hard and dense epithelium, and having only upon its root some softer sensitive papillæ supplied by branches of the glosso-pharyngeal nerve, the Tongue is obviously but ill adapted to serve as a very refined instrument of taste; still however the extent to which this function is enjoyed varies in many Birds.

Setting aside, as belonging rather to the special province of Ornithology, a detailed description of the great diversities of form and structure which this organ presents in the several genera of Birds, we shall be content with only noticing here some of its most striking modifications. It is of moderately large size, but hard and horny in the Rapaces, Corvidæ, &c.; short, thick, subcylindrical, and soft in the Parrots, where alone it is frequently provided with small soft

and filamentary papillæ. Other Parrots, as the Lorikeets (Trichoglossus), are furnished with an extensile tongue terminated by a pencil of hairs (whence the generic name), adapting them admirably for feeding upon the nectar of flowers. In the Woodpeckers the tongue is very long, slender, and vermiform, and beset with small retroverted hooks. In the Humming-birds it is also very long and, as in many other birds, deeply slit at the apex, but each half is in them hollowed out into the form of a groove, so that the two divisions when approximated form a tube, which serves as a syphon for pumping up the nectar from the flowers. The tongue is in the Flamingo exceedingly large, angularly curved, and fleshy, or rather provided with an abundant cellular and adipose tissue (upon which account it was esteemed by the Roman emperors as a savory article of food), and its upper surface is covered with recurved spinous papillæ. It is, on the contrary, extremely small and rudimentary in the Picariæ and Auks, and even more so in the Pelican and Gannet (Sula), where in fact the styliform and slightly curved hyoid cartilage covered by the mucous membrane of the mouth is all that can be detected, so that a proper tongue may be said to be completely wanting. In the Tenuirostral and Passerine birds generally, the greater part of the gustatory organ is horny with acute lateral margins. Frequently, as in the Toucans (Ramphastos), it is comb or brush-shaped upon either side, from being provided with horny fringes. There is found within the substance of the tongue posteriorly a usually double, rarely single, cartilaginous or frequently osseous body (*os linguale, ossa entoglossa Nitzch*), which abuts against the hyoid bone, and forms at the same time the apicial portion of its body. In the two-toed Ostrich (Struthio camelus) this lingual ossicle coalesces with the hyoid bone, and in many Birds consists of an anterior and posterior division.

The *Os hyoides* consists of an elongated and narrow body, which usually extends posteriorly into a short pointed, or longer filamentary cartilaginous portion, and has upon the middle of its sides or more posteriorly a pair of articulating surfaces for the lesser cornua. These are often very long, and formed of an anterior thicker osseous, and a posterior slenderer piece, which is more or less cartilaginous, and terminates in a filamentary manner. In the Woodpeckers and also in the Humming-birds peculiar modifications are exhibited in the arrangement of the above parts; in them the cornua of the os hyoides are exceedingly long and slender, and continued round the skull beneath the skin to the base of the upper mandible, where their

extremity is inserted in a groove above the nasal apertures; by this contrivance the tongue admits of being projected far out of the mouth to nearly the length of the body, and thus constitutes a most efficient implement for either spearing rapidly their insect food, as is the case with the Woodpeckers, or, as in the Humming-bird, for probing in search of nectar to the bottom of tubular flowers.

The tongue, together with the hyoid bone that supports it, is moved by three to four pairs of muscles, which correspond to the *genio-* *stylo-* and *sterno-hyoid* muscles in Man; besides which there is an additional pair of very short muscles. All these are remarkably developed in the Woodpecker; where we meet also with a singular pair of muscles, called *cerato-tracheal*, which arise from the trachea about half an inch beneath the superior larynx, wind several times spirally around it, and are inserted into the terminal portion of the hyoid cornua; they serve chiefly to forcibly retract the tongue. The most complicated condition of lingual muscles occurs in the Parrots, from their being the only Birds that truly chew their food. The usual number of muscles is here increased; the most important being the *myloglossus*, which retracts and bends the tongue in the direction downward.

Organs of Touch.

The tongue serves frequently in Birds for an organ of touch, as in the Woodpeckers, where it is darted into the chinks and holes in the bark of trees in search of the larvæ of insects. Many Natatores, *e. g.* the Ducks and Geese, and the Flamingo among the Grallæ, have the upper mandible soft and profusely supplied with nerves from branches of the fifth pair, so that they possess a delicate tactile sensibility in that part which enables them in stirring up the mud with the bill in quest of food to appreciate more readily its presence. An apparatus of touch is also developed at the apex of the Snipe's bill, which is provided for that purpose with numerous osseo-cellular depressions.

DIGESTIVE SYSTEM.

The superior, inferior, and intermaxillary bones of the Bird are generally invested by horny sheaths, which form in the several orders and families a beak of very varied character, the modifications in the structure of which are commonly depicted in Zoological works.

It is in the Parrot-tribe alone that the horny mandibles perform the functions of a proper instrument of mastication; for, as a rule, they are adapted only for seizing and retaining the food within their grasp. The peculiar degree of mobility of which the superior maxillary arch is capable in Birds, has been already alluded to in speaking of their skeleton. The jaws are moved by several muscles (see Muscular System) analogous to those of the Mammalia.

In place of the velum palati, we find near to the opening of the posterior nares within the faucial cavity, tubercular elevations of epithelium, or dentated ridges similar to those upon the root of the tongue and the margins of the glottis, and behind these are situated glandular follicles, which have been regarded by some as analogous to the *amygdalæ or tonsils*. These follicles are frequently aggregated into a thick glandular layer, provided with numerous excretory openings, as in the Birds of Prey, while in others of the class Aves *e. g.* the Cormorant (Carbo) they are altogether wanting.

The *Œsophagus* is always very muscular, slightly plicated internally, and expands in many Birds usually below its middle and in front into a sacciform pouch called the *crop, craw,* or *ingluvies*. This is commonly of a thin membranous texture, provided internally with small mucous glands, and when distended with food hangs down in the neck in front and between the branches of the furcula, and, as in the Gallinæ, is there supported by a special muscle. The crop is found in all the Diurnal birds of Prey, but it is only feebly indicated in the nocturnal Rapaces or Owls; it is of large size in the Parrots, particularly so in the Gallinæ and Pigeons, and more rarely in the Grallæ and Palmipedes, as in the Flamingo (Phœnicopterus). The craw is extremely large in the Pigeons, and during the period of incubation obtains in both sexes a remarkable degree of vascularity, its lining membrane becoming, at the same time, developed into a network of folds and cells, which form two large lamiuiform layers, that secrete and pour out into the crop a creamy or lacteal fluid; with this alone, discharged from the crop of the parents, the young are at first fed, but at a later period of their existence it is mingled with grain, that has been macerated in the ingluvial secretion. The craw is generally wanting in the Struthionidæ, with the exception of the Cassowary, and also in the Scansores and Passeres, where the œsophagus is frequently much expanded and even wider than the proventriculus. In rare instances, as in the Pelican, there occurs an additional expansion of the gullet which is situated between the rami of the lower jaw, and being provided with muscular arches,

serves as a bag for carrying food. It may be compared to the cheek pouches of the Rodentia, A very singular peculiarity occurs in Palamedea cornuta, which consists in the presence of a craw-like dilatation between the proventriculus and gizzard.

At the extremity of the gullet there is found very generally occurring throughout the class of Birds a first division of the stomach, called the *proventriculus* or *bulbus glandulosus*, the walls of which, as the latter name implies, are thickly studded with a layer of simple or divided glandular follicles, that pour out their secretion by separate mouths upon the internal surface of the stomach. The proventriculus is in general, *e. g.* in the Gallinæ, Geese, and Ducks of a smaller size than their very largely-developed gizzard, but frequently the reverse is the case to a striking degree, as in the genus Thalassodroma or Storm-petrel, and the Puffin. In the Pigeons long slender strips of glands are sent upward from the proventriculus over the œsophagus as far as the crop, and between these the œsophagus is thin and membranous. More rarely, as in the Northern Divers, the commencement of the proventriculus is indicated by a narrow chaplet of glandular follicles situated at the termination of the gullet, or it is not recognisable externally by any expansion, as in Euphone violacea; its cavity, however, is provided throughout its entire extent with follicles. The gastric follicles are usually simple cœca of very small size, as in the carnivorous Birds, and frequently also in the granivorous Birds, as the Peacock and Cassowary, but they are larger and divided at the extremity in the Common Fowl, or even slightly racemoid, as in the Ostrich. The proventriculus is distinctly separated by a constriction from the gizzard in all cases where the latter is very fleshy, but when it is more membranous, both stomachs communicate with each other by a wide aperture.

The second fleshy muscular stomach or *Gizzard* is very highly developed in the Granivorous birds, as in the Fowls and Pigeons, and also in many Grallæ and Palmipedes, as the Swan, Goose, Duck, Coot, and Flamingo. The thick muscular layers upon either side are here divided in the middle by a tendinous disc, into two halves. The cavity of the gizzard is of but small extent, owing to the projection internally of its strong muscular parietes, and is invested by a hard, pergamentaceous or even horny epithelium, which can be readily detached. Occasionally corneous tubercles project from the epithelium, as in the Puffin. The gizzard is frequently also of very small size, not very muscular, and provided only with a flat thin disc of radiating tendinous fibres. In the Pelican and Gannet

the œsophagus is much wider than the gizzard; the latter is very thin and membranous, as in the Divers. It is very rarely, as in Euphone violacea, that all traces of a muscular stomach or gizzard are wanting. On the contrary, there occurs occasionally, as in the Herons and Pelican, though not in the genus Sula, so nearly allied to the latter, a third always smaller gastro-pyloric dilatation, which is tolerably distinct, and conducts by a narrow pyloric opening into the duodenum.

The *Intestinal Canal* always makes a number of convolutions upon itself that are retained in their place by mesenteric folds of peritoneum; the latter membrane does not, however, develop true omenta. The duodenum forms at its commencement a long loop, within which the pancreatic gland is situated, while the small intestine is continued at its lower extremity into a large intestine not much wider, but shorter, and passing downward in front of the vertebral column, its commencement being usually indicated by a symmetrical pair of short or longer cœca coli. The large intestine terminates by opening into a wide sacciform or rather bladder-shaped compartment of the urethro-sexual cavity, the cloaca. The villi of the small intestine are generally much elongated, and extend also occasionally as far as the extremities of the cœca, *e. g.* in Fulica, but this is not the case in the Gallinæ and Owls. The villi are, however, frequently wanting, or rather, there occur instead zigzag folds of the lining membrane, as in Corvus, Euphone, Turdus, and perhaps in the Passeres generally.

Many varieties occur in reference to the two cœca just alluded to. They are, for example, completely wanting in nearly all the Scansores and Picariæ, as Picus, Psittacus, Rhamphastos, Alcedo, Upupa, Cypselus; they are very short in the Pigeons, Owls, most Passeres, and many Grallæ, *e. g.* the Stork and Spoon-bill, somewhat longer generally in the Diurnal birds of Prey, while they attain, on the other hand, a considerable development in most of the Natatores, as the Geese, Ducks, &c., where they are frequently also asymmetrical, being longer upon one side than the other. The cœca are of surprising length and width in the Gallinæ, as in Tetrao, where they each measure a yard in length; in the Ostrich the cœca are upward of two feet long, provided internally with a spiral valve, and blend, at their inferior extremity, into a single cavity; the large intestine is here also, as an exception, much longer than the small intestine. It is very rarely that, as in the Mammalia, a single, and in such

cases invariably shorter, cœcum is present, as in the whole genus of Herons.

There is not unfrequently found, about the middle of the small intestine, a small cœcum or diverticulum, which indicates the former place of entrance of the vitelline duct into the intestine. This persistent remnant of an embryonic structure is remarkably constant and normal in many of the Grallæ and Palmipedes, as the Goose, while it is scarcely ever to be perceived in the orders Rapaces, Passeres, and Scansores.

The whole intestinal canal is of very variable length, being scarcely double as long as the body in Mormon fratercula, while in the Penguin it is fifteen times its length.

The *Salivary Glands* vary greatly in number and development throughout the several orders and even genera of birds, in accordance with their mode of life. In general four pairs of these glands are to be met with, namely, a pair of sublingual glands situated upon either side beneath the tongue, two submaxillary glands divided each into an anterior and posterior, which lie the one behind the other, and open by special ducts in front of the lingual organ, and a gland that may be compared to the parotid, which is placed close beneath the skin upon the angle of the mouth, and frequently extends into the orbitar cavity. Occasionally one or the other pair of the above glands are wanting, and in Sula, Carbo, Phœnicopterus, they appear to be all of them absent, or, as in the Grallæ and Palmipedes generally are but slightly developed. In the Geese and Ducks all the pairs, however, are met with, and in the Goose the sublingual gland is of particularly large size. The Herons possess only the sublingual gland. In the Watercoot (Fulica), and still more so in Hirundo esculenta, the parotid gland is very much developed, and in the latter bird its secretion serves for the preparation of their edible nests; in the Rapaces, Passeres, and Gallinæ, the salivary glands are generally all present. In the Woodpecker and Wryneck (Yunx) the anterior and posterior submaxillary glands are constantly blended into a large, white, and flattened gland, which secretes a very viscous salivary fluid.

The *Liver*, which is of a brownish red color, is divided always into two halves or lobes, of equal or else very unequal size. In the Rapaces, many Grallæ and Palmipedes, both lobes of the liver are of equal magnitude, while in the Passeres the left lobe is generally much smaller than the right. The *Gall-bladder* is absent only in a few genera, as in the Ostrich, the Pigeons, and many of (though

not all) the Parrots. As a rule, two hepatic ducts are met with (in the Ostrich however there is only one, and a single cystic duct), which open generally near to (more rarely apart from each other, as in the Pigeons) the extremity of the duodenal loop. Other slight varieties occur in these parts, thus the gall-bladder is very long and intestinoid in the Toucan, and in the Flamingo the short hepatic duct dilates into a bladder-like receptacle after its exit from the liver.

The *Spleen* is in general small and exhibits manifold diversities of form, being elongated and cylindrical in the Passeres and in Rhamphastos, disc-shaped in the Bustard, rounded and broad in many Palmipedes. It is unusually small in the Cuckoo. In the Struthionidæ a small accessory spleen is frequently observed.

The *Pancreas* is almost always a gland of considerable size, invariably lodged within the loop formed by the duodenum and of a white or yellowish white color; it is small and single in the Heron and Cuckoo, and frequently double, consisting of two lobes united by a very slender isthmoid portion, as in the Gallinæ, Pigeons, many Rapacious and Natatorial birds; it is even tri-lobed, as in the Woodpecker. It has mostly two, though frequently three excretory ducts, as in the Rapaces, Pigeons, Ducks, &c., but more rarely only a single one, as in the Ostrich and Cassowary.

ORGANS OF CIRCULATION.

The Heart of birds is highly muscular, and of very large size in proportion to the bulk of the body. It presents but a few trifling diversities of form, such as being more elongated than usual in the Passeres and Grallæ, or broader, as in the Parrots. The whole organ is situated, enveloped by a thin pericardium, in the middle line of the body resting upon the sternum, its apex being directed straight backward, and lodged between the two lobes of the liver. It consists of two auricular and two ventricular chambers, which are not however portioned off, as in the Mammalia, by a well-defined circular groove, nor are the appendices of the auricles so distinct. The cavity of the right ventricle is wider, but its walls are much thinner and shorter than the left, so that the apex of the heart is formed by the left ventricle alone, which is much stronger, being furnished with walls three times as thick as those of the right. The usual valves are found in front of the openings of the venæ cavæ into the right auricle, and between the latter and the right

ventricle there is found a peculiar valve of very great strength, and formed of longitudinal muscular bundles, which pass obliquely from the right wall of the ventricle to the interventricular septum, and serves obviously to bring into forcible approximation the opposite parietes of the ventricle, and thus to drive out the blood more effectually into the pulmonary artery. The septum ventriculorum is directed convexly toward the right, concavely toward the left ventricle. In the inter-auricular septum the fossa ovalis is found always completely closed, and surrounded by a strong muscular ring (*annulus ovalis*). The left auricle is smaller, but more muscular than the right, and the openings within it of the two pulmonary veins are commonly provided with valves. Three semilunar valves, provided in the middle of their margin with a small ossified nodule, are found at the commencement of the pulmonary artery and aorta.

The trunk of the systemic circulation, the *Aorta*, is extremely short; from its root two coronary arteries arise to be distributed to the heart, and it then divides at once into three main branches, one of which forms the descending aorta; the two others, a right and left arteria innominata, giving off their corresponding carotid and subclavian arteries. The carotids, which are of small proportional size, exhibit many remarkable varieties, that are frequently characteristic of the several orders. As a general rule, in the Rapaces, Gallinæ, most of the Grallæ and Palmipedes, the Ostrich, and a few Scansorial birds, *e. g.* Kakadus, Psittacus bullarius, passerinus, &c., the two carotids traverse the canal formed by the transverse processes of the cervical vertebræ. On the other hand, in all the Passeres without exception, and many Scansores, *e. g.* Picus, Sitta, Merops, and some of the Parrot-tribe, as also the genus Podiceps, and the Rhea or American Ostrich, there is only a single, and that the left, carotid present; it is much more rare, as in the Flamingo and Pelican, for the right carotid to exist and the left be absent. In a few instances the two carotids adhere so closely together as to appear like a single trunk, as in the Bittern. A lesser degree of variety is found in most of the Parrots where both the carotids are present, but the left mounts upward, without entering the canal of the cervical vertebræ, by the side of the jugular vein. The subclavian artery runs beneath the furcular bones in the direction outward, gives off the brachial artery to the wing, and a still larger thoracic artery to the pectoralis major muscle. The descending aorta curves over the left instead of the right bronchus, as in Mammalia, passes along and in front of the vertebral column be-

tween the two lungs, and gives off large visceral trunks within the thoracico-abdominal cavity to the stomach, liver, spleen, and mesentery, a superior and inferior artery passing transversely to the kidneys, and a small anterior or femoral with a much larger posterior ischiadic artery to the leg; the aorta is then continued along the spine, as the arteria sacra media, and gives branches to the contents of the pelvis. Several of the arteries, as the anterior tibial in the Goose, Heron, and Crested Grebe, form here and there beautiful retia mirabilia or vascular plexuses.

The *Veins* of the body, as in Mammalia, have but few valves. The blood of the superior half of the body is poured into the right auricular sinus from the two distinct mouths of a pair of superior venæ cavæ. They are formed by the junction of a jugular and subclavian vein, of which the right jugular is generally three to four times thicker and stronger than the left. The inferior or posterior vena cava collects the blood from the posterior moiety of the body, and receives especially the large renal veins. The inferior vena cava is very broad, especially in the Diving-birds. The *Pulmonary artery*, single at its commencement, divides into two main trunks for the two lungs; in a similar manner, also, the pulmonary veins enter the left auricular sinus by a single trunk. The vena porta receives principally the blood from the viscera, but some also from a large branch of the caudal vein and the veins of the posterior extremities. The blood of Birds has the highest temperature of all the Vertebrate animals (about 110° Fahr.), and the blood corpuscles are always of an elliptical form, and of very uniform diameter, throughout all the orders.

The *Chyliferous* or *Lymphatic Vessels* are numerous, and provided with valves, but do not form any conglobate glands upon the mesentery, though in the neck these glands often occur, and are of considerable size, as in the Heron, where there are from five to six pairs. A receptaculum chyli is situated upon the origin of the cœliac artery, and the lymph of the body, as well as the chyle, is collected into two lymphatic trunks, which enter the angles formed by the junction of the superior venæ cavæ with the jugular and subclavian veins. Lymphatic hearts have not as yet been satisfactorily demonstrated to exist in Birds; still, however, in the Cassowary a lymphatic sinus has been found, situated beneath the integument, upon the transverse processes of the second sacral vertebra, and which, reasoning from the analogy of its position with that of the Frog, may perhaps be regarded as a lymph-propelling organ.

ORGANS OF VOICE AND RESPIRATION.

The air during the act of inspiration in Birds passes through the nasal openings to the *Rima glottidis*, the opening and closing of which aperture may be very well observed in the expanded mouths of young birds while they are being fed. The rima glottidis forms a longitudinal fissure in the superior larynx, and is generally provided with pointed or obtuse epithelial papillæ more or less strongly developed, and frequently arranged in rows that would appear in some measure to supply the place of the epiglottis, which is wanting in the present class; they offer varieties in the several genera, and are wanting only in the Struthionidæ. Occasionally there is found behind the tongue a membranous valve-like fold, as in many Ducks and in the Ostrich; in some cases this fold has a median lappet, as in Scolopax gallinula, while a thicker dentated fold is found as a rudiment of the epiglottis in Fulica atra. A true epiglottic cartilage appended to the superior border of the thyroid cartilage occurs however in a few Birds, as the Swan and some other Natatores and Grallæ.

The *Superior Larynx* consists of several cartilaginous pieces, which admit of being compared with analogous parts in the human subject, and are constantly ossified in adult Birds. The largest of these pieces is a single bony plate, which forms the anterior part of the larynx, and abuts posteriorly and inferiorly against two lesser elongated and narrow cartilaginous pieces, not united in the median line, which appear at first sight in adult Birds to be separated from the anterior bony plate, but are blended with it at an early period in young birds. These three bony pieces are the conjoined representatives of the thyroid cartilage; the anterior plate is usually interrupted by several transverse intervals, that indicate its original formation from the coalescence of a short series of tracheal rings, these last being distinctly perceptible in many cases. Two to four of these rings are generally to be recognised, except in the Parrots, where there is no visible trace of their fusion. Posteriorly and internally the thyroid plate presents a more or less elevated ridge, dividing incompletely the cavity of the superior larynx into two symmetrico-lateral halves. Another process (*processus epiglotticus Henle*) arises from it superiorly, and in many Birds, as Larus, Alca, from its soft and slender condition approaches in character to the epiglottis of the mammiferous animal. Posteriorly, between

and above the two posterior thyroid pieces, there is situated a small rounded, cordiform or quadrangular plate, which must be viewed as the cricoid cartilage. In the Cassowary and Parrot, the posterior surface of the cricoid cartilage lies perfectly free, but is partly concealed in many Birds, as the Gallinazo, and in others can not be seen upon an external view of the larynx. The narrow elongato-triangular arytenoid cartilages are somewhat similar to those of the Mammalia, and bound the fissure of the glottis.

Three pairs of *Laryngeal Muscles* varying only in their size may be distinguished in all Birds. Upon the anterior surface of the thyroid cartilage there is situated, particularly in the Rapaces, a strong muscular fasciculus, which arises from the lingual bone, descends the trachea to a greater or less distance, and is attached to the inferior margin of the thyroid cartilage; it serves to draw up the larynx as well as the trachea, and correspond thus in action with the *hyo-thyreoideus* and *crico-thyreoideus* muscles of the higher animals. A *thyrio arytænoideus posticus*, the function of which is to open the rima glottidis, is situated upon the uppermost part of the dorsal surface of the larynx, takes a broad origin from the lower margin of the lateral posterior pieces of the thyroid cartilage, and passes to the extreme apex of the arytenoids. Upon removing this pair a broader thinner muscle will be brought into view, which constantly arises from the superior margin of the arytenoid cartilage and unites posteriorly and anteriorly with that of the opposite side. It acts as a sphincter contracting the fissure of the glottis, and is called *thyreoideus lateralis s. compressor laryngis*. There are no chordæ vocales in the superior larynx.

The *Trachea* of Birds is usually of great length, and consists of a large number of rings, the fewest 20 to 70 occurring in the Passeres, while among the Grallæ and Natatores the Ducks present above 100, the Heron, Pelican, and Ostrich, above 200, and the Crane and Flamingo the surprising number of upward of 300 rings. These rings are for the most part complete, approximated very closely together and remain often partly membranous as in Tetrao. In many Birds the rings, at least at their commencement, are fissured, *e. g.* in the Woodpecker. In the Scansores and Picariæ, many Gallinæ, Rapaces and Grallæ, the rings continue cartilaginous throughout the whole of their existence, while in the majority of cases, as in the Passeres, the Ostrich, many Grallæ and Natatores, they are completely ossified, so that the trachea becomes a hard cylindrical tube, as in the Goose. The trachea generally descends straight

down the neck from the superior to the inferior larnyx, and then divides at the commencement of the thoracic cavity into two bronchi. It is very rare for the trachea to divide higher up, namely, in the neck, as in the Humming-bird. The bronchial tubes are mostly short, and usually narrower than the trachea, though occasionally they are wider and dilated at their origin, as in the Pelican and Merganser. They are usually composed of a series of half-rings completed by an elastic membrane; more rarely, as in the Stork, of perfect rings which are occasionally continued some distance into the lungs.

Two pairs of muscles are generally found which draw down the trachea, one of which is frequently arrested in its development, or wanting altogether. The superficial pair, which is particularly well-developed in the Natatores, as the Merganser and Duck, but absent in the smaller birds, *e. g.* the Passeres, Scansores, and Picariæ, lie upon the sides of the whole length of the trachea, and arise from the upper part of the inferior larynx, and the internal surface of the furcula, whence their name of *m. cleido* or *ypsilo-tracheales*. The second pair, which are generally present, yet appear to be wanting along with the first in the Parrots, are called the *m. sterno-tracheales*, arise from the external part of the anterior margin of the sternum, are attached likewise to the lateral surfaces of the trachea and the upper part of the inferior larynx, and ascend more or less upward covered by the preceding pair of muscles. In the Pigeons the last two muscles or sterno-tracheales arise as usual from the sternum, but pass both asymmetrically to the right side of the trachea.

In addition to the normal peculiarities of structure already noticed, the trachea exhibits singular dilatations and convolutions, which appear however to occur only in some orders, as the Natatores, Grallæ, and Gallinæ, and what is remarkable, are frequently absent in closely allied genera, or even species of the same genus, and often constitute characteristic sexual distinctions, occurring in many cases only in the male, and being either entirely absent, or exhibited under a lesser degree and with particular modifications in the female, or else being met with in the same conditions in both sexes.

Claiming our attention in the first place are those elongated dilatations which are situated commonly about the middle of the trachea, and provided with cartilaginous and bony rings; they are usually single, but are double in the Drake and male Merganser. Anas leucocephala and Mergus serrator have a single dilatation of the

trachea, which is more strongly developed in Anas fusca and in Clangula. Feeble traces of a double widening of the tube occur in Anas crecca and tadorna; there are elongated dilatations in Anas rufina, glacialis and Mergus merganser, and a single one in Palamedea cornuta. In the Emeu a peculiar structure is observed, for in that bird an elongated slit, several inches long, is found above the bifurcation of the trachea, and communicates with a large cellular air-sac situated in the neck.

In other Birds from the orders just mentioned convolutions occur of the lower part of the trachea, and are situated either free beneath the integument at the commencement of the thoracic cavity, or are enclosed to a greater or less degree of depth within the sternal keel. Thus in Platalea, Penelope, the Cock of the Woods, the Corn-crake, and some Pheasants, especially in the males of these species, and in Anas semipalmata (where it makes the most complex convolutions of all), the trachea descends beneath the skin to beneath the level of the anterior border of the sternum, ascends and having made a second curve upon itself, bifurcates into the bronchi for the lungs. In both the male and female of Grus virgo and cinerea, with however certain sexual modifications, the trachea penetrates the keel of the sternum, is enclosed within it as in a bony capsule, and there makes several spiral convolutions upon itself which extend in the male as far as the posterior extremity of the keel. In both the sexes of Cygnus musicus and Bewickii, a loop-shaped coil of the trachea lies within the keel of the sternum; in the Black Swan however this structure is more feebly developed, and does not exist at all in the mute Swan (Cygnus olor). It is most strongly indicated in the Trumpeter Swan (C. buccinator), where the tracheal convolution descends as deeply as in the male Crane. In Numida cristata a coil of the trachea is situated between the shafts of the furcular bone. A well-marked sexual difference is observable in the Black Stork, where in the male the bronchi, long and having complete-rings, are always curved in the shape of the letter S; this is the case also, though in a lesser or scarcely noticeable degree, in the male of the White Stork. A peculiar condition of the trachea is met with in the Penguin, by the ridge upon the inner wall of the thyroid cartilage forming a septum, which is prolonged throughout the whole of that tube. A similar structure is found at the inferior extremity of the trachea in Procellaria glacialis.

The existence of an *Inferior* or *Bronchial Larynx*, in which the

voice is produced, constitutes a special peculiarity of the class of Birds. It is situated in the upper part of the thoracic cavity at the extremity of the trachea, where that divides into the two bronchi. The length of the inferior larynx is mostly greatest from before backward, and its interior forms a quadrangular cavity, which is generally divided inferiorly (at its outlet) by a *cross-bone* passing from before backward, into two lateral halves, that receive the two openings of the bronchi, which are to be viewed as forming a double rima glottidis. The cross bone consists of the last tracheal ring increased in size, or else of several rings which have become firm and rigid, approximated and even blended together, so as to form a firm bony drum of variable size. The commencement of the bronchial tubes is also to be regarded as forming part of the inferior laryngeal apparatus, since their first rings and the membranes which unite them must exert the greatest influence upon the production of the voice.

As might be expected from the great variety of character which the voice of Birds presents, the structure of the inferior larynx in the several genera and species offers for our study a very extensive series of modifications. In some cases this larynx appears to be entirely absent, there being neither expansions of the trachea nor vibratory membranes to produce, by combining in action with the lingual apparatus, any kind of sound, so that voice may be said to be totally deficient. These conditions are exemplified in both the Black and White Stork. The rings are very soft and cartilaginous throughout the whole extent of the trachea, and there are no indications whatever of a larynx at its bifurcation; and as little of an internal and external tympanic membrane, or even of a single pair of muscles. The bronchi are long, and formed, like the trachea, of numerous (about 50) entire rings, the intervals between which are cartilaginous, so that the bronchi form soft but elastic cylindrical tubes, which become membranous so soon as they enter the substance of the lungs. The storks, as is known, with the exception of a clattering noise produced by the bill, give utterance to no distinct tone, but only a feeble hiss. The muscles of the inferior larnyx are wanting in the Struthious birds, several Grallæ and Natatores, and in the Gallinæ and Owls; the bronchi are partially surrounded by segments of rings, and completed by membrane on their internal side.

From the preceding examples we pass to those Birds, as the true Vultures, which have been also stated, though incorrectly, to possess

no inferior larynx. It is true that in the Vultur cinereus and fulvus as also in Gypaetos, there can not be found, as in many other Birds, any coalescence of the lower tracheal rings, or an external tympaniform membrane, but between the demi-rings of the bronchi (which appear, however, in the American Vulture or Gallinazo to be almost complete) there is situated the internal tympaniform membrane, while a single pair of muscles placed externally at the extremity of the trachea, serves to elevate slightly the bronchi upon either side, shorten the trachea, and thus expand the two bronchio-glottidean fissures. This pair of muscles acts moreover as an antagonist to the sterno-tracheales.

In the majority of those Birds which are capable of uttering sounds membranes are found situated both exteriorly and internally to the inferior larynx. There arises from the cross-bone a thin membranous slightly elastic and easily lacerable membrane, which completes the bronchi upon their internal aspect. The extent of this membrane is greater or less in proportion to that of the segment formed by the imperfect bronchial rings; the first two or three of these are usually very slightly curved, and in the form only of a small semicircle; the membrane completing the rings is therefore largest in this situation, and fully merits its appellation of *membrana tympaniformis interna*. In some Birds, as in several Ducks, especially the Mergansers, large flat cartilaginous discs are situated in this tympanic membrane, or, as in Fulica, thick cordiform cushions of cellular tissue, either of which structures must exert an indubitable influence upon the formation of the voice. There is generally found a *membrana tympaniformis externa* presenting the form of a fenestroid oval membrane placed between the cross-bone or the lowermost tracheal ring and the most superior of the bronchial semicircular cartilages.

This external fenestra or membrane may be wanting and still the inner one present and the trachea form an osseous drum, as in the Ducks and Mergansers. Or else the hard rings of the trachea may lie closely approximated and invested by fibro-cartilage, beneath which is situated the external ovale membrane, as in the Flamingo. No important change however can be effected in the relative degree of tension of the two membranes in cases where a single pair of muscles is present, and attached high up to the border of a drum formed of immoveable rings, whereas when inserted in the uppermost bronchial rings, a far greater share of mobility is attainable by the membranes.

Such a single pair of muscles (m. m. broncho-tracheales) occur in the Rapaces, some Scansores and Picariæ, *e. g.* Picus, Cypselus, Caprimulgus, and, though but feebly developed, in the Cuckoo; also in the Pigeons (which have a large external membranous fenestra), and many Grallæ and Natatores, while it is absent in other Scansores and Picariæ, *e. g.* Alcedo, Upupa, other Grallæ, and Natatores, as Hœmatopus, Anser, Anas, Mergus, and in the Brevipennes and Gallinæ. This single pair of muscles often ascends high up close to the sterno-tracheal muscles, draws the bronchi in the direction outward and thus expands their glottidean fissures.

Two special muscles of the larynx do not appear to occur in these cases, to which succeeds the peculiar structure of that organ in the Parrots, where it has three strong pairs of muscles, but the sterno-tracheales are absent. The inferior glottis is single and narrow in the Parrots, from the inferior partition or cross-bone being wanting. The structure of their larynx is as follows: the trachea passes into a short tympanum, and beneath this there is constantly situated a semilunar ossified cartilage (*cart. semilunaris*), having its concavity directed downward, and between its border which excavated in a crescentic form is curved upward, and the first bronchial demi-ring, is situated the external tympaniform membrane. The superior semilunar pieces can be moved inward and outward upon the tympanum, or raised and depressed like a pair of valves, and the membrane follows these movements. Of the three muscles, that which is situated most deeply is the shortest; it arises from the upper part of the tympanum, and is inserted by its whole breadth to the upper semilunar cartilage which is moveable like a valve. This is the *m. abductor cart. semilunaris*, and while this muscle elevates the corresponding semilunar bone, it draws also the membrane outward, and thus widens the opening of the glottis. Above this is situated another longer muscle, which arises close to it, and passing in a bridge-like manner over the tympaniform membrane, is inserted into the uppermost bronchial ring; it elevates the bronchus of the corresponding side, by which movement the two membranes approximate, come nearly in contact in the middle line, and thus narrow the fissure of the glottis. Above this short *levator bronchi*, is situated another, the *levator longus*, which has the same function, though at the same time its muscular belly arises higher up and is continued into a long tendon which, running over that of the former muscle, is occasionally inserted into the anterior side of the fifth to the seventh, or often the third to the

fifth bronchial ring. Upon the internal side of the tympaniform membrane, which is thrown into vibrations during the passage of the air from the lungs, there is placed a strip of membrane, which also vibrates and may be regarded as corresponding to the *ligamentum vocale externum* of the Singing-birds.

The structure of the inferior larynx is still more complicated in the Singing-birds, and those birds generally which are provided with what is called a true *muscular vocal apparatus*, among these the Ravens being included, from the power they possess, like the Parrots, of imitating the human voice. Although a number of slight varieties occur in the different genera and species, which stand in direct relation with the degree of complexity of their song, still, however, a great general conformity may be perceived in the structure of the singing apparatus, it, as a rule, being formed of five well-developed pairs of muscles. In the Nightingale and other small Singing-birds, this muscular apparatus is indeed very powerfully developed, but on account of its small size, the student will do best to select a larger bird, as the Raven or Rook, for the purposes of examination.

The trachea here consists of a short bony tympanum or drum, constituting its inferior extremity, and usually formed by the early coalescence of three rings. The tympanum is divided as usual inferiorly by a transverse or cross bone. From the superior border of this, a membranous semilunar fold (*membrana semilunaris Savart*) rises to about a line in height, as in the Rook; its dimensions, however, are very various, and in birds of accomplished song, or such as can learn to speak, it is more largely developed. In other Passeres, as in the Sparrow, Haw-grosbeak, &c., these membranes are of course wanting. From these observations it may be inferred that this membrane is of essential importance to the production of song or the power of uttering articulate sounds, since when it is absent or slightly developed, the voice is feeble or has but little variety of tone. The first three bronchial demi-rings exhibit also remarkable peculiarities. The first or uppermost ring is thicker in the middle than at the extremities; at the posterior end inferiorly it becomes broader, and curves in such a manner backward and inward, as to form the posterior and internal wall of the bronchial portion of the inferior larynx; below it passes into an acute angle, which forms the point of support of the internal lip of the glottis. The second bronchial demi-ring is more moveable than the first, especially in the direction outward and upward. The third demi-ring is nearly straight, and between it and the second demi-ring there is a triangular membranous fenestra, and between the first and second bronchial demi-ring an oval *membrana tympaniformis externa*. Upon its inner surface there is found a remarkable fold of the mucous membrane, consisting of tolerably thick and elastic tissue; it forms a true vocal chord, *ligamentum vocale externum*, which always forms the external lip or wall of the glottidean fissure. This membrane or fold is thrown into vibrations during the passage of the air from the lungs. Besides this the *membrana tympaniformis interna* is found as usual completing the inner side of the bronchi, and is in continuous connexion with the *membrana semilunaris* of the cross-bone. A small pliant cartilage (*cartilago arytænoidea Savart*) is situated in the upper part of this membrane, is in connexion with the second arch of bone, and exhibits manifold diversities.

Two anterior and three posterior pairs of muscles may be distinguished as belonging to the inferior larynx. In front, a long elevator muscle (*m. levator anterior longus*) arises tolerably high up from the trachea, and is firmly attached to the second bronchial demi-ring, the anterior extremity of which it draws upward and outward, and so widens the larynx. In like manner the transverse elevator (*m. levator anterior transversus*) arises in front, but obliquely, from the external part of the superior border of the tympanum; it proceeds in the direction forward, and is attached by its inferior extremity to the anterior part of the second and third bronchial demi-rings, and to their interjacent membrane; elevating and drawing these parts also in the direction outward. By both of these muscles, as well as by the *m. depressor trachææ s. sterno-trachealis*, which arises externally from the tympanum and passes forward to the border of the sternum, the cavity of the inferior larynx is shortened and dilated. The *membrana semilunaris* and the *ligamentum vocale externum* will be also synchronously stretched in a variety of ways by the action of these muscles, joined to that of the three posterior pairs, the description of which will now occupy our attention. The posterior long elevator (*m. levator posterior longus*) arises high up behind the corresponding anterior elevator muscle, and is inserted posteriorly into the extremities of the second bronchial demi-ring which it draws upward, and at the same time rotates the third. The posterior short elevator (*m. levator posterior*) is partly covered by the former muscle, but is situated more in the direction backward and inward, and at its origin from the upper part of the tympanum abuts closely

against its fellow of the opposite side, and is attached higher up to the posterior extremity of the first bronchial arch, which it serves to elevate. The fifth pair of muscles is situated between the posterior long, and the anterior transverse, elevator, and is called the oblique elevator (*m. obliquus posterior s. rotator posterior*); it arises externally from the superior border of the tympanum by a short and thick muscular belly, passes obliquely backward, and is inserted into the posterior extremities and lower border of the second bony arch, which it rotates and draws in the direction outward.

The voice of Birds appears like that of the human subject to be produced by the combined vibrations of the laryngeal membranes and the tongue. The flute-like tones of the Singing-birds are doubtless accomplished by a vibration of the whole column of air while passing through the trachea. Where all the membranes are absent and the bronchial rings complete, the voice is also deficient, as in the Stork.

In addition to the already recorded peculiarities in the anatomy of the inferior larynx, there occur in many Birds expansions of the tympanum or apparatus of resonance which strengthen the tone of their voice. To these belong the large bladder-like dilatations and expansions of the tympanum met with hitherto only in the Natatores, as the Drakes and Ganders. These expansions, which have been called the labyrinth, are peculiar from their occurring only in the male and never in the female sex, and in being asymmetrical or of unequal dimensions upon the two sides, the left being always considerably larger than the right; as a rule, this structure is found upon the left side, it being very rare for the right tympanum to be the largest.

In the Ducks the labyrinth consists for the most part of round bony ampullæ about the size of a pea in the lesser species, as Anas crecca, still smaller in A. clypeata, but much more developed in the larger species. More rarely there occurs a double irregular labyrinth larger upon the right side than the left, as in Anas tadorna. These ampullæ are wanting in the Dipper (Hydrobates), and both sexes are alike in this respect. Other Ducks, as Anas marila, fuligula, glacialis, leucophthalmos, have a perforate labyrinth: the enlargement is here more angular, and partly provided with membranous fenestræ. This also is generally the case in the male Mergansers, where the labyrinth in M. merganser attains its highest grade of development. The larynx here forms a thick-walled and hard bony expansion nearly one and a half inches in length, having an uneven

tubercular surface, and an irregular triangular form. Upon the left the labyrinth has the form of a somewhat irregular tetrahedron, from the basal surface of which the left bronchus arises, its three sides being occupied by oval membranous fenestræ. The membranes are stretched within arched bony frames, so that the whole resembles a lantern. In the female the inferior larynx forms only the usual bony tympanum, but is still somewhat asymmetrical in form. This labyrinth obviously acts in modulating and strengthening the voice, and reminds us of that bony dilatation of the os hyoides constituting an apparatus of resonance in the Howling-apes, as has been already described under the head of the Respiratory Organs in Mammalia. The male Ducks have, as is well known, a stronger voice than the females, and can even produce a considerable variety of tones. Among the more remarkable diversities of the inferior larnyx, one in particular deserves to be here indicated. In Sula-alba (at least in the male) the trachea is formed as usual, and the bronchi are composed of half-rings, but there invariably projects in the direction outward from between the first and second bronchial demi-ring a yellowish body, tolerably hard and solid, of the size of a pea, and which contains fibres and a great quantity of adipose-cells; with its basis is connected the strong inferior larynx, and by means of this arrangement the bronchi admit of being drawn much apart from each other. This body does not appear to be a gland, for no excretory duct can be detected.

As regards the immediate organs of respiration, the *Lungs*, they are in Birds, as in Mammalia, invariably two in number, but proportionally of very small extent to what they are in the latter class. They are flattened, irregularly triangular, and attached posteriorly to the vertebræ and ribs (from the heads of which last they receive deep permanent impressions) by cellular tissue. They are of a bright florid red color, invested in front only by the pleura, and made up of a loose parenchymatous tissue. They are of largest proportional size in the Singing-birds, but are destitute of lobes throughout the whole class, and exhibit great uniformity of character. The bronchi as soon as they have entered the lungs form always a wide vesicular cavity, perforated by a number of apertures. It is only anteriorly and posteriorly that there are some imperfect cartilaginous arches, and there are here found between the fifth to the sixth most anterior cartilaginous demi-rings, four or five oval apertures, which are kept open by the cartilages already named, and their mutual lateral connexions; they lead into larger superficial membranous tubes,

which traverse the internal and inferior side of the lungs; behind these openings are situated others for the superficial tubes, and lesser ones for the deeper. The superficial tubes pass almost completely round the lung upon every side, and their external walls are very thin and transparent. The deeper tubes resemble cylindrical pipes, traverse the lungs in many directions, and are nearly straight and parallel to each other; they are the most numerous, and open in such a manner into the superficial tubes, that they pass from the upper to the under side of the lungs, and communicate laterally with each other. From their walls being thick and remaining constantly patulous, and from those of the superficial tubes into which they open being transparent, the lungs of Birds acquire the perforated tubular appearance which they present. The parietes of the tubes and canals are covered with a most beautiful and delicate network of small cavities and cells, with intervening septa mostly of an hexagonal form, and within the meshes lie other still smaller open cells. The cells of the lungs in Birds are therefore never terminal cells, as in the Mammalia, but open parietal cells from $\frac{1}{4}$th to $\frac{1}{20}$th of a line in diameter, upon which the vessels expand and thus come into contact with the air. All the cells and tubes of the lungs communicate naturally with each other, so that the lungs can be perfectly inflated from any one point.

Upon the surface of the lungs near to their posterior margin and upon the inner side, there is observed, upon stripping off the pleura in this situation, openings from five to seven in number, by means of which the bronchi are brought into communication with the peculiar *Air-cells* of the Bird. These highly remarkable receptacles for the atmospheric fluid are membranous, being formed by reflected prolongations of the pleura and peritoneum, and surround all the viscera. These cells may be distinguished in general into the following principal divisions, which are separated by membranous partitions, and for the major part transmit air. 1*st*, The two empty lateral cells which descend beneath the sternum as far as the pelvis, divide again into an anterior and posterior, or frequently even into three cells, and enclose no viscera. In the Passeres the two anterior lateral cells coalesce into one, and communicate with the bronchial cells. 2*d*, the two cells which enclose the lobes of the liver, do not communicate with any air-opening, and therefore receive no air, and merely result from the subdivision of the remaining air-cells. 3*d*, An intestinal cell, also conveying no air, which includes the intestinal canal, and is divided by the mesentery into two

halves. 4*th*, A cell for the heart. 5*th*, A cell situated in front of the breast for the bronchi, which it surrounds, together with the inferior larynx. A still greater extension of the air-cells occurs in some Birds. Thus, the Roller (Coracias) is provided with a pair of large air-cells beneath the skin of the head and neck, and these communicate with the nasal cavity, but not with the trachea. The distribution of air throughout the body is nowhere more extensive than in the Booby (Sula) and the Pelican. In these genera the lateral cells of the trunk are uncommonly large, and separated by two partitions into three large chambers, from the most anterior of which the air gets beneath the axilla under the integument, and fills the space upon the breast and belly from the furcular to the pubic bones. Several larger and various smaller cells are also met with, and the fat, which is generally abundant in such situations, is here wanting. The air-cell above the great pectoral muscle and on the inferior part of the neck is particularly large, and the delicate cellular tissue here forms partitions including cells several lines in diameter, which are continued almost beneath the epidermic layer of the skin as far as the quills of the contour-feathers, but not into their interior. These cellular air spaces are further distributed beneath the short investing feathers of the wing, and between the quills of the great primaries. Upon the middle and upper part of the body tegumentary air-cells do not exist; and upon the head there is found beneath the crisp-feathers covering the occipital region, only a single solitary cell partitioned off into some small spaces. The communication which exists between the pneumatic cells of Birds and the interior of many of their bones, the latter being for this purpose devoid of medullary tissue, and thus rendered permeable to air, has been already mentioned in treating of the skeleton. The Apteryx offers a striking contrast to the Pelican in being entirely devoid of air-cells, and is hitherto the only known exception of this kind among Birds. This extensive distribution of the atmospheric air throughout the body of Birds contributes obviously, by highly oxygenating the blood, to increase the general activity of their arterial system, conditions which are manifested in the greater number of its pulsations within a given time, and its more elevated temperature (107° to 110° Fahr.), as contrasted with that of the Mammalia.

The mechanism of the function of respiration, according to the recent special researches of Dr. Edward Weber, is performed in the following manner. The ramifications of the bronchi with the network of tubes they form within the lung are during inspiration

drawn apart by means of the expansions of the ribs, to which the lung is firmly fixed, and the contraction of those fasciculi of the diaphragm that are inserted upon the free surface of the lung. By this action not only are the tubes expanded and lengthened out, but in like manner also the interspaces included between them. The air must of necessity therefore penetrate and distend the terminal bronchial ramifications situated between these interspaces. The lungs derive their supply of air, which they receive by the process just mentioned, partly from the trachea and partly from the air-sacs, the latter forming pneumatic reservoirs, from and into which the lungs both inspire and expire. Now as each of these reservoirs is in communication with the bronchus through a wide tube, the air they contain is always in a respirable condition, for while the thorax is being expanded that portion also of the pneumatic sac which lies concealed beneath it is expanded also, and sucks in the air upon the one hand through the trunk of the trachea, upon the other, from that part of the air-sac that projects out of the cavity of the thorax, and which may accordingly be seen to collapse during the act of inspiration. When, however, the capacity of the thorax becomes narrowed during expiration, that portion of the air-sac covered by it is compressed and drives out its contained air upon the one hand into the tracheal trunk, upon the other into the projecting part of the air-sac which is then observed to dilate. There appears, moreover, to exist a special provision whereby, when the wings are elevated during flight, and their pressure is consequently removed from the great pneumatic sacs situated in the axilla and between the pectoral muscles, that the sacs become distended with air, which, when the wings are depressed, is driven out of them into the lungs, so that a bird, such as the Lark, while mounting perpendicularly upward to a great altitude in the air, is still enabled to sing without at the same time getting out of breath.

A pair of small glandular bodies devoid of excretory ducts occur in Birds, and from the situation they occupy may be regarded as *Thyroid glands*. They are very generally of a rounded form and of a reddish color, richly supplied with vessels, and lie upon either side of the lower part of the trachea, where they are more or less attached by cellular tissue and an arterial ramuscule to the carotid, or else to the jugular vein. Immediately beneath and united to them, there are found in many Birds small corpuscles of a denser texture, and whitish or yellowish color. Both thyroid glands are separated from each other in the middle line by a wide interval.

URINARY ORGANS.

The *Kidneys* in the Bird are very large and impacted within deep depressions in the pelvis, which they completely fill up; they commence immediately beneath the lungs, and like those organs, they retain the impressions of the lowermost ribs, but particularly of the transverse processes of the sacral bone. They almost invariably consist of three principal lobes, of which the middle one is generally the smallest, the anterior frequently the largest, as in the Rapaces, but in other cases, as the Pelican, the posterior lobe. In the Rapaces, Gallinæ, and Columbidæ, they are separated from each other by a wide interval, in which the aorta passes, and do not occupy the whole extent of the cavity of the sacrum, part of it being occupied by air-cells. In other Birds, as the Passeres, they come in contact in the median line, and even coalesce in several species, *e. g.* Lanius Excubitor, and more rarely in Ardea cinerea. The kidneys form, however, as a rule one blended mass in the Loons (Colymbus s. Podiceps). In the Coot (Fulica atra) the kidneys are divided on their postero-superior surface into a great number (about 60) small lobules, which are only loosely connected together by cellular tissue. The kidneys are of a brown color, and friable texture; the delicate urinary canals give off short lateral branches, presenting thus a pinnatifid appearance, and do not terminate upon conical papillæ. The urine of Birds is very rich in earthy constituents, and contains but little water, so that the kidneys frequently appear, after death, as if injected from a deposite of urate of ammonia having taken place and filled their tubes. In the Struthious birds papillæ and calyces are met with in the kidneys, and in the Ostrich a true renal pelvis. Several excretory ducts generally proceed from the kidneys to form the ureters, which descend along the anterior surface of the kidneys, and terminate by perforating the cloaca posteriorly and superiorly. A proper urinary bladder is absent, though the ureters in many Birds open into a distinct pouch-shaped dilatation of the cloaca, bounded above and below by a valvular fold, separating it on the one hand from the urethro-sexual cavity, on the other from the orifice of the rectum, and which is by many writers viewed as a rudimentary urinary bladder; this structure is most strongly developed in the Ostrich.

A pair of yellow or orange colored *Suprarenal Capsules*, of the shape of millet-seeds, flat and usually of small size, are constantly

found, situated on the mesial line of the anterior extremity of the kidneys, are in contact externally with the large vascular trunks, and are partly covered by the testes and ovaria.

PARTICULAR ORGANS OF SECRETION.

Particular glandular organs are found very generally distributed in the region of the tail and cloaca; but really specific secretions, such as occur so frequently in several of the orders and genera of Mammalia, do not appear to occur in Birds.

A peculiar gland, which is called the *Glandula Uropygii*, exists very commonly throughout the class, and secretes an oily fluid of a whitish or yellowish color, having occasionally a musky odor, and which is applied by the bill to anoint the feathers, so as to prevent their getting wet. It is situated above the last caudal vertebræ upon the quills of the remigial feathers of the tail, and consists properly of two distinct glands, which are either united in the median line, or frequently only by their posterior extremities. They consist internally of close-set elongated cœcal tubules, not intercommunicating and opening into a mostly linear cavity of greater or less size situated in the centre of the gland. A double orifice, rarely one (or many, as in the Pelican, where twelve apertures are found arranged in two rows), which opens upon a papilla, and, as in the Diurnal birds of Prey, the Parrots, Gallinæ, and Natatores, is surrounded by a tuft of small feathers, indicates the outlet of the excretory duct. The gland itself is usually triangular or cordiform in the Natatores, as the Ducks, where it is of the largest size, and divided by a fissure into two clavate lobes. It is very rarely absent, as in the Brevipennes, *e. g.* the Bustard, in the Penguin, and some only of the American Parrots, for others possess it.

Another organ that may be conjectured to be one of secretion also, is called the *Bursa Fabricii*. It occurs in nearly all Birds, being wanting in the Ostrich, probably alone among the Brevipennes, and is situated deep within the pelvis between the ureters and behind or above the cloaca, in front of the extremity of the sacrum, and is usually covered by cellular and adipose tissue. It opens below the two ureters into the cloaca by a considerable orifice, which is separated by a fold from the urinary compartment of that cavity. Covered externally by a layer of muscular fibres, it is in some cases of a thin membranous texture, but in others frequently provided with a thick layer of small follicles, as is especially the case in the Grallæ

and Natatores. It appears to be very much developed in young Birds, but dwindles in size so as to be scarcely apparent in adult age; still, however, it exhibits varieties of form and proportions. Its function is not accurately known. At first sight it might be compared to the anal sacs of the Mammalia, while some anatomists on the contrary regard it as the urinary bladder of the Bird, but both its position, and the certain fact that urine gets into it only by accident, militate against this opinion. Furthermore, its equal degree of development in both sexes is opposed to the view of its being destined to receive in the female the seminal fluid of the male, and be thus analogous to the spermatheca in the female insect.

ORGANS OF GENERATION.

The Generative apparatus in Birds, especially of the female, departs very considerably from its conditions in the Mammalia, and throughout the whole class exhibits a very close conformity of character with the type of organization in the inferior Vertebrata.

The *Female* organs of generation are, as a rule, asymmetrically disposed, being only fully developed upon the left side. The ovarium consists of a small stroma made up of a bed of compact fibres, in which are situated the very small vitelline vesicles. It is situated in the lumbar region, and is attached to the superior or anterior extremity of the left kidney, and partly also to the renal capsule. The free surface, or that directed toward the abdominal cavity, is disposed in transverse folds, from beneath which the vitelli gradually protrude during their growth, so that the ovarium soon assumes the appearance of a cluster of berries supported upon pedicles or stalks. The oviduct, spirally contorted like an intestine, and attached to a fold of the mesentery, descends parallel with the left kidney, and commences by an open funnel-shaped or truncate abdominal ostium, adapted for receiving the ova after they have been detached from the ovarium. This part is called the *infundibulum*, and after being continued into a narrower portion, the oviduct again expands into a kind of ventricle, within which the vitellus obtains its complete investiture of albumen, and external to that the calcareous shell; the rest of the tube is termed vagina, and short and narrow opens upon the left side of the cloaca. The mucous lining of the oviduct presents well-developed longitudinal folds, and the whole organ augments in length as well as in capacity during the period of oviposition. There are only a few Birds that possess a

clitoris or organ of sexual excitement. These are some of the Ducks, as Anas clangula, in which the clitoris is upward of half an inch long, but without any groove. It is of more considerable size, and provided with a demi-groove like the penis, in the Brevipennes, as the Ostrich and Cassowary.

Several Birds furnish a remarkable peculiarity, and one which is interesting in a developmental point of view, namely, in the coexistence along with the left, of the right ovarium either in a rudimentary or completely developed condition. In the earlier stages of the existence of the embryo within the ovum, it would appear that the two ovaria and oviducts are in general formed of equal size. Upon the right side, however, these structures soon cease to grow, become absorbed, and disappear almost always before the exclusion of the young bird from the egg. In rare cases, however, as in the adult Duck and Goose, rudiments of this arrest of structure are to be seen, and in some Parrots, Eagles, and Vultures also, there constantly occur small rudiments of the right ovarium. The Gos-hawks, as Falco palumbarius and nisus, and the Harriers (Circus) have always two ovaria, provided with mature ova at the period of propagation.

As regards the *Male* organs of generation, the testes of Birds are always double, and situated like the ovaria behind the lungs against the renal capsules. They are either of an elongated or rounded form, and very small during the winter season when the generative functions are at rest, and in small Birds are then so diminutive that they are with difficulty discovered. They become however remarkably turgid at the breeding season, increasing from 20 to 50 times their former size, and are particularly voluminous in some Birds, as the Fowls and Ducks. They are then rarely of equal but mostly unequal size, the left being usually the largest. At this period too of sexual excitement, the contorted seminal vessels are seen very distinctly through their external transparent tunica albuginea, and a very beautiful plexus of vessels is expanded over them. From the seminal vessels proceed the seminal ducts, or vasa deferentia, which pass in the form of serpentine canals upon the anterior surface of the kidneys near to the ureters. Occasionally, as in the Passeres, the seminal ducts form a complex skein of contortions like a ball of thread within the pelvis near to the cloaca, into which they open by a double orifice upon two papilliform projections of the mucous membrane.

The *Spermatozoa* or seminal animalcules constituting the moveable

essential elements of the vivifying fluid in the class of Birds, have in general an elongated body terminated at one end by a filamentary appendage or tail. Those of the Passeres, which exhibit some slight varieties of form in the different genera, are characterized without exception by a very long body, and a tail spirally contorted after the fashion of a cork-screw; they are situated freely in the seminal excretory duct, but within the testicle itself are found enclosed in long pyriform cysts.

A true *Intromittent Organ* or *Penis* is wanting to most Birds; some, however, as the Ostrich, have this part very developed, and traversed by a groove for the passage of the semen; it is of smaller size, tongue-shaped and grooved, as in Crypturus among the Gallinæ, or of a membranous texture and cylindrical, lying in a state of rest folded upon itself, or spirally twisted within the cloaca, as in the Drake. According to the recent researches of Joh. Müller, the varieties in the structure of the penis in Birds may be referred to three principal types. 1*st*, The penis is formed, as has hitherto been observed, only in the Two-toed Ostrich, of two solid fibrous bodies, provided superiorly with a web of cavernous tissue which is traversed by a cleft or groove; a third, more elastic and internally cavernous body, is situated upon the opposite side, and forms the extremity of the penis or rudimentary glans. Erection is the result of the distension of the cavernous tissue. 2*d*, The glans is wanting and the penis has a seminal groove imbedded in cavernous tissue, and also two fibrous bodies. The extremity of the penis with a continuation of its groove is involuted so as to form a sack-like part comparable to a prepuce, which can be partially everted and again retracted by an elastic ligament. This structure is met with in the Cassowary and Three-toed Ostrich or Rhea. 3*dly*, There is found a small tongue-shaped rudiment of a penis, surrounded by a circular pouch, and either with or without a groove. Examples of this type are furnished by the Bustard, several of the Gallinæ, *e. g.* Crypturus, Crax, Penelope, and of the Grallæ, as the Heron, Stork, and Flamingo.

Cloaca.

The term Cloaca is applied to the terminal bladder-like expansion formed by the rectum before terminating in the anus, which occurs in several Mammalia, as the Marsupials and Monotremes, as well as

in Birds and Amphibia, and is the common cavity receiving the orifices of the intestinal, sexual, and urinary organs.

In Birds the cloaca usually forms a very wide vesicular dilatation, a continuation properly of the intestinal tube, nearly as long as it is broad, and invested externally to a considerable extent by peritoneum and lined with mucous membrane, a muscular layer being interposed between these two. The rectum enters the upper and anterior part of the cavity, protected by a circular fold, and to the left behind it the oviducts in the female, or the two vasa deferentia in the male, terminate from either side upon papilliform eminences, provided with similar folds; behind these papillæ is found a well-developed plexus of vessels, or rete mirabile. Between and posterior to the orifices of the excretory ducts of the sexual organs, those of the ureters are found in juxtaposition with each other, while behind them is situated a very prominent circular valve, beneath which the bursa Fabricii opens directly by a small aperture; last of all, is the large circular aperture of the cloaca which at the same time constitutes the external anal outlet. The space between the two circular folds guarding the urethro-sexual cavity and the rectum, has been regarded as a rudimentary receptacle for the urine. The penis, when present, arises from the lower wall of the cloaca, where it is either surrounded by folds, or situated, as in the Ostrich, in a special pouch.

The cloaca is closed by a circular sphincter muscle. From the longitudinal muscular layer particular fasciculi are developed, or, as in the large Brevipennes or short-winged birds, muscles of considerable size, which are inserted into the ischium and expand or open the cloaca. Peculiar muscles are connected with those of the cloaca for moving the penis when present, such as an elevator and retractor of that organ.

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CLASS III.—REPTILIA.*

TEGUMENTARY SYSTEM.

The external coverings of Reptiles have not been so closely investigated, especially in an histological point of view, as those of Mammalia, Birds, and Fishes.

The naked Amphibia, such as the Frogs, have a smooth slippery skin covered by a tesselated epithelium, which is continually being shed in large irregular patches, or shreds. The nuclei of the epithelial cells are usually distinctly visible in the layers thus thrown off. Simple glandular follicles, closely aggregated, and more or less numerous, with frequently star-shaped or ramified pigmentary cells, are found beneath this epithelial layer. The skin surrounds but loosely the muscles of the body, and numerous spaces for lymphatic vessels are found beneath it. It is exceedingly vascular and richly supplied with nerves, and is therefore very sensitive, and capable of producing when irritated the most lively reflex phenomena. The small slightly-developed glandular follicles of the integument attain so large a size in the Toads, Frogs, and Newts, as to effect a transition to the more composite forms of glands. In some instances, as in Salamandra, Triton cristatus, &c., small pyriform follicles, either solitary or aggregated, extend over a great part of the back, or form, as in the Toads and Newts, a large warty protuberance behind the ear, from which an acrid milky fluid may be readily expressed, the excretory ducts of the several sacs being readily recognised during this operation.

* Class REPTILIA.

Sub-Class 1. Reptilia squamigera.
- Order I. Sauria.—Ex. *Crocodile, Lizard, Chameleon.*
- II. Chelonia.—Ex. *Tortoise, Turtle.*
- III. Ophidia.—Ex. *Rattlesnake, Boa, Viper.*

Sub-Class 2. Reptilia nuda s. Amphibia.
- Order IV. Batrachia. { B. Anoura.—Ex. *Toad, Frog.* / B. Urodela.—Ex. *Salamander.*
- V. Ichthyodea.— { Derotremata.—Ex. *Amphiuma, Menopome.* / Perennibranchiata s. Proteidea.—Ex. *Proteus, Siren, Axolotl.*

The transition from the Naked to the Squamigerous Reptiles appears to be effected by those kinds of Reptiles, as the Chameleon, that are provided with a thin and delicate epidermis, having beneath it soft tubercles or excrescences, endowed with the power to expand and contract. These tubercles, which are continued also upon the circular eyelids, are separated from each other by strong annular layers of fibres, and consist of a bed of fibro-cellular tissue, within which a double layer of pigmentary cells may be detected. The most superficial pigmentary cells are black, either small and rounded, or of larger size and ramified, and beneath them are found some smaller nucleated cells or spots of a bright red color. The general appearance of these structures remind us very strikingly of the chromatophorous cells of the Cephalopoda, and it is probable that in the living Chameleon the same lively contraction of the walls of the cells may take place as in the Cuttle-fish; and to this property may be owing the well-known power of changing color which that animal possesses. In specimens preserved in spirits of wine, these cells may be rendered beautifully distinct by treating the skin with caustic potash.

The Squamigerous Reptiles exhibit various degrees in the development of their epidermic structures, giving rise to those numerous diversities of form which it is the special province of Zoology to depict. Frequently, as in the Snakes, in Scincus and other Saurians, scales are found that overlap each other like tiles, as in Fishes, or are disposed in a quincunctial order, or so as to form annular bands, as in Ophisaurus. Scutes, provided with tubercles and spines, are also commonly met with, or large plates containing bony matter, as in the Crocodiles and Chelonia; in the latter indeed they constitute true dermal bones, which coalesce with the skeleton, and form the dorsal and ventral shields, as will be described more minutely further on. The laminæ or scuta of the epidermis are formed by the coalescence of horny cells, which may be brought into view by submitting the scales of a tortoise to the action of caustic potash.

The scales of the Snakes exhibit under the miscroscope very delicate longitudinal and transverse striæ, which are probably caused by the coalescence of cells. In the parts of the epidermis situated between the scales, the cellular structure may be often more distinctly recognised. The epidermis is cast several times during the year, either piecemeal, or like the exuvia of the caterpillar, in one entire piece from off the whole surface of the body. A kind of

moult is thus performed, as by Birds, and something analogous occurs not only in many Saurians, but even in Emys among the Chelonia. The exuviation usually takes place in spring, but frequently upon the occurrence of a change of weather several times in the course of the year.

Tegumentary follicles of a particular kind are developed in several Sauria, as the true Lizards, *e. g.*, Lacerta, but also in Iguana, Cordylus, Gecko, though they are here fewer in number. In the above named genera a single row of them provided with from 12 to 20 orifices is found extending from the inguinal region to the knee-joint. These apertures are placed upon scales of a particular construction, forming tubercular or bulb-shaped elevations. Each opening conducts into a sac, the commencement of which is divided into small cœca.

OSSEOUS SYSTEM.

The remarkable diversities which the Osseous System of the Reptilia presents throughout the several orders and genera, render its description by no means easy without entering into very considerable detail.

As regards the *Cranial bones*, the best plan will be to consider them separately in each of the orders belonging to the two subclasses of Reptilia, commencing with the naked Amphibia. The Ichthyodea or Fish-like Amphibia and the Batrachia agree closely in the conditions of their skeleton, though that of the former approximates more closely to Fishes. This is exemplified in the structure of the occipital bone in the Proteus, where the two lateral occipital bones do not articulate by condyles with the vertebral column, but are united firmly by synchondrosis with the first cervical vertebra. In the Salamanders and Frogs, on the contrary, each of the two lateral occipitals has an elongated condyloid process, and both abut against each other superiorly and inferiorly, so as to circumscribe an interjacent foramen magnum. The body of the *sphenoid* bone is of considerable size, forming the basilar surface of the cranium, and is of a cruciform figure in the Anourous Batrachia, running to a narrow point anteriorly; it is broad, however, in the Pipa, and to a still greater degree in Siren and in Cœcilia. In the direction upward, it supports the alæ-majores, which are osseous only in the Tailed Batrachia, being in the Anoura membranous, and perforated by a large opening for the passage of the optic nerve. Each of the inferior wings or alæ (*processus sphenoidei*) is provided

in the Frogs with two large processes, one in the direction forward and outward, uniting them with the supra-maxillary, palatal and nasal bone, and the other, or posterior process, with the os quadratum. In the Tailed Batrachia, as the Salamander, the sphenoidal wings are not united to the supra-maxillaries, but project forward into a free and pointed process; in Acholotes they unite with the vomer, but in the Siren are absent together with the palatal bones. The *temporal* bone has only the articulating portion of the petrous bone developed to form part of the cranium, and this is let in between the circumjacent bones. The articulating portion of the temporal, or what is called the *os quadratum* or *tympanicum*, is freely detached from the petrous, and consists mostly of one, more rarely as in Proteus, of two pieces. It is united above to the cranium by a suture, abuts inferiorly against the jugal bone, and articulates with the lower jaw. The pair of *parietal* bones are always distinctly present, but occasionally, as in Hyla and Bombinator, separated by an interval or membranous fontenelle. The two *frontals* of considerable size are very distinct in the Tailed and in the Fish-like Batrachia, but are either absent in the Frogs or anchylosed with the parietals. In front of the frontals, between them and the intermaxillaries, certain bones are found, the homologies of which it is by no means easy to determine. A pair of ossicles placed in this situation in the Frogs and Pipa have been regarded by some writers as the *nasal*, by others as *lateral ethmoidal* bones. In the Salamander, a pair of similarly placed, but smaller bones, separated from each other in the middle line by the principal frontals, have been regarded as particular bones under the name of the *anterior frontals*, if they be not upon the other hand viewed as ethmoids. A single azygos bone, which in many Batrachia and also in Cœcilia appears as a small plate in front of the parietal and frontal bones, and usually projects downward in the form of a septum, may be well considered as a *middle ethmoidal*. The *lacrymal* bones are generally absent. The analogue of the jugal bone is seldom met with, or is at all events not to be determined with certainty. In the Frog there lie in front of the apex of the body of the sphenoid a pair of narrow transversely directed bones, which are united to the superior maxillary, and by a small ascending ramus, with the nasal bones; they may be regarded as the *palatal* bones. In front of them is situated in the Frog a pair of bones of considerable size provided with minute teeth, and which are probably the representatives of the *vomerine*. On the contrary, in the

Tailed Batrachia, *e. g.*, Siren, only a single pair of ossicles is found provided with teeth, and which admit therefore of being taken either for palatal or vomerine bones. The *superior maxillaries* are usually of very large size, being rarely, as in the Siren, in a minute or rudimentary condition. The *intermaxillaries* are also considerably developed. The *inferior maxilla* generally consists of an anterior piece supporting teeth, and a posterior articular portion of nearly equal length. A small ossicle is occasionally placed upon its articulating surface, but is generally anchylosed thereto. A fourth piece is seldom found in the middle of the lower jaw, as is the case in the rest of the Amphibia.

The Squamigerous Reptiles are characterized by the greater extent to which ossification is carried in the several bones composing their skull, many parts that in the naked Amphibia were only membranous having become in them converted into bone. The individual bones of the cranium are here also multiplied by division, as is especially exemplified in those that enter into the construction of the occipital, sphenoid and parietal. In this respect the present order of Reptiles seems to be most closely related to the Osseous Fishes.

In all the three orders composing this sub-class, namely, the Sauria, Ophidia, and Chelonia, the occipital bone is furnished with only a single condyle, which articulates with the first cervical vertebra, and is usually formed by the coalescence of three ossicles, namely, by the *body* of the *occipital* bone, which is always present, and the two *lateral occipitals*. Between the two last is interposed the *supra-occipital plate* completing the foramen magnum from above; it is of small size in the Ophidians, but mostly large in the Chelonia, where it projects backward into a pointed crest. In the last named order, and in the Crocodiles, a pair of *supra-laeral occipital* bones, as in Fishes, are intercalated between the others; they abut in the direction outward against the mastoid bone, internally against the petrous, and assist in forming the bony part of the organ of hearing. The body of the *sphenoid* is broad and short in the Chelonia, very elongated and narrow in the Ophidians, whereas in most Sauria it projects forward in the form of a style. The alæ majores of the sphenoid are in the Ophidians and Saurians perfectly membranous. There occurs here, however, a peculiar, narrow, long and style-shaped bone, usually called the *columella* (*os tympanicum Bojanus, os suspensorium Nitzch*) which ascends perpendicularly like a small column from the inferior wings of the

sphenoid upon either side, and supports the parietal bone, which rests upon it like the capital upon a pillar. This columella corresponds according to some anatomists with the great wings of the sphenoid. The inferior wings of the sphenoid are very large in the Chelonia, and united with the body of the bond, and to each other in the middle line, by suture; they represent at the same time the great alæ, and unite in front with the palatal bones. In most of the Sauria they are narrow and elongated, frequently support teeth, and are connected by synchondrosis with the body of the sphenoid; they are separated from each other, and abut posteriorly against the os quadratum, and in front, generally by means of two processes, against the palatal and jugal bones. In the Crocodiles they are very broad, unite in the middle line by suture, and conceal the body of the sphenoid. In the Ophidia the two wings are widely separated, very elongated, frequently provided with teeth, and bifurcate into an internal piece united with the palatal bones, and which can be regarded as an internal pterygoid process, and an external corresponding with the external pterygoid, and connected to the superior maxilla. The first piece extends very far back posteriorly to the union of the os quadratum with the inferior maxilla. The last piece is considered by many anatomists as a particular bone under the name of *os transversum*. The *temporal* bone is divided upon an average in all three orders into four pieces. In the direction inward and backward is situated the *petrous* bone, posteriorly and externally the *mastoid*, which in the Ophidia is very much elongated and style-shaped, but shorter in the other orders; in front of and in contact with this is generally placed the *squamous* element, united in the Chelonia and Sauria by suture with the parietal and jugal bone, but being quite free in the Ophidia, and advanced further forward. This piece is however viewed by many anatomists as a peculiar bone, under the name of *anterior frontal*, and being divided in the Tortoise into two pieces; the posterior of them has been in like manner termed the *posterior frontal*. The right interpretation of these bones has, however, given rise to much contrariety of opinion, relative to which the reader must consult and compare the special treatises on the osteology of the Reptilia. The articulating portion of the temporal, called the *quadratal* or *tympanic* bone, is particularly broad and concave in the Chelonia so as to be adapted for the reception of the large tympanic membrane, and superiorly is united by suture with the squamous and mastoid elements, while inferiorly it always projects

into a rounded condyle for articulation with the inferior maxilla. This bone is similar in character, only narrower, in the Sauria, still more elongated in the Ophidia, and in both, especially the latter, moveably united to the mastoid bone. The *parietal* bone is double in the Tortoises, but throughout almost all the Ophidia and Sauria, as in the Crocodiles, and even the anomalous genus, Amphisbæna, it consists of a single usually insignificant bone. The two *frontals* are still smaller, and united by a suture in the Chelonia, Ophidia, and some Sauria; the Crocodiles and other Sauria have a single frontal. A pair of bones situated in front of the frontals, frequently separated, as in the Ophidia and Crocodiles, by the nasal bones, may be regarded as *ethmoidal*, or according to others *nasal* bones. They appear to be absent in other Reptilia.

The *Facial bones* exhibit fewer deviations from their normal type in the higher Vertebrata, and admit, therefore, for the most part, of being readily and consistently referred to their analogues in the human subject. In front of the frontals lie generally a pair of mostly elongated *nasal* bones, there being very rarely only a single bone in their place, as in Moniter niloticus. Between the squamous element of the temporal and the superior maxilla the *jugal* bone is intercalated; it is of very large size in all the Chelonia and Crocodiles, and is met with in the rest of the Sauria, but appears to be absent in the Ophidia, and its place to be supplied by the external wings of the sphenoid. The *palatal* bones are very generally present, situated between the pterygoid processes and the superior maxilla, and are broad in the Chelonia, very elongated and mostly furnished with teeth in the Ophidia. Between the superior maxillary, nasal, ethmoid, and jugal bones, there is introduced, as in the Crocodile, a bone of tolerably large size, which may be either regarded as a distinct bone by itself, or from the analogy of its position, as a *lacrymal* bone. It would appear to be absent in the remaining Reptilia. The *vomer* is in the majority of instances, as in the Ophidia and Sauria, of large size and double; in the Crocodile, however, it is absent. In the Chelonia this bone is single, and frequently concealed from beneath by the palatal bones. Those bony plates, called *ossa superciliaria* s. *squamæ supra-orbitales*, which are placed in the Lizards upon the edge of the frontal bones, and form the roof of the orbitar cavity, are rather to be considered as pertaining to the tegumentary skeleton, than as true bones of the face. The *intermaxillary* bone is generally small and single in the Ophidia, Sauria and Matamata Turtle (Chelys); but double in the

rest of the Chelonia and Crocodiles. Externally and behind the intermaxillary is placed the *superior maxillary* bone. This bone is long, and beset with teeth of equal size in the ordinary Serpents, but very short and thick in the Venomous species, where it is hollowed out posteriorly, and supports the poison-tooth or fang. The *lower jaw* consists generally of two halves, which are completely anchylosed together to form a continuous arch of bone, without any trace of suture, in the Chelonia; in the Crocodiles and the rest of the Sauria, both halves are firmly connected by suture and synchondrosis; in the Ophidia, however, they are generally perfectly loose, being connected only by an intervening membranous symphysis, so that they can be separated widely from each other; indications of this separation may even be remarked externally in the groove upon the integument covering the chin. By means of this structure the mouth can be prodigiously expanded so that the Serpents can swallow living prey of much larger bulk than themselves. Each half of the lower jaw consists regularly in the Chelonia, Crocodilia, and most other Sauria, of six bony pieces. The Serpents have at least five, but the venomous kinds probably only three pieces. When, however, all six pieces are present, they are as follows: 1st. Most anteriorly, the large Dental piece (*pars alveolaris*) which, with the exception of the Chelonia, supports teeth. 2d. Posteriorly, the mostly small Articular piece (*p. angularis*) which, either alone, or in conjunction with No. 4, forms the concave joint for receiving the quadratal bone. Between these two terminal pieces, the following, united together by suture, and separable by maceration, are interposed, namely, 3d, the External accessory piece (*p. complementaris externa*) a bony plate, forming the greatest part of the external and posterior wall of the inferior maxilla. 4th. The Posterior accessory piece (*p. complementaris posterior*), which is situated beneath the former, and frequently concurs with the articular in forming the cavity for the os quadratum. 5th. The Anterior or Internal accessory piece (*p. complementaris anterior*), a plate of bone which assists in forming the inner wall of the lower jaw, and abuts anteriorly against the dental piece. 6th. The Coronoid piece (*p. coronoidea*), forming the highest part in the middle of the lower jaw, and which obviously corresponds to the coronoid process in Man and the Mammalia.

Associated with the diversified forms of the several classes of Reptilia, are many peculiar modifications in the structure of the

cranium, which will not admit of being included under the general description already given. Thus, in the Chameleon, long processes invariably project backward from the temporal and parietal bones, and unite to form an arch, thereby occasioning a most singular form of skull. The serpent-like apodal Saurians, as Pseudopus, Anguis, have the head constructed completely upon the Saurian type, presenting as in them the same style-shaped bone or columella which occupies the place of the large alæ of the sphenoid. Still more abnormal are the conditions of the cranium in the Saurian genera, Amphisbœna and Trogonophis, in which, however, the halves of the lower jaw are firmly consolidated; and also in those genera of Serpents, which depart most from the Ophidian type, as Rhinophis, Tortrix, and particularly Typhlops, where the maxillary and nasal bones form in front a hollow bony bladder, the pterygoid bones are represented by long squamoid bones, and the lower jaw, which in the Rattlesnakes consists of three pieces, appears to be formed of one piece, and to be edentulous.

The *Vertebral Column* exhibits remarkable diversities in the several orders of Reptilia.

The vertebræ of the Icthyic Reptiles (Proteus, Siren, &c.) have their bodies conically excavated at either end, and the intervals between them filled up by a gelatinous substance, as in Fishes. The number of the vertebræ is remarkable in the elongated bodies of the animals belonging to this order, for 60 are to be counted in the Proteus, 80 in the Siren, and above 100 in the Amphiuma. The vertebræ are divided into those of the trunk and tail; the first of these presenting distinct and often strongly developed transverse processes, and for the most part spinous processes also, which entirely disappear at the extremity of the caudal series. The number of the vertebræ is also very great in the Tailed Batrachia, as in the spotted Salamander and Tritons, where there are 15—16 in the trunk, 20—30 in the tail, the numbers varying somewhat in different individuals. The bodies are concave anteriorly, and convex posteriorly; the reverse of this is, however, the case in the Tailless Batrachia, as the Frogs. These, as well as the Tree-frogs, have but very few vertebræ, there being from 8—9; in Pipa there are only 7, with stout transverse processes, which are especially long upon the second and third lumbar vertebræ, to which succeeds the single though large sacral vertebra, the transverse processes of which are particularly broad. A long style or sabre-shaped bone

forming the terminal portion of the vertebral column, and extending nearly to the pubic symphysis, is to be regarded as a caudal vertebra.

In the Icthyic Reptiles, as also in the Batrachia, with the exception of Pipa, the first cervical vertebra or atlas is distinguished by the absence of transverse processes. It never supports any costal appendages in the true Frogs, though these are present in the Icthyic and Tailed Batrachia under the form of small, pointed, bony processes. The Pipa, among the Anoura, has only upon two of its vertebræ a pair of cartilagino-membranous appendages. In Proteus, Amphiuma, and Siren, only from 7 to 8 vertebræ of the trunk, while in Salamander and Triton, nearly all of them support ribs. The *Sternum* is very rudimentary in the Sirens and Tailed Batrachia, being here reduced to some cartilaginous lines and laminæ. The Toads exhibit the first traces of a distinct sternum, which, as a short bony piece, projects in them posteriorly into a cartilaginous plate, and abuts against the posterior clavicle. In Pipa, this cartilaginous plate is very broad. Besides the posterior, the Frogs have an anterior osseous piece which rests in front upon the anterior clavicular bone. The Serpentoid genus, Cœcilia, which from its having a scaleless integument, and gills at an early period of its existence, has been referred by systematists to the Batrachia. presents a perfect anomaly in the fact that all the vertebræ, with the exception of the atlas and some few caudal vertebræ, bear short ribs. The number of its vertebræ is also very great, amounting in Cœcilia lumbricoidea to upward of 200.

The vertebræ of the Ophidia are short and strong, the bodies concave anteriorly, and provided behind with a spherical head, articulating in a ball and socket fashion with the vertebra next succeeding. The vertebræ are united moreover by means of the anterior and posterior oblique processes, which present eight articulating surfaces invested by cartilage, and surrounded by capsular ligaments, sufficiently loose to admit of a great degree of mobility, but at the same time of an adequately firm union between the several bones. Superior spinous processes, short and broad, are generally met with, and frequently also, inferior spinous processes. The first vertebra, or usually the first two vertebræ, belong to the neck, being destitute of ribs. The succeeding vertebræ, support large, strong, cylindrical and arched ribs, with short appended costal cartilages; they are very moveably attached by concave articulating heads to the corresponding, smooth, rounded transverse processes of

the dorsal vertebræ, and are more numerous than those of the caudal vertebræ. In the true Serpents, there are always above 100 vertebræ, usually above 200, or 300, as in the great Boas, while the Python presents even 400 and upward, of which the caudal make up only a fourth to a seventh part of the whole series. No traces of a sternum are met with in the Ophidia.

In the true Sauria the number of the vertebræ and ribs is also considerable, being greatest in the elongated serpent-like forms of that order, as Anguis, Pseudopus, Chirotes, Amphisbœna, where they amount from 30—60 or 100, while that of the caudal vertebræ, which at the extremity of the tail become very small and rudimentary, frequently exceeds 100, as in Lacerta, Monitor, &c. The bodies of the vertebræ, like those of the Ophidia, are generally concave anteriorly, and provided with a hemispherical head posteriorly. The cervical vertebræ, of which the second has an odontoid process, are few in number, and generally devoid of ribs, but occasionally support them; to these succeed numerous dorsal vertebræ, and more rarely behind them some lumbar vertebræ, *e. g.*, in Monitor, Lacerta, Chameleon, Draco; lastly, a sacrum may be distinguished, usually consisting of two vertebræ, with long transverse processes that unite it to the iliac bones; to the sacrum follow next the numerous caudal vertebræ, frequently provided at their commencement with superior and inferior spinous processes. Superior spinous processes are usually found upon the cervical and caudal vertebræ, and upon the latter, inferior processes also, forming at their root a hemispherical canal, within which the aorta passes. Transverse and oblique processes are likewise met with. The ribs are numerous, and there are several anterior and posterior ones, as in the Lizards, which are not connected to the sternum. In the Chameleon, the broad body part of the sternum is merely cartilaginous, and the costal cartilages, corresponding with the sternal ribs, coalesce together in the middle line, so as to form so many intersecting bands. In the Flying Dragon (Draco viridis), the anterior ribs alone are united with the sternum; the posterior, especially the three middle ones, are very long and straight to support a membranous expansion, which serves the animal as a parachute, to sail through the air with from tree to tree. Nearly all the Saurians, with very few exceptions, such as Amphisbœna, possess a sternum, which occurs, however, in a rudimentary condition in the other serpentoid genera. It consists, as is well exemplified by the genera Lacerta, Monitor, &c., of an anterior slender T-shaped or cruciform bone, which

corresponds to the manubrium, and behind this of a very broad, flat, cartilaginous piece representing the body of the sternum, whereunto are appended posteriorly two small elongated pieces, parallel with each other, which, but for their receiving some of the costal cartilages, might be regarded as analogous to the ensiform cartilage of the Mammalia. The sternum becomes smaller, and more rudimentary in Chirotes, where the ensiform cartilage is formed by the uni-perforate plate of the body of the bone. In Anguis, even this is wanting, and there is only left a thin cartilaginous plate behind the clavicles; while in Pseudopus, the T-shaped manubrium is present along with it, though furnished with shorter processes.

The Crocodiles exhibit in the conditions of their skeleton, as in other general points of structure, various departures from the type of the remaining Sauria. The relative number of the vertebræ, with the exception of the caudal, agrees with that of the human subject, there being seven cervical, twelve dorsal, and five lumbar. The atlas is remarkable for consisting of four pieces, and supporting, as does also the second cervical vertebra, a moveable bone or rib of considerable size. The five succeeding vertebræ of the neck, like the twelve dorsal vertebræ, have their laminæ united by suture to the vertebral bodies, and support also short rib-like appendages, which are attached, like true ribs, by two crura, or in a furcate manner to the double (superior and inferior) transverse processes, and terminate externally by a hammer-shaped head, the anterior and posterior ends of which lie in such a way upon those of the adjoining vertebræ, as to limit the movements of the vertebræ in the lateral direction. This structure explains the fact, why one can easily escape when pursued, from a Crocodile, by moving in a circle. The sternum is broad anteriorly, and there projects into a pointed and free median process, while posteriorly it extends by means of two long slender pieces (sternal ribs), as far as the pubis. The part opposite to the lumbar vertebræ supports five pairs of free costal cartilages, without any vertebral ribs. There are only two sacral vertebræ, as in the rest of the Sauria, and about forty caudal vertebræ.

It is in the Chelonia unquestionably that the vertebræ, ribs, and sternum, present the most abnormal structure, for it is in them that a coalescence of some of the tegumentary bones takes place with those of the true skeleton, so as to form the dorsal shield, or carapace, and the ventral or plastron. The cervical vertebræ, eight in

number, are always freely moveable, and to such a degree in the Land and Fresh-water Tortoises, that the neck can be retracted beneath the carapace. They are similar to those of the Lizards, and provided with long but very depressed superior and inferior spinous processes. The odontoid process of the second cervical vertebra is constituted by a distinct bone. The two sacral, as also the caudal vertebræ, few in number, are provided with strong transverse processes. The bodies of the dorsal vertebræ are of very peculiar construction, being very long and narrow, and anchylosed to the dorsal shield, and hollowed out superiorly for the lodgement of the spinal cord. By making a perpendicular section of young specimens, the bodies may be readily perceived with the arches alternating with them. A distinct series of bones of a flattened form may at the same time be seen in the upper part of the section, to be situated upon the spinous processes; they form the middle row of dorsal scutes, and are partially anchylosed together, and with the ribs, by suture. They belong to the dermo-skeleton, and in adult animals coalesce completely with the spinous processes. The lateral parts of the carapace also consist of anchylosed ribs and dermal bones. In young specimens the ribs are seen to be narrow, and are plainly distinguishable from the dermal bones. The origin of the rib, or its narrow neck, may be also detected, and the mode by which the head uniting with the bodies of two vertebræ, and also with their arches, forms the *tuberculum costæ*. In adult specimens of the Land Tortoises, the tegumentary bones are so strongly anchylosed together, that the two ribs which were originally distinct, become completely absorbed, and even the costal necks and heads are represented by only thin bony fibres. Externally the carapace is surrounded by a circle of quadrangular, or elongated bony scutes, which belong entirely to the tegumentary skeleton, and replace as it were, the costal-cartilages, while they are in part firmly united to the plastron. This union is effected moreover by means of a sternum, and several dermal bones anchylosed to it, as may be also seen in young specimens. The plastron consists of eight pieces united by suture, or by fibro-cartilage, and of a single piece intercalated between the four anterior ones, and which may be regarded as a kind of manubrium sterni. In the Land and River Tortoises, at least in Emys, this piece consists of a large and entire plate; in Trionyx, and the Marine Tortoises (*e. g.* Chelonia), it is perforated by irregular apertures, and the anterior pieces concur to form a T-shaped bone, which reminds us of the structure of

this part of the sternal apparatus in the Lizards. In Trionyx and Chelonia, the apices of the ribs are free, and abut against marginal scutes, which never become anchylosed to them. In Testudo and Emys the dorsal scutes are most perfectly developed, but they are all blended together, and united by suture.

The typical structure of the *Scapula* and *Clavicle* is best exemplified in the Tailless Batrachia, or the Frogs, whence we will pass to consider its modifications in the other orders. The Scapula consists in the Frogs of two bony plates, the superior one of which rests upon the transverse processes of the anterior vertebra, the inferior narrower helps to form, along with the two succeeding bones, the articulating surface for the humerus. The clavicles are two in number upon either side; the anterior one is narrow, and flattened like a scale, the posterior is broader; they both diverge from each other in front, and come in contact in the middle line with their fellows of the opposite side, so that the anterior coalesces with the anterior, the posterior with the corresponding piece of the sternum.

Next in order to the above, we have to consider the structure of these parts in the Chelonia. The Scapula is in them a longer and narrower bone, slightly and loosely connected superiorly by ligamentous bands with the first cervical vertebra, while inferiorly it is continuous directly with the anterior and also narrow clavicle, so that the two bones are anchylosed into a single one. The posterior clavicle is mostly broader, and expanded in the form of a shovel at its free extremity, which is directed backward, while in front it unites with the two former bones by means of synchondrosis, to form the articulating cavity for the humerus. The whole of this osseous girdle is completely covered by the carapace and plastron, and is therefore not visible externally.

In most of the Sauria, the scapula, as in the Frogs, is formed of two pieces. The posterior clavicle is very broad, projects into several points, which abut against a cartilaginous piece that is united to the sternum, and a corresponding cartilaginous piece of the other side. The anterior clavicle is rib-shaped, and does not contribute in any way to the formation of the shoulder joint. Both the anterior clavicles abut against each other in the middle line, and together form a narrow arch in front of the T-shaped portion of the sternum. The above arrangement of parts is principally displayed by the Lacertæ, and other closely-allied genera. The Crocodiles have a single elongated scapula, and also a single, tolerably broad and flat

clavicular bone, forming, with the preceding, the articulating cavity for the humerus; the two clavicles rest upon the supra-lateral border of the broad sternum. The structure is in a like degree simple in Chameleon, and also in Chirotes. In Anguis and Pseudopus there is found beneath the skin a bony girdle, without any further development of extremities; in this the anterior flattened clavicles which converge and come in contact with each other, are distinct, and in a less degree, may the rudimentary scapula, and still less the posterior clavicle, be distinguished. In Amphisbœna, at least in Trogonophis Wiegmanni, only a rudiment of the anterior clavicle is present, so that this animal exhibits the greatest amount of imperfection, and, as it were, the last link in the interesting metamorphoses of the anterior extremities in the Sauria. While, however, these subcutaneous rudiments of bones occur in the serpent-like Sauria, it would appear, at least according to present researches, that in the Ophidia every trace of anterior extremities has disappeared. In the Tailed Batrachia, as the Salamanders and Tritons, the structure is more simple. The scapulæ continue in a more cartilaginous condition, and instead of the clavicles, there is found anteriorly, a broad, partly cartilaginous plate, which comes in contact with that of the opposite side. The structure of these parts is similar in the Icthyic Reptilia; in Siren, and Proteus, the scapula is at least osseous inferiorly, but in Amphiuma is reduced to a mere cartilaginous plate. Every trace of extremities appears to be wanting in Cœcilia.

In the disposition of their *Anterior Extremities*, the Reptilia approximate the Mammalia. The humerus is of moderate length, and in the Chelonia very much bent, and twisted in such a manner in relation to the axilla, that the arched surface looks in the direction backward; two bones are generally met with in the fore-arm, whereof the radius is usually placed anteriorly, but in the Chelonia, internally and posteriorly; it is only the Tailless Batrachia who have a single bone to their fore-arm, but even this presents a double groove indicative of its division into two bones, and possesses internally a double medullary canal. In many Reptiles a peculiar ossicle is developed in the extensor tendon of the humerus, above the projection of the olecranon, and, from its resemblance to the patella, has been called the patella brachialis. It occurs in many Batrachia and Sauria, more rarely in the Tortoises, but is wanting in many genera, and in the Crocodiles. In all Reptiles, the carpus is composed of a double, more rarely a single or triple, series of small ossicles, which

vary in number, and present a merely cartilaginous condition in the Sirens. To these succeed the metacarpal and phalangeal bones of the fingers, the latter differing in number and proportion, three in a row being the usual quantity, though in the Sauria there are from four to five phalanges upon some of the digits. The Ichthyic Reptilia have a few somewhat cartilaginous carpal bones. The Land Tortoises appear to have no metacarpal bones; the phalanges are here very short, but in the Marine Tortoises very long, and well developed to sustain the swimming paddles. In the Frogs, and Salamanders, there are found from 5—7, and in the Chelonia and Sauria mostly 9—10 phalanges. The two latter orders have mostly five, the Batrachia four fingers. There is frequently found however in the males of the Tailless Batrachia, a special rudimentary bone, or thumb. In the Sauria the third digit has four, the fourth five joints, and both of them are very long. The Proteus and Amphiuma tridactylum, as the name of the latter implies, possess only three digits, while there are only two in A. didactylum, and one in Chœmasaura.

The greatest resemblance to the Mammalian type, and consequently the most perfect condition of the bones of the *Pelvis*, is manifested by the Sauria and Chelonia; for it is here that we constantly find an ilium united to the sacrum, as well as a pubis and ischium, all these three bones remaining permanently separated, and meeting in the acetabulum; in both orders the ischiac unite in front, like the pubic bones, thus giving rise to a symphysis, as in the latter; in the Chelonia these two symphyses approximate, so as to leave an intervening obturator foramen. In the Anourous Batrachia the pelvis has a V-shaped form; the two iliac bones are very long and narrow, form the branches of the letter, and coalesce within such a narrow space behind with the very small pubic and ischiac bones, as to leave a bony disc, perforated by the two closely adjacent acetabula. In the Tailed Batrachia, and the Ichthyic Reptiles (though in some of the latter, as in Siren, it is wanting), the ilium is a narrower bone, united by ligament with the vertebral column; the pubis and ischium are blended together so as to form a single plate of considerable size, loosely connected to that of the other side, and for a great extent cartilaginous, especially in the Sirens. The rudiments of the pelvis are still further diminished in the Apodal Sauria, wherein a single bone is all that is invariably found, situated as in many Ophidia beneath the skin, behind the rib-bearing vertebræ, and nearest to the anus; it actually supports

in several species small osseous rudiments of feet. The structure of the posterior extremities in Pseudopus, Anguis, and Acontias, is very interesting, as exhibiting an advanced condition, for here indeed the single elongated pelvic bones are attached by ligament to the transverse processes of the last dorsal vertebra; in Eryx, Boa, Typhlops, Amphisbœna, &c., a pair of very elongated bones, consisting occasionally of several pieces, lie always free, and at a distance from the vertebral column, in a parallel position with the rectum. The Amphisbœnas, such as Trogonophis, exhibit the simplest form of pelvis, since it consists in them of a very small flattened bone, lying posteriorly beneath the integument, and near to the vertebral column; it may be regarded as a rudiment of the ilium. This structure is rather more complete in Ophisaurus.

The *Femur* is of large size, and strongly curved in the Chelonia; the tibia and fibula are generally met with, with the exception of the Anourous Batrachia, where only a single bone is found, as in the fore-arm, presenting marks of division. There is frequently developed in the extensor tendon of the femoral muscles, in many Sauria, a patella, and in several Batrachia, as in Pipa, a second patella occurs, situated behind, between the tibia and tarsal bones. These last, disposed in three rows, continue partly cartilaginous in the Tailed Batrachia, and present themselves under similar conditions in the Ichthyic Reptiles; on the contrary in the Anourous Batrachia the two tarsal bones, corresponding to the os calcis and astragalus, are constructed after the type of the crural bones, being of an elongated form, while in front of them is situated a row of lesser tarsal ossicles; in the Chelonia, and Sauria, the small tarsal bones are disposed in two rows. The metatarsal bones correspond completely in the several orders with the metacarpals. The number and form also of the phalanges of the toes correspond, with some exception, to those of the fingers. The last toe but one is usually the longest. Several Ophidia, and Apodal Sauria, possess the rudiment of a single toe, which is even provided with a nail, as in Pseudopus, where the rudiment is very small, and turned in the direction upward. It is more developed in the true Serpents, but it is only in some genera, as Tortrix, Boa, Python, and also Eryx, in which this rudiment of a toe supports a strong pointed claw. The poisonous Snakes, Natterers, &c., appear to be destitute of these structures. In Siren, and Cœcilia, all trace of posterior extremities is likewise wanting.

MUSCULAR SYSTEM.

The two sub-classes of Reptilia exhibit, even in the structure and arrangement of their muscles, certain constant differences.

The muscles of the Squamigerous Reptiles who rank nearest to Birds and Mammalia, are of a redder color, more isolated and separated from each other into several bundles, and generally possess greater energy of action, although those of the Frogs, which are white, are endowed also with remarkable strength. In the Sirens, and also in the Tailed Batrachia, the mode of arrangement of the muscles is analogous to that of Fishes, their body, as in them, being adapted for swimming. The distinctness and degree of separation of the muscles increase as we approach the Sauria, in which the muscles are most readily referred for comparison to those of the human subject. In other respects such great diversities occur throughout the class, that it were difficult to give a general description, without entering into more tedious detail than would be compatible with the nature and extent of this work, and we must therefore refer the student to the list of books and illustrations given at the end of the class, for further information upon this subject.

The *Tegumentary muscles* are not always so developed in Reptiles, as in Mammalia and Birds, and are completely wanting, for example, upon the trunk of the Chelonia. Powerful and distinct muscles of this kind are found, however, in the Serpents, upon the ventral scutes, to the number of six pairs to each of the latter, which by means of their action can be slid one within the other; tegumentary muscles occur also in the Batrachia.

The Ichthyic Reptilia, the Water-Newts, and the Tadpoles or larvæ of the Raniform Amphibia, which progress in the water by inflecting trunk and tail, possess large laternal masses of muscle similar to those of Fishes, which cover the whole back, and are continued directly into the ventral muscles. The large lateral muscle always arises from the occipital and temporal bone, and from the arches and transverse processes of the vertebræ, and is continued to the end of the caudal portion of the column. It is usually intersected transversely by as many tendons as there are vertebræ present. A superior and inferior layer of muscles may be distinguished, which correspond to the *m. sacro-lumbaris*, and *longissimus dorsi*. Besides the two oblique muscles of the abdomen, a

rectus may be distinguished, provided with many transverse tendinous bands. The muscles of the extremities are more analogous to those of the higher Reptilia.

In the Frogs the muscles of the back, are much shorter, and the parallel tendinous intersections are limited, as in man, merely to the abdominal muscles. The dorsal region in the Frog, particularly behind the head, is covered chiefly by the powerful muscles of the scapula, and the very small latissimus dorsi. The temporal muscle is very developed, and in like manner the strong muscles of the lower law. The *pectoralis major* is of very remarkable strength, and gives off narrow strips in the direction forward and backward, and is also divided into several stout bellies; beneath it lies the small pectoral, also of considerable size. The extensors of the humerus and fore-arm (*m. m. deltoideus* and *triceps brachii*) consist of very short, but uncommonly fleshy and strong muscular bellies. The flexor and extensor muscles of the hand present a similar character, so that in this respect the organ obtains a form analogous to that of the human subject. Upon the posterior extremities, on the contrary, the large glutæi are very different from those of Man, appearing as short, narrow, and but slightly developed muscles, adapted to the elongated form of the iliac bones, to which they are attached. The muscles of the legs, from the hinder extremities being adapted by their length for leaping and swimming, exhibit forms more analogous to the human structures, this holding good, both with the extensor and flexor muscles, as the *m. sartorius, adductor magnus, semitendinosus* and *membranosus*, and the strong muscles of the fibula, the *gastrocnemii*. The strong tendo-Achillis is continued into the *plantar aponeurosis*, and the patella-like bone already alluded to, as placed between the tibia and tarsal ossicles, serves it as a pulley over which to play. The muscles of the feet are greatly subdivided, and their short bellies pass into delicate tendons.

The slightest or most rudimentary degree to which the muscles of the trunk, including those of the back and ribs, are developed, is met with in the Chelonia, by reason of the peculiar manner in which their tegumentary is anchylosed to the true skeleton. The muscles of the face are equally rudimentary, and upon removing the hard closely overlying integument, we perceive only the temporal and palpebral muscles. The muscles of the neck, and its nape, are, on the contrary, well developed, particularly the *m. spinalis cervicis*, which divides into single detached bundles, and is inserted

into the carapace, beneath which it serves, together with the *retrahentes capitis et colli*, to retract the head of the animal. The oblique and transverse muscles of the abdomen are of considerable size, being important agents in the movements of respiration, and there is found in this region of the body, as in Birds, a rudimentary form of diaphragm, which arises as a broader thinner muscle than in them, from the vertebral column and carapace, and is interposed between the peritoneum and pleura, without, however, meeting its fellow in the middle line from the opposite side. Beneath the plastron lie the great pectoral muscles, which, like the large glutæi, are strongly developed, this being the case also with the muscles of the extremities, among which the flexor muscles of the leg, the *biceps femoris* and *semi-tendinosus*, are remarkable for their length.

In the Ophidia the cranial and maxillary muscles, especially those of the lower jaw, are distinguished by their great development; for instance, the temporal, from which a layer is given off over the poison-sac of the Venomous species, and acts upon it as a compressor. The muscles of the trunk, however, by which locomotion is effected, are the most remarkable in the Serpents. It is here chiefly the *intercostales*, as well as the *spinales, semi-spinales, interspinales* and *inter-transversales* muscles that act upon the very moveably united vertebræ and the free extremities of the ribs. Of the intercostals, some pass directly from one to the next adjoining rib, while others pass over several of these bones. Even the pelvis and rudimental feet of many Serpents (the osteological relations of which have been described above) are provided with muscles that bend the extremities as far as their ungual phalanx, and extend or draw them in different directions.

NERVOUS SYSTEM.

The *Brain* of the Amphibia ranks greatly inferior to that of Birds in the relative proportional size which it bears to the bulk of the body, though it fills up tolerably the cranial cavity, and is surrounded by the usual membranes. What is remarkable, it exhibits no very important differences in the several orders, though in this respect we are confessedly still in want of more accurate investigations.

The *Spinal Cord* is prolonged into the caudal vertebræ, and is generally furnished with two swellings corresponding with the

origin of the nerves to the extremities, but which are wanting in the Ophidia; the genus Bipes among the Sauria possesses only a posterior swelling upon the cord, and Chirotes only an anterior, in accordance with the position of the rudimentary extremities already described. The spinal cord is always traversed by a central canal. The *medulla oblongata* is flattened like that of Fishes in the naked Reptilia, and the rhomboidal sinus is broad and patulous; in the Squamigerous Reptilia this part is more dilated, especially in the proximity of the pyramidal tracts, and the pons is absent. The *cerebellum* arises by two crura, and consists in the naked Amphibia and Ophidia of a hollow medullary layer, which passes as a small narrow band transversely over the fourth ventricle, without covering it completely; in the Chelonia it forms a smooth spherical and hollow swelling, and in the Sauria, as in the Crocodiles, it is provided with one or several lateral transverse grooves. In front of the cerebellum are situated a pair of large oval ganglia, hollow internally, and partly coalescing in the middle line in the naked Amphibia, as the Ichthyic genera Proteus and Amphiuma, but which are of largest proportional size, and distinct from each other in the Frogs, and also in the Sauria; they represent the *corpora quadrigemina*, probably incorporated with the optic thalami. To these succeed the oval *cerebral hemispheres* of considerable size, and which, smooth and devoid of convolutions, give off the olfactory nerves. Within their lateral ventricles is placed, at least in the Crocodiles and Tortoises, an elongated ganglion, which corresponds perhaps to the corpus striatum; and by the side of this is a distinctly developed choroid plexus, while a system of commissures for uniting the double parts of the brain is always met with. The *pineal gland* is very large in the Chelonia, but smaller in the other orders, and lies uncovered by the hemispheres in front of the corpora quadrigemina. Although this gland is met with in all the Amphibia, it is difficult to determine whether it is really present in the Frog. The *pituitary appendage* is constantly present, and of noticeable size. The ventricles coalesce together; the aqueduct of Sylvius is a very wide canal, and the fourth ventricle is quite open and uncovered from above, especially in the Amphibia.

The *Cerebral nerves* admit of being very easily reduced to their analogues in the human subject and the rest of the Vertebrata, and have been traced with the most special care in the Frog, Tortoise, and Serpent.

In the brain of the Frog only eight separate nerves are found, the facial, glosso-pharyngeal, accessory of Willis, and hypoglossal, exhibiting no distinct roots; the facial is still supplied as a branch from the acoustic; the vagus, which arises behind the auditory nerve from the most posterior limits of the medulla oblongata, passes at a right angle through an opening lying to the outer side of the articulating tubercle of the occipital bone; some very delicate nervous radicles, arising from the inferior tracts of the medulla oblongata near to its anterior fissure, unite with it and appear to correspond with the glosso-pharyngeal. Some of the roots of the accessory nerve appear to be absent, and the hypoglossal is given off by the first pair of cervical nerves. In the Frogs, as in all the Reptilia, even the Ichthyodea, which live habitually in water, the olfactory nerves are of very considerable size, and proceed generally from some medullary ganglia situated in front of the hemispheres. The optic nerves are flat and form a chiasma, and at this seat of union there is found a partial decussation formed by the overlapping of several distinct laminiform faciculi of nervous matter.

In the Tortoises, and probably all the Squamigerous Reptiles, all the twelve pairs of cerebral nerves are to be found, and their roots admit of being traced to the base of the encephalon.

As regards the *Spinal nerves*, their origin by two roots is always very distinct, and those of the Amphibia, especially of the Frogs, are particularly well adapted for the purposes of physiological experiment. Their number varies very much, ten pairs being found in the Frog, and several more in the Tortoise. In the Squamigerous Reptilia the last cervical and first dorsal nerves usually form the brachial plexus; from the lumbar nerves is given off the crural, and from it and the sacral nerves the ischiadic plexus.

The *Sympathetic nerve*, the existence of which was formerly overlooked in the Serpents, has now been proved of general occurrence throughout the present class. In the Frogs the ganglia admit of being very readily demonstrated lying upon the sides of the vertebral column; they are here situated near to those small white vesicles which protrude by becoming swollen chiefly during the spring of the year, and contain numerous microscopic calcareous crystals. The plexuses of the sympathetic nerve unite with the vagus, and by a ganglion with each of the spinal nerves. The sympathetic then enters the skull through the condyloid foramen, and unites with the ganglion of the fifth pair or trigeminus, and also with the other cerebral nerves. The cranial portion of the sympathetic in the Ser-

pent establishes at the base of the cranium communications with the n. trigeminus, vagus, glosso-pharyngeus, hypo-glossus, and also with the facial nerve. External to the cranium we meet with ganglia, which may be compared with the superior cervical and spheno-palatine ganglion. Upon the heart and the greatest portion of the trunk, and upon the internal processes of the vertebral bodies, the sympathetic nerves may be traced as extremely delicate streaks. The ganglia are also very small even in the largest Serpents. In the Crocodiles, the cervical portion of the sympathetic is situated deep within the canal formed by the transverse processes of the cervical vertebræ. The vagus is distributed in the Serpents as far as over a third of the cavity of the trunk.

The lateral branch, that arising chiefly from the nervus vagus, runs along the sides of the trunk as far as the tail, and is of general occurrence in the class of Fishes, is met with also in the Perennibranchiate Amphibia, the Proteidea, and the larvæ of Batrachia; but in the metamorphosis which the latter undergo, it disappears by degrees, and becomes finally reduced to the auricular branch of the nervus vagus, or some tegumentary offset corresponding to the former. In the Serpents and Lizards, no lateral nerve exists.

ORGANS OF THE SENSES.

Organs of Vision.

The Eyeball with its several component parts, approximates in the naked Amphibia most in structure to that of Fishes, since they live in the same element as the latter, and the globe of the eye having to receive the rays of light through the water, is accordingly flatter in front, and the lens more spherical. In the Squamigerous Reptiles, the structure of the globe of the eye agrees more with that of Birds, yet even in them presents certain characteristic differences, as may be readily perceived, upon examining a longitudinal section of the eyeball. In Proteus the eye is very small, but provided with a lens, and the usual tunics; in the genus Typhlops, the eye is still more rudimentary. The sclerotic frequently contains a bony plate, or several bony scales united to form a ring, as in Birds. This is the case with the Tortoises, where ten bony pieces may be most usually counted, and in many

Sauria, as Lacerta, Iguana, Monitor. The cornea is more convex than in Fishes, and the anterior chambers of the eye of various dimensions. The choroid coat is very thick, frequently covered externally and internally with a dense layer of black pigment; the ciliary body usually gives off some projecting folds, or ciliary processes. The iris in the Batrachia is invested in front, with a gold-colored pigment. The pupil is capable of a slight degree of expansion; for the most part of a circular form, as in Pipa; it frequently, however, as in the Frog and Salamander, presents the figure of a transversely directed nearly rhombic oval; in the Crocodile, and many Ophidia, as the Viper, and Rattle-snake, but without bearing any reference to the poisonous qualities of the Serpent, the pupil forms a perpendicular slit. The optic nerve perforates the tunics of the eye in the direction externally and inferiorly, but usually enters the eye of a rounded shape. The papillary layer of the retina is very greatly developed. The vitreous humor is mostly small in proportion to the lens, which last is in those Reptiles that live in water, very spherical, or else compressed, and frequently, as in Emys, elliptical. In several Sauria, as in Lacerta, Iguana, Chameleo, Monitor, a feebly-developed process from the choroid, slightly plicated, and invested by a layer of pigment, is prolonged into the interior of the eye, from the point of entrance of the optic nerve, and appears to be analogous to the pecten in the eye of the Bird, though it never has so many folds, there being occasionally only two. The globe of the eye is usually moved by six muscles, four recti, and two oblique or rotator muscles. To those is superadded in the Frog an infundibuniform muscle (*suspensorius oculi*) divided into several fasciculi, which arises, in a manner perfectly similar to that described in the Mammalia, from the bottom of the orbitar cavity, and is attached to the posterior part of the eyeball.

The *Protective* and *Glandular appendages* of the eye exhibit very diversified degrees of development in the Reptilia. In the Ichthyodea, the external integument is partly continued over the eye, as a transparent lamella. The Squamigerous Reptiles have for the most part a superior, and larger inferior eyelid provided with a cartilaginous plate, and usually very moveable, and in addition to these, a third internal eyelid, or nictitating membrane. Numerous varieties however occur; thus in Scincus, and Gecko, both eyelids are small and immoveable; the Salamanders possess only two short eyelids, but the Frog the additional third

one, which is very moveable; in the Chameleon the eyelids form a thick cushion, furnished with a dense muscular layer, and having a small central aperture opposite the pupil. The nictitating membrane of the Frog slides underneath the upper eyelid, and is moved by a mechanism, that reminds us of that already described in Birds. There are found a detractor and an elevator of the nictitating membrane; the latter muscle arises superiorly and in front from the nictitating membrane, and gives off a tendon, which passes though a pulley to beneath the eyeball, perforates the infundibuliform muscle, and terminates by a small muscular belly attached to the posterior angle of the eye. In the Ophidia the eye is covered by a transparent lamella of epidermis, which is shed along with what is called the exuvia or cast skin. Beneath it lies the conjunctiva which is reflected over the sclerotic coat, invents the cornea, and so forms a completely closed sac, which receives the excretory ducts of the lacrymal gland, and conducts the secretion from the latter through a duct between the maxillary and palatal bones into the cavity of the mouth. The *Lacrymal gland* is situated behind the eyeball, and is particularly large in the non-venomous Serpents, as the genus Coluber, but also in the Vipers, *e. g.* V., berus, where it was formerly falsely taken from the poison-gland. The Sauria and Chelonia have for the most part two lacrymal glands, an external, the largest, and an internal, smaller; one of these is destined for the nictitating membrane, and corresponds to the Harderian gland. The naked Amphibia do not appear to be furnished with a lacrymal apparatus.

Organs of Hearing.

The naked Reptiles completely approximate the Fishes in the structure of their organ of hearing, while the Squamigerous subclass exhibit a higher grade of organization, by the appearance of a true cochlea. The tympanic cavity is absent in the Ichthyodea, and Tailed Batrachia, and both integument and muscles are continued over the external ear; the oval fenestra is closed by a cartilaginous operculum, into which is inserted a horizontal, elongated, style-shaped ossicle, like that in Birds, and called the *columella*; the Eustachian tube is wanting. The tympanic cavity is also absent in the Ophidia, but they have for the most part a columella and operculum. The Anourous Batrachia have in general a membranous tympanic cavity, which commences by an infundibuliform

cartilaginous ring, upon which the membrana tympani, uncovered from without, is stretched. The fenestra ovalis is closed by a cartilaginous, slightly concave operculum, upon which the broad end of the columella rests, while to its outer extremity a small cartilage is united, the swollen head of which is fixed upon the membrana tympani; the two Eustachian tubes open into the cavity of the pharynx, and occasionally in the middle of the latter by a common aperture. In the Chelonia and Sauria the tympanic cavity receives a partly bony, partly membranous Eustachian tube, which is mostly very short and broad in the Sauria; several of the latter have also the membrana tympani covered by skin and muscle. The fenestra ovalis is closed by an operculum, upon which rests the columella, and is united to the membrana tympani by a small cartilaginous frequently divided body, that presents a discoidal form in the Chelonia. If we compare this chain of auditory ossicles with those of the Mammalia, the small cartilage united to the tympanic membrane will be found to agree with the malleus, the columella with the incus, and the operculum with the stapes, if not in form, at least in function. Two muscles are found in the internal ear of Reptiles, namely, a *tensor tympani*, and a *stapedius*.

A variety of specialities belonging to the auditory apparatus occur in this diversely constructed class; of these the following are perhaps the most important to be mentioned. The operculum is found in Cœcilia, Amphiuma, Siren, and Tortrix, and a small columella, such as occurs also in the true Serpents, in Amphisbœna. Typhlops and Rhinophis have no auditory ossicles. In the Salamander there is situated a membrane upon the fenestra ovalis, beneath the operculum, and a short canal conducts to the vestibule. The Bufo igneus, and Rana cultripes Cuv., perfectly resemble the Salamanders, in the absence of a tympanic cavity, and they have also, like Pipa, only a single opening within the pharynx for the two Eustachian tubes. In the Tortoises, the incomplete canal of the Eustachian tubes is seen at the base of the sphenoid bone, made up inferiorly by membrane; in several, as in the genus Chelonia, the columella is lodged in a posterior excavation of the os quadratum, which receives the membrana tympani, and in Emys expansa is in the form of a foramen. The columella is moved by a single muscle. In Chameleo, Anguis, Acontias (in which last the columella even is wanting), and partly in Pseudopus, the membrana tympani is covered by muscles and integument, but is freely exposed on the contrary in Ophisaurus, while in Chirotes the whole

tympanic cavity is absent. The malleal cartilage is tripartite in the Crocodile, and round in the Chelonia. No external ear is present in Reptiles, and it is only the highest form of them, the Crocodile, that possesses a rudiment of this structure, under the condition of a double tegumentary fold or flap, the superior portion of which contains in its interior a bony plate, and can be shut down by a muscle like a valve.

All Reptiles have a bony labyrinth lined by a membrane, and completely separated from the cranial cavity, with which it is merely associated by the openings for the passage of nerves; it is situated within the temporal bone, and partly within the latero-inferior pieces of the occipital bone. The vestibule is of varied form and size, and receives the semicircular canals by four or five openings; the external canal is placed horizontally, and the anterior and posterior stand perpendicularly, and have one of the crura common to them both. Two grooves are usually found in the vestibule, and the sac lying within it encloses a friable crystalline cretaceous mass, and in rare instances harder lithic bodies; the membranous canals expand into ampullæ. The cochlea appears to be entirely absent in the naked Amphibia, but on the contrary to be found in all the Squamigera. It is found in its simplest condition, as a rounded cavity with a sac in the interior containing a watery fluid, in the Chelonia. Yet even in them, a round or cochlear fenestra, separated from the fenestra ovalis by a thin septum, is found placed in the direction backward, and closed by a second tympanic membrane. In the Sauria and Ophidia the cochlea is a hollow cone, blunt and somewhat dilated at the apex; it includes a pair of cartilages, which turned toward each other, are clothed by a plicated membrane, upon which, as upon the spiral plate of the higher animals, the auditory nerve expands into delicate filaments; at the extremity of the bony sphere is situated a peculiar retort-shaped sac (*lagena*) which contains the fluid of the labyrinth, and receives, like the vestibular sac, a twig from the acoustic nerve. The branches of the portia dura pass only though the tympanic cavity, and there appears to be a true chorda tympani present. Hollow cells are frequently found in the tympanic and mastoid bones, and stand in communication with the internal ear.

Organs of Smell.

It is a very general character of the Reptilia, and is in relation to their peculiar mode of pulmonic respiration, that the posterior nasal apertures perforate the palatal bones internally, this being the case even in the Ichthyodea, though, however, some genera occur among these, in which, as in some Fishes, the nostrils merely open as small slits behind the lips, as in Proteus and Siren, while in Amphiuma, Menopoma, Acholotes, &c., the openings of the choanæ or posterior nares are found in the palate. The nasal cavities are frequently lined by a plicated pituitary membrane, *e. g.* in Proteus, as in Fishes. It is rarely, as in Trionyx among the Chelonia, that the nose is lengthened out into a small membrano-cartilaginous snout. The nasal canals are in other respects very simple in the Naked and in the Squamigerous Reptilia; in the Batrachia the nostrils are contractile externally. A cartilaginous partition separates the two nasal passages, and cartilaginous plates, invested by mucous membrane, and which correspond to the turbinated bones, clothe the rest of the nasal parietes, and project slightly beyond the bones, as cartilaginous external nasal organs. The nasal passages are of greatest length in the Sauria, as the Crocodile, and are frequently expanded in front, in the form of a pouch, and, as in the Cetacea, can be closed by valves; feebly developed cartilaginous, or bony turbinated organs are also present. Besides the olfactory nerves which pass through small ethmoidal plates, and divide and ramify is a simple manner, a twig also from the fifth pair of nerves is distributed chiefly to the external part of the nose. A special nasal gland is found in many Serpents, constantly situated between the superior maxillary, lacrymal, and nasal bones, and having a proper excretory duct, that opens into the palate. The Cœcilia and many Serpents have also an orifice between the nose and eye, which leads into a small blind sac, from which arises a small tentacle; the function of this organ is unknown.

Organs of Taste and Touch.

Although it is doubtful whether the members of the present class are endowed with a distinct sense of taste, this is certainly not the case with the Land Tortoises. Reptiles swallow their food nearly

whole, and the *Tongue*, though frequently developed to a very great degree, seldom exhibits an organization adapted for the exercise of the gustatory function. The tongue is very variously formed, being but slightly developed in many genera, and in some instances scarcely projects from the bottom of the mouth; it is for the most part however freely moveable, frequently more or less deeply divided, and surrounded at the root by a membranous sheath.

The tongue is developed in the most imperfect manner in the lowest order, or that which comes next to the Fishes, and is actually wanting entirely in the Proteus and Siren, though this is the case in some other Batrachia, as Pipa. In the Tailed Batrachia, as the Salamanders, the tongue is attached to the floor of the mouth. In the Frogs and Toads the tongue, which is soft, and lubricated by a viscid secretion, is free and bifurcated posteriorly, but on the contrary, is broad where it is attached in front behind the symphysis of the lower jaw, and under this form is admirably adapted for being flirted out of the mouth with rapidity, to seize the prey that adheres when touched to its apex.

Among the Tortoises the tongue in the Marine species, at least in Chelonia, is small and hard, slightly moveable in Emys, and provided with depressions. In Testudo, on the contrary, it is more manifestly constructed as an instrument of taste, being beset all over with small soft papillæ.

In the Serpents the tongue is soft and smooth, generally long, highly moveable and protrusile, slit at the apex, and surrounded at the base by a sheath. The tongue is exactly similar in many Sauria, as in the true Lizards, where it is very deeply slit, especially in the genus Monitor; it is entire, though at the same time retractile, in most Apodal Sauria, as Anguis, Pseudopus. The smooth apapillary tongue of the Crocodile is very flat, depressed, and united by its whole extent to the floor of the mouth.

The Chameleon is remarkable for the peculiar structure of its lingual organ. It is very large and protractile, can be stretched out to a great length like a worm, is traversed by a central canal, and terminates in front by a kind of fleshy disc, which is concave, and covered by a viscous secretion. The creature is able to dart out the tongue suddenly to seize the prey that adheres the instant it is touched to the tip of the organ, which is so extended during the act as to appear even longer than the entire body; the exercise of this function depends upon the peculiar structure and arrangement of the lingual muscles. During rest the tongue lies retracted

within the mouth, lodged in a deep groove of the palate, and enclosed within a long sheath.

The *Lingual bone* of the Reptilia, which supports the tongue, exhibits great diversities, and in the Ichthyodea it resembles most that of Fishes. It consists in them of one or two middle azygos pieces lying behind each other, and supporting in front a broad cartilaginous plate. A pair of lateral pieces represent the anterior cornua, and serve to attach the lingual bone, through the intervention of ligaments, to the skull. Posteriorly, the single piece coalesces with the superior pieces of the branchial arches, which represent in some respects the posterior cornua. In the Batrachia, *e. g.*, the Frog, a similar structure is met with in their tadpole or larval state. At a later period of existence, after the disappearance of their branchiæ, the parts blend more together, and there remain a middle piece or body, a pair of anterior flattened, and a pair of lesser posterior, cornua. In the Chelonia, the lingual bone is very different, and consists frequently of a great number of pieces, amounting even to 20 in Trionyx. A single median body is however invariably present, and two pairs of cornua, the posterior of which usually consist of several pieces; occasionally a very small third pair of cornua is appended to the body in front, as in Emys. The lingual bone of the Ophidia is very simple, for here the body is entirely wanting, and there are present only the anterior cornua, as a pair of long cartilaginous filaments, connected in front by ligaments. In the Lizards a very delicate cartilaginous filament (*appendix styloidea* Losana) unites the small body of the lingual bone to the skull. The structure of the body of the bone in the Crocodile is directly the reverse, being flat, very large and broad, with only the posterior pair of cornua occurring as appendages. In the rest of the Sauria the middle portion or body is prolonged into a fine cartilage which penetrates the substance of the tongue; two pairs of cornua are found, whereof the anterior are by far the longest, and frequently present several curves; the posterior pair are more simple, regular in form, and always consist of bone. Occasionally, as in the Lizards proper, the body is slit posteriorly into two crura, or processes, which correspond to the single process in Birds. In Ophisaurus and Anguis the anterior cornua are entirely cartilaginous, and the body is very small in Amphisbœna, so that these structures conduct at once to those already described as existing in the Serpents.

As regards the *Muscles*, the tongue is furnished with a protrac-

tor and retractor, and four to five additional pairs of muscles, a detailed description of which would lead us out of the plan of the present work.

The study of the different structural conditions of the lingual bone possesses a great amount of interest with the philosophical or transcendental comparative anatomist, namely, in reference to the development of the branchial apparatus, or of the visceral arches, and the mode of division of the fœtal vessels in the Vertebrata.

The tongue may in the Reptilia be frequently used as an implement of touch. Special organs of touch do not exist, but in the naked Amphibia, as the Frogs, the whole skin is endowed with the highest sensibility, being supplied by numerous nervous filaments, and it is on this account that, on irritating the skin in these animals, they exhibit such strong and varied reflex movements, and are thereby best adapted for making experiments upon the dynamics of the nervous system.

DIGESTIVE SYSTEM.

The form and armature of the jaws is exceedingly diversified in the Reptilia. The *Teeth*, when present, never serve to masticate, but only to seize the prey, or else they form, as in the Venomous Serpents, what occurs in no other class of animals, peculiarly constructed weapons for inflicting a deadly wound.

The teeth are completely wanting in the order Chelonia; the maxillæ, with the exception of those of the Chelydes, which are merely covered by skin, are invested with horn, consisting of superimposed lamellæ, like those of Birds. In Trionyx, however, the lips are soft and fleshy.

Some edentulous genera are also found among the Batrachia, *e. g.*, Pipa. The Toads have palatal teeth, and besides these in the Frogs, there are rows of short pointed teeth in the upper jaw, and more rarely also in the lower jaw, as in the genus Hemisfractus, and the Tritons, and Salamanders. Similar diversities occur in the Ichthyodea; thus Proteus possesses teeth in both the upper and lower jaws, and the Axolotl also upon the palate, while in Siren a pair of large dental plates are found upon the palate, but no teeth on the inter and supra maxillary bones.

The Sauria, however, exhibit the greatest variety in this respect. In some cases, numerous very small and pointed teeth stand principally upon the edges of the jaws, but occasionally on the palate. In others, the teeth are either uncinate, chisel, awl, or lancet-shaped, finely dentated upon the edges, or deeply serrated at the apices, and occasionally they are conical and blunt. The teeth consist of osseous substance, and a coating of enamel, are rarely implanted in distinct sockets, but are either anchylosed externally by their fang to the maxillary bones (*dentes adnati*), while internally the fang is free, and only covered by the gum, or they are firmly (*dentes innati*) anchylosed to the edges of the jaw. Thus the teeth in Monitor, Basiliscus, Anolis, Polychrus, Iguana, and others, belong to the first kind, and to the latter those of Calotes, Draco, Stellio, Uromastrix, Chameleon, and Ameira. The teeth are small and blunt in Lacerta, Pseudopus, and Amphisbœna, and denticulated upon the edges in the Monitors. The Crocodiles have pointed, conical teeth, becoming blunter posteriorly, and implanted in sockets; the numerous teeth that are destined to replace them are imbedded, of a conical form, in the interior of the first set. Upon the more minute specific arrangements of the teeth, it is the province of Zoology to dwell.

The Serpents, when unprovided with poisonous teeth, have curved hook-shaped teeth in the lower jaw, and upon the palatal and supra-maxillary bones, while the small inter-maxillary bone is edentulous, or only rarely toothed, as in Tortrix. In different kinds of Serpents suspected to be dangerous, we meet with a gradual transition from the solid teeth of the non-venomous, to those of the Venomous species. Even in our harmless Snake, the Coluber Natrix, several of the posterior teeth of the upper-jaw appear to be larger and longer than the others. In some other species, formerly included under the genus Coluber, and in Dipsas, Homalopsis, &c., the last tooth of the upper jaw is not only longer, but provided with a more or less deep groove, into which the poison escapes from the posterior poison-gland. The superior maxillary bone is shorter in the true Venomous Serpents, and supports upon either side a very long pointed tooth, behind which, several smaller ones are situated with their points curved backward, and which are destined to rise up and replace each other in succession, as they may chance to be lost; they are all surrounded for the sake of protection with a common wide membranous sheath, formed by an elongation of the substance of the gum. These teeth are either traversed by a demi-groove, open externally, as in Elaps, Naja, Bungarus, or by a closed canal, which stands in communication superiorly with the excretory duct

of the poison-gland, and opens anteriorly at some little distance from the apex of the tooth, as is the case in Vipera, Crotalus, Trigonocephalus, and others. During the commencement of development of the teeth, this canal is an open channel, or groove in the tooth, which becomes either a closed canal at a later period of existence, or remains always open in particular genera, as already mentioned.

The *Cavity of the Mouth* is occasionally bounded from that of the pharynx by membranous folds; in the Crocodile these form a true velum pelati, and opposite to this, inferiorly behind the tongue, a second fold projects; hard papillæ frequently occur upon the palate.

As regards the structure of the organs of digestion, and of the alimentary canal. the differences that occur are by no means so great as might be anticipated upon viewing the varieties of outward form, and of the rest of the organization in the several orders of Reptilia. The peritoneum, frequently colored, as in Fishes, by black pigment, forms mesenteric folds, but never true omenta. It however invests, more or less completely, all the viscera contained within the abdominal cavity.

The *Œsophagus* is generally wide, or at least very extensible, as in the Ophidia, where it is thin and membranous; it is much more muscular in the Batrachia. In the Marine Tortoises, numerous soft, cylindrical, and pointed papillæ, arranged in an imbricated manner, are developed upon the epithelium, and have received the name of œsophageal teeth; similar papillæ occur also in the Fresh-water Tortoises, but are much smaller in size, and more sparingly distributed.

The *Intestinal Canal* always presents a gastric dilatation, although that is frequently but slight, as in the Proteus, where the canal passes as a tube, nearly as broad as it is straight from the mouth to the anus. The stomach is generally very elongated, and has a more or less perpendicular direction; frequently, however, as in the Chameleon, it is placed horizontally, and presents a somewhat curved figure. It is here also most muscular, and provided internally with strong longitudinal folds, while, on the other hand, it is most membranous in the Serpents. The Crocodiles are distinguished by a very rounded form of stomach, divided into two cavities. The first, which closely resembles the gizzard of a rapacious Bird, is of very considerable size, lined with a hard epithelium, and exhibits externally a feebly developed tendinous disc, while, by means of a narrow opening, it leads upward and backward into the second lesser and

more thinly walled cavity that rests upon it. A similar double form of stomach occurs also in other Reptiles, as in Trigonocephalus and Acrochordus javanicus among the Serpents, in whom both the sacs are separated by a valve. A pyloric constriction is nearly always present, but is absent in several genera out of all the orders. The intestine often exceedingly short, as in Pipa, where there is no trace of a division into particular portions, makes nevertheless in most cases some convolutions, and is divided into small and large intestine, the limits of the latter being defined by means of a cœcum coli. The intestinal canal is longest in the vegetable feeding Chelonia, although it does not exceed the length of the body more than twice, and next to them, in the Crocodiles.

The *Cœcum Coli* varies very much, being absent in the naked Amphibia, and most Serpents, though it occurs among the latter in Tortrix and Python; among the Chelonia, Testudo is provided with a short but wide cœcum; it is very small in Lacerta, somewhat larger in Scincus. Other Sauria, as the Crocodiles, have no cœcum whatever.

The alimentary canal terminates by opening into the cloaca, and is usually provided with longitudinal folds or cells, the forms of which either vary greatly, or pass gradually into each other.

The *Salivary glands* are exhibited under very different degrees of development, and are actually wanting in most genera, as entirely in the aquatic Ichthyodea, Batrachia, and the marine Chelonia. Even in the Crocodiles, and many other Sauria, they are either absent entirely, or only very slightly developed. They occur, on the contrary, very generally among the Ophidia. The Serpents have in addition to a gland, that is occasionally developed to a great extent at the base of the tongue and within the oral cavity, a pair of considerably elongated glands, which cover the jaws. One of these, called the supra-maxillary or labial gland, lies along the border of the upper jaw, and is very conspicuous in the Vipers, less developed in the large Serpents, and nearly obliterated altogether in the true Venomous kinds, although it is still to be seen distinctly in Homalopsis and Trigonocephalus. The other, the inferior maxillary or labial gland, is situated upon the external side of the lower jaw, and is tolerably distinct, even in the true Venomous Serpents. The poison gland can not be included among the salivary glands, but is to be viewed as a special organ of secretion.

The *Liver* of the Reptiles is of large size, either very elongated and undivided, as in the Serpents and Ichthyodea, or broader, as in

the Sauria and Batrachia, while it is divided, and still more distinctly in the Chelonia, into two lobes. A *Gall-bladder* appears to be always present, and the hepatic and cystic ducts usually pass separately to the intestine; they are very long and slender in the Serpents; occasionally, as in Python, several ducts proceed from the gall-bladder, that subdivide themselves into ten tubes, opening each singly into the intestine. Sometimes, as in the Frog, Viper and Crocodile, the two principal ducts unite.

The *Spleen* is pretty generally present in the Chelonia, and is of largest size in the Sauria, and, as in the Crocodiles and Tortoises, situate more to the right than left side. The spleen is small and rounded in the Batrachia, and more elongated in the Ichthyodea. It is singularly situated in the Serpents, being, as in Coluber Natrix, firmly attached to the pancreas, and smaller than it in size (though in other Serpents it is larger), and readily distinguished from that gland by its reddish color.

A *Pancreatic gland*, more or less developed, is always found; it is more rarely lobed than simple, and is frequently of a spherical form. It is provided, as in the Chelonia, with a single, or, as in the Crocodiles, with a double excretory duct, while in Python there are several. They enter the small intestine behind the pylorus, accompanied by, or near to, the gall ducts. In the Serpents the biliary ducts perforate the pancreas.

ORGANS OF CIRCULATION.

The diversities in the arrangement of the Circulatory system in Reptiles are of a very remarkable character, and depend in the Ichthyodea upon the peculiar combination of lungs and gills which they possess, and in the Batrachia, upon the remarkable metamorphosis that they pass through from their larval, or tadpole mode of respiration by gills, to that by lungs at a later period of existence.

Those genera of Ichthyodea, as the Axolotl, Proteus, and Siren, which retain during their whole life three tufts of Branchiæ, rank nearest to the class of Fishes. The *Heart*, however, consists in them of a single ventricle, and two auricles (the left the smallest), separated by a delicate septum, and covering with their auricular appendages part of the ventricle and *bulb of the aorta*. Within the ventricle of the Siren, there is even found a rudimentary septum. The blood, returning from the body, is collected in the large superior and inferior venæ cavæ, which dilate, as in Fishes, into a

great, contractile venous reservoir (*sinus venosus*), from which the blood is driven into the right auricle, of considerable size also. The blood of the two auricles becomes mixed in the ventricle, and its regurgitation is prevented by means of valves. From the ventricle arises the *truncus arteriosus*, which soon dilates into a contractile bulb, and is furnished with two pairs of superincumbent valves. Three branchial arteries are always given off from this trunk, to ramify upon the gills; while from the latter three branchial veins take their rise, and constantly unite into a common trunk, which, anastomosing with that of the opposite side, forms the descending aorta. The trunk of the pulmonary arteries is given off in a remarkable manner from the most posterior of the branchial veins, while the most anterior of these last furnishes the trunk of the carotid. The pulmonary veins pour their blood into the left auricle.

Those Ichthyodea, as the Menopoma, Amphiuma, and Menobranchus, which in their perfect condition have no gills, but only branchial fissures, depart in some degree from the type of structure just described. The trunks of the venæ cavæ, with the auricles and ventricle, are similar in character to those of the Perennibranchiate Ichthyoidea, but the number of valves in the bulb of the aorta is increased, and from it there arise upon either side two main arches, which unite together behind the œsophagus to form the abdominal aorta, after having given off branches for the supply of the head.

In the larvæ of Batrachia, the heart consists at first of a single ventricle and auricle, with a *sinus venosus*, and *bulbus arteriosus* which gives off branchial twigs, as in the Ichthyodea; the left auricle is formed as the lungs become developed, and then the vascular system resembles very much, *e. g.* in the larvæ of the Salamanders, that of the fish-like Reptiles with persistent gills, *e. g.* Proteus and Siren.

In the Batrachia, when perfectly developed, we always meet with two auricles, not separated externally, but divided within from each other by a membranous partition, and a single ventricle. From the latter arises a single long arterial trunk, which is divided internally at its origin by an imperfect septum into two halves, and then splits into two branches, each of which again subdivides into an arch for the aorta, and an artery for the lungs; these two trunks communicate throughout life by a pair of *ductus arteriosi*, so that a mixture of two different kinds of blood takes place in

them, as well as in the single ventricle. In the Tailed Batrachia the aortic arches unite at an early period of existence and high up; in the Anourous kind very low down to form the abdominal aorta.

In the Squamigerous Reptiles, as in the Chelonia, the heart is larger and stronger, the auricles separated externally and provided with a stronger muscular partition, and the ventricle is divided into two cavities, by a more or less perforate or complete septum, traces of which occur, in Pipa, among the Batrachia. The ventricle is properly the right one of the higher animals developed to a greater degree, and the *conus arteriosus* is in like manner a special division of the cavity from which the aorta and pulmonary artery arise. Between the auricles and ventricles are interposed strong valves, and the usual valv. semilunares at the commencement of the arteries. Each of the two main branches of the pulmonary artery gives off a large *ductus arteriosus* to join one of the two aortic arches, which pass over the corresponding branch of the trachea to the vertebral column, in order to unite and form the trunk of the abdominal aorta.

Manifold diversities occur in the circulatory system of the several orders of Squamigerous Reptiles; thus the heart of the Ophidia, and also of the Sauria, is more elongated, while on the contrary in the Chelonia it is short and very broad. The true Ophidia on account of their single lung have only the left branch of the pulmonary artery developed, which gives off its *ductus arteriosus*, and a twig to the rudiment of the right lung. The two trunks of the pulmonary veins usually enter the left auricle, united together, but rarely separate.

The Crocodiles exhibit the most complete form of heart, for in them the arrangement of its several parts agrees essentially with that of Birds and Mammalia. The walls of the heart are very thick and muscular, and the two ventricles are completely separated by a strong septum from each other. But just at the outlet of the ventricles we find a communication established between the two, so that the two kinds of blood, to wit, the vitiated and purified, become mixed together, and thus a similarity is established with the rest of the Reptilia, and the fœtal condition of the heart in Birds and Mammalia. The *ductus arteriosus of Botal* is to a certain extent persistent, and the aorta arises by an externally single, but internally double trunk from the right as well as left ventricle of the heart, and thus forms two corresponding aortæ.

In all Reptiles the heart is surrounded by a pericardium, which

in many, as in the Serpents, Tortoises and Lizards, and also in some Batrachia, sends off one or more tendinous threads upon the apex of the heart. The heart is generally situated far forward and in the middle line.

As regards the course of the *Arteries* great differences naturally occur in the several orders and genera, which can not be minutely described in the present work. First of all, a single coronary artery usually arises from the truncus arteriosus. Two carotids are generally present in the Squamigerous Reptiles, but only the left in the Ophidia conveys the blood to the brain; the right carotid situated more deeply gives twigs to the cervical muscles and ribs. A common trunk usually proceeds from the aorta, for the supply of the viscera, as the stomach, liver, spleen, intestines, and of the mesentery, or as in the Ophidia, the mesenteric artery arises separately, or many small branches occupy the place of the two. In the Batrachia there is found upon the carotid of either side a small dilatation, which is formed by the artery here dividing into a number of exceedingly fine vessels, which constitute a spherical spongy kind of vascular rete, through the meshes of which the main trunk of the carotid is continued. In the Serpents several arteries anastomose with the pulmonary arteries, for instance, the hepatic, gastric, and œsophageal.

The *Veins* of the body in which, among the larger Sauria and Chelonia, valves may be demonstrated, usually unite into a posterior and two anterior venæ cavæ, which pour the blood into the venus sinus already described.

Reptiles possess a double *Portal system*, one for the liver, and one for the kidneys, and both of these exhibit somewhat different relations in the several orders. In the Frog the veins of the intestinal canal, of the spleen, &c., concur to form the vena porta of the liver; those of the abdominal coverings, the urinary bladder, and partly of the posterior extremities, form the portal vessel of the kidneys, while the efferent veins from the latter organs constitute the trunk of the posterior vena cava, into which the blood returning from the sexual organs and liver is poured; some of the veins of the abdominal parietes empty themselves into the umbilical vein. For a further description of the renal veins the reader is referred to the description of the urinary organs.

The *Lymphatic vessels* are highly developed as a system in Reptiles, and form very numerous plexuses, but no glands. The lacteal vessels, which are very abundant upon the mesentery, are

collected together into a receptaculum chyli; one or several thoracic ducts convey the lymph and chyle into the anterior venæ cavæ.

The pulsating *lymphatic hearts*, which have been discovered chiefly in the ischiadic region of the Frogs, Salamanders, Serpents, Tortoises, and Crocodiles, constitute one of the most remarkable peculiarities of the present system in Reptiles. They are provided with muscular walls, the fibres composing which exhibit under the microscope the peculiar transverse striæ characteristic of the voluntary muscular tissue. The posterior pair of these hearts may be seen externally pulsating very distinctly immediately beneath the integument covering the ischiadic region in the Frog; they discharge their contents into a branch of the ischiadic vein; situated more deeply above the third cervical vertebra, lie the anterior lymphatic hearts in the same animal, and they appear to impel their contained fluid into a branch that opens into the jugular vein. These organs appear to be largest in the Chelonia, where, placed invariably behind the superior extremity of the iliac bones upon the origin of the semitendinosus muscle, they measure an inch in diameter, and receive lymphatic vessels of the thickness of a quill; they pour their lymph into a vein that forms a twig of the reno-portal vein.

If the results be correct (for some degree of uncertainty always attends them) that have been obtained by injections of the vascular system of Reptiles with mercury, it would appear that their blood-vessels are surrounded, to wit, in the Serpents and Tortoises, in a sheath-like manner by very large and broad lymphatic vessels, and that plexuses of the latter cover all the viscera, and are moreover attached by ligamentous filaments to the arteries. A very large reservoir of lymph is usually situated in the lower part of the belly, and from its bifurcation the thoracic ducts take their rise; in the Frog several such reservoirs are met with. A more direct passage into the venous branches is never met with.

The relative size and form of the *Blood-corpuscules* in the present class is most remarkable; in all the naked Amphibia, as the Frogs, Tritons, and Salamanders, they are large and oval in shape, but it is in the Ichthyodea, as in Proteus, that they attain the greatest size in the whole animal kingdom, being from eight to twelve times longer than in man. The corpuscules are smaller, but invariably oval in all the Squamigerous Reptiles, even in the Crocodiles, and resemble in figure and diameter those of Birds. The rounded lymph-corpuscules are always smaller and more irregular.

ORGANS OF RESPIRATION AND VOICE.

One order is met with among the Amphibia, namely, that of the Ichthyodea, in which several genera of the family Proteidea or Perennibranchiata, including the Siren, Proteus, and Axolotl, breathe thoughout the whole of life by means both of branchiæ and lungs. The remaining Ichthyodea, as the Menopome and Amphiume, respire by gills like the raniform Amphibia and Salamanders, only during their larval or tadpole state. The structure of the *Branchiæ* differs in many respects from that of the same organs in Fishes. They are united in a similar manner to the lingual bone, but are not appended to the skull as in Fishes. The branchial arches are constituted in the Proteus of three, or, as in the Siren, of four strips of cartilage upon either side, consisting of several pieces, and which are united with the posterior shaft of the lingual bone, and frequently, like in Fishes, are provided upon the surface turned toward the cavity of the mouth with small teeth, while upon the external side they support the fringed gills. The coverlids of the gills are merely membranous, and the complicated opercular apparatus met with in the Osseous Fishes is completely wanting. In the Derotremata, as the Amphiume and Menopome, where the external gills are absent, an open fissure exists throughout their whole period of existence. In the larval condition of the Batrachia four cartilaginous branchial arches are found, but these disappear at a later period, and then represent the posterior appendages or cornua of the lingual bone. In this respect the Tailed and Anourous Batrachia exhibit several differences.

Three external branchiæ only are usually found in the Ichthyodea and Tadpoles, the posterior branchial arch, when present, supporting no gills. Each gill consists of a long shaft, supporting upon its edges a double row of branchial fringes in the form of simple unbranched filaments, upon which the very fine arteries and veins are so distributed as to form single currents of blood. In rare cases the fringes are ramified, and project into small but broader terminal leaflets. In the larvæ of the Salamanders and Tritons the external branchiæ are very large, while in the Tailless Batrachia they are more retracted internally, and a small hole conducts from without into the branchial cavity.

The *Trachea* is completely absent in the Ichthyodea and some Anourous Batrachia, as the Frog and Toad, in which the rudimen-

tary larynx is continued directly into the membranous bronchi. In the Salamanders a short membranous trachea exists, and in some genera of Batrachia, as in Pipa, more or less perfect cartilaginous leaflets and rings appear upon it. In the Ophidia also, as in Coluber and Vipera, the trachea is often membranous at its commencement, but provided further down with cartilaginous rings, which are frequently osseous, *e. g.*, in Crótalus and Python, where their number is very considerable, amounting to 300 rings and upward. The rings are continued also over the single, or, where two lungs are present, double bronchi. In the Sauria, the trachea varies in length, being short with only 20—30 rings in the Chameleon, while in the Crocodile upward of 80 occur. In the Chelonia, as in Testudo græca, the trachea is divided deeply and higher up, and is furnished with strongly developed rings, which are continued throughout the bronchi into the lungs.

The *Lungs* exhibit remarkable diversities of form and structure. Thus, in the Ichthyodea, as in the Proteus, the lungs form a pair of very long narrow tubes which terminate inferiorly in a slightly-expanded pyriform bladder. In the Triton they present the appearance of elongated sacs, of tolerably uniform width throughout, and terminating in a point, while in the Frogs they are much shorter and broader. When the lungs have been fully expanded, they extend through the greater part of the abdominal cavity. In many Sauria the lungs present similar characters, and are both of equal size, *e. g.*, Scincus. In the Apodal Sauria, as Anguis, Pseudopus, and also in Chirotes, only one lung, and that usually the right, is present, but in those Sauria with very short or only a single pair of feet, as Zeps and Bipes, the left also exists, but is one third or more shorter than that of the right side. In the Ophidia, as Boa and Python, the length of the left lung is generally less by a third or half than that of the opposite side, but in Coluber, Crotalus, and others, it is much smaller, and quite rudimentary, appearing as an almost obliterated appendage. The genera Cœcilia and Amphisbœna appear on the contrary to have the left pulmonary organ developed, and the right shortened, this arrangement probably varying according to the species. In the Viper and other Serpents there is only a single lung, which on that account is always very long. The lungs are flat and short in the Crocodile, but largest and most perfectly formed in the Chelonia, where they extend beneath the carapace as far as the pelvis. Here and there, as in Polychrus and Gecko, and especially in the Chameleon, hollow cœcal diverticula are given off from the lungs.

The internal structure of the lungs differs in the several orders and genera of Reptiles, the respiratory surface being very much increased in the Squamigera by the development internally of cells, while in the lowest orders, the lungs are simply hollow bags. In the Ichthyodea and Tailed Batrachia their condition is of the simplest kind, as in Proteus and Triton, where they form, as already stated, simple bladder-like sacs, directly continued from the membranous larynx. In the Salamander the lungs begin to assume an uneven appearance from the occurrence of small inversions. In the Anourous Batrachia their respiratory surface is increased by membranous cells which project into them internally, and form with the lateral walls open rhomboidal, or more or less hexagonal or polyhedric spaces, upon which lesser cells again rest, these last opening in the inward direction into the common cavity of the lung. The lungs are more perfectly formed in the Chelonia and Sauria, although several genera of the latter frequently retain the simple character of membranous sacs, with an areolar tissue developed upon the internal surface of their walls, but no internal dissepiments. In both orders the cartilaginous rings of the bronchi becoming more imperfect are continued as strips, which, cartilaginous at first, are next converted into tendon, and form rounded or angular meshes which rest partly upon the walls of the lung, and enclose lesser meshes or air-cells, or are united together internally so as to form numerous dissepiments; thus the whole lung is filled more or less by a coarser or finer areolar tissue, and presents a number of cellular portions which can be all inflated from any one point. The middle areolar tissue is usually absent in the upper and lower (or only in the latter) parts of the lung, and the cells are then merely parietal, and leave cavities of considerable size in the interior of the organ. The lungs of the Crocodile and Monitor are the most completely made up of cells. In the Serpents it is commonly only the commencement of the one developed lung that is replete with cells and areolar tissue, its posterior extremity being in the condition of a thin walled and very extensible bladder. The size of the cells varies, but they are always larger than in Birds.

In the Amphibia, which present the lowest forms of air-breathing animals in the class Vertebrata, the study of the structure of the *Larynx* as an *instrument of voice* is one indeed of particular interest.

Its simplest structure is exhibited by some Ichthyodea, *e. g.*, Pro-

teus, in which it forms a cylindrical cavity, which is narrow superiorly toward the glottidean fissure, and beneath the latter is continued through the intervention of two sacs into the lungs. Within this rudimentary larynx are situated several strips of cartilage, corresponding to the *pars arytænoidea* and *laryngo-trachealis*. In the Tritons and Salamanders, where the sacs or rudimental indications of the bronchi are absent, the laryngeal or vocal box, compressed from before backward, is supported by a *superior arytenoid*, and an *inferior lateral or laryngo-tracheal cartilage*. The structure is similar in one family of Ichthyodea, comprising the Menopome, Amphiume and Axolotl, as also in Cœcilia, where several tracheal rings are already met with.

Resembling more nearly the larynx of the higher animals, but with diverse modifications, we come now to consider the structure of the laryngeal cavity in the Anourous Batrachia; a subject of special interest from the differences which it presents in the two sexes of these Amphibia. This latter circumstance is very strikingly exemplified by its conditions in the males of the genus Pipa. The *arytænoid cartilages* are here of considerable size, triangular in form, and articulate with the lateral or *laryngo-tracheal cartilages* situated beneath them, and here united into a single body; this, which corresponds to the thyroid cartilage, forms at the same time the upper part of the trachea, and diminishes greatly in size opposite to the arytænoid cartilages. The glottidean fissure is situated quite close to the root of the tongue, and there are always found in this situation, with but few exceptions, as in Pipa and Dactilethra, a pair of vocal chords, that correspond to the *ligamenta inferiora* of the Mammalia, and are attached before and behind to the arytænoid cartilages. Beneath the vocal chords are situated a pair of cavities analogous to the *ventricles of Morgagni*. A pair also of inferior vocal ligaments, narrower than the true ones, and formed by simple folds of mucous membrane, frequently occur.

In the Squamigerous Reptiles, the separation of the larynx from the trachea is more distinctly shown. The arytænoid and thyroid cartilages in the Serpents are frequently blended together. In the Crocodiles and Tortoises, and in many of the Sauria, the thyroid cartilage is very developed, isolated from the rest, and being provided with special processes, resembles that in the larynx of Man. Frequently there is developed from it in the direction upward a fold of mucous membrane or a *processus epiglotticus*, which as in the Chameleon, may be viewed as a rudiment of the laryngeal valve.

A true cartilaginous epiglottis is found to be present either as a narrow papilla, or broader lobule, in different Serpents and Sauria. The vocal ligaments are not nearly so generally present among the Squamigera, as the Anourous Batrachia. They are wanting in all the Serpents, the hissing sounds of these animals being produced like the act of whistling in the human subject, by the edges of the narrow laryngeal outlet performing friction against the air in expiration. The Lizards possess a pair of narrow vocal chords. A thick fold of mucous membrane with a subjacent pouch is all that is to be remarked in the Crocodile.

A peculiar structure in the genus Chameleo, reminding us of the laryngeal pouches in many Apes, is well deserving of notice. Between the larynx and first treacheal ring is found an opening which leads into a membranous sac that can be distended with air.

As concerns the *Laryngeal muscles*, an expansor of the glottis (*m. dilatator aditus laryngis* Henle) is found, very generally in the Batrachia, and arises either from the vertebral column and the skull, or from the lingual bone (this being the case in all the Anoura), and is inserted into the edge of the vocal fissure, or into the *cartilago lateralis* of its corresponding side. Besides this muscle, in examples of a more perfect structure, we may distinguish three others, a dilator of the laryngeal inlet, with a contractor and a compressor of the cavity of the larynx, all of which exhibit manifold diversities. Among the Squamigera an elevator and a depressor of the larynx are found in the Serpents, as a pair of long muscles, that are absent in the higher orders of the sub-class, but a *compressor* and *dilatator aditus laryngis* are universally present.

In some of the Anourous Batrachia, *e. g.*, in the Tree and Meadow Frogs (Hyla and Rana esculenta), but not in R., temporaria, accessory organs are associated with the vocal apparatus. They consist of a pair of thin-walled, very dilateable bladders, situated by the articulating surface of the inferior maxilla, and which open always into the cavity of the mouth below the Eustachian tubes; they contribute to strengthen the voice, by serving as an apparatus of resonance.

Between the carotid arteries and resting upon the trachea, a small vascular gland, which may be viewed as the analogue of the *Thyroid gland*, is found in several Squamigerous Reptiles, as in the Tortoises, Crocodiles, and also in the Serpents.

URINARY ORGANS.

All Reptiles are provided with *Kidneys*, which are commonly situated far backward and deeply within the pelvis. In the Anourous Batrachia, however, and especially in the Ophidia, they are placed far forward, and in the latter order the right kidney lies asymmetrically in relation to the left, being placed higher up and in advance thereof. The size of these organs varies in the several orders, but is generally very considerable; they are very narrow, elongated, and run to a point anteriorly in the Ichthyodea and Tailed Batrachia; of an elongato-oval form with slight incisures in the Lizards and Anourous Batrachia; in the Ophidia they are for the most part very elongated and flat, and divided into round lobules, while in others, *e. g.*, Boa, they are portioned out into narrow plates lying one upon the other; in the Crocodiles and Chelonia they are broader, and frequently, especially upon the posterior part, provided with indentations. Occasionally, as in the Rattle-Snakes, each kidney is completely divided into an upper and under piece. In rare cases both kidneys, as in Lacerta ocellata, appear to coalesce inferiorly into one entire mass, a structure of which we are reminded in several Fishes and Birds, and occasionally in its very interesting occurrence as abnormal in Man, where it is due to an arrest of development. As regards the more minute structure of the kidneys, we may perceive in their early conditions in the Batrachia and Ichthyodea, narrow cœcal canals supported upon the extremity of the ureter, and in the Ophidia these, which are much longer and more contorted, unite together in a racemiform manner, and give off at intervals small trunks into the ureter; even in the more compact substance of the kidneys in the Chelonia and Sauria, the blindly terminating cœcal canals are found to be continuous from the peripheral to the middle part of the organ, with ramifications of the ureter. The kidneys, as has been already stated, have a special portal system. The afferent veins form, *e. g.*, in the Frog, a couple of small trunks which enter the kidney inferiorly and externally, and are distributed upon its posterior surface. The efferent veins take their origin by radicles from the anterior surface, and pass to the inferior vena cava. The ureters are mostly short and delicate, situated usually upon the internal inferior edge of the kidney, and in the Ophidia attain no inconsiderable length; they perforate the walls of the posterior region of the cloaca, discharging

into that cavity in the Squamigerous, a constantly firm chalk-like and crystalline urinary secretion, but which is on the contrary in the Naked Reptiles in a fluid state. There arises usually from the anterior walls of the cloaca (with however it would appear the exception of the Ophidia) a bladder which is usually small and rounded in the Sauria, elongated but simple in the Sirens, in the Chelonia mostly slit into two round lobules, and frequently, as in the Batrachia, fissured and developed to a very great degree; this is filled usually with a large quanity of colorless fluid, and has been viewed as an urinary bladder. Its walls are very thin and membranous, traversed by vessels, and the fluid contained therein consists of real urine and uric acid.

The *Renal Capsules* are found in all the Squamigera, and may be distinctly demonstrated in all the larger Serpents, Lizards, and Tortoises; they are mostly of a yellowish color, elongated in form, and are usually situated above the kidneys, either within the folds of the peritoneum, or more freely near to the sexual organs; internally they rest upon the vena cava, to which they are united by vessels. Besides the Ichthyodea, they are wanting also in the Batrachia, but in the Anoura, we meet with large, yellow-colored lobes of fat divided in a digitate manner, and placed upon the anterior extremities of the kidneys, while delicate streaks of granular fat course over the anterior surface of those organs.

PARTICULAR ORGANS OF SECRETION.

In the order Amphibia the tegumentary follicles are occasionally, as in the Toads and Salamanders, developed to a very considerable degree, being in part distributed in small groups over a great extent of the body, and forming, *e. g*, in Bufo and Salamandra, a protuberant conglomerate mass upon either side the head behind the ears. In the Salamanders and some Tritons they are situated chiefly in rows along the back; these follicles, as well as the crural glands of the Lizards, have been described in treating of the tegumentary system. Each aperture leads into a pouch, the commencement of which is slit into small blind pockets or cœca. In some Sauria an aperture is constantly found behind the anus, which conducts into a small pouch secreting a substance of a peculiar odor. The analogous follicles in many of the Ophidia, as in the common Snake (Coluber natrix), male as well as female, are very long and distinct. They are situated below the vertebral column near to the penis and behind the anus, upon the verge of which they

open. They are lined internally by a mucous membrane, which is covered with a net-work of flat cells and depressions, that secrete a fetid kind of grease. An epithelium provided with the same cellular surface rests quite freely upon the mucous membrane of these *Anal sacs*. The Chelonia possess similar but more rounded anal sacs. The Crocodiles have a thicker walled pouch situated beneath the integument upon the middle of the lower jaw, and which is called the musk gland, from its secreting a dark-colored grease smelling like musk.

The most remarkable peculiarity in the secretory organs of the present class is afforded by the *Poison glands*, which occur, however, only in the order Ophidia.

The Poison-gland corresponds in some measure with the parotid salivary gland, and agrees most strikingly in situation with the latter in the Venomous Serpents, having posterior venom-teeth, *e. g.* Dipsas, Homalopsis, where it lies more freely, not invested by any fibrous tunic, and has a short excretory canal. In the typical Venomous Serpents, as Vipera, Naja, Crotalus, Trigonocephalus, the poison-gland is situated more behind and beneath the eye, consisting of short tubes in Naja, or of hollowed ramified lobules (Trigonocephalus) and is surrounded by a dense, mostly double fibrous sheath, this again being covered by a layer of muscular fibres, which proceed partly from the temporal muscle, and serve to compress the gland and force its contained secretion into the excretory ducts; the latter courses along the external surface of the superior maxillary bone, and enters an opening placed at the root of the poison-tooth. The situation and structure of the poison-gland are similar in the Aquatic Serpents (Hydrus and Hydrophis). This gland occurs in an unusual situation in Causus rhombeatus, being ensiform, situated in a channel-like cavity, and extending to the 18th or 19th vertebra, so that it reaches over more than a seventh part of the whole length of the body; its excretory duct extends from the poison-tooth to behind the quadrate bone. The ejection of the poison into a living animal is accompanied by peculiar and frequently fatal effects.

ORGANS OF GENERATION.

Reptiles, like all the Vertebrata, have two distinct sexes, which exist in tolerably equal numerical proportion to each other, though with some preponderance upon the part of the female. The germ-preparing sexual organs are always situated within the abdomen,

and usually in front of the kidneys. The ovaria and testes are usually placed symmetrically upon the two sides, and are of equal size; it is rare for the testis or ovarium of the right side to be situated higher up than the left, as in the Ophidia and Blindworms (Anguis), where their asymmetrical arrangement reminds us of that of the lungs and kidneys of the same side.

In all the naked Amphibia and among the Squamigera, as the Ophidia and Sauria, the *Ovaria* are in the form of simple sacs or bags, mostly of a rounded shape, *e. g.*, Ichthyodea, Tritons, Salamanders, and Ophidia, or of a more elongated form, *e. g.*, Sauria, lined internally with a smooth mucous membrane, beneath which the ova are developed, and externally invested by peritoneum. Occasionally, as in the Anourous Batrachia, the ovaria are divided into lobes; and partitions projecting into their interior, form there cells within which the ova are found. In the direction forward, each sacciform ovarium is provided with a round or sometimes tubular aperture for the exit of the ova; within the smallest and most primitive ova a chorion, vitellus, and germinal vesicle may be clearly distinguished, the latter being in the Naked Amphibia provided with numerous small germinal spots. In the Squamigera the germinal spot is always single. In the Chelonia each ovarium, as in Birds and Cartilaginous Fishes, consists of a stroma, upon the free surface of which, namely, that turned to the ventral side, the ova are developed.

The *Oviducts* are two long membranous, frequently multi-contorted tubes, which are kept in their place by folds of mesentery, and are provided in the direction forward in some Reptiles, as in the Chelonia, with an infundibuliform abdominal ostium, into which the ova, after being detached from the ovarium, are received. In the Batrachia the opening of the oviducts is placed at a great distance from the ovarium, in the proximity of the heart. Strong and even muscular fibres lie between the external peritoneal and internal mucous membrane, and by means of these the oviducts are capable of exercising considerable peristaltic movements like the intestines. Their internal mucous membrane exhibits, chiefly in their lower or posterior part, strong longitudinal folds or villi, upon which the albumen is secreted, being the first investment which is here obtained by the ova. The oviduct is usually more widely dilated in the posterior part. Both oviducts open into the cloaca separately. A clitoris has been found hitherto only in the Chelonia and Crocodiles.

The *Testes* are of an elongated form in the Ichthyodea and Ophidia, or rounded, as in the Frogs, Sauria and Chelonia, and frequent-

ly divided by constrictions into several portions. A single testicle is most commonly found upon either side; occasionally, however, we meet with two and even several testes united one behind the other merely by the seminal vessels, as is the case in the Salamanders, where three to four such testes occur. The testes are invested externally by a thick fibrous coat, and consist internally of long or short and narrow cœca. The open extremities of these cœca pour the seminal fluid into several ducts, which unite to form a straight or contorted vas deferens, running down in front of the kidneys. Both vasa deferentia open into the cloaca. Upon the testes, as also upon the ovaria, there are appended occasionally in front, large yellow-colored lobes of fat divided in a digitate form, *e. g.*, in the Tailed Batrachia, while on the Anoura the adipose lobes are elongated, undivided, and attached by mesentery to the internal side of the sexual organs, or that turned toward the vertebral column.

The *Spermatozoa* contained in the semen of the Reptilia exhibit very numerous diversities. Those of the Squamigera, however, present the greatest degree of uniformity. They have, in general, in the common Snake for example, like those of Mammalia, an elongated body pointed anteriorly, and a very fine filamentary tail. In the Naked Amphibia greater varieties occur, while in the Frogs their body is elongated and narrow, but not very long; the spermatozoa of the Tritons and Salamanders are slender and circularly contorted, attain a very remarkable length, and exhibit very peculiar movements; other anomalous and singular forms occur, *e. g.*, in Bombinator. The spermatozoa are probably of largest size in the Proteus, thus exhibiting an interesting analogy with the blood corpuscules.

A proper external organ of copulation or sexual excitement, namely, a *Penis*, is absent as a rule in all the Naked Amphibia, Batrachia as well as Ichthyodea. Still however in the Tritons, and in some also, perhaps all the Ichthyodea, there is developed, at least during the period of the coitus, an organ which may be viewed as a rudiment of a penis. It consists of an acuminate papilla of considerable size, situated within the cloaca, and continued posteriorly into two short thick crura, which form a groove with the posterior wall of the cloaca, into which the semen is conveyed as it issues from the adjacent mouths of the vasa deferentia. This papilla is imperforate, but, though very irritable, is incapable of erection. This structure resembles much the rudiment of the penis that occurs in the male Ray-fish. Accessory glands occur in the Ichthyodea and Tailed Batrachia. They consist of a very dense

glandular layer, which surrounds the cloaca, and forms a protuberance around the anus, which consists of several layers of cœca, and projects very much at the time of the coitus.

The Lizards and Serpents possess a double penis capable of being everted; these two intromittent organs are in the Serpents often very long, slender and pointed, and are here, frequently like other organs, *e. g.*, Coluber natrix, asymmetrically developed, the left being the longest. They lie extended beneath the integument in a cavity behind the anus at the commencement of the tail, and can be everted from the cloaca, as in the Ducks and Geese, by a pair of special muscles; they are devoid, however, of elastic tissue and a fibrous body. At the season of the coitus they form, when everted, a double tube, which serves for the exit of the semen. Frequently, as in the Vipers and Rattlesnakes, and also in Python, each of the two penes is bifurcated at the extremity.

The penis is single in the Tortoises and Crocodiles, and resembles more that of the Two-toed Ostrich among Birds; it consists of a fibrous body, and has a groove upon its upper and anterior surface, which is imbedded in cavernous tissue, and into which the seminal fluid is received from the seminal ducts. In front we find a glans of varied form, infundibuliform in the Crocodiles, and very largely developed in the Tortoises; the whole of it consists, as in Man and Mammalia, of cavernous tissue. A muscle serves to draw the penis out of the cloaca. It is peculiar to all Reptiles, that the urogenital orifice lies invariably, as in the higher Vertebrata, in front of the anus.

In the males and females of the Tortoises and Crocodiles, there is found what are called the *Peritoneal canals*, which conduct as membranous tubes or slits from the peritoneal cavity into the cloaca, and are continued upon the penis as far as the glans, and there terminate blindly; in the female they are to be traced to the root of the clitoris; in both sexes they remind us of the vaginal canals of the Mammalia (see p. 54), and are probably the remnent of a fœtal structure, viz., the excretory ducts of what are called the false kidneys or Wollfian bodies.

The two sub-classes of Reptiles, differing, as we have already seen, in so many important particulars from each other, are also developed from the ovum in an entirely different manner. The Naked Amphibia agree with Fishes in having neither amnion nor allantois, both of which fœtal structures occur, however, in the Squamigera, of whom many have proposed to form a distinct class, limit-

ing to it the name of Reptilia. In the presence of these embryonic structures, the Serpents, Lizards, and Tortoises, agree therefore with Birds, Mammalia, and Man.

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CLASS IV.—PISCES.*

TEGUMENTARY SYSTEM.

The skin and other tissues belonging to the tegumentary system in the class of Fishes, exhibit very numerous diversities of structure; they have not, however, been so carefully investigated as hairs and feathers.

An *Epidermis* is always present, lubricated frequently by a copious viscid secretion, and occasionally entirely devoid of scales, as in the Cyclostomi, Lophius piscatorius, Murænophis, and others, while, on the other hand, many Fishes that appear almost smooth and scaleless, such as the Burbot (Gadus Lota), are in reality provided with small scales. The scales are usually disposed in an imbricated manner upon the body of the Fish, and adhere by one extremity being implanted in a sacciform depression of the corium.

The *Scales* generally exhibit great varieties of form, being either round or angular in their contour, and frequently provided with jagged edges. They usually consist of transparent, or highly refractive laminæ like mother-of-pearl; upon their external surface we observe a series of circular lines, which are disposed concentrically around a common nucleus or spot, which is not always

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Sub-Class 1. Pisces Ossei s. Ostacanthi.

Order I. Acanthopterygii.—Ex. *Perch, Bream, Mackerel.*

II. Malacopterygii.—Ex. *Carp, Pike, Salmon, Herring.*

III. Plectognathi.—Ex. { *Diodon, Tetrodon, Orthagoriscus, Ostracion, Balistes,* &c.

IV. Lophobranchii.—Ex.—*Syngnathus, Hippocampus.*

Sub-class 2. Pisces Cartilaginosi s. Chondropterygii.

V. Plagiostomi.—Ex. *Rays* and *Sharks.*

VI. Eleutherobranchi.—Ex. *Sturgeon, Chimæra.*

VII. Cyclostomi.—Ex. *Petromyzon, Ammocætes, Myxine, Bdellostoma.*

Sub-class 3. (Provisional). Pisces Anomali.

VIII. Amphibioidei.—Ex. *Lepidosiren.*

IX. Helminthoidei—Ex. *Amphioxus,* s. *Branchiostomæ.*

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situated in the centre of the scale; the circular are frequently intersected by longitudinal lines, and of this arrangement there are abundant examples. To determine the more minute structure of the scales of Fishes is a subject attended with much difficulty. The scales are always included within the cutis itself, and consequently, uuless the latter is injured, it is impossible for the scales to come off. The layers, which cover the scales, are as follows: 1*st*. An *epidermis*, formed of tessellated cells; these may be found detached in small masses in the slime that covers a Fish, and constitute its principal part. 2*d*. A layer of *pigment-cells;* these are frequently ramified, and are continued into spirally-contorted terminal canals, which do not, however, anastomose with each other. 3*d*. The *cutis*, consisting of a fibrous tissue, within the areolæ of which is a deposite of fat. 4*th*. A very fine *layer of membrane*, distinct from the cutis, and in which linear-shaped depressions and elevations may be remarked corresponding to the concentric grooves and ribs of the scales. This layer consists of fibres, which, in a histological point of view, are related to cellular tissue.

Each scale is lodged in a sac, formed by two lamellæ of the cutis, the superior of which is alone covered by pigment-cells and epidermis. Each scale has an inferior soft portion, consisting of fibro-cartilage. It is not easy to determine whether or not the concentric striæ are merely the optical expression of the lamellæ of the scale lying upon each other. This part of the scale appears actually to consist of bony tissue, although true osseous corpuscules are generally absent. The scales are, moreover, traversed by broader channel-like longitudinal lines; these are, however, frequently absent, and their nature and signification are unknown.

The manner in which the scales clothe the body of Fishes varies very much in the several genera, as do the feathers upon Birds. As a rule, the scales lie in an imbricated fashion upon each other, leaving a part of their border free, so that they abut against each other in a variety of ways. Occasionally the upper edge of a scale is provided with a hook-shaped process, which catches in a depression of the inferior edge of the next scale that covers it. The lines of direction of the rows of scales upon the body vary also.

The form and contour of the scales present an almost endless variety; they are either round or oval, angular or provided with undulated edges and projecting lobes; these edges are frequently dentated, and provided with several rows of spines. A row of peculiarly-formed scales is situated upon what is called the lateral line,

and they are here perforated by a canal, or frequently by a short tube, through either of which the mucous ducts, presently to be described, open externally upon the integument.

The bony scales of many Fishes, *e. g.*, Lepidosteus, Polypterus, Trigla, differ from the ordinary scales of the Osseous Fishes, for in them we find distinct osseous corpuscules. True tegumentary bones occur in the Sturgeons, many Siluri, and in the genera Polypterus and Lepidosteus, and form large bony plates, which are frequently invested by enamel. In the Trunk-fish (Ostracion) these form tolerably regular six-sided plates, which are so accurately fitted to each other, as to form a very compact and hard coat of mail. In the Spinous Globe-fishes (Diodon, Tetrodon), the scales project from the surface of the body into long and pointed spines. Small acuminate elevations are seated upon the integument in the Rays and Sharks, and in the intervals between them, in the Rays, several larger ones, situated upon a broader basis, are prolonged externally into a transparent spine, and exhibit internally, like the teeth, a medullary pulp, to which vessels are distributed.

The integument is traversed by the peculiar narrow *Mucous Canals*, which give off short, transversely-directed branches, and terminate externally by free open mouths, in different situations, but especially upon the lateral line, on the head and snout, *e. g.*, in Fishes of the Eel kind. In the Gadus merlucius, in which these mucous canals have been most carefully examined, there is one which runs like a vessel along the whole length of the body, bifurcates behind the eye, and gives off a pair of branches to the snout, while at intervals branches arise from it that open upon the integument; a small twig also passes over the præoperculum to the lower jaw. In the Rays and Sharks particularly strong and tortuous canals are found imbedded in the integument of the head. In Torpedo two rows of openings lie upon either side of the back, and open into two corresponding longitudinal canals. Special layers of glands are situated beneath the lateral line, and are, in the Carp, Tunny, and several other Fishes, much developed. They appear to secrete the mucus, which passes out through the canals traversing the scales of the lateral line. In rare cases these mucous canals are wanting, as in some, but not all, the genera of the order Cyclostomi. The mucous canals of the head are frequently covered by hard scales, which serve to protect them; this is the case throughout the whole course of the mucous canals in Polypterus Bichir. In other in-

stances, these canals are even imbedded in the cranial and facial bones.

The study of the structure of the scales of Fishes, in reference to the deciphering of the fossil remains of the latter, has recently led M. Agassiz to adopt them as an element of classification, and he finds that the class may be divided in accordance therewith into four great orders. 1*st*. The *Placoidians* (πλὰξ, a broad plate). This order contains Fish whose skin is covered irregularly with enamelled scales, often of small size, in which case they give rise to an appearance like the shagreen on the skin of the Shark; or they are of considerable dimensions, and provided with prickles. All the Cartilaginous Fish of Cuvier, including the various tribes of Sharks and Rays, with the exception of the Sturgeon, are included in this order. 2*d*. The *Ganoidians* (γάνος, splendor). The scales are here angular, and form horny or bony plates, coated with a thick layer of enamel. To this order belong the Sturgeon, the Bony-Pike (Lepidosteus), and a large number of genera of fossil Fish, termed Sauroid, from their approximation in several respects to Reptiles. 3*d*. *Ctnenoidians* (κτεὶς, a comb). The Ctenoid Fish are covered by hard scales, jagged on the outer edge like the teeth of a comb, and devoid of enamel. The Perch and many other Osseous Fish will serve as examples. 4*th*. *Cycloidians* (κύκλος, a circle). The Fish of this last order have their scales soft and flexible, with simple rounded margins and a variety of linear markings upon the upper surface. The Carp, Herring, Salmon, and many other Fish, are comprised under this order, which, with the former, includes almost the whole number of existing species.

The above divisions, in their general application, are correct, but are not always abruptly defined in nearly approximated genera. In many cases, *e. g.*, in Pelamys sarda, two kinds of scales occur upon the same Fish; most of them being round and with the margins entire (cycloid), while around the pectoral fins the scales present a jagged border (ctenoid). In other cases, in one and the same family of genera, or even among the species of a single genus, some have ctenoid, others, on the contrary, cycloid scales; as is exemplified in the family of Clupeæ, Cyprinodontes, Gobiodæ, and others.

The rays supporting the fins belong also to the tegumentary structures. They consist either, as in the dorsal fin of many Fish *e. g.*, the Perch and Bream, of stiff, pointed, inarticulate horny spines (*radii spinosi*), or they are soft, divided at the apex, and articulated throughout their whole extent by transverse joints (*radii articulati*), as is exemplified by the majority of our freshwater Fish, *e. g.*, the Carp, Pike, and Flying-fish or Exocetus. The Osseous Fishes have accordingly been divided into two great groups, the Acanthopterygii or spiny-finned, and Malacopterygii of soft-finned; an arrangement, however, which does not admit of perfectly precise definition. The pectoral, ventral, and caudal fins, are always provided with soft articulated rays.

OSSEOUS SYSTEM.

In the external arrangement and structure of its several component pieces, the Skeleton of Fishes exhibits by far the greatest diversities of all the classes of Vertebrated animals.

As regards the Osseous Fishes, their skeleton indeed offers the greatest analogy to that of the other Vertebrata, but even this, upon a closer examination, is found to be less than it at first sight appears. For upon first commencing its study, we are too apt to carry out the doctrine of analogy to the utmost extent, while, as we advance, a higher and more philosophical method of comparing the structure of the skeleton, namely, that which is based upon the history of its development throughout the several classes of Vertebrata, suggests itself, and causes many apparent analogies to disappear.

The minute organization of the bones in Fish is still but little known. The cartilage and osseous corpuscules are never so distinct as in the other Vertebrata.

The *Cranial bones* of the Osseous Fishes, though exhibiting several remarkable varieties, admit of being contrasted to a considerable extent with those of the higher Vertebrata, and even the human subject. Our best plan will be to select for the purposes of illustration the skeleton of a Carp, as one which presents a tolerably normal type of structure, and is generally found ready prepared and mounted in museums, or else that of the common Perch and Pike.

The *Occipital bone* consists very generally of six pieces, two of which are single, or not in pairs. The body, still very similar in character to that of a vertebra, is not united to the first cervical by means of a joint, but immoveably by means of firm ligaments, like the other vertebræ. In the Carp the *body* of the *occipital* bone is actually provided, inferiorly, with a strong pointed process projecting backward, and which supports a broad plate invested by car-

tilage, and opposed to the pharyngeal teeth. The two *latero-inferior occipital* elements rest upon this basilar portion of the bone, and, analogous in part to the articular or condyloid pieces of the higher Vertebrata, concur in forming the lateral and superior parts of the occipital bone, and leave between them the foramen magnum for the exit of the spinal cord. Each of these pieces is perforated in the Carp by a large oval opening, situated laterally above the foramen magnum, and which remind us of similar apertures in many Wading and Aquatic Birds. Superiorly to the above pieces are placed the two *latero-superior* elements, which in many cases receive the membranous semicircular canals of the auditory organ, and therefore represent, in some respects, certain portions of the temporal; they have been viewed, accordingly, by some anatomists as mastoid bones. These two pieces are generally smaller than the inferior pair, and correspond in part to the squamous element of the occipital, which is here, however, principally formed of a single plate of bone. This, the *supra-occipital*, is usually provided with a strong crest or spine-shaped process for the attachment of the nuchal muscles. This crest is more strongly developed in the Bream than in the Carp, and to a still greater degree in Coryphæna, Chætodon, &c. It corresponds to the spinous processes of a vertebra.

The *Sphenoid* is divisible into seven pieces, three of which are in pairs. The single *body* of the sphenoid is mostly of a very elongated form, frequently also of great depth, laterally compressed and keel-shaped, *e. g.* in Anarrhicas. It forms the largest and chiefly the middle part of the base of the skull, abuts posteriorly against the body of the occipital, and in front against the vomer. It supports in the direction upward the two *alæ majores*, if we do not regard these as partly united to the temporal bone. At the point posteriorly where these pieces come in contact with the petrous bone, they have a notch through which the second and third branch of the trigeminal nerve issue from the skull. Still further upward and forward are situated the *alæ minores*, which are frequently two in number, but often replaced, as in the Carp, by a single osseous leaflet, excavated superiorly by a keel-shaped groove; in other Fish they coalesce at an early period of existence into one bone. All the above-named parts of the sphenoid are, like those of the occipital, united together, and with the rest of the cranial bones, by suture. This is not, however, the case with the two pairs of *inferior wings* or pterygoid processes, which, of considerable size, abut against the middle part of the inferior surface of the body of

the sphenoid, and are united in front with the palatal bones, and posteriorly and inferiorly with the articular portion of the temporal. Occasionally, as in Pleuronectes, they are divided into two pieces, an internal and external alar lamina. As constituent elements of the *temporal* bone, we regard with more or less justice a remarkable number of ossicles, which may be resolved into two principal divisions, belonging to the *cranial* and *articular* portion of that bone. The cranial division consists always of three bones, which, intercalated between the already described pieces of the occipital and sphenoid bones, are united with these, as well as the parietals and frontals, by suture. The *petrous* bone is of larger size, disc-shaped, and is situated most deeply, being interposed between the body and inferior occipital bone, and also the great wings of the sphenoid; it rests upon the body of the latter bone, and is perforated by a large opening for a branch, the opercular, of the fifth pair of nerves. In the direction upward and backward is placed the *mastoid* bone, which by some has been taken for the squamous element. We may regard, however, as the *squamous* portion of the temporal, a bone which rests in front of the mastoid, above and upon the petrous; but if this analogy will not hold good, it must be viewed as a particular scale-like bone, comparable to that which occurs in the Reptilia, and be called the *posterior frontal*. Between this portion of the skull and the lower jaw a number of bones, amounting to five at the utmost, or four, three, or only two in number, are introduced; the most anterior of these articulates with the lower jaw, and constitutes the *articular* portion of the temporal, which, in Reptiles and Birds, is reduced to the single quadratal bone. The first, the uppermost and most posterior bone, is always the largest in size; it forms the *superior articular* bone, and unites itself by means of a mostly moveable process with a corresponding depression in the mastoid piece and squamous element of the temporal bone; behind and above we meet with a condyle upon it for articulation with the operculum. In front of, and leading somewhat downward from, the superior articular bone, lies the *great opercular*, a flat and very thin bone, beneath which again is placed the narrow *hamular* ossicle, and against this the inferior articular, which articulates with the lower jaw, abuts in the direction forward and downward. There is found sometimes a fifth, smaller and flatter bone, situated between the others. The above-mentioned bones are partly united together by squamous suture, partly by fibro-cartilage, and concur to form a bony wall, abutting posteriorly against the *præoperculum*, which

bone is reckoned not improbably by some as belonging also to the articular division of the temporal. The whole of the quadratal bone abuts in front and superiorly against the inferior wings of the sphenoid. In cases where several of the bones now described are wanting, or have coalesced together, four, three, or only two bony pieces, may compose the articular portion of the temporal. Thus in Cyprinus and Esox we find five, but in most genera, as Perca, Pleuronectes, and Cobitis, only four of these elements. The quadratal bone, *e. g.* Zeus, Silurus, and Heterobranchus, is formed of three pieces. Two pieces only, firmly united by suture, are fouud, *e. g.* in Muræna and Murænophis, where this bone more resembles in form the os quadratum of the higher Vertebrata. A pair of mostly small flat *parietal* bones, which are situated upon the upper surface of the cranium, between the occipital, temporal, and frontal bones, are very generally present. In front of these lie the double *frontal* bones, mostly of considerable size, and to which the ethmoid is affixed in front. This latter bone consists of a middle azygos piece or *body*, and two large *lateral ethmoids*, which have been viewed by many as particular bones under the name of *anterior frontals*. Spaces forming fontanelles occasionally intervene, *e. g.* Silurus, Cobitis, between the frontals and also the parietal bones. The distinct want of symmetry in the bones of the two halves of the cranium in the Plaice and Flounder is another osteological peculiarity deserving our attention.

The greater proportion of the *Facial bones* in the Osseous Fishes admit of being very readily referred to their analogues in the higher Vertebrata. The upper jaw consists very generally of an anterior pair of *intermaxillary* bones, mostly supporting teeth, and of a *superior* maxillary, occasionally very rudimentary, situated behind these, and scarcely ever furnished with teeth. In the Carp tribe both bones are devoid of teeth; the intermaxillary bone is usually the smallest of the two, but is largest in Sparus and the Fishes of the Eel kind *e. g.* Murænophis, in which the intermaxillary and vomer appear to have coalesced, while the superior maxillary supports teeth. In some cases the latter bone coalesces with the vomerine, palatal, and nasal bones to form a single bone, which unites, however, with that of the other side by suture, as in Orthagoriscus and Diodon. The superior maxillary bone is very small and rudimentary in Silurus, and is even absent in Balistes, where, however, the intermaxillary is much developed. A second bony piece in rare instances, *e. g.* in the Trout, Pike, and Herring, is situated above

and upon the superior maxilla, and may be probably compared with the labial cartilages of the Plagiostomi. Other bones, however, besides this occur in many of the Osseous Fish, which are still more analogous to the system of labial cartilages in the Sharks. Thus a cartilage is frequently found in the fold of the angle of the mouth, which in Sciæna aquila is of very large size; it is mostly conical in form, attached by its basis to the lower jaw, and by the other end, which is free, to a fold of the mucous membrane. It is much more rare for a similar cartilage to exist in the upper jaw, as, for example, the two fine strips of cartilage in Dactyloptera volitans, where they correspond completely with similar structures in the Sharks.

The *vomer* is attached posteriorly to the anterior extremity of the sphenoid bone, and lies beneath the ethmoid. It very frequently supports teeth, but in the Carp projects into a couple of rounded nodules. The *palatal* bones are situated in front of and to the sides of the ethmoid, and in the direction backward they abut against the pterygoid bones. Each palatal bone is united to the vomer by means of a joint, and by means of this the mobility of the bony apparatus that rests upon the articulating or quadratal portion of the temporal is effected. Occasionally, *e. g.* in Muræna, Murænophis, the palatal and pterygoid bones concur to form a single bone, which is very large in Gymnotus. The *nasal* bones are usually situated, as a pair of elongated flat bones, in front of and upon the ethmoid, *e. g.* in the Pike. In the Carp, an elongated, stile-shaped bone occupies their place; it is somewhat dilated at each end, and upon its sides there is always found a smaller discoidal bone. In Fish of the Eel kind, the nasal bones, or their analogues, are completely absent. Externally, upon the lower edge of the orbitar cavity in many Fishes, there is situated a series of flat bony scales, frequently five in number, which are much developed in the Carp, and the most anterior of which is the largest. They are called *infra-orbital* bones, and, from their forming a kind of arch, may be compared to the *jugal* bone. This chain of ossicles is subject to much variety, being wanting in Muræna, Murænophis, Balistes, and other anomalous Fishes, while occasionally six bony scales occur, as in Perca, where they are very small, or they are only four in number, as in Trigla, and of remarkably large size; in some cases only two or one exist. There is occasionally found upon the border of the orbit, and situated upon the frontal bone, a peculiar bone of small size, the *superciliary;* examples of it are furnished by Cypri-

nus, Salmo, and Cobitis. The bones called nasal bones and infra-orbital, are probably bones appertaining specially to the dermo-skeleton, and are, therefore, improperly so termed. The *inferior maxilla* invariably consists, upon either side, of at least two pieces, of which the anterior is usually blended with that of the opposite side to form a firm arch, and supports the teeth, whence it is called the *dental* piece; the posterior or *articular* piece articulates by ginglymus with the os quadratum. Usually, though not always, a third bone, the *angular* piece, is found lying behind and beneath the articular; and more rarely a fourth, or *complementary* piece, is superadded, which lies in the direction inward between the dental and articular piece. Six pieces are rarely met with as in the genus Lepidosteus, where the structure of the lower jaw reminds us of that in the Reptilia, as the Crocodile. Occasionally a very considerable gap remains between the dental and articular piece, *e. g.* in Zeus, Pleuronectes maximus. The asymmetrical condition of the bones of the cranium in the Plaice is extended also to those of the face, but slightly to the lower jaw.

Many Fishes exhibit greater varieties of cranium than those already mentioned, as is the case, for example, in Uranoscopus, Lepidoleprus, Lophius, Chironectes; yet the description already given is applicable in general to the Soft and Spiny-finned Fishes. The genera Centriscus, Polyodon, Lepidosteus, Polypterus, &c., with the Syngathi and Hippocampi, exhibit greater anomalies, not only in the structure of their skull, but in the rest of the skeleton.

As concerns the *Vertebral Column* of the Osseous Fishes, it consists properly only of thoracic and caudal vertebræ, the first vertebræ supporting ribs as well as the others, so that the cervical series is wanting. The number of vertebræ is very various: in the elongated Fishes, as the Eel, and others of that kind, *e. g.* Sphagebranchus, it exceeds 100; in Trichiurus lepturus above 150; in Gymnotus and Ophisurus above 200; in others only 20—30, as in Balistes.

The bodies of the vertebræ in Fishes are well characterized by the deep grooves upon their sides, and which penetrate so far as to perforate the latter, so that they present a series of apertures, as in the Shad, Silurus glanis. Their anterior and posterior surfaces, where the bodies unite to each other, exhibit a conical depression. In this way a double infundibuliform cavity is formed, similar to that in the Cartilaginous Fishes, between two vertebræ, and is filled up with a gelatinous fluid which is found even in the centre of the vertebral body. This fluid is enclosed in a membrane forming a kind of sac

and being interposed in the above manner between two vertebræ, constitutes an elastic apparatus, performing functions similar to those of the intervertebral ligaments in Man; it is formed partly out of the remains of the chorda dorsalis and its sheath, as will be pointed out more closely further on in speaking of the Cartilaginous Fishes. The vertebræ frequently possess anterior oblique processes (often absent) and posterior, which are rarely wanting; both the one and the other, however, can be but improperly compared with the oblique processes of Man and the higher Vertebrata, seeing that they are not united by articulating surfaces. The parts that form the arch of the vertebræ are continued into very large *superior spinous processes*, which are well developed in Sparus, and still more in Chætodon, Pleuronectes, &c.; but they are, on the contrary, low and depressed in the Anguilliform Fishes and in Lophius. In Syngnathus the superior spinous processes of the vertebræ support the dorsal fins, and are divided into several widely radiating pieces. The thoracic vertebræ are frequently provided with transverse apophyses directed somewhat downward: although they may be called transverse processes, yet, judging from what we know of the developmental history of the vertebræ, they must be essentially different from those of the higher Vertebrata. They are frequently absent; when present they support ribs, but invariably project backward and downward, where, converging, they coalesce to form the inferior arches, which together constitute a canal, opposite to that of the superior arches enclosing the spinal cord, and through which the aorta passes. Upon the caudal vertebræ they support very large *inferior spinous processes*. Occasionally, as in the Carp, Shad, Pike, in Clupea, Zeus, Trigla, one or more ribless vertebræ, provided with peculiar processes, are situated in front of the costiferous set, and are regarded as cervical vertebræ. Situated above and upon the superior spinous processes, to which they are usually connected by membrane to a greater or less extent, are the *accessory* or *interspinous* bones, frequently of considerable size, and supporting superiorly the *rays of the fins*. It is rare for the interspinous bones to advance, as in Plagusia, far forward upon the skull, and form there a crest. The fin-rays are in some instances, as in the Acanthopterygii, simple, pointed, horny spines, but in others, as the Malacopterygii, they are softer, divided several times at their extremity, and transversely articulated; they are united by ginglymus with the interspinous bones, and it is between them that the membrane of the dorsal fins is expanded. Perfectly similar interspinous and ray-

bones are met with in the anal fins, where the foremost of these *inferior interspines* are frequently of remarkable length and strength, as in Pleuronectes. The last vertebræ, or those which abut against the caudal fin, are usually formed in a peculiar manner, being very strongly compressed laterally, and their superior and inferior spines forming large flat bones. Frequently, as in the Anguilliform Fishes, the last vertebræ become smaller in size, but exhibit no peculiar conformation from the absence of the caudal fin.

Most of the Osseous Fishes are furnished with *Ribs*, which vary greatly in number, and are attached partly by their upper and strongest extremity to the transverse processes, and partly to the bodies of the vertebral series, inclining chiefly in the direction forward. The ribs are never, as in Man and the higher Vertebrata, laterally compressed, but from before backward, or they are rounded, and frequently present the appearance of slender spiculæ. In many fishes, *e. g.* Balistes, the ribs are small and few in number; in others they are rudimentary or entirely wanting, as in Lophius, in the Pectognathi, and others.

In many Fishes we meet with a series of bones that have been falsely termed *accessory ribs*; they consist of lateral spines, which are attached to the vertebræ above the true ribs, and are plunged among the muscular fasciculi to which they properly belong. They are greatly developed in the Herring, where they stand in two rows.

It is only in a few Fishes that parts are found which admit of being very remotely compared to a *Sternum*. To these belongs the chain of little bones, parts of the dermo-skeleton, that in Zeus and Clupea extend from the girdle of the thoracic fins to the anal fin. In other Fishes, *e. g.* Balistes, a single long bone occupies their place. No costal cartilages are, however, found connecting the ribs with the parts just described, so that the latter can only be viewed improperly as a sternum.

The *Thoracic* and *Ventral fins* of the Osseous Fishes correspond in position to the anterior and posterior extremities, and attempts have been made to reduce the osseous structures which serve for their support to corresponding bones in the arm and foot of the higher Vertebrata.

As regards the *Anterior Extremities*, they appear to be completely wanting in probably none of the Osseous Fishes. As in many Serpents and Apodal Lizards, even where they are not indicated externally by fins, they still exist, of which examples are met with in

many Fishes of the Eel family; and it is here that their structure exhibits an interesting series of gradations. Their form appears to be of the simplest kind in Murænophis, where, upon either side, there lies beneath the skin behind the gills a single bone, sloped out anteriorly and surrounded by muscles, which supports no fin. A similar pair of very delicate styliform bones, abutting together anteriorly, are situated behind the branchial apparatus in Sphagebranchus; these bones are more largely developed in Synbranchus (Unibranchapertura, Lacep.), where they form a girdle that corresponds somewhat to the clavicles. In Muræna each of these bones is already divided into two, the uppermost of which may be viewed as a rudimentary scapula, while the remaining divisions enter into the composition of the fin—an arrangement approximating the usual structure which is as follows: There is generally situated most superiorly one bone, or occasionally several, that represent the *scapula*. The uppermost is usually bifurcated, and unites by means of its two processes with the occipital bone; it is rarely, however, firmly united to the skull by suture, but usually by ligament alone. To this, or to a second small bone, succeeds inferiorly one that is very much larger, presents a slight semilunar excavation in front, and comes in contact with that of the opposite side, so as to form a girdle for the anterior extremities, which gives off the main support of the fin. The bone, which corresponds to the single one in Murænophis and Synbranchus, has been named, perhaps justly, the *anterior clavicular*. It is more difficult to admit the title of *posterior* or *coraco-clavicular* applied to the next bone, as the analogue of the coracoid process of the Mammalia, and the posterior clavicle of Birds. It is for the most part longer, more pointed, and rib-shaped, and, in the direction backward and inward, rests against the convex part of the anterior clavicle, and converges frequently to that of the other side; it consists usually of two pieces, of which the superior is broad and flat.

To the above follows the second or middle division of the bones of the thoracic fins, which is viewed as corresponding to the *humerus* and *antebrachial* bones. This division consists of three, or frequently only of two bones, perforated by openings, and often of very considerable size. A row of smaller, flatter, and rarely more elongated bones, follows the above division, and has, in conformity with nature, been viewed as corresponding to *carpal* and *metacarpal* bones. Four separate bones are mostly here present, but the number varies from two to five. A special division is in rare cases,

formed for the metacarpus. To these bones are appended the *digital* articulations or fin-rays (*radii pinnæ pectoralis*), which form the supporting frame-work of the pectoral fins.

The varieties in the construction of the anterior extremities in the several genera are very great. The arrangement in the Eel is of a very simple kind, there being a single bone or scapula not bifurcated, and below that the clavicular bone. In addition to these are two bones for the second division, and several for the carpus and the fin-rays. The bones are somewhat more developed in Gymnotus, where the scapula is united to the skull. The genera Exocætus, Lophius, Silurus, Tetrodon, possess also but one bone for the scapula; most of the Osseous Fishes, *e. g.*, Perca, Esox, Cyprinus, Cyclopterus, Trigla, Scomber, Chætodon, Gadus, Brama, &c., are provided with two, an anterior and posterior, clavicular bones, two to three brachial, three to four carpal bones; and next in succession with fin-rays or phalanges; many, as several species of Sciæna, Sparus, Labrus, &c., have as many as three scapular bones; the posterior or coraco-clavicular bone is absent in Anarrhicas, Silurus, Uranoscopus, Fistularia, Exocætus, and consists invariably of only a single bony piece in Cyprinus, Esox, Batrachus, Lophius, and Chironectes; in Chætodon it abuts against the bones of the pelvis; in Zeus the two clavicles coalesce inferiorly; the carpus in Lophius and Chironectes is formed of two very long bones, that have been falsely compared with the ulna and radius; in Batrachus there are five similar bones, and in Polypterus two elongated bones, with one or several discoidal ossicles interposed between them; this Fish has also, as an occasional peculiarity, a row (amounting even to 18) of elongated bones, which correspond to the metacarpus. The carpal bones are very seldom wanting, as in Exocætus (where the fin-rays are remarkably long) and in Uranoscopus. For the second or antebrachial division of the anterior extremity we find, in Silurus and Heterobranchus, only one bone; the first fin-ray is, on the contrary, strong and linked to the anterior clavicular bone; so that here, as in Pimelodes, Platycephalus, and others, it is very broad inferiorly, and united with that of the opposite side by a zigzag suture.

The *Pelvis* and *Posterior Extremities* are but very rudimentary in the Osseous Fishes, and not connected to the vertebral column, but are imbedded simply in the flesh, as in the Amdominales, or abut against the anterior clavicular bones, as in the Thoracici and Jugulares; occasionally they are completely wanting, or we find in their place two usually long flat bones, which support on their posterior

edge the digital portion or abdominal fin; it is rare for a third set of bones to be interposed between these.

More diversities appear in the posterior than in the anterior extremities; thus they are often completely absent, as in Xiphias and Fishes of the Eel kind, *e. g.*, Muræna, Murænophis, Sphagebranchus, Gymnotus, &c., and are placed in some instances far forward, in others far backward; upon these varieties of position of the ventral fins the old Linnæan division of Fishes into Apodal, Abdominal, Pectoral, and Jugular, was based.

Both pelvic or iliac bones are usually more or less united to each other; in some Fishes they are completely anchylosed, in others prolonged backward in the form of a spine, as in Cyprinus, Scomber, Zeus, &c.; they are occasionally separate, as in Lophius, Batrachus. Polypterus possesses four elongated bones, that correspond as the third division of the extremities to the tarsus and metatarsus.

The Skeleton in the Cartilaginous differs altogether in structure from that already described as belonging to the Osseous Fishes, and it is only its fundamental types which are common to the two as Vertebrate animals. It is scarcely possible to offer any general remarks relative to the skeleton of the Cartilaginous Fishes, and we must therefore characterize its peculiarities in the several orders and families.

In the Cartilaginous Fishes the skeleton remains throughout life in a cartilaginous condition, and true ossification occurs only in the tegumentary bones, *e. g.*, in the Sturgeon, or in particular parts of the skeleton. In some Cartilaginous Fishes, such as those with free branchiæ (Acipenser, Chimæra), the permanent cartilage resembles the cartilage that precedes the formation of bone in the Osseous Fishes: the cyclostomi, however, are distinguished by possessing a very peculiar kind of cartilaginous tissue with coarse cells, while the Plagiostomi possess the cartilaginous tissue of the Sturgeon and Chimæra; and in addition thereto, other kinds of cartilaginous tissue, namely, 1*st*. The hyaline or transparent tissue, with more or less membranous cartilaginous corpuscules; this occurs in the Sturgeon, and also in the Osseous Fishes, and forms mostly the internal part of the cartilage, with the exception, however, of the vertebral bodies. 2*d*. The tessellated calciferous cartilaginous tissue, which occurs only in the Sharks and Rays, and invests the hyaline cartilage like a hard crust, with the exception of the vertebral bodies. This cartilage consists of prismatic pieces which resemble brick-work, and are separable from each other. 3*d*. The cellular cartilaginous tissue

occurs in the Cyclostomi. The cartilaginous corpuscules disappear by degrees, and the cartilage appears devoid of cells, like the hairs of one of the Goat tribe. 4*th*. The completely-ossified cartilaginous tissue, as exemplified in the solid vertebral bodies of the Rays and Sharks.

The Sturgeon, although a true Cartilaginous Fish, effects the transition from that type to the Osseous, of which we are reminded by the disposition of the parts of its skeleton. Already do we find in many of the Osseous Fishes, as the Pike and Trout, that the cranium consists internally, where it encloses the brain, of cartilage, upon the external surface of which the bones of the cranium, as already described, are deposited. In the Sturgeon the cartilaginous cranium becomes ossified at its base, this bony portion corresponding to the basilar element or body of the occipital and sphenoid. But even here the ossific process has taken place only externally, and that surface which forms the cavity of the cranium still continues cartilaginous; the ossification is most apparent in the fibrous tunic, which, continued from the fibrous sheath of the medulla spinalis, lines the skull. In other parts the cranium is perfectly cartilaginous, and covered in with firmly adherent bony scutes, which belong properly to the dermo-skeleton, and admit only of an inaccurate or very remote comparison with the cranial bones of the Osseous Fishes. In front and on the sides the cartilage of the head presents depressions for the eyes and nasal cavities, and then projects into a long process. The palatal bones are separate from the skull, united with the superior maxilla, and consists posteriorly of an azygos bony plate, and two anterior osseous pieces in pairs. The quadratal bone consists of a superior bony piece united to the cranium and two inferior cartilaginous pieces; the last of these is united to the lower jaw, which, with the small and double superior maxillary bone, closes the edentulous mouth.

In the Chimæra, the Sharks, and the Rays, the skull is a large cartilaginous capsule, enclosing the brain and auditory apparatus; it is free of the vertebral column, and exhibits no traces of ossification. In the Plagiostomi there usually remains upon its upper surface an open space or fontanelle, closed only by a fibrous membrane. This cartilaginous capsule is particularly flattened upon its upper surface in the Rays, and has posteriorly an opening, the occipital or foramen magnum, and lesser apertures also for the exit of nerves. A portion of this capsule, convoluted upon itself laterally, forms the orbitar cavities, and frequently presents superiorly, as in Scymnus

an orbitar process. United to the anterior extremity of the cranium we meet with a deep hollow leaflet of cartilage, forming the nasal fossa. The upper jaw is constituted by a narrow arch of cartilage, occasionally, however, deep, as in the Sharks, and of a semilunar form; it is beset completely, both upon its edge and posterior wall, with teeth. A quadratal cartilage, more simple and elongated, is lodged in a posterior lateral depression in the skull, and articulates with the lower jaw, an arch provided with teeth, and composed of two lateral halves like the upper. There occur, moreover, in the Rays small palatal cartilages, as also peculiar cartilages belonging to the spiracles, and which correspond somewhat to the pterygoid bones or processes in the Osseous Fishes. The intermaxillary bone must be regarded as absent, if we do not consider it united with the superior maxilla in the arch of cartilage just described. In the Chimæræ the skull is very peculiarly formed, being provided with distinct convoluted nasal cartilages, while upon the fore part of the head stands a style-shaped piece of cartilage.

Furthermore, there exists in many of the Sharks and Chimæras a peculiar system of labial cartilages, which is wanting in the Rays and Sturgeons; the question of its homology has given rise to various incorrect speculations; a portion of it was regarded formerly by some anatomists as belonging to the maxillary apparatus. It consists of several more or less elongated muzzles of cartilage varying in form and particularly remarkable in the Chimæra, which rest externally and laterally against the upper and lower jaw. In Acanthias and other genera, for example, a lower labial cartilage is to be distinguished lying upon the inferior, and a superior upon the upper maxilla, and occasionally, as in Scymnus, Chimæra, a third cartilage situated above the latter one. Among the Rays, it is only in Narcina that small labial cartilages are met with. In them and in the true Electric Rays (Torpedo) there is situated in front of the body a cartilaginous production of the muzzle which unites the pectoral fins to the skull.

Still more abnormal is the structure of the cranium in the Cyclostomi, and in them we are again met by numerous varieties in the structure of the buccal cartilages. With this group, indeed, all attempts to draw any analogy or comparison with the typical Fishes must be laid aside.

The craninm of Petromyzon marinus and fluviatilis consists of a hard, nearly osseous brain-capsule, having a detached flattened basilar portion, that gives off in the direction backward a pair of pro-

cesses. Upon its sides are found the hard, oval auditory capsules, united continuously with the skull, and enclosing the membranous labyrinth; upon the upper part of the skull itself we remark, as in the Rays, a fontanelle closed by fibrous membrane. In front also and inferiorly, the arch of the cranium is to a great extent membranous. Superiorly, and in front of the skull, is the opening of the nasal tube, which perforates the palate, and on its posterior wall the olfactory nerve is distributed as it issues from the cranium. A number of cartilaginous plates lying behind each other belong to the parts of the mouth: thus there is found an anterior and posterior operculum of the oral aperture, to which are superadded inferiorly a pair of lateral plates; a ring-shaped piece of cartilage, the labial ring, corresponds to the maxilla, and to this is fastened laterally a styliform cartilage, which is directed horizontally backward.

The skull is still more simple in Ammocætes, where the parts of the mouth just described are in a great measure wanting, while the cranial capsule is essentially similar in structure to that of Petromyzon.

In the family Myxinoides very varied and peculiar forms of oral cartilages are developed, while the cranium of the genera Myxine and Bdellostoma admits of a comparison with that of Petromyzon. All the essential parts described above, namely, in reference to the capsule of the brain, are here repeated, and we meet with similar hard auditory capsules; but there is also a singular frame-work to the pharynx formed of cartilaginous hoops, a long nasal tube consisting, like a trachea, of cartilaginous rings, the nasal capsule, and the palatal plate with its raised borders. In the Myxinoides the nasal canal is open inferiorly toward the palate, while in Petromyzon and Ammocætes it there terminates in a cœcal manner.

In the remarkable genus Amphioxus s. Branchiostoma, a case or shell is completely wanting for the rudimentary brain, which is merely included in a membranous capsule; in the mouth, however, is found a cartilaginous ring with cartilaginous filaments; there is also present a system of oral cartilages, as in the Sharks, Chimæræ, and Petromyzon.

The structure of the head in the Amphibious Fishes, including the genus Lepidosiren, of which it is doubtful whether it should be arranged among the members of the present class or among Reptiles, offers very great peculiarities. The skull, as in all Fishes, is immoveably united to the occiput, presents a cartilaginous substratum upon which the peculiarly-formed bones of the head repose, and

remain themselves partly cartilaginous. The number of the cranial bones is small, and their homologies difficult to determine by comparison with those of other Osseous Fishes; yet we find lateral occipital elements, and a single bone forming the upper covering of the skull; to this last there corresponds a similar bone at the base of the cranium, which may be viewed as the body of the sphenoid. The bones of the face also attract our attention from their peculiarities; the superior maxilla appears to be wanting, while the intermaxillary is present; and there exists moreover a system of labial cartilages, which, with the tooth-bearing lower jaw, exhibits a relationship of structure with that of Chimæra. A more simple quadratal cartilage unites the inferior maxilla to the skull.

In the structure of the *Vertebral Column of the Cartilaginous Fishes* we encounter peculiarities and differences in the several orders and families, which are the more interesting when the development of vertebræ comes to be studied, and the plan of their formation followed out through the series of Vertebrate animals; an extensive subject belonging to the departments of philosophical anatomy, and not to be entered upon here.

In the Sturgeon and Chimæra the vertebral column is constituted by a fibro-cartilaginous tube, which is filled with a gelatinous substance, and surrounded by a fibrous tunic, that is closed above to form a tube for the spinal marrow. Upon the inferior surface of this fibro-cartilaginous tube are situated the rudimentary basilar parts of the vertebræ; they are united beneath by a membrane, along which the aorta passes. Between the upper triangular pieces of the arch other triangular pieces of cartilage (*cart. intercrurales*) are found, and the roof of the spinal canal is closed in by a series of more elongated cartilages, above which there are placed in the Sturgeon large spinous processes. The fibro-cartilaginous tube of the Chimæra, very beautifully annulated by thin transverse rings that were formerly falsely compared to vertebræ, remains in a great measure exposed to view, and corresponds to that part in the rest of the vertebrata, present only in their fœtal condition, but in Fishes more or less persistent, namely the *chorda dorsalis*, or central cylindrical axis, around which the formation of vertebræ takes place. The persistent structure of the vertebral bodies in the Sturgeon and Chimæra corresponds to that which exists only in the fœtal state of the Osseous Fishes. In these latter Fish, when fully formed, the gelatinous tube is reduced to constricted masses of gelatine, surrounded by the conical facets forming the bodies of the

vertebræ, and opposed to each other; but the gelatinous column with its fibrous sheath that occurs in the Sturgeons and Chimæræ, and also in the Cyclostomi (as will be described further on), has a cellular structure, like the chorda dorsalis, quite different from cartilage.

In the Plagiostomi the formation is of a more perfect kind, and similar to that of the Osseous Fishes, for the upper and lower pieces of the vertebræ having become more complete, the gelatinous column is so enclosed that the conical facets of the vertebral bodies are alone left. The points of ossification in its interior are very complex. In some Rays and Sharks a hyaline cartilage rests upon the surface of the vertebral body (*e. g.* Spinax, Scyllium); in others the vertebral body, with cellular interstices, ossifies up to the surface, but in its interior there remains a cross of hyaline cartilage, the crura of which are directed toward the points of origin of the arches and transverse processes (*e. g.* Carcharias, Zygæna); or other varieties occur, as in many genera, *e. g.* Hexanchus, Heptanchus, where the whole vertebral column remains cartilaginous throughout life. As a rule, however, the vertebral bodies, the pieces forming the arches, the intercrural cartilages, and the laminæ forming the roof of the spinal canal, are always to be distinguished. In the Rays a large anterior portion of the vertebral column is not distinctly divided into vertebral pieces, these being blended together.

In Petromyzon the fibro-cartilaginous tube is found to be annulated, filled with gelatine, and surrounded by a fibrous tunic, which forms above it a tube for the spinal marrow. In the upper membranous tube cartilaginous crura are seen to arise, and may be viewed as rudiments of vertebral arches.

In Myxine, Ammocætes, and Bdellostoma, we meet with the lowest persistent condition of the vertebral column, and one which disappears at a very early period of existence in the higher Vertebrata; this consists of a chorda dorsalis, filled with gelatine, and surrounded by a fibrous tunic that forms above a tube for the spinal marrow; but all special divisions or rudiments of ossification in this tube are wanting. A similar chorda dorsalis, projecting as far as the snout, together with a fibro-membranous capsule for the spinal marrow, is found also in Amphioxus. Even in the Lepidosiren the vertebral column consists of a mere chorda dorsalis, without any indication of vertebral rudiments, and provided only with a ligamentous capsule and gelatinous substance.

Cartilaginous accessory spines occur in the dorsal and anal fins

of the Sturgeon as in those of the Osseous Fishes; in the Sharks and Rays several divisions of triangular and quadrangular cartilaginous laminæ occur; they correspond to the accessory spines and support the fin-rays.

Many of the Cartilaginous Fish, as the Rays, Sharks, Sturgeon, and the genus Lepidosiren, are provided with *Ribs*. The Cyclostomi, at least the Lampreys, possess a peculiar sternal series, formed of a number of ramified rib-shaped cartilages which are united together, and to an elongated sternoid cartilage; it encloses the gills, and may be therefore most properly compared with the branchial skeleton of other Fishes.

Among the Cartilaginous Fishes we meet with an entire absence of *Extremities* in the Cyclostomi, while in the Sturgeons, Chimæræ, Rays, and Sharks, they exist in the form of pectoral and ventral fins. The anterior extremities of the Sturgeon resemble those of the Osseous Fishes in being composed of several pieces, which correspond to a scapula and clavicle; the posterior extremities are a pair of small ventral fins. The Chimæra approximates most in this respect to the Plagiostomi.

Among the Plagiostomi the Rays present us with a surprising development of their *pectoral fins*, which correspond to anterior extremities, and are in some degree analogous to those of the Osseous Fishes. Their first portion consists of a scapular and a clavicular cartilage; frequently, however, of three cartilages that form a pretty broad arch, which in the Rays firmly unites with the anterior anchylosed section of the vertebral column, but does not reach the latter in the Sharks. To this first portion succeeds a second, which consist in the Rays of three or four very elongated cartilaginous pieces; next we meet usually with two rows of rays, the posterior of which may be perhaps likened to the metacarpus, while the anterior or external represents as fin-rays the digital phalanges. In the Rays the digital phalanges are somewhat dilated at the two ends.

In the Plagiostomi and Chimæræ the arrangement of the *posterior extremities* is rather more perfect than in most Osseous Fishes. An iliac cartilage is here present as a rudiment of the pelvis, and to this follows a series of more elongated cartilages, which may be regarded as tarsal, while arranged upon these are the rays or pedal phalanges supporting the ventral fins. In the male Rays and Sharks a pair of long, slender, cartilaginous appendages are united to the iliac cartilage; they are hollowed out by a groove above for

the passage and exit of semen, and thus perform the function of external generative organs.

The genus Amphioxus, like the whole order of Cyclostomi, is devoid of all extremities. In Lepidosiren there are found externally, in the situation of the pectoral and ventral fins, two pairs of inarticulate filaments. The first pair rest upon a bone or cartilaginous girdle forming their support; and for the posterior rudiments of fins there exists likewise a pelvic piece.

MUSCULAR SYSTEM.

The Muscles of Fishes are characterized by their slight degree of separation from each other, by the absence of long tendons (which occur only in some anomalous muscles of the cranium, *e. g.* in the Electric Ray), and by the softness of their fibres. The color of the muscles is generally pale, being either white or having a tinge of yellow; occasionally, however, as in the Tunny (Scomber thynnus), they are red like the flesh of Mammalia. Their microscopic structure does not differ from that of the other Vertebrata, nor are the characteristic transverse striæ wanting even in the whitest fibrillæ.

Peculiar muscles of the integument do not appear to exist; still the small superficial muscles which move the several rays of the dorsal and anal fins are obviously analogous to the muscles that act upon the feathers in Birds, and upon the ventral scales in Serpents. Each fin-ray is constantly provided with a single superficial muscle upon either side (right and left) of its basis; they arise from the integument, and wave the fin to and fro so as to maintain the act of swimming. Besides these, there are other muscles more deeply seated, and of some length, which cover the interspinous bones. Each fin itself is provided with a pair of protractor and a pair of retractor muscles, those that correspond upon either side being separated by the interspines, and covered by the great lateral muscles of the body. By means of these muscles the dorsal and anal fins can be elevated and depressed. Those Fishes which, like Gasterosteus, Silurus, Lophius, and Balistes, are furnished with certain strong but loose spines or fin-rays as instruments of defence, present greatly developed and isolated fin-muscles.

By far the largest portion of the fleshy mass of Fishes is made up by the large *lateral muscles* of the body; they consist of longitudinal fibres, which are interrupted by numerous tendinous undulating lines passing from the dorsal to the ventral aspect, and extend from

the head and scapular arch to the base of the caudal fin. This mass of muscle is not, however, so simple as it appears, but divided into numerous parts. We may distinguish an upper layer where the tendinous strips are directed obliquely backward, and then a second and third, the last of which is situated beneath the lateral line. The tendinous transverse strips here alter their direction, but correspond to the number of vertebræ. These layers of muscle arise from the skull itself, from the occipital and mastoid bones, in which situation they correspond to the nuchal muscles; also from the scapula and clavicle, then from the lingual bone, the vertebræ and their spinous processes, clothe the ribs, and are inserted by short tendons into the base of the caudal fin. Below them lies another layer upon the belly, which corresponds to the abdominal muscles, while the upper layers are analogous to the dorsal muscles of the higher animals, especially the *m. m. spinalis*, *semispinalis*, *multifidus spinæ*, *longissimus dorsi*, and *sacro-lumbaris*. The symmetry displayed by the dorsal and ventral portions of the lateral muscles, upon a perpendicular section, is most striking, and we are in this way best enabled to see the peculiar infundibuliform arrangement of the several muscular layers.

Each lateral muscle bends the body toward its own side, at the same time producing powerful lateral inflexions of the rudder-like tail; movements so necessary in the act of swimming. The head can be also moved to a slight degree, when its freedom of attachment to the vertebral column admits of it. By the co-operation of the two lateral muscles upon either side at their anterior part, the compression of the swimming-bladder may be also affected.

The several orders and genera of Fish naturally exhibit numerous muscular varieties. Beneath the lateral muscles, between the ribs, are found the *intercostal* muscles. In the interspaces between the two great lateral muscles, both upon the dorsal and ventral side, but chiefly upon the latter, two very slender muscular strips may be seen to pass, as in the Perca fluviatilis, and to be interrupted only by the dorsal and anal fins.

The *caudal fin* is moved chiefly by small thin muscles, which form two layers, a superficial and a deep, and are inserted, like those of the dorsal fins, into the rays composing it; occasionally there occurs, as in Perca, a third layer. The several rays of the caudal fin can be moved by means of these upward, downward, and laterally.

The *muscles of the anterior extremities* consist of two principal layers, upon each of the two surfaces of the antebrachial and carpal

bones. The superficial layer of the external side arises from the clavicle, and covers entirely that which lies beneath it; that also of the inner surface of the fin, or the one turned toward the trunk, exhibits similar relations. The latter draws the fin toward the body, while the external, as abductors of the fin, move and raise it outward.

The arrangement of the *muscles upon the posterior extremities*, or ventral fins, when the latter are present, is of a similar kind. Here we find proper elevators and depressors in a double series, which arise from the pelvis and are inserted into the fin-rays. The rudimentary pelvic bones obtain fasciculi from the lateral muscles, that correspond to an oblique abdominal muscle and a rectus.

The muscles of the anterior extremities, or pectoral fins, are particularly developed in Lophius and in the Flying Fish, *e. g.* Trigla, Exocœtus, among the Osseous Fishes.

The *muscles of manducation* are very strongly developed, and form more or less a mass constituting what is called the cheek-flesh of Fishes, and which in the Trout has a particularly delicate taste. The whole depression occupying the external surface of the articular portion of the temporal bone is covered by this muscular mass; and it arises not only thence, but also from the anterior edge of the præoperculum, and is inserted partly into the upper, partly into the lower jaw. The disposition of these manducatory muscles is very different from that of the *masseter* and *temporal* muscles of the higher animals, to which, however, they correspond.

The muscles of the Cartilaginous Fishes exhibit more noticeable diversities. In the Plagiostomi, as the Rays, the dorsal and ventral muscles are more separated by a horizontal tendinous layer, that divides each lateral muscle into an upper and lower half. Several muscles are also given off for the cranium, so that the head can be slightly moved. Remarkably large horizontally expanded layers form, in the Rays, the muscles for the great pectoral fins, without, however, these admitting of a separation into superficial and deep layers, as in the Osseous Fishes. In the Electric Ray a pair of peculiar muscles with long tendons also occur; their fleshy part or bellies arise behind the skull from its lower surface, and are inserted into the anterior margin of the head in front of the electric organs; they have no analogue in other Fishes.

In the Cyclostomi the same numerous tendinous strips are found intersecting the lateral muscles, which are here much developed, and surround the body. In the Myxinoides we find superadded a

system of lateral ventral muscles, which, as a rule, is absent in other Fishes, and consists of an oblique and a straight ventral muscle; by means of these the powerful movements and vermiform deflections of these animals are effected.

NERVOUS SYSTEM.

The Nervous System also of Fishes, especially the Brain, exhibiting numerous diversities, it will be best to become first acquainted with the regular arrangement of these structures as they are found in the majority of Osseous Fishes, and then to describe their varieties in the several genera and families of that sub-class; lastly, their mode of formation in the remaining orders.

The ordinary type of structure in the Brain of Osseous Fishes is to be observed in many Acanthopterygians, *e. g.*, Perca fluviatilis, and Malacopterygians, as the Pike (Esox lucius), in both of which it presents a very close conformity; in the common Carp, however, which, from its frequent occurrence, has been chiefly recommended for the purposes of dissection, we already encounter peculiar cerebral anomalies; and other species of that genus, as Cyprinus barbus, are therefore better suited for examination.

The *Brain* in general does not nearly fill up the cranial cavity, so that between the dura mater that lines the internal surface of the cranium and the soft membrane which very closely invests the brain itself, we find a free space filled up by a quantity of loose cellular tissue, interrupted throughout by adipose cells. A fluid oil is frequently found floating in large drops between the meshes of this tissue. The membranes situated between the dura and pia mater may be viewed as the arachnoid; the analogy being still more obvious where they cover the third ventricle. The dura mater is often of a silvery lustre, or partially coated by black pigment.

We shall do best to commence the consideration of the several parts of the brain with the *medulla oblongata*, which, though it differs slightly, is to be distinguished from the rest of the spinal marrow by being broader and flatter. Upon the medulla oblongata may be distinguished four thickened tracts, two superior and two inferior; the first are slightly enlarged, from the corpora restiformia, and recede from each other in the middle line, so that the floor of the fourth ventrical or rhomboidal sinus lies freely exposed to view; they give off processes that are prolonged, forming its crura, into the cerebellum. Some transverse fibres upon the inferior sur-

face of the medulla oblongata probably replace, as in other higher Vertebrata, the pons Varolii, that occurs only in the Mammalia. The *cerebellum* is a large spherical ganglion, for the most part slightly lobular in form, and curved upon itself posteriorly; it is destitute of transverse grooves, but frequently furnished with obtuse lateral projections. The fourth ventricle extends far into it. In front of the cerebellum are situated two large obovate hemispheres or ganglia, which in size, form, and situation, are similar to the hemispheres of the higher animals, and, from their forming the most considerable portion of the brain of the Osseous Fishes, have been regarded as such by some anatomists; others term them optic lobes, and they obviously correspond to the mesocerebrum, the corpora quadrigemina and optic thalami of the human subject taken conjointly; they may be called *median lobes*. Upon making a superficial section of one of them, we find beneath a thin roof of medullary matter, a large cavity extending through the whole ganglion. Upon the floor of this cavity or ventricle, in the posterior direction, are usually situated four small round ganglia (*e. g.*, in Perca, Esox, some Salmonidæ, Clupea, Trigla, Gadus Lota), more rarely two (as in Gadus, Lophius, Blennius, Muræna, Cyclopterus, some species of Pleuronectes), or six (*e. g.*, Scomber thynnus, Salmo trutta); these ganglia certainly appear to resemble the corpora quadrigemina of Man, and are even united with the cerebellum by some fasciculi of fibres, the *crura cerebelli ad corpora quadrigemina*. Further outwardly lies a larger ganglion, similar to the optic thalamus or corpus strtiatum, and on its external side we perceive a radiated expansion of fibres, called the staff-wreath, or *corona radiata*. Several transverse fibres or *commissures* are found, which partly correspond to the corpus callosum, partly to the commissura mollis; a rudiment also of the fornix probably exists. The hollow space included between the above-named ganglia is prolonged deeply into the infundibulum, and thence backward into the fourth ventricle, and corresponds itself to the third. Inferiorly and posteriorly, at the base of the brain, and behind the chiasma or decussation of the optic nerves, are situated a pair of mostly large ganglia, which agree in their position with the eminentiæ candicantes of the human subject, but can not certainly be compared with them. They are usually styled the *lobi inferiores*, are oval in form, and rest for the most part upon the pituitary body. In front of the pair of mesocerebral masses (*lobi optici*) are situated another pair of smaller yet tolerably distinct ganglia, which are united also posteriorly by a narrow me-

dullary band, or anterior commissure; the ganglia themselves correspond principally to the hemispheres of the higher Vertebrata; they are usually called the olfactory lobes, or *lobes of the hemispheres*. These ganglia are solid, and almost always smaller than the mesocerebral ganglia; for the most part they are composed of two kinds of substances, an anterior and a posterior; the first of these, the largest, presents a delicately tuberculated surface, or, as it were, traces of convolutions; this is distinctly to be seen in the Pike, and also in Gadus morrhua, the Salmonidæ, and others. From, or in front of, these ganglia of the hemispheres arise the nerves of smell; not, however, directly from them, but usually from small interposed round or oval ganglia, which are occasionally themselves of some considerable size, and have received the names of *olfactory ganglia* or *tubercles;* they are present in most, probably all, the Osseous Fishes, and are very distinct in all our indigenous Fishes, *e. g.*, Esox, Salmo, Clupea, Perca, Pleuronectes, Gobius, Gadus, Labrus, Uranoscopus, &c. They are, however, frequently so small and elongated as to be easily overlooked, *e. g.*, in the Carps. A small, vascular, and frequently all but membranous lobule, which is situated freely exposed, and directly in the middle line between the mesocerebrum and the ganglia of the hemispheres, may be regarded as the *pineal gland*. The *pituitary appendage* is of considerable size, and depends from its stem or the infundibulum; it is particularly large in Pleuronectes and Cyclopterus; indeed, generally speaking, Fishes have the largest pituitary body of all the Vertebrata.

The above-described is the usual arrangement of the structure of the brain in the Osseous Fishes, but it is subject to many varieties in the several families and genera, these consisting chiefly in the number of the several hemispheres or superficial ganglia being increased, or in their being severally enlarged and subdivided to a striking degree.

In Fishes of the Eel kind we find two pairs of olfactory lobes or ganglia introduced between the small olfactory tubercles and optic lobes. The posterior pair is largest, and manifestly identical in its whole structure with the olfactory lobes of the remaining Osseous Fishes; for, as in them, they exhibit two divisions of structure, their anterior portion being rendered uneven by rudimentary convolutions, the posterior presenting a smoother surface. This structure is particularly distinct in the common Eel, but occurs also with modifications in the Conger and Murænophis. In the Electrical Eel

(Gymnotus) the mesocerebrum is very strikingly developed. A larger lobe, divided by a median groove, arises from the optic lobes by sloping semilunar-shaped roots, and forms a conical eminence that extends far forward. The whole brain from this derives a peculiar appearance; it is in this ganglion that the roots of the nerves destined to supply the electric organ arise, so that it may be termed *lobus electricus*.

A median lobe is developed in a similar manner in Echeneis remora, and probably contains the nervous elements for the supply of those remarkable organs situated upon the skull, by means of which this fish adheres to ships, stones, and other bodies.

Behind the cerebellum, and to the side of the fourth ventricle, are situated frequently a pair of *posterior lobes*, which are occasionally further subdivided into a special pair of lobes for the roots of the nervi vagi. They are very small and rudimentary in many Fishes, and are therefore easily overlooked; but are most developed in the Carps, being as large, or even larger than the optic lobes. Other Cyprinidæ likewise possess these lobes of the nervi vagi, and they appear also to contain the special nervous elements for a very irritable and contractile organ situated at the base of the cranium above the pharyngeal bones, and which will be described more minutely in speaking of the organs of taste. The lobes of either side are connected by transverse white fibres, forming a kind of commissure upon the under surface of the medulla oblongata. There frequently occurs, as in many also of the Carp tribe, a single median ganglion, which rests upon the floor of the fourth ventricle. This ganglion is of largest size in the common Carp, and appears to exist also in the Sheat-fish (Silurus).

In many Fishes, *e. g.*, in Trigla, from three to five ganglia are constantly interposed behind the already-mentioned lobi posteriores, near to the medulla oblongata, resting upon its upper tracts or corpora restiformia; they are also in connexion with peculiar structures, namely, with the large digitiform rays that are given off from the pectoral fins in the Triglæ, and which receive nerves of proportionate size. Besides this, great diversities occur in the relative proportions of the several parts of the brain; thus the cerebellum is in some cases greatly developed, in others very small. It is largest indeed in the Tunny-fish (Scomber thynnus), and perhaps generally in the Scomberidæ, at least in S. scomber, where it forms a lobe covering the mesocerebrum in the direction forward and upward.

In Silurus glanis it is very large; very small, on the contrary, in Gobius, but rarely provided, *e. g.* Echeneis remora, or Sucking-fish, with transverse grooves, as in the higher Vertebrata.

A want of symmetry between the two sides of the brain occurs in different Osseous Fishes; it is present in the least degree in Gadus, where the cerebellum is mostly placed more toward the right side. In Pleuronectes this asymmetrical condition is carried to a greater degree, being extended to the cerebral ganglia, the optic lobes (the left of which is usually placed above the other), and still more to the olfactory lobes and olfactory turbercles, which are much larger upon the left or uppermost side than upon the right.

In the structure of the brain, as in many other points of its organization, the *Sturgeon* makes the transition from the Osseous to the true Cartilaginous Fishes. The medulla oblongata is broader; the spinal canal opens into a very long and patulous rhomboidal sinus, which is bounded upon either side by the ridges formed by the posterior columns of the chord or corpora restiformia, that enter, as its crura, the broad but small cerebellum. In front of the cerebellum are placed the two moderately large optic lobes, which form the mesocerebrum, together with the narrow mass that inferiorly and laterally includes the freely exposed third ventricle. The olfactory lobes are considerably larger in proportion than in the Osseous Fishes, already presenting more the form of hemispheres, are further subdivided and continued into small olfactory tubercles. The very large pituitary body rests, without any stem or infundibulum, upon the base of the brain. Upon the sides of the medulla oblongata are a pair of posterior lobes, which appear to be chiefly in connexion with the root of the fifth pair of nerves.

The brain varies also in form in the *Plagiostomi* (Rays and Sharks), but not nearly so much in proportion as that of the Osseous Fishes; and from its agreeing more, even when very different in external appearance, with the brain of Amphibia, it is easier to determine the signification of its component parts. The brain is chiefly characterized by the more considerable development of its hemispheres, from which arise either thick or slender nerves of smell; the lobes of the hemispheres are actually blended into a common mass, divided only above in the longitudinal direction; they are either solid, as in most of the Rays when they have grown old, or they are provided with a ventricle, which is continued then into the olfactory nerves, as is seen chiefly in the Sharks, as Scymnus, Acanthias. This mass is prolonged by means of a narrow part of the

mesocerebrum that is open superiorly into the lesser optic thalami and quadrigeminal bodies. The open cavity corresponds to the third ventricle. A pineal gland is not always distinct, but probably occurs at least in the Rays. The middle cerebral ganglia or lobes (*lobi optici* and *corpora quadrigemina*) are largest in the fœtal state in proportion to the hemispheres, but are always much smaller than in the Osseous Fishes; they are hollow in their interior, but simpler in structure, and covered in great part by the cerebellum. A pair of large inferior ganglia are siuated in front of (not, as in the Osseous Fishes, behind) the very large pituitary body (that is provided with membranous appendages, and supplied by vessels of some size), and partly beneath the narrow part of the brain enclosing the third ventricle. The cerebellum is very large, of varied form, and for the most part crucially divided by a longitudinal and transverse groove; more rarely, as in some of the Sharks and Rays, by several transverse grooves, as in the higher animals. The medulla oblongata forms a considerable ganglionic enlargement, and the corpora restiformia are usually much corrugated, and provided with ganglionic dilatations, which may be viewed as posterior lobes or ganglia, such as were described in the Osseous Fishes, and which correspond in position to the clava of the human brain, as also to the funiculi cuneati. The fourth ventricle is prolonged far backward into the completely open rhomboidal sinus. The roof of the fourth ventricle often sends off several divisions into the cerebellum, *e. g.* in the large transversely-furrowed brain of many Rays.

The cerebellum not unfrequently exhibits an asymmetrical position, as in many Osseous Fishes, *e. g.* Scyllium catulus and canicula, and in other Rays and Sharks. The anterior or posterior lobe is indeterminately placed in one instance more to the right, in another to the left side.

In rare cases the posterior lobes are developed to such a degree as completely to cover the fourth ventricle, as is the case in the *Electric Rays* (Torpedo). The lobes of the fourth ventricle are here connected with the electric organ, and may be called *electric lobes;* they are characterized by their yellow color, and present under the microscope a peculiar structure, consisting of numerous ganglionic corpuscules surrounded by dense sheaths.

The structure of the brain in *Chimæra* (at least C. monstrosa) is very different from that of the Sturgeon, and approaches in a striking manner to that of the Sharks; only the hemispheres are far removed from the mesocerebrum by the very long and narrow division for the third ventricle. The brain exhibits a remarkable bend from the mesocerebrum to the right.

Another form of brain occurs moreover in the *Cyclostomi*. In Petromyzon we find a double (more or less fused) pair of ganglia, from the anterior of which the nerves of smell arise; they represent the olfactory lobes and tubercles of the Osseous Fishes. Between these and the pair of optic or quadrigeminal lobes, which are of small size, is found the anterior part of the mesocerebrum, where a single median lobe, that of the third ventricle (the pineal gland?), is developed. The cerebellum is in the whole genus uncommonly small, consisting only of a transverse commissure connecting the corpora restiformia. The inferior lobes are absent or rudimentary, and developed near to the azygos lobes of the third ventricle. The posterior lobes appear to be absent, though the medulla oblongata is very broad superiorly and somewhat corrugated.

The structure is still more abnormal and singular in Myxine and Bdellostoma, where the brain is formed of several double divisions, amounting to four pairs of ganglia, from the anterior of which arise the olfactory nerves. A small median lobe belonging to the third ventricle is also present. The cerebellum is absent, if the last bifold division of the brain be not regarded as constituting it. The ventricles are also absent.

The brain of the Lepidosiren has been described in speaking of the *Amphibious Fishes* (see p. 150). It is considerably developed, being very similar to that in the naked Amphibia, especially the Proteidea; it has two lobes of the hemispheres, single quadrigeminal masses, a lobe for the third ventricle (*glandula pinealis?*), a narrow medullary band representing the cerebellum, and a bilobed pituitary appendage.

In the *Vermiform Fishes, i. e.* in Amphioxus s. Branchiostoma, the rudiments of the higher senses are indeed present, as we shall see further on, but the parts of the brain appropriated for the organs of smell and sight are chiefly absent. The brain is not at all to be distinguished from the spinal marrow; the latter terminates obtusely, and this part is to be viewed as the medulla oblongata, and as the only appreciable part of the brain which is formed in this the lowest of all the Vertebrata.

The *Spinal marrow* of Fishes does not exhibit nearly so many varieties as the brain. It is generally almost cylindrical; in the genus Petromyzon, however, and some other Fishes, *e. g.* in its posterior part in Chimæra, it is flattened out like a band and extensible; it

possesses a central canal. Occasionally it is very short, as in those Fishes, Orthagoriscus, Lophius piscatorius, that are provided with a short truncate vertebral column. The spinal cord, however, is usually very long, and exhibits generally a faint enlargement at the spot whence the nerves arise that supply the extremities.

As regards the *Cerebral nerves*, from ten to eleven pairs are distinguishable in the Osseous and true Cartilaginous Fishes, and they agree in the relations of their origin and course with those of the higher Vertebrata and Man.

The *olfactory nerves* are for the most part slender in the Osseous Fishes, and arise frequently by several roots (3 to 5), from the olfactory tubercle of which they appear to be the immediate continuation. In the true Cartilaginous Fishes they are often thick and short, as in Scyllium, or, as in the Rays, frequently long and slender; they arise from the hemispheres, being in connexion with their ventricular cavity when present, and form at their extremity very large ganglionic enlargements, comparable to the clavate extremities of the olfactory nerves in Man and Mammalia.

The *optic nerve* arises from the mesocerebrum (*i. e.* the lobi optici and that narrow part of the brain that surrounds the third ventricle in the Plagiostomi): in the Osseous Fishes each optic nerves takes its chief origin from the optic lobe of the opposite side; both nerves thus cross each other completely, so that the left passes to the right eye, and *vice versâ*; in the Herring, indeed (Clupea harengus), the optic nerve of the right eye perforates that of the left, passing by means of a slit through its fibres, without forming a chiasma. The optic nerves form band-like strips, folded longitudinally. In the Plagiostomi and the Sturgeon the optic nerves are united by a true chiasma, some fasciculi only crossing each other.

The *ocular nerves*, namely, the third, fourth and sixth pair, exhibit similar relations of origin and course to those of Man. The oculo-motor nerve issues of large size from above and behind the inferior lobes; the nervus patheticus from between the optic lobes and the cerebellum, and passes to the trochlear muscle. The delicate abducens nerve arises distinctly by two roots at some distance behind the inferior lobes from the basal surface of the medulla oblongata, and passes to the rectus externus muscle. The ciliary branch of the oculo-motor nerve appears to be absent.

The *fifth pair* (*n. trigeminus*) is in the Cartilaginous Fishes, at least in the Rays, the most largely developed nerve, but frequently, as in the Osseous Fishes, yields in respect of size and extent to the

system of the vagus. It arises behind the optic lobes laterally from the medulla oblongata by a series of roots, several of which admit of being traced to behind the fourth ventricle upon the Rhomboidal sinus. A large and small, or sensory and motor portion are found to enter into the composition of the fifth pair; several roots, *e. g.*, in the Sturgeon, the nervous fascicula of its third and fourth root do not pass into the ganglion, which is formed by other roots, and principally its first. Three main branches are to be distinguished, as in Man, namely, the orbitar, supra, and infra-maxillary; and besides these, a large posterior branch (*ramus opercularis*), which proceeds from the posterior root, and is principally distributed externally upon the opercular apparatus of the gills; it corresponds to the seventh pair, which does not appear to be present as a separate n. facialis.

The *auditory nerve* is always separate from the rest, and is far more strongly developed in the Osseous than the Cartilaginous Fishes; it takes its origin quite close behind the fifth pair, with which it is united by a branch of communication (*communicans faciei?*).

The ninth, tenth, and eleventh nerves, or the *glasso-pharyngeal vagus and accessory of Willis*, form a common system of nerves, with many roots and united origins; we must regard as its main branch the *branchial nerve* (*n. vagus*), with which the glosso-pharyngeal nerve is frequently united, while, however, the nervus accessorius is usually free and distinct from it. This vagus arises frequently by special ganglia that are occasionally much developed, forms also upon its roots ganglionic enlargements, gives three main branches to the last three gills and to the pharyngeal maxillæ, and passes then to the stomach and swimming-bladder. The twelfth cerebral nerve, or *hypoglossal* of Man and the higher Vertebrata, is absent in Fishes, owing to the want of mobility in their tongue; still, however, it has been recently described as occurring in the Sturgeon.

From the vagus and accessory nerve proceed the large *longitudinal* or *lateral nerves* of the Osseous Fishes, which run parallel with the lateral lines, and straight within the muscles, to the tail, and in their course enter into numerous communications with the spinal nerves. Another longitudinal nerve is frequently present, and is formed by two recurrent branches of the trigeminus and vagus; it passes through the supra-occipital bone, whence the nerve of either side runs near the points of the spinous processes and be-

neath the fin-rays to the tail. Varieties occur in these lateral nerves in the several genera of Fish.

The number of spinal nerves differs greatly in the several genera of Fish. The two to four pairs of nerves that succeed the most anterior pairs, usually give branches to the anterior extremities; the succeeding pair of nerves passes, in the Pectorales, generally to the posterior extremities or ventral fins; in the Jugulares these same nerves bend in the direction forward; and in the Ventrales they usually arise further back from the seventh to the tenth pair. In the Rays, which have such large pectoral fins, more than twenty pairs coalesce together in one trunk for supplying the same; about eight or nine pairs pass to the also large ventral fins.

A *Sympathetic nerve* occurs in all the Osseous and Cartilaginous Fishes, but is developed however in very different degrees. It runs upon either side of the vertebral column, where it forms more or less distinct ganglia, and enters into connexions with the spinal nerves. It forms plexuses with the vagus, which accompany the arteries, and are in several Fishes particularly distinct upon the stomach, swimming-bladder, and sexual organs. It unites at the base of the skull with the trigeminus and vagus, but unquestionably obtains twigs from the other cerebral nerves.

In the very anomalous Cyclostomi the cerebral nerves, for example, the ocular nerves, become simplified in their condition. In Petromyzon the abducens is absent, its elements being united with the oculo-motor, but the trochlear nerve is present. The nervus trigeminus appears to contain motor fibres, since it ramifies upon the muscles of the eye. A really distinct facial nerve also appears to exist.

The Myxinoidæ have only six pairs of cerebral nerves, the olfactory, optic, trigeminal, facial, acoustic, and vagus; the ocular nerves are absent with their corresponding muscles, the eyes being merely rudimentary.

Lastly, in Amphioxus all the cerebral nerves appear reduced to the trigeminal. There arises, for example, from the cerebral end of the spinal cord, a nerve somewhat thicker than the rest, that passes to the snout of the animal; it corresponds only to a part of the trigeminus, the greater portion of the head and sides of the mouth being supplied from the five succeeding spinal nerves. No branches of spinal nerves appear to pass to the gills.

The Cyclostomi exhibit the peculiarity of being destitute of a

proper sympathetic nerve, this being replaced by the vagus. It has been found in the Myxinoidæ that the vagus nerve is not limited to supplying branches to the stomach, but that upon the cardiac extremity of the latter viscus a single intestinal branch arises from both vagi, and passes along the whole length of the intestinal canal to the anus, and gives off those nerves of the organic system that are in other Fishes furnished by the sympathetic. The lateral nerve is present in Petromyzon, but is so short that it supplies with branches only the anterior third of the body.

ELECTRIC ORGANS.

It is in the class of Fishes (and according to what has been hitherto observed, in this class of animals alone) that we meet with certain species which are provided with remarkable apparatus, capable of producing, like an electrical machine or galvanic pile, electric shocks, and so constituting weapons whereby these animals both defend themselves and entrap their prey.

These *Electrical Fishes*, as they have been called, are some inhabitants of the sea, others of fresh water; and all the species known at present belong to the order Plagiostomi and to the soft-finned Fishes. All the known electrical Fishes are characterized by a smooth, naked, or scaleless integument provided with numerous mucous canals. Two genera are known to belong to the family of Rays. The European Electric Rays form the genus Torpedo, and comprise two species, the T. narke s. ocellata and T. Galvanii s. marmorata; to these may be probably added a third, described by L. Bonaparte under the title of T. nobiliana, and which is of very rare occurrence. The first two species exist chiefly in the Mediterranean and Adriatic seas, are in rare instances found in the Atlantic ocean, and occasionally roam as far as the English coast and the Northern sea. A peculiar species discovered by Ehrenberg and Hemprich, the T. Panthera, has been found also in the Red sea. A second genus, Narcine, very similar to Torpedo, is found upon the coasts of Brazil and India; three species of it are known.

From the family of Eels we are already acquainted with the Gymnotus electricus, that has been brought alive to Europe, and is met with in the inland seas and small tardily-flowing rivers of southern tropical America, especially in Colombia, Surinam, and Guiana.

The third electrical Fish, Silurus electricus, belongs to the family

of Sheat-fish, and occurs in the Nile, as also in other rivers in Africa, as the Niger.

In the European Electric Rays, the *Electric organs* are situated upon both sides of the head, occupying the space between the skull, gills, and pectoral fins, and covered only by the fascia and skin, through which they can be distinguished glistening both upon the dorsal and ventral aspects. The electric organ of one side is completely separated from that of the other, is of a flattened form, *i. e.*, compressed from above downward, obovate in contour, being broader in front where it extends nearly to the anterior edge of the body, but narrower behind where it abuts against the gills. Upon both the upper and under surface the electric organs present the appearance of a tessellated pavement, divided into irregular obtusely-angular, polygonal or hexagonal spaces. This depends upon each organ itself being formed of a great number of triangular or hexangular membranous prisms or columns passing into those of a globular form, and thus resembling basaltic crystallizations; they may be compared to so many galvanic columns; each column is divided into compartments by numerous transversely-disposed horizontal lamellæ, which can with difficulty be separated from each other. Each column is moreover separated from the others by a tendinous membrane or aponeurotic partition, which isolates the several columns in a manner similar to that whereby artificial galvanic batteries are carefully isolated by lateral glass rods. The number of these columns differs in individuals of the same species, and probably according to their age; in young specimens only some hundreds may be counted, while old animals, which attain a length of four feet, number above a thousand. Upon the posterior edge of the galvanic apparatus lesser rows of columns are to be observed; these are probably in a nascent condition. Each column may perhaps contain 150 to 500 plates or septa, that may be compared with the metallic plates of a galvanic pile; the depth of the columns and the number of their contained plates (?) varies according to age and the position of the part itself, the middlemost columns being the deepest (six to seven lines), while those upon the edges are more depressed, and in small animals measure only about a line in depth. The partitions between the columns are composed of fasciculi of fibres, similar in character to elastic tissue. The transverse plates or septa consist of a very thin and delicate prolongation inward of the fibrous membrane composing the intercolumnar partitions, which forms the basement membrane, invested upon both its free surfaces

with layers of epithelium. In the intervals between the septa is found some fluid. Upon the septa themselves may be recognised the terminal plexuses of vessels and nerves, those of the latter organs resembling the terminal plexuses within the substance of voluntary or transversely striated muscles. The electric organs, taken as a whole, are very rich in vessels and nerves. Upon either side they are supplied by four large nervous trunks, one of which, a branch of the trigeminal nerve (*n. electr. trigemini*), is distributed specially upon the most anterior part of the electric organ, while the three other trunks are given off by the vagus; the most anterior of these is the largest, and much more developed than the branch of the fifth; the posterior is the smallest. The origin and mode of distribution of these branches offer to our notice several remarkable peculiarities. Thus the *n. electricus trigemini* arises, along with the inferior maxillary branch, deeper than the remaining roots of the fifth pair from the medulla oblongata, and appears to correspond to the lesser or motor root of that pair of nerves. The branches proceeding from the tenth pair or n. vagus, pass to the electric organs between the branchiæ, and give off alternate twigs to them. The branchial branches are furnished with ganglionic enlargements containing ganglionic corpuscules, but these are absent upon the far thicker fasciculi of the electric nerves. It appears that these motor fibres, which here reach their maximum development, correspond to the accessory nerve of the higher Vertebrata.

The structure of the electric organ is in Narcine very similar, but here its shape is the reverse of that in Torpedo, being narrower anteriorly; the nervous branch corresponding to the *r. electricus nervi trigemini* is much more feebly developed.

In the *Electrical Eel* the organ in question is situated in the tail, which, from the very anterior position of the anus, is so large in this animal as to exceed more than a quarter the length of the whole body, and is in great part filled up by the very largely developed electric apparatus. This is divided into two detached parts and a single one consisting of two that have coalesced: the first are situated laterally and more toward the upper surface, the last inferiorly, and the extent of all three organs closely accord with that of the caudal fin. Each of the two lateral organs is invested by a tendinous membrane, and glimmers through the external integument; superiorly they abut against the muscles of the back, inferiorly against the muscular system of the caudal fin; posteriorly they run to a point. The inferior electric organ is situated above and between

the muscles of the caudal fin, and is also invested by an aponeurotic covering: it resembles in form a three-sided prism. The internal structure of the electric organ is essentially similar to that of the Torpedo, with this difference only, that the columns lie horizontally upon each other, instead of standing perpendicularly. They resemble a row of horizontal bands, are much shorter than in the Electric Rays, and their septa are placed perpendicularly, owing to the position of the columns. The number of the septa admits of being only proximately reckoned; in an adult Electrical Eel there may be perhaps several millions. The nerves that enter these organs in the Eel are all spinal nerves; neither the cerebral nerves nor the lateral nerves giving branches to them. The number of nervous trunks amount always to above two hundred, and from these sensitive branches pass off also to the integument. It would appear, too, that the anterior or inferior motor roots of the spinal nerves, whose branches are distributed to the electric organs, are more strongly developed.

In the *Electric Silurus*, with the more minute anatomy of which we are unacquainted, the electric organs extend immediately beneath the integument from the fore part of the head and the branchiæ to the anal fin. An external and an internal organ may be distinguished, which receive their nerves partly from the n. vagus and partly from the spinal nerves.

We know now, from the numerous experiments that have been performed, principally in Europe, by eminent philosophers upon living specimens of Gymnoti, that the electricity generated in the apparatus of these animals can be discharged by the voluntary exercise of their nervous influence, and that what is called animal electricity is perfectly analogous to that which is produced by the Leyden jar or voltaic pile. Some experimenters have gone so far as to succeed in obtaining from the Gymnotus an electric spark; aberrations also of the magnetic needle have been observed, and it is probable that heat also is developed, during the discharge. The Electric Eel is capable of producing the most violent shocks, sufficient indeed to stun and throw down men and horses.

ORGANS OF THE SENSES.

Organs of Vision.

The Eyes are generally developed in Fishes, and provided with all the parts that enter into their composition in the rest of the Vertebrata. They are lodged in a cartilaginous or bony orbit, imperfectly closed. The external integument becoming thinner in texture and transparent, forms usually around the eyes a shallow circular fold, beneath which muscular fibres may be frequently seen to pass, forming a kind of sphincter. In some instances the integument forms a transparent lamina which is continued simply over the surface of the eye, as in Fishes of the Eel kind, Ammocœtes and others. Not unfrequently an anterior and posterior *plica semilunaris* may be distinguished, as in Clupea, Scomber, Salmo, but particularly in the Sharks, where a true nictitating membrane exists; this, however, being wanting in the genera Scyllium and Acanthias. The Sharks possess also free eyelids, which in the Rays are soldered together.

The *Sclerotic* is usually dense and cartilaginous, or actually formed of thin bony plates, which in many large Fishes, as in Xiphias, coalesce to form an osseous shell, having an opening left posteriorly for the passage of the optic nerve. In front of the sclerotic is inserted the very flat *Cornea*, which is usually thickest at its margins. The *Choroid coat* is usually separated from the sclerotic by a loose mass of adipose cells, and consists frequently of two widely separated layers; the outer of these, or the pigmentary, is of a silvery lustre in the Osseous Fishes, and consists of very delicate fibres, which almost resemble under the microscope needle-shaped crystals; it is continued in front to form the iris, which encloses a pupil that remains probably always round and immoveable. The inner layer is very highly vascular, and covered upon the internal surface by black or purple-colored pigment. Between the two layers of the choroid is situated in many Osseous Fishes what is called the vascular gland, which will be described more minutely further on. In the choroid of the true Cartilaginous Fishes (Plagiostomi) a layer of black pigment is placed externally, and internally a tapetum of metallic splendor. The ciliary body is, for the most part, feebly developed. In the Sharks the ciliary processes are most distinctly formed, but, though less so in many of the Osseous Fishes, they still

may be proved to exist. The Rays, *e. g.* Torpedo, exhibit a peculiar disposition of the pupillary margin, for golden-colored processes, shaped like palm branches, depend from the iris, and are capable of closing the pupil like a curtain.

The *Optic nerve* in Fishes is generally formed of plicated laminæ, which can be unfurled from each other like the vanes of a fan. It perforates the sclerotic obliquely, and at a distance from the central axis of the eye. The point of exit for the retina is a round opening, frequently, however, an elongated slit, from which the nervous tunic of that membrane expands. The latter exhibits the same component parts as in the remaining Vertebrata, such as a strongly developed racemose or papillary layer arranged in a peculiar manner.

The *Crystalline lens* is of large size, perfectly spherical, and enclosed within a thick capsule; it usually protrudes through the pupil, and approaches, like the iris, very close to the cornea, so that the posterior chamber of the aqueous humor is completely wanting, and the anterior very small, containing only a very slight quantity of that fluid. The lens consists, as in other animals, of peculiar fibres, which are united by toothed edges, like the sutures of the cranial bones. The *Vitreous body*, flat, and having the lens deeply imbedded in it, contains a small quantity of thin fluid.

The eye of a Fish, when most perfectly constructed, presents always a very flattened form of bulb and a short axis; owing to the watery medium in which they live being denser than that of air, the vitreous and aqueous humors appear to be present in smaller quantity, while the lens is more dense and spherical, so as to bring the rays of light to converge at a shorter focus. But besides these general, other special peculiarities occur in the structure of the eye-ball in Fishes. Thus in Pleuronectes both eyes are placed asymmetrically upon one side. In Anableps tetrophthalmos the cornea of each eye is divided by a transverse band, and is thus rendered double along with the pupil, while the other parts remain single. The size to which the eyes are developed varies greatly; thus they are largest in many Osseous Fishes, and particularly so in the Plagiostomi, where, as in Priacanthus, they are of remarkable magnitude, and still more so in the rare Pomatomus telescopium, which lives in the greatest depths of the Mediterranean sea. The eyes are generally small in those Fish that bury themselves, as the Eels and Cyclostomi, in mud and sand. There are Fishes also with very small and rudimentary eyes, *e. g.* Silurus cœcutiens and Apterichthus

cœcus. The eyes are in a still more rudimentary condition in the remarkable, and in many respects anomalous, family of Myxines among the Cyclostomi, which comprises some species that live as parasites upon the internal viscera of Fish, although others are also met with in a free state. The most imperfect state of development is that presented by the Myxine, where the eye is not even visible externally. It consists, in fact, of nothing else than a small bulb, covered by muscles, but which contains a nerve, and internally a transparent nucleus that may be compared to a vitreous body. The rudimentary eye is larger in Bdellostoma, in which it projects somewhat above the surface, and is covered by a thin prolongation of integument; it is enclosed in a spherical cushion of fat, through which passes the delicate optic nerve; several ocular tunics are distinguishable, which probably contain internally a transparent nucleus. The lowest stage of structure appears, however, to exist in the eye of Amphioxus; for here we find, as in many of the Invertebrate animals, only a couple of pigmentary spots, without, it seems, any organs for intercepting the light in its passage through the eye; they receive, however, a delicate nervous twig from the cerebral end of the spinal cord. The eyes are also but slightly developed in the Amphibious Fishes, and are devoid of eyelids and muscles; in the small bulb, however, we may distinguish a cornea and a small lens, while a delicate optic nerve may be also observed.

In many Fishes peculiar structures are superadded to the organs of vision. To these belong the *Choroidal glands* of the Osseous Fishes. Between the silver-colored and the internal plate of the choroid there is situated, as already alluded to, in many genera a red vascular mass, which, upon closer examination, is found to consist of a plexus or rete mirabile of vessels, formed by tufted ramifications of arteries as well as veins; these belong to what is called the amphicentric system of retia mirabilia, or that with double arterial and double venous vortices, and are connected with the vessels of the accessory branchiæ. Those genera which do not possess the latter organs, as Silurus, Pimelodus, Cobitis, and Muræna, have no choroid glands. The choroid, indeed, in all the Vertebrata is properly formed of retia mirabilia, but these are made up by the radiating distribution of arteries and veins from a single centre. In the Carp this vascular gland is much developed.

A still greater peculiarity occurs in many Osseous Fishes, as the Pike, and in the Sturgeon among the Cartilaginous. In all these Fishes, at the point where the optic nerve enters the longitudinal

slit, we find what is called the *falciform process;* this is a fold of the choroid invested by black pigment, that passes through the above-mentioned slit and the substance of the vitreous body, and is inserted into the side of the capsule of the lens. A filament of the ciliary nerve frequently accompanies it, and dilates into a pear-shaped knot forming the *pyriform body* or *campanula Halleri*. Occasionally, as in Muræna Conger, two falciform processes have been observed, an anterior and a posterior one, which hold the lens between them like two poles. These structures, such as the falciform process, which reminds us of the pecten in the eye of Birds, are wanting in the Plagiostomi and many Malacopterygii, *e. g.* the Carp.

The bulb of the eye is but slightly moveable in Fishes. In the Osseous Fishes it is attached to the orbit by a short ligament near to the insertion of the optic nerve; in the Plagiostomi it stands upon a moveable cartilaginous stalk, which articulates with a short process of the sclerotic. Four straight and two oblique muscles move the eye, and between them we find some adipose and cellular tissue. In the Bdellostoma the rudimentary eyes are entirely destitute of muscles, which in Petromyzon among the Cyclostomi are present in their usual number and position.

Organs of Hearing.

In the structure of the organs of hearing in the class of Fishes we meet with an interesting series of gradations, ranging from the lowest and simplest stage, wherein their structure resembles that of the Invertebrate animals, to that which exhibits a combination of parts corresponding to some one or other of the more highly organized Vertebrata.

The general arrangement of the auditory organs in the Osseous Fishes is as follows: the whole membranous labyrinth lies for the most part free within the cranial cavity, and adjacent to the brain, or it is only imperfectly and partially enclosed in bones, which have been already (p. 189) regarded as belonging to the system of temporal and occipital bones. These cavities are, as it were, lateral continuations of the cranial cavity, and are, like the latter, often filled up by a lax cellular and adipose tissue containing freely floating drops of oil. In cases where the auditory ossicles (which we shall presently describe) of the membranous labyrinth are of very large size, the cavities for containing them are dilated into a bladder-like form, as in Gadus, Sciæna, and in a lesser degree in Perca and

others. The external coverings, namely, the skin and muscles, are continued over the organs of hearing as well as over the whole skull, so that the sonorous vibrations propagated in the water have no special or direct access to the auditory apparatus. Still, however, we may regard as external meatuses or conductors of sound certain membranous intervals in the skull resembling fontanelles, and situated upon the crown of the head, *e. g.*, Silurus, Cobitis, Clupea, &c. It is very rare to find, as in Lepidoleprus, an infundibuliform canal, comparable to the external auditory meatus, and invariably situated above the external branchial fissure, where it opens upon the sides of the occipital bone and is there closed by integument.

The *Membranous Labyrinth* consists, 1*st*. Of the simple *vestibule;* this is a transparent sac, provided with nervous expansions, and of very varied form, which is loosely attached to the skull in the vicinity of the cerebellum, and receives the ampullæ of the semicircular canals. 2*d*. Of the *auditory sac* (*saccus vestibuli*), which, lying close upon the vestibule, is externally more or less detached, and internally always separated from the vestibule by a partition. Occasionally, however, it is united to the vestibule by a membranous commissure, lies further posteriorly, and is usually divided into a pair of chambers, which, like the vestibule, contain mostly auditory ossicles or calcareous parts, surrounded by the fluid of the labyrinth. 3*d*. Of the *arciform* or *semicircular canals;* of these an anterior and posterior canal are constantly found, both standing perpendicularly, and two of their crura usually opening together; lastly, an external horizontal canal. Toward the vestibule the canals are dilated into ampullæ, and their arched portions are not unfrequently received partly into the adjacent bones, to which they are fastened by cellular ligaments. The structure is similar in the true Cartilaginous Fishes (Plagiostomi); the labyrinth, however, is in them completely separated from the cranial cavity, and completely imbedded in a mass of cartilage, which is much harder where it is in contact with the membranous labyrinth. The sac and vestibule do not appear to be separate in these Fishes, though the labyrinth is elongated to form a flask-shaped duct leading upward and outward upon the middle of the occipital bone. In this situation are also placed either two or four openings, closed by membrane, and approximated to each other, which correspond to the two fenestræ, and have the external integument continued over them.

In the Rays, and some species of Sharks, we find four openings upon the skull, two for each ear; the posterior conduct only into the

cartilaginous vestibule, and correspond to the round fenestræ; the anterior are comparable to the oval fenestræ; between each of these openings and the external skin a membranous sac is placed, which is filled with a calcareous mass, and extends into the membranous vestibule. At their commencement we find a muscle arising from the integument, and serving to compress the two sacs.

The Plagiostomi have a pair of soft calcareous concretions (otoliths), composed of carbonate of chalk, appended to the walls of the sacs; the Osseous Fishes are generally furnished with three stones (lapilli), hard and dense as porcelain, and of very varied form; one of these is situated in the vestibule, two in the two chambers of the sac.

Manifold diversities occur in the form, number, and structure of these otoliths. Thus the porcelainic otoliths are frequently, as in Cyprinus, Gadus, Scomber, toothed at the edges, and are occasionally, as in Sciæna, Lepidoleprus, and others, of remarkable size.

The form, size, width, and mode of union of the semicircular canals, with their position also in the cranium, exhibit likewise remarkable diversities; while, *e. g.*, in Cobitis, they are situated quite free in the cranial cavity, the external and posterior canal, or only one of the two, are partly enclosed in the bones, or, as in the Pike, Orthagoriscus, the Sturgeons, and Chimæras, they are more or less surrounded by cartilaginous coverings; this, as has already been mentioned, is their condition generally in the Plagiostomi. The ampullæ are retained in their expanded condition by peculiar double-coned septa, upon which the auditory nerve expands; the expansions and terminal looped plexuses of this nerve may be very easily and distinctly observed under the microscope.

In many Osseous Fishes, but particularly the Ventrales, a most remarkable communication subsists between the swimming-bladder and the internal ear. The vestibule always gives off in the direction backward a canal which coalesces with that of the opposite side into a single reservoir (*sinus impar*); this latter is a pouch of more membranous texture than the vestibule: it is situated in the basilar portion of the occipital bone, bifurcates again in the direction backward, and forms constantly a round saccule placed between the first cervical vertebra and occipital bone, and filled with the fluid of the labyrinth; it is called the *sinus sphærici s. atria sinus imparis*. Three ossicles are placed near to the three most anterior vertebræ, and are connected to their transverse processes by joints and ligaments; they are of varied form; the most posterior, which is the

largest, corresponds to the *malleus*, and is appended by an unciform process to the swimming-bladder, the middle to the *incus*, the anterior to the *stapes*. The last-named ossicle may close the prevestibulum (*atrium sinus imparis*), and by pressure upon the swimming-bladder may be drawn apart from or pressed against it. Each prevestibulum is provided with a peculiar ossicle encircling it like a staple (*claustrum*). The auditory ossicles are found distinct in all the species of Cyprinus, in Cobitis, and Silurus, while in other Osseous Fishes they are wanting. The swimming-bladder is slit in front to form two ducts, which enter the vestibule.

As Fishes, at least the Osseous, are destitute of external auditory passages, sound in these animals must penetrate or be transmitted through the bones of the head to the labyrinth. The different membranous regions of the skull may indeed serve the function of tympanic membranes, and the swimming-bladder exert some similar office by exercising compression upon the fluid contained in the labyrinth.

The organ of hearing becomes remarkably simplified in the lower organized Fishes, and in this respect the Cyclostomi exhibit very interesting stages of development, which partly correspond to the fœtal structure of the auditory organs in the higher Vertebrata.

The organ of hearing in Petromyzon and Ammocœtes consists of a bony or cartilaginous part, and of a pair of hard, yellow, oval capsules connected with the skull, and enclosing, like a bony labyrinth, the membrane lining the same; between the two is placed a fibro-membranous layer. The membrane of the labyrinth consists of a small sac, which is divided into two symmetrical cells by an external groove that forms a fold projecting into its interior. Two wide, depressed, simicircular canals arise with ampulliform enlargements, and unite into a common opening which enters the vestibule. A single smaller, more rounded appendage to the vestibule corresponds to the auditory sac (*sacculus*) of other Fishes. Two branches of the auditory nerve pass to the supply of the ampullæ.

The structure of the auditory apparatus is still more simple in Myxine and Bdellostoma. It is situated, as in Petromyzon and Ammocœtes, in a hard ellipsoid capsule, the cavity of which resembles a ring, filled up by a similarly formed membranous labyrinth, within which the single semicircular canal is blended with the vestibule.

Otoliths are completely absent in the hearing organs of the Cyclostomi. Not a trace even of calcareous crystals can be detected

by the microscope; and this is the more remarkable, as these structures appear to occur generally in the auditory organs of the Invertebrate animals.

No vestige of an organ of hearing has hitherto been found in Amphioxus, so that we have an example among the Vertebrata of a creature completely destitute of the auditory function.

The Amphibious Fishes have a more complete organ of hearing. At least in Lepidosiren annectens a large labyrinth has been found with three small semicircular canals, and two great sacs containing otoliths, but without a trace of tympanic cavity.

Organs of Smell.

In all Fishes we find distinctly developed organs of smell. They consist of cavities situated at the anterior extremity of the snout, in front of the eyes, and beneath the nasal bones; they are bounded by the maxillary bones and vomer, present an elongated, oval, or round form, and open by two nasal apertures lying one behind the other; the anterior opening is occasionally, as in Muræna, lengthened out to form a short contractile tube; the posterior is in some instances removed to a distance from the first, and patulous. This is the general arrangement of these parts in the Osseous Fishes; the nasal passages are scarcely ever perforate throughout, as in the air-breathing animals, though in several species of Conger (as in the Amphibia that breathe by branchiæ) they are found to open internally beneath the upper lip. Minor peculiarities frequently occur in the structure of these organs, as in Lophius piscatorius, where the nasal cavities exhibit the form of two small bell-shaped sacs situated beneath the upper lip, and lined by folded mucous membrane. In the Plagiostomi the nasal depressions are very large, and can be closed by means of a membranous or cartilaginous operculum; they are placed inferiorly near to the angles of the mouth, and the operculum can be raised by muscles. The mucous membrane lining them is very vascular, provided with crypts that secrete a copious mucus, and disposed in exceedingly delicate and frequently very vascular folds. In some instances these folds radiate from a projecting middle elevation of the mucous membrane; more frequently, however, they arise like the teeth of a comb, in the form of ridges transversely directed, from the sides of a middle longitudinal fold; the transverse plications in the Plagiostomi are further provided with stellated folds upon their walls, in order to increase the extent of surface of the

mucous membrane; in other Fishes we even meet with tufted ramifications of the folds. The olfactory nerve usually dilates close against the nasal cavity of its side into a considerable bulb, or it forms, as in the Plagiostomi, an elongated knot corresponding to the chief mucous fold, and from this its branches proceed along the plaits of the mucous membrane and their subdivisions; frequently the olfactory nerve divides previously to this into several branches; a branch of the fifth pair passes also as an accessory nerve to the organs of smell.

Peculiar arrangements of the organs of smell are exhibited by the Cyclostomi, for in them the nasal cavity is single, but the two families composing this order differ in some respects from each other. In that family to which Petromyzon and Ammocœtes belong, we find a single nasal aperture or spiracle upon the head, which leads into a rather narrower nasal canal, that finally expands into the single nasal cavity lined by plicated mucous membrane; upon the bottom of this cavity is found a more membranous, contractile flask-shaped cœcal pouch, an appendage that does not communicate with the pharynx, but with the nasal cavity by a small opening.

In the second family, the Myxinoidæ, the palate is perforated in a remarkable manner, and in Myxine there is a broad naso-palatal opening. In Bdellostoma the lesser naso-palatal opening lies above a fold of the mucous membrane at the extremity of the palate, and leads freely into the naso-palatal duct. The external nasal aperture communicates by means of the nasal tube formerly described as composed of cartilaginous rings, with the naso-palatal opening.

As regards the Amphibious Fishes, typified by the Lepidosiren, the two species of this genus at present known appear to comport themselves differently as regards the structure of the olfactory organs. In L. annectens the nasal depressions are imperforate; the olfactory nerve passes through a cartilaginous ethmoidal plate to the organ of smell, which always consists of a sac lined by transversely-plicated mucous membrane; an external opening is merely found beneath the upper lip. L. paradoxa seems to agree completely with Siren and Proteus among the Amphibia, for in it we find a posterior opening upon the internal side of the upper lip, and the mucous membrane disposed in folds.

The organ of smell, recently discovered in Amphioxus, is of a still more simple kind. It consists of a single depression, situated to the left side, which terminates freely in a small cup, and rests directly upon the central axis of the nervous system. It presents upon its

mucous membrane a glistening epithelium; it does not perforate the mouth, but terminates in a small blind pouch, having its mucous surface increased by folds.

Organs of Taste.

The tongue is absent in Fishes, and the anterior part of the lingual bone, which frequently supports teeth, exhibits neither in its external condition, nor in the distribution of its nerves, any analogy with the tongue of the other Vertebrata. In cases where the glosso-pharyngeal nerve is developed, as in the Sturgeon, it only gives twigs to the branchial arches and palate, which last is in Fishes probably the seat of the sense of taste. No branch arises from the fifth pair that can be compared to the lingual nerve.

That the gustatory function is probably seated in the palate, appears to be confirmed by the fact that in many Fishes, *e. g.* the Cyprini and in C. carpio, peculiar organs, richly supplied by nerves, are developed in that situation. In the Carp there is found at the base of the skull, in front of the excavated plate, which is met with on the body of the sphenoid, and supports what has been called the Carp's stone, and also in front of the pharyngeal jaws, a single white spongy mass, which receives numerous large branches from the glosso-pharyngeal nerve, and is possessed of such a high degree of irritability, that it becomes erect and turgescent upon mechanical and chemical stimulants being applied. This organ forms a very broad cushion immediately above the inner edges of the branchial arches.

Organs of Touch.

As organs of touch in Fishes, we must unquestionably regard the beard-like filaments that occur in many, as in sundry species of Cobitis, upon the chin and at the commencement of the mouth; they receive large branches from the fifth pair of nerves.

DIGESTIVE SYSTEM.

If throughout the class of Fishes we have seen the hard parts of the body assuming the greatest variety of structure as compared with those of other Vertebrata, so also in the *Teeth* that form the armature of the jaws, and other facial bones, shall we find the same

character to hold good in a pre-eminent degree. For not only do the dental organs vary in their more minute structure, but in number, form, situation, mode of attachment, and development, so that it is by no means easy to give a general survey of these peculiarities without describing them in the several families and genera.

All Fishes, with but few exceptions, are provided with teeth. In some, however, they are completely wanting, as in the Sturgeon, the genera Aodon, Syngnathus, Amphioxus, while others, as the Salmons, exhibit them upon all, or nearly all, the bones that generally support teeth. These bones are chiefly the intermaxillary and inferior maxillary, the palatal bones, the vomer, lingual bone, and branchial arches; also, though rarely, the superior maxilla, instances of this bone supporting teeth occurring, at least in the Osseous Fishes, only in Salmo, Clupea, and Murænophis; it is rare too for the pterygoid bones or the sphenoid to be, as in Sudis, armed with teeth. It is very uncommon for a broad dental plate to be present upon the occipital bone, the base of which in the Carp exhibits for this purpose a broad process with a concave surface. Teeth are in some instances met with only upon the pharyngeal bones, which are peculiar bones situated behind the branchial arches, and found both above and below the entrance to the pharynx, their number varying from one to six. The jaws in the Cyprini are edentulous, but there are teeth upon the pharyngeal maxillæ, which in the Carp exhibit broad molar-like crowns; other forms occur in other Cyprini, so that the several species may be partly distinguished by the varieties of the pharyngeal teeth. In other genera, such as Labrus and Scarus, the true as well as the pharyngeal jaws are furnished with teeth. Occasionally, as in the Lampreys, and in the genus Helostomus among the Osseous Fishes, the teeth are chiefly fastened to the lips. As regards, however, the situation of the teeth, the Rays and Sharks, and then the Chimæra, agree most with Man and Mammalia, for in all three the teeth are limited to the two arch-shaped maxillæ. A singular position for the teeth occurs in the Saw-fish (Pristis), where, besides the jaws, the bill-shaped process prolonged from the cranium is armed upon either edge with a row of pointed teeth, giving it the appearance of a double saw.

Diversities occur, moreover, in reference to the mode of attachment of the teeth in Fishes, such as are met with in no other class of Vertebrata. In some instances the teeth are inserted in cavities or distinct sockets, as in the weapon of the Saw-fish. Some teeth have their basis hollow, and implanted like the claws of a cat upon

bony projections, which arise from the bottom of the dental socket; this is the case with the incisor teeth of Balistes, that thus present a double gomphosis. There is frequently a slight anchylosis of the bases of the teeth to the walls of the alveolar cavity, as in Sphyræna, Acanthurus, and others. In the majority of cases an actual fusion of the bony substance of the jaws with the sockets of the teeth exists. Before, however, this anchylosis is completed, the tooth has been united to the jaw by ligament. Occasionally, as in the posterior teeth of Lophius, the teeth are fastened by elastic ligaments to the maxillæ, and so disposed that during deglutition they yield downward and backward so as to offer no obstruction to the passage of food, and again spring up into their usual erect position when the pressure is removed. The teeth of the Sharks, for the most part bifurcated inferiorly, are attached by ligaments to the partly ossified edges of the maxillæ. A very curious mode of attachment is exemplified by the teeth of the Eagle-Ray (Myliobatis), in which the flat hexagonal teeth are united by suture to a series of quadrangular pieces.

The form of the teeth is likewise very varied, being either conical as in most Fishes, flat, prismatic, or cylindrical. The conical kind are frequently very numerous, and in such cases so small as to appear like papillæ, and may possibly serve only as instruments of touch; in other instances they are longer, almost filamentary like bristles, and divided at their apex into two or three prongs; in many Fish, *e. g.*, in Trichiurus, they are provided at their points with hooks; they are frequently largely developed, for instance, the canine teeth of many Carnivorous Fishes, *e. g.*, the Sea-wolf (Anarrhicas Lupus). The incisor teeth also may be perfectly flattened like those of the human subject, as in Sparus sargus, L., and behind these stand short cylindrical teeth with rounded flattened crowns. Such flattened teeth differ both in form and size; their plates are cylindrical, elliptical, elongated, triangular or quadrangular, semilunar or falciform; the same flat, tessellated kind of teeth are found in the jaws of the Saw-fish. It is not rare for the teeth upon the two jaws to differ, as in the Sharks, where the teeth that are destined to rise up and replace the others when they fall out, form numerous rows lying like tiles one over the other upon the inner walls of the maxillæ.

The number of the teeth ranges from one to so many that they can be scarcely counted. Thus the Myxinoidæ (*e. g.*, Bdellostoma, Myxine) have only one single slightly-curved tooth on the palate.

The genera Ceratodus and Ctenodus have two teeth above and two below, while in Chimæra we find four superior and two inferior teeth.

The substance of which the teeth in Fishes is composed presents very different characters. The teeth of the Cyclostomi belong to the category of epithelial structures, or horn-tissue. The dental plate upon the occipital process of the Carp consists of a peculiar brown, semitransparent tissue, harder than the substance of the horny teeth of the Lampreys. In most Chætodonts the teeth are delicate, flexible, and elastic, and composed of a yellow transparent tissue, this being the case also in the labial teeth of Helostomus. In most Fishes, however, the teeth consist of Osseous substance, slightly denser than that of the jaws to which they are attached. Occasionally, as in Exocœtus and Echeneis, the substance of the teeth is uniform throughout, and not invested by a layer of denser texture. In others, *e. g.*, the Sharks, the tooth is covered by a dense transparent enamelloid substance; it is not, however, true enamel, but the proportion this substance bears to the rest of the tooth may be determined from the larger quantity of earthy constituents which it contains, the finer division and more parallel arrangement of its calciferous tubules. In Sargus and Balistes the peculiar osseous substance of the tooth is still harder, and covered by a thick layer of a denser substance, which differs little from the enamel of the higher Vertebrata. In Balistes also, and some other Fishes, we find a third layer superadded, that may be compared to the cementum of the Mammalia. In Scarus there is found even a fourth material, forming a very dense ivory-like layer upon the periphery of the tooth. In Fishes the small dental tubes (*canaliculi chalcophori*) are extremely distinct, and the microscopic structure of the teeth in general exhibits manifold modifications, which can not be further discussed in a work like the present.

The *Intestinal Canal* offers for consideration a number of diversities, which, like those of the teeth, can not be well described without entering into the anatomy of the several orders and genera.

The *Cavity of the Mouth* in the Osseous Fishes opens externally upon either side through the branchial fissures. Peculiar tooth-like processes stand out upon the internal edge of the branchial arches, and protect the fissures between the latter from the intrusion of food. The pharynx commences in the Osseous Fishes immediately behind the pharyngeal teeth, and there is found surrounding it in this situation a strong sphincter-like muscle; an œsophagus may be

continued from it as a short infundibular tube, but frequently only its commencement, or the pharynx, is developed, which then forms an extremely short canal, which is surrounded throughout its entire length by an annular layer of muscular fibres. There being no larynx in Fishes, the œsophageal intestine is attached to the vertebral column and pericardium by cellular tissue. A dense mucous membrane, frequently beset with tubercles and papillary projections, lines the œsophagus, and is usually disposed in coarse longitudinal folds, that are frequently continued into the stomach.

There are Fishes in which the intestinal tube is continued from the pharynx without any indication of a gastric enlargement or of convolutions, and with which no organ of secretion is connected, except the liver. It is interesting to commence with such simple structures and ascend to the more complex.

The greatest departure from the structure of the Vertebrata generally, and also from that of Fish, is furnished by the anomalous genus Amphioxus. Its internal branchial cavity is prolonged into a narrow canal, the œsophagus, which is continued into a much wider intestine. The latter is always of a green color, as is also a cæcum that is developed from it. The green fluid or gall is secreted by a glandular layer situated in the parietes of the intestine, and which, as in many Annelides, has not yet freed itself from the intestine in the form of a more highly organized parenchymatous liver. The green-colored portion terminates by an abrupt line, and then the walls of the intestine present, as do those of the cæcum also, their natural translucency and delicate texture. The intestinal sac exhibits, upon the whole of its internal surface, a glistening epithelium and an active vibratory or twinkling movement that hitherto has not been observed in any other vertebrated animal. This remarkable fish appears to be nourished simply by swallowing the microscopic animalcules met with in the sea-water. Nevertheless, excrements are extruded from the body of a dark color and stringy form.

Devoid of convolutions, and without any special dilatation for the stomach, if we except a slight increase in its width at one particular part, the intestine runs straight from the mouth to the anus in the Cyclostomi, *e. g.*, Petromyzon, in Myxine, where, however, it is wider, in Syngnathus, and in Chimæra, so that such is its condition in the most different orders. In many other Fish, as the Cyprini and Labri, in which the intestinal canal is long and spirally contorted, a special gastric dilatation is also absent, while in others that are furnished with smaller and insignificant convolutions, we meet with a well-defined stomach, as in Gasterosteus, Gobius, and some species of Blennius and Pleuronectes. In other instances the stomach is not developed directly in the course of the intestine, but to the side of the latter, and forms either an oval or spherical dilatation, as in Cobitis and Blennius viviparus, or passes from this form into that of a retort, examples of which may be seen in the majority of Bony Fish, *e. g.* the Salmon. The cardiac portion of the stomach is frequently extended into a more or less elongated cæcum, *e. g.* in the Eel, in Gadus, Scomber, Clupea, and many other Fish, but more especially in Ammodytes tobianus. To the stomach, when present, succeeds the intestine properly so called; it makes either few or many convolutions, and is not unfrequently continued backward to form a thicker portion that may be regarded as the large intestine, the limits of this being defined frequently by a cæcal valve, as those of the pylorus are by a constriction. Beyond this point, however, the intestine frequently narrows toward the cloaca, as in many Carps and Salmons, and it is not rare for the valve to be wanting. Occasionally a valve is found upon the cardiac orifice of the stomach. Anomalies also occur of a peculiar kind, *e. g.* in Lepadogaster biciliatus; for here to a short narrow pharynx succeeds a dilatation from four to five times wider, which occupies the greatest part of the ventral cavity, and represents at once both the stomach and the small intestine, while after it comes another bag of a more oval form, the large intestine. Applicable as they may so far appear, we shall find that in other cases the names of divisions borrowed from those of the intestinal canal in the human subject are not applicable to Fishes any more than they are to some of the naked Amphibia, and that it is better to adopt the terms oral, meso, and anal intestine, as expressing the regions of the body to which the portions of intestine may happen to belong. An equal amount of variety is displayed also by the mucous membrane lining the canal; thus it is often simply disposed in longitudinal folds, as in Pleuronectes, Silurus, Blennius, Cyclopterus, Petromyzon, or in zigzag folds, *e. g.* in several Cyprini, while in other Carps, and in Gasterosteus, transverse folds are observable, that are particularly developed in the Salmon-tribe, in the terminal portion of the intestine. Most Fishes, however, exhibit a very varied net-work formed by confluent longitudinal and transverse folds of mucous membrane. It is more rare for true papillæ, or tongue-shaped prolongations of the folds, to be met with, as in the Pike, and many species of

Salmon, Perch, and Flounder. Still, however, papillæ similar to those of the human subject have been found upon the smooth mucous membrane, *e. g.* in Mugil cephalus. The mucous membrance lining the stomach is usually soft as velvet, forms delicate reticulations, but is rarely provided with papillæ and projecting folds. Occasionally, as in Uranoscopus scaber, we meet with clusters of secerning follicles within the intestinal cæca.

The structure of the intestinal canal in the Plagiostomi, or Rays and Sharks, merits a separate consideration, though an extremely near approach to it is made by the Sturgeon. They have a short but wide œsophagus, continued into a large oval stomach that is furnished with muscular layers; to this wide gastric cavity succeeds a narrow intestiniform canal, which may be viewed either as the cardiac portion of the stomach or the duodenum; in its place we find, in the Sturgeon, a larger loop of intestine. In some instances; and perhaps these are very rare, there would appear to occur, *e. g.* Squalus maximus, a more compound kind of stomach than is usually observed in the class of Fishes. In this Shark the stomach is parcelled out by constrictions and inversions into several divisions, the first of which is separated from the œsophagus by two large triangular valves, and the fourth division by a strong internal pyloric projection from the remainder of the intestine. This latter, in the Sturgeon and Plagiostomi, is very wide, and (with some modifications peculiar to the different species that can not be considered in this work) distinguished by a singular structure that is developed in its interior. The mucous membrane here projects in the form of a plate that winds spirally like a staircase as far as the very anus, and in this way the extent of the absorbent surface of the intestine, which throughout its course is very short, becomes much increased. Posteriorly where it is continued into the cloaca the intestine narrows, and presents to our notice, as in Squalus canicula, a small cœcal appendage.

We have yet to consider, as occurring in many Osseous Fishes, a peculiar set of cæcal canals developed from the pylorus, and that are known under the name of *Pyloric appendages*. These cæca were formerly viewed as the analogues of the pancreatic gland, which is actually absent as a true parenchymatous viscus in many Fishes. The propriety, however, of thus interpreting the pyloric appendages is rendered doubtful by the fact, that these organs have been found in Fishes, *e. g.* the Trout, in which there exists also a compact pancreatic gland. The pyloric appendages are invariably absent in

those Fishes that do not possess a perfectly-formed stomach, as in the Cyprini, Gobii, and Syngnathi, but they are wanting also in other Fishes with that organ properly developed, *e. g.* the Pike. As a rule, however, they are present in the latter instances, and vary exceedingly in number. It is very rare to meet with a single cæcum, as in Ammodytes tobianus; there are sometimes two, as in several Plaice (Pleuronectes), while other species of this genus have, like the River Perch and Common Loach, three of them; four occur, *e. g.* in Mugil cephalus and Cottus gobio, five in Salmo spirinchus, six in Perca lucioperca and in Sargus annularis, seven to eight in Trachinus Draco, ten to thirty or more in many Salmons and Herrings, and from eighty to ninety in the Salmon; but these appendages are most numerous in Gadus and Scomber, for in the Mackerel about two hundred may be counted. These cæcal appendages either encircle the pylorus, or occupy longitudinally a greater or less extent of the commencement of the intestine. In some of the Fishes already named, as in the Herring and Mackerel, the cæca begin to divide, and two of them open by a single aperture into the intestine. In Gadus Lota two or three of the twenty cæca unite to form a common trunk; in the Tunny (Scomber thynnus) they divide so as to form tufts; in Cyclopterus, Gymnotus, and others, those of the second row are further subdivided. In the Sword-fish (Xiphias gladius) the finely-divided cæca are united by cellular tissue, and invested externally by a common membranous covering, so that the whole organ resembles a gland. In the Sturgeon, indeed, the pyloric appendages, by being still more subdivided and again united, acquire the form of a true parenchymatous pancreas. The mucous membrane lining the pyloric appendages exhibits a reticulated appearance similar to that of the intestines. No nutritive matter is found in these cæca, but only some slimy fluid; chyme, however, has been frequently observed in them. Their function is in other respect highly problematical, though it is possible they may secrete a fluid analogous to the pancreatic juice.

In the Osseous Fishes, *e. g.* the Eel, Pike, Trout, we constantly find a true compact and glandular *Pancreas* of a yellowish-white color, which sends from two to three excretory ducts into the intestine; these are frequently accompanied by the biliary ducts, but are so closely attached to the latter as to be easily overlooked. In the Sturgeon a second kind of pancreas has been described as also existing. The Rays and Sharks possess a lobulated and reddish-yel-

low pancreatic gland, more analogous to that of the higher Vertebrata.

The *Salivary glands* appear to be very generally absent in Fishes, or their place to be occupied by an increased development of the mucous glands of the mouth. A small cylindrical and lobulated gland has been found in Lophius piscatorius, lying immediately beneath the integument posteriorly to the wide branchial opening; it would appear to be analogous to a salivary gland, from the fact of the branchial cavity of this Fish serving as a receptacle for its prey.

The *Liver* is in general of large size, and colored in different shades of red, brown, or yellow. It is frequently very simple in form, and alobular, or often tongue-shaped, *e. g.* in Petromyzon, Syngnathus, Esox, Salmo, and, in a word, in the most different families. It is bilobed in Silurus, Blennius, Perca, Cobitis, and the Sharks, but trilobed in Gadus, Clupea, many species of Cyprinus, and in the Rays. In other species of Cyprinus, *e. g.* C. barbus, carassias, it is divided into a number of lobes united by narrow bands, and placed between the convolutions of the intestine. The biliary ducts do not usually unite into a single tube, but proceed together into the gall-bladder, or into the vesical duct. The gall-bladder is seldom wanting, as in Petromyzon, Cyclopterus Lumpus, and in Scomber Leuciscus. Its form is either elongated and pyriform, cylindrical, or spherical. Occasionally it is completely imbedded in the liver, and in many cases, as in Uranoscopus scaber and Orthagoriscus Mola, is of very large and disproportionate size compared to that of other Vertebrata. The gall-dust (*d. choledochus*), generally single, opens mostly in the vicinity of the pylorus, but sometimes at a part of the intestine remote from the latter, as in the Pike.

The *Spleen* appears to be either absent in several Fishes, or so small as to be readily overlooked, *e. g.* in the Cyclostomi and Lepadogaster. It is mostly of a reddish-brown color, small size, and very varied form; thus it is elongated in Blennius, triangular in the Pike, large, irregular, and slightly lobular, in Cyprinus and the Sturgeon, very large in many Sharks, and divided into lobes of unequal size, but united together. The liver and spleen do not exhibit the same symmetrical and regular position in respect to each other that they do in the higher Vertebrata; the greater portion of the liver frequently lies to the right, but very often to the left side, while the spleen is usually placed upon the right side, but often in the middle line above or behind the stomach.

The *Peritoneum* in Fishes invests the whole intestine, and is attached above to the pericardium, so as to form a kind of diaphragm or partition, though not one of a muscular texture; it also completely clothes the sexual organs, but not the kidneys. In some Fishes, as in the Plagiostomi, the Sturgeon, and Salmonidæ, a pair of openings are situated upon either side of the anus which lead into the cavity of the peritoneum, and allow the ingress of water to the cavity and its contained viscera. The intestine is seldom secured by a perfect mesentery, as is the case in the lower Fishes, *e. g.* Myxine, but this is usually effected only by some thin filaments or vasiferous bands. It is remarkable that during the embryonic existence of all Fishes a mesentery appears to be fully formed, but disappears at a later period by absorption. When a swimming-bladder is present, it usually opens into the œsophagus, but sometimes by a second orifice into the stomach.

In the genus Lepidosiren several peculiarities occur in the organs of digestion, and both spleen and pancreatic glands are absent.

ORGANS OF CIRCULATION.

To give a general description of the organs of circulation in the class of Fishes is attended with much difficulty, from the many peculiar varieties of structure which they present in the several genera and families. Still, however, we may attempt a general survey of the vascular system by first selecting a normal example of the Osseous Fishes, such as the Common Perch, and a Shark or Ray, as types of the Chondropterygians.

The principal or only heart in many Fishes is a *branchial heart*, in other words, a heart that is placed between the trunks of the branchial veins which it receives, and the trunks of the branchial arteries, which it gives off; it corresponds therefore to the right heart of Man and the higher Vertebrata, and is traversed by venous blood alone. The heart consists of one auricle and one ventricle, both of which are lodged within a pericardium, to the inner surface of which the heart is frequently attached, as in many Amphibia, by special filaments. In the Plagiostomi the pericardium communicates by openings with the peritoneum, so that it is bathed by the water brought through the apertures in that membrane, and already described as being situated near the anus. The heart is placed be-

tween the pharyngeal jaws and the girdle supporting the anterior extremities, and is small and angular in the Bony Fishes, but broad and flat in the Plagiostomi; it varies in size, and considerably also in weight relatively to the entire body, in different genera and species; thus Meckel has calculated the weight of the heart in the Ray at about $\frac{1}{300}$th, that of the Carp $\frac{1}{500}$th or $\frac{1}{600}$th, and in other Fishes $\frac{1}{1000}$ of the weight of the body. The auricle is generally much wider and its parietes thinner than those of the ventricle, above and somewhat behind which it is placed, while between the two cavities we find mostly two, more rarely three, as in the Sturgeon, muscular valves. The thick and very muscular ventricle is characterized in most fishes by a peculiar structure, for it is composed of two muscular layers so loosely connected to each other, that the external consisting chiefly of longitudinal fibres, may be separated, like a shell, from the internal, which is formed principally of transverse fibres. The contractile trunk of the branchial arteries arises from the anterior part of the ventricle by a strongly-developed oval enlargement, called the *bullus arteriosus*, which is formed of very powerful annular muscular fibres, and is likewise situated within the pericardium. Between it and the ventricle we usually find two valves, as in the Osseous Fishes and in Petromyzon; in the Plagiostomi and in the Sturgeon, however, several, from two to five, rows of semilunar valves are met with lying one above the other.

The ventricle discharges its blood through the aortic trunk into the gills. This trunk of the branchial arteries usually divides upon either side into four, as in most Osseous Fishes, or into five branches, as in the Plagiostomi; these becoming gradually more slender, run in a groove on the convex side of each branchial arch, and ramify upon the branchial leaflets. Delicate ramuscules return the blood into the trunks of the branchial veins, which are lodged in the same groove behind the arteries, being usually single, but rarely double; they run upward to the base of the skull and the commencement of the vertebral column, and here form a large circle of arterial vessels (*circulus cephalicus magnus*) which receives the branchial veins and gives off the arteries; posteriorly the single aorta arises from it, which sends first branches to the muscles of the branchial arches, to the mucous membrane of the mouth and pharynx, and to the upper end of the kidneys; very near to these branches and to each other arise a cœliac and mesenteric artery, the two branchial arteries for the pectoral fins, and some renal arteries. In front, or, as it were, from the most anterior branchial veins, the two large posterior and two

smaller anterior carotids arise from the arterial circle; slight varieties and peculiar arrangements of these vessels occur, but can not be investigated in this work. The posterior carotid supplies chiefly the opercula of the gills, the pseudobranchiæ or retia mirabilia, and muscles of the lower jaw, with blood. The brain receives its arteries, which are very small, from the anterior and posterior carotids.

After the aorta has supplied the liver, the intestine, the organs of generation, and the swimming-bladder, it runs within the canal formed by the inferior spinous processes of the vertebræ to the tail, and there gives off branches to the kidneys, the muscles of the trunk, and the pelvic extremities. The substance of the heart receives its blood directly from the branchial vein. The blood returning from the viscera enters partly into the inferior or posterior trunk of the vena cava, which lies below the aorta, and is usually single in the Osseous Fishes, but double in the cartilaginous; partly also into the hepatic veins, and from the two into a large sinus-like expansion or contractile sac of the vena cava that opens into the auricle (being frequently of larger size than the latter), but is situated external to the pericardium. The blood also from the head enters the same venous sinus by two anterior venæ cavæ, which are expanded into sinuses upon the cranium; they also receive the blood from the branchiæ and anterior extremities. Between this sac of the vena cava and the auricle are found a pair of valves. The number of hepatic veins is subject to variety.

A large proportion of the venous blood of the posterior half of the body passes in Fishes from finer ramifications into trunks, that are again subdivided to form a portal system. We find, as in many Amphibia, a double portal system; one for the liver, which obtains its blood from the stomach, spleen, intestinal canal, and sometimes from the generative organs; the blood from these viscera usually entering by several smaller branches into different parts of the liver, but rarely uniting, before entering that gland, into a common portal vein. The second portal system belongs to the kidneys, which organs receive venous blood from the tail, partly also from the sexual organs and swimming-bladder; blood is also sent from this system to the venæ cavæ. The arrangement, however, of the two portal systems varies greatly, according to the species and genus.

Lymphatic vessels appear to be generally present in Fishes, and in some number; their parietes are thin and membranous; they are very wide, and form even large sacs and reservoirs, but are destitute of valves, and have no conglobate glands or plexuses developed in

their course. They consist partly of lacteals that proceed from the intestinal canal, and partly of ordinary lymphatic vessels. When filled by injection with quicksilver, they cover the vascular trunks, the veins for instance, completely. They unite in the anterior part of the body, and pour their contents by two trunks into the anterior, and partly also by several branches into the posterior, venæ cavæ. The main trunks (*ductus thoracici*) proceed from lymphatic sinuses near the cardiac orifice of the stomach, analogous to the *cisterna chyli*. Several lesser lymphatic branches would appear to lose themselves in venous ramuscules.

Peculiar *Caudal* and *Cranial sinuses* and a special *system of Lateral vessels* were recently discovered in Fishes, and seem to belong to the lymphatic system. Beneath what has been formerly described (p. 185) as the lateral or mucous canal of the integument, we find another sinus-like canal that is filled with a clear and limpid lymph, and communicates with a number of adjacent branches, all pursuing a subcutaneous course, and forming a ring of vessels around each scale, so that the body of Fishes is completely intersected by this net-work. This system of vessels communicates with a peculiar caudal sinus, that is placed in many Fishes, as the Eel, in the same situation as the caudal heart, which will presently be described. This sinus is double, the divisions lying close upon either side of the flat rays supporting the caudal fin; but both of them communicate by means of a transverse canal that passes through an opening in one of the fin-rays. The sinus varies in size, and passes into the caudal vein, being there provided with a valve. It is invested by a strong fibrous tunic, and contains a clear lymph; whether it is endowed with powers of expansion and contraction has not yet been determined. A similar sinus has been observed upon either side the cranial cavity external to the jugular veins; it is pear-shaped, smaller than the caudal sinus, and appears to be contractile. The occurrence and position of these reservoirs remind us very much of the lymphatic hearts of the Amphibia.

The *Blood* of Fishes is, with one single exception, of a red color, and contains almost always oval, flat, and slightly biconvex *corpuscules;* those in the Plagiostomi are distinguished by their great size, and in this respect, as well as in their form, agree with those of Frogs; in the Osseous Fishes they are smaller. The Cyclostomi, at least Petromyzon, have, however, circular biconcave corpuscules resembling the human, but larger.

The greatest departure from the circulatory system of the rest of

Fishes is exhibited by the Amphioxus or Lancelet. The blood is quite colorless, and has not as yet been found to contain any corpuscules. The hearts, however, are numerous. There is found, 1*st*. An *Arterial Heart*, a tube of uniform thickness placed below the branchial thorax in the middle line where the branchial artery in other Fishes is situated, but without any trace of a pericardium; it is continued for a short extent backward as far as the end of the œsophagus, where it makes a curve and joins the tubular hearts of the venæ cavæ. 2*d*. The *Bulbilli* of the branchial arteries, which, given off regularly from the arterial heart, are continued into the angles between each pair of branchial arches, and represent the commencement of the branchial arteries; in young individuals we find twenty-five, but in older specimens fifty, such branchial hearts on either side. The branchial veins probably bring the blood into the aorta that lies beneath the vertebral column, but in addition to these, the blood enters the aorta through, 3*d*. The *Cardiform aortic arches;* it is a double contractile *ductus Botalli* arising from the median heart. 4*th*. A *Portal heart*, long and tubular in form like a vessel, and contracted throughout its whole length, runs along the ventral side of the intestine, and extends to the extremity of the cæcum. 5*th*. A *heart of the vena cava*, which lies on the opposite or dorsal side of the intestine, and is also tubular in form. Both venous hearts contract alternately. This structure of the vascular system obviously reminds us of that in the Annelida, where numerous pulsating heart-like vessels also occur.

The Cyclostomi are also characterized by many remarkable peculiarities in their vascular system, but to describe them in the present work would be entering into too great detail; one distinguishing feature, however, is the want of a muscular or contractile *bulbus arteriosus*, the trunk of the branchial artery exhibiting a uniform structure. In Lepidosiren annectens we find a *bulbus arteriosus*, and a single auricle and ventricle. In L. paradoxa we meet with a right and left auricle imperfectly separated, the former receiving the pulmonary vein, the latter the venæ cavæ.

Among the Osseous and Cartilaginous Fishes the number of hearts is occasionally found to be also increased. Thus in Chimæra an elongated fusiform *accessory heart* is always developed upon the two axillary arteries destined to supply the pectoral fins. Similar axillary hearts also occur in Torpedo, but not in Raia.

In the Eel there is found, upon both sides of the last caudal ver-

tebra, a pulsating organ which receives the blood from the delicate veins of the end of the caudal fin and propels it into the caudal vein, thus constituting a *caudal heart*, that occurs too in Murænophis. It is a true blood-propelling organ, but occupies the same position as the already-described lymphatic reservoirs found in many Fishes, and conjectured to be contractile.

In Myxine the sac of the vena porta contracts rythmically, and so forms a heart; thus in the class of Fishes have heart-like expansions been found developed in different parts of the circulatory apparatus, and would appear to be the more necessary from the numerous plexuses of vessels through which the blood has to pass.

These plexuses, or *Retia mirabilia*, have been found of the most complex form and arrangement in very different organs. Thus they occur upon the hepatic, portal, intestinal veins, and cœliac artery in the Tunny and several species of Shark; in the choroid gland of the Bony Fishes, in the swimming-bladder, and the so-called pseudo or *Accessory branchiæ*. These latter organs, which occur in most Osseous Fish, were formerly, from their resemblance to the true branchiæ, regarded as such, although they differ completely from them in structure. They are situated mostly upon the palatal portion of the branchial cavity in front or external to the upper extremity of the branchiæ, like which they are pectinated and provided with cartilaginous strips for their support. The blood-vessels ramify upon their leaflets in a regular manner, like the barbs of a feather, and receive their blood, like the opercula of the gills and lingual bone, through a branch which proceeds downward from the first branchial vein. A second or glandular form of these accessory branchiæ also occurs, and consists of deep red vascular organs composed of several lobes, not presenting the shape of gills, although they are covered by the mucous membrane of the branchial cavity. The lobules themselves, however, appear like small feathers with cartilaginous shafts, the latter being provided with lateral leaflets. Such glandular pseudobranchiæ are found in the Carp, Pike, and species of Gadus.

In the Sturgeon we find two accessory branchiæ: a large one situated against the operculum is a true respiratory pseudobranchia; the second, very small, and situated on the anterior wall of the spiricle, consists of folds and transverse lesser folds, possesses the plexiform structure of the pseudobranchiæ, and obtains its arterial blood from a branch of the vein upon the first branchial arch, while

the respiratory accessory gill receives dark-colored blood from the branchial artery. A similar pseudobranchia is possessed by the Rays and Sharks upon the valve of the anterior spiracle.

ORGANS OF RESPIRATION.

All Fishes respire by means of branchiæ or gills, for the support and protection of which organs we find a very complicated framework of bone or cartilage developed, and exhibiting the greatest diversities of structure in the several orders and genera. The whole of this apparatus may be reduced to three principal divisions: 1*st*. The lingual bone and branchiostegous rays. 2*d*. The branchial arches. 3*d*. The opercula or gill-covers. A *fourth* division of this part of the skeleton may be regarded as formed by the upper and lower pharyngeal bones or maxillæ, from the resemblance they bear to branchial arches; but as they do not support branchiæ, but only teeth, they more properly belong to the organs of digestion.

In the Osseous Fishes the *Hyoid bone* consists of a large arch, situated behind the lower jaw in front of the first branchial arch, and formed of several bony pieces symmetrically placed upon either side of a single intermediate piece. The lateral branches of the hyoid arch are of very large size in the Osseous Fishes, and correspond to the great cornua; they are composed almost invariably of four pieces, the posterior of which, mostly style-shaped, is the medium for attachment of the hyoid to the bone that is analogous to the os quadratum; the several pieces sometimes coalesce into two or one, but are generally united by fibro-cartilaginous bands. In front the two lateral branches abut against and are united by a single intermediate ossicle (*copula*); this represents the body of the hyoid bone, and commonly supports in front an elongated ossicle, upon which the rudimentary tongue rests; this is called the *lingual bone*, and is frequently provided with teeth. To the two branches externally a series of mostly narrow and slender, or frequently broad and strong ossicles, are fastened by ligaments or moveable joints; they support the opercular membrane of the gills, and have been therefore called the *Branchiostegous rays*; their number varies according to the genera and species, or even sometimes the individual. In the true Cartilaginous Fishes, parts occur which correspond to the hyoid arch, but true branchiostegous rays are entirely absent.

In the above structures we meet with numerous diversities. The hyoid arch is very narrow in Muræna, Syngnathus, and others, and

in the latter genus it always consists of a single piece, but in Diodon and Tetrodon of two; in all these genera, as in Uranoscopus and Cyclopterus, the copula is wanting. The piece supporting the tongue is absent in Tetrodon, Diodon, Balistes, Muræophis, and others. The branchiostegous rays are very rarely wanting, as in Syngnathus. Polypterus has only one of these rays, while three are found in Cyprinus, Cobitis, and others; seven in Muræna anguilla, twenty-five in M. colubrina, and upward of thirty in Elops. The passage from the Osseous to the Cartilaginous Fishes is made by the Sturgeon, in which the hyoid arch consists of three pieces instead of four, and both copula and branchiostegous rays are entirely wanting. In the Sharks a cartilaginous arch is found upon either side, supporting some cartilaginous rays, divided simply in a digitate manner. In the Rays similar arches are found, supporting a pair of pseudobranchiæ.

Behind the hyoid bone is situated a system of bones or cartilages called the *Branchial arches*, very generally four in number, and which support the vascular fringes or leaflets of the gills. Each arch consists of several pieces, varying in number according to the species of fish and the several arches themselves. There are, however, never more than four pieces, mostly three, and rarely two; upon their convex side they are channeled out for the lodgement of the branchial vessels, while on their concave side, or that turned toward the cavity of the mouth, they are mostly beset with teeth, and the upper segments of the posterior arches are usually so strong, that they have been distinguished by the special name of *ossa pharyngea superiora*; the postero-inferior pharyngeal jaws are also intimately related, both by form and position, to the last and rudimentary branchial arches. In the direction downward the branchial arches are usually attached, like ribs to a sternum, to an intermediate chain of bones or cartilages, two to four in number, which are articulated in front with the copula of the hyoid bone; the posterior arches are frequently united to this central chain by fibrous ligaments only, for it is seldom that all the arches are directly continued and connected to it by bone. Superiorly the branchial arches are generally attached by muscles and cellular tissue, or by true ligaments, to the basal surface of the skull, or sometimes further backward to the first vertebræ. The teeth are usually disposed in two rows upon the inner side of the branchial arches, and are rarely absent, as in Cyprinus, Muræna, Murænophis, Lophius, Fistularia, and others. The median chain of ossicles uniting the

branchial arches below are seldom wanting, as in Murænophis, Syngnathus, and Lophius. The Cartilaginous Fishes possess similar branchial arches, only they are cartilaginous, and five instead of four in number, of which, however, the most posterior corresponds to a pharyngeal maxilla; the arches abut, in the Sharks, against some intermediate cartilaginous pieces, and consist themselves of several segments; the branchial arches in the Rays resemble in general those of the Sharks, and are united inferiorly by one or two very broad sternoidal cartilaginous plates. In most Osseous Fishes the branchial arches are situated beneath the skull, but in Fishes of the Eel kind, *e. g.* Muræna, Murænophis, they are situated further back beneath the first vertebræ; in the Rays and Sharks they are united still further back to the commencement of the vertebral column. In the Cyclostomi we find a very peculiar branchial skeleton, formed of narrow arch-shaped cartilaginous rays that surround the gills.

The gills, which in the earlier stages of development of Fishes were freely exposed and unprotected, are always concealed at a later period of existence beneath the skin, and protected also by special covers or opercula; these are most evolved in the Acanthopterygians, and form for the most part a large bony apparatus, seldom inferior in size to the branchial, but which is superseded in the Chondropterygians by another contrivance. There are most frequently four, or if we regard, with many anatomists, the præoperculum as the quadratal bone, three bony pieces, composing the opercula of the gills. The *Præoperculum* is of a semilunar form, and bounds posteriorly the series of bones belonging to the articulating or quadratal portion of the temporal bone. To this succeeds, in the direction upward and backward, the true *Operculum*, a flat and more or less quadrangular bone, the largest in size, and presenting upward and forward a socket that articulates freely with a capsular head upon the uppermost quadratal bone. Upon the posterior and inferior edge of the operculum is situated the *Postoperculum*, and between this and the præoperculum, behind the lower jaw, is placed the *Interoperculum*. This opercular apparatus serves as a valve, whereby the fissure leading from without into the branchial cavity, and placed between the posterior edge of the operculum and the anterior girdle of the pectoral fins, may be opened or shut. The position, but more especially the size of the opercular bones, varies; one or other of them is frequently ill-developed, as in the Eel family. Among the true Cartilaginous Fishes we find, instead of this appa-

ratus, narrow, digitiform, cartilaginous plates, the analogues of the branchial rays, and which are fastened to the quadratal cartilage. The peculiar disposition of the branchiæ themselves in the Sharks, Rays, and Cyclostomi, renders a true operculum unnecessary.

In the majority of Fishes, but particularly in those of the Osseous kind, a double row of pointed lanceolate leaflets project, like the teeth of a comb, from the convex side of each of the four branchial arches; they are mostly separate as far as their base, where they coalesce, but are sometimes united higher up; each leaflet is provided in the middle with a thin fibro-cartilaginous plate, that keeps it stiff and straight. Upon these leaflets we find a number of thin membranous transverse ridges, which contribute to increase the respiratory surface, and the plexuses of blood-vessels further expand upon peculiar siliquose elevations; it is rare for only three of the branchial arches to support such pectiniform leaflets, as in Lophius, Batrachus, Diodon, Tetrodon; and very rarely do three, or only one row of branchial leaflets rest upon an arch. The branchial leaflets in Syngnathus and allied genera forming the group of Lophobranchii are of an unusual form, being lanceolate, but very broad and short, so as to form tufts. All these branchial combs are lodged in a common cavity situated behind the opercular apparatus, and communicating with the mouth by the slits between the branchial arches, and externally by a single large or frequently very small slit between the edge of the operculum and the girdle of the pectoral fins. The arrangement of these parts is somewhat different in the true Cartilaginous Fishes; upon the middle of each of their branchial arches we find a dense cellular plate, which attaches them to the external integument; in front and posteriorly the mucous membrane of the mouth is prolonged over this plate, and forms upon it elevated folds standing perpendicularly upon the cartilaginous arches, like the branchial leaflets of the Acanthopterygians; externally the mucous membrane is continuous with the external integument; each branchial arch is furnished with an anterior and posterior row of such branchial folds, but the anterior arch has only the posterior set, so that only four and a half gills are to be counted. From the branchiæ being united externally to the integument, five (and in other genera, as Hexanchus, Heptanchus, six to seven) branchial fissures are found both internally and externally, between which the integument forms narrow bridge-like strips. The Cyclostomi present a still more peculiar structure. There are here from six to seven pairs of branchiæ present; each pair forms a flat

sac or pouch, upon the internal walls of which strongly-developed folds project, as in the Plagiostomi; each sac opens externally by a round aperture, and in the inward direction by a canal into the œsophagus, or even into a special membranous tube or *bronchus*, situated beneath the œsophagus, and opening anteriorly into the pharynx, where it is closed by a membranous valve, and terminates blindly posteriorly.

The movement of the branchial arches, and also of the operculum and branchiostegous membrane of the Osseous Fishes, is effected by numerous muscles, which are absent in the Cartilaginous Fishes with fixed gills. By their action the branchial arches are separated or approximated, the branchiostegous membrane spread out, and the operculum flapped to and fro so as to open or shut the external branchial fissure. Smaller muscles move the double row of branchial leaflets against each other. Similar muscular fasciculi are found in the Cyclostomi, and serve to expand the branchial sacs. The water taken in at and streaming through the mouth, is driven by the movement of the branchial arches and hyoid bone between the gills, where it bathes the leaflets with their superimposed plexuses of vessels, and is again expelled through the external branchial fissures.

In many Osseous Fishes, *Branchial follicles*, as they are termed, that secrete a copious mucus, are found at the posterior commencement of the branchial cavity.

In addition to this mode of respiration by branchiæ, we find that in many Fishes this function is performed by pulmonary organs. The Amphibioid Fishes, like Proteus among the true Amphibia, possess a pair of truly-developed *Lungs* near to the gills. In Lepidosiren annectens a partly single, partly double row of branchial filiments project from the six branchial arches with the exception of the second and third, and in the vicinity of the anterior extremity we find the single branchial fissure. Besides these gills, however, a double sacciform lung is present, each portion being divided into several lobes; it is situated behind the kidneys against the ribs, and is internally cellular like the lung of a serpent; anteriorly it opens by a tolerably long, narrow, and membranous tube into the œsophagus. Each lung receives a branch of the pulmonary artery which arises from the branchial arteries.

Among even the true Bony Fishes we meet with *Accessory or pulmonic organs of respiration*, *e. g.*, in Silurus fossilis of Bloch, and among Fishes of the Eel kind in Amphipnous Cucia; they consist of vascular hollow sacs, which are either situated within the bran-

chial cavity, or extend thence to beneath the lateral muscles; they receive branches from the branchial arteries, and their veins enter the aorta.

With the above organs we may also include the hollow arborescent tufts of accessory branchiæ which lie, in Heterobranchus anguillaris, behind the true gills, as also the labyrinthine accessory gills of Anabas, Osphromenus, Ophiocephalus, and others; a part of the upper pharyngeal Maxilla is here divided into a greater or less number of leaflets, from between which cells arise, wherein water can be retained for a long time. These fishes form a peculiar family, the Pharyngii Labyrinthiformes, and are able by this structure to live a long while on dry land; the arteries of these organs proceed from those of the gills; the veins enter, after the analogy of the branchial veins, into the aorta.

THE SWIMMING-BLADDER.

Frequently as it has been compared with the lungs of the higher Vertebrata, and certainly, from its mode of development, position, and internal structure, reminding us exceedingly of these organs in the Amphibia, still the disposition of its vessels forbids our regarding the *Swimming-bladder* as an instrument of respiration, and thus we are still in doubt as to its precise functions; it occurs only in the Bony Fishes, but not in all the genera, and among the Cartilaginous in the Sturgeon alone, which forms the transition-link to the Osseous Fishes. The swimming-bladder must, however, exist in connexion with definite modes of life in several Fishes, since it is frequently absent in different species of a genus, or in nearly allied genera, *e. g.*, Scomber scombrus, Polynemus paradiseus, and the genera Pleuronectes and Lophius.

In ordinary cases the swimming-bladder is situated beneath the spinal column, to which it is firmly attached by cellular tissue, and, covered by the kidneys, overlaps the intestinal canal. It consists of two coats; of an external, which is very tough, fibrous, and glistening, and an internal or soft vascular mucous membrane. It is invested upon its lower surface, or that facing the viscera, by peritoneum. The swimming-bladder in some instances, as in Esox, Gadus, Holocentrus, Cepola, is of very great length, extending through the whole body; in others, as in the Eels, it is very short. Its longitudinal dimensions usually predominate over the transverse, the reverse, as in Silurus and Orthagoriscus oblongus, being of rare occurrence. As a rule, the swimming-bladder contains only a single cavity; frequently, however, two, one placed behind the other, and separated by a deep constriction, as in the Carps and many Salmons; in Blennius Phycis we find three, and in Polypterus two such divisions; in Trigla hirundo there are also three, but they are arranged side by side. Pimelodus filamentosus is furnished with two completely-separated swimming-bladders lying one behind the other. The swimming-bladder is sometimes provided with cæcal pouches, varying in size, form, and length, *e. g.*, in some species of Gadus; but they are most distinct in the family of Sciænidæ, as in S. umbra, in Johnius, Pogonius, Corvina, and Otolithus, where the appendages are divided in a digitate manner. It is rare for cells to be developed upon the internal surface of the swimming-bladder, in which case that organ greatly resembles the lung of an Amphibian; this is exemplified in many Erythrini, and in several genera of Siluroidæ, *e. g.*, Bagrus and Arius, where the swimming-bladder is divided into several intercommunicating chambers by imperfect partitions; in Platystoma we meet, in addition, with a pair of cellular wings or appendages. The very long swimming-bladder of Lepisosteus, which extends from the pharynx to the anus, is provided superiorly with two blind appendages, but is in other respects simple, except that a part of its internal cavity is furnished with smaller cavities or pouches upon the floor of which the mucous membrane forms a network of parietal cells. In many Fishes the swimming-bladder is peculiarly situated. Thus in Cobitis fossilis it is completely enclosed in a bony capsule formed by the transverse processes of the third cervical vertebra. In Heterobranchus it is situated transversely within a conical bony capsule opening by a fissure inferiorly, and formed by an expansion of the transverse processes.

The swimming-bladder is either entirely closed, or provided with a tube, as in most of the Ventrales, while in the Pectorales and Jugulares this is usually wanting. The tube consists of the same coats as the bladder, and is either short or long, narrow and tortuous; it runs in the direction downward and forward, and perforates the œsophagus in different situations, and in some cases the commencement, or what is more rare, the bottom of the stomach. In the genus Salmo the tube arises from the anterior extremity of the bladder, or from its second division, as in Cyprinus, where it is very narrow and tortuous; in the Pike, however, it is short and wide, and in Clupea it enters the base of the stomach. This opening of communication of the swimming-bladder with the intestine has been

compared to a glottis, but this analogy will not hold good as regards the laryngeal aperture of the higher Vertebrata, for the opening of the swimming-bladder is usually found in the dorsal wall of the gullet, and sometimes in its side, as in the Erythrini; in Polypterus, however, the two lateral swimming-bladders open by a common slit of considerable size into the ventral walls of the gullet, so that here indeed their resemblance to lungs becomes more striking. In many Fishes, *e. g.*, Muræna and Gadus Callarias, the tubes are connected with the œsophagus, but there terminate blindly; a fact which is the more remarkable, since the swimming-bladder is first manifested during development as an eversion, like the lungs, from the œsophagus.

A very remarkable union of the swimming-bladder with the organs of hearing had been long ago detected in Heterobranchus, all the species of Cyprinus, Silurus glanis, Cobitis, Clupea, and others, and has been recently found to exist also in the Erythrini. This union is in some cases, as in Cobitis, effected by means of the auditory ossicles; in others, as in Clupea and allied genera, large air-canals are given off from the swimming-bladder and enter the labyrinth.

In many Fishes we find a red *Vascular gland* interposed between the two coats of the swimming-bladder, usually in its inferior region. This gland has been falsely compared to the thymus gland, and in this way the supposed analogy of the swimming-bladder to the lung has been further exaggerated. But the gland in question presents much more the character of a rete mirabile, and agrees in this respect with similar plexuses formed by the portal vein and choroid gland. It consists of a double plexus of arteries and veins, and these plexuses occur in many swimming-bladders, whether provided or not with an air-tube. They extend over the whole swimming-bladder in the Cyprini, so that in these Fishes we find no local concentration of vessels, and consequently no true vascular gland. The arteries of this organ arise from the branchial veins, while its veins enter those of the body generally.

One or several pairs of muscles, arising usually from the transverse processes of the adjacent vertebræ, are inserted into the swimming-bladder of many Fishes, and appear destined to compress that organ, and thus condense the air contained within its cavity. In several Siluroidæ, and probably also in other Fishes (*e. g.*, Ophidium), a remarkable apparatus has been discovered upon the swimming-bladder, which probably serves to rarefy or condense this air. Thus

in the genera Malapterurus, Synondontis, and others, the first vertebra is invariably provided with a large process that arises from it, narrow and slender, but finally expands into a large round plate, which, when at rest, is deeply imbedded upon the anterior surface of the swimming-bladder. A thick muscle arises from the internal surface of the spine of the cranium, and is inserted into this plate. When it contracts, it lifts the process from off the swimming-bladder, and by thus removing its pressure upon the latter, renders the air within it more rarefied. If this muscle be pulled in the dead fish, and then the traction withdrawn, the bony process springs back by its own elasticity, and condenses again the air in the bladder.

The swimming-bladder is almost always tightly distended with air; this air consists usually of nitrogen and a very small quantity of carbonic acid gas; in some instances, however, it has been found to contain nearly pure oxygen. Now, since the above-named gases are diffused in the blood of the vertebrata, it is probable that they have been disengaged in a free state by the vessels of the swimming-bladder. Whatever be its other uses, this organ serves, for obvious reasons, to facilitate the ascent and descent of Fishes in the water.

URINARY ORGANS.

The *Kidneys* are of very large size in proportion to the body in Fishes, and distinctly developed without exception in all the genera; they are placed close to each other upon the sides of the vertebral column, to which they are firmly attached, but they very seldom project freely into the ventral cavity from behind the peritoneum, or the swimming-bladder when that organ is present. In the Osseous Fishes they extend more or less through the whole extent of the ventral cavity, and as far forward as the commencement of the skull; in most of these Fishes, also, they coalesce in front and behind into a single mass. From its anterior half each kidney sends off a large transverse lobe, so that the two together acquire the form of a cross. In many instances the kidneys may be said to form only a single mass, which is divided by the passage of the vena cava, that vessels receiving much of its blood, and sometimes, as in the Cyclostomi, appearing completely imbedded in its substance. The ureters (frequently numerous) pass along the external or internal margin of the renal organs, and emerge from their substance inferiorly. They unite either into a common duct, or enter separately into a true

urinary bladder that is rarely absent, and is always situated posterior to the intestinal canal; a position by which, according to our present knowledge, Fishes may be distinguished from all other Vertebrata. The urinary bladder, or when this is wanting, as in Uranoscopus scaber, the urogenital aperture, opens behind the anus. The ureters open into different parts of the bladder, and the form of the latter varies exceedingly, being either cylindrical or fusiform, and frequently, as in many species of Gadus, prolonged into cæca or cornua.

In the Rays and Sharks the kidneys are proportionately much shorter than in other Fishes; they are frequently more or less lobulated, and resemble the kidneys of the Chelonia; the urinary bladder is either absent, or present, as in the Rays, where it is two-horned. The Cyclostomi have no bladder, and in Petromyzon the external rounded edge of the kidneys projects freely into the ventral cavity, and the organs themselves are prolonged in front into a dense spongy mass of adipose cells. In Lepidosiren annectens, the kidneys, long and narrow, are completely separate, and the urinary bladder opens into the posterior region of the cloaca. Some detached glandular bodies have been found in the posterior part of the ventral cavity in the vicinity of the abdominal pore in Amphioxus, and been stated to be renal organs.

As regards the more minute structure of the urinary organs, their substance is generally loose and spongy in the Osseous Fishes, but firmer in the Plagiostomi. The urinary canals are for the most part long and very tortuous, but not ramified; in the Cyclostomi, at least in Petromyzon, they form short, straight, cæcal tubes. The Malpighian bodies, or renal glomerules, are not absent, though they are of small size in Fishes, and, as would appear from injections that have been made of them, imperfectly formed.

Certain bodies have been recently discovered to occur pretty generally in Fishes, and been regarded as *Renal Capsules*. They are particularly distinct in the Plagiostomi, as the Rays, but even in these large Fishes they are very small, and, as in Raia oxyrhynchus, are seen as small bean-shaped bodies, similar to the kidneys, but of a paler color. The renal capsules of either side are connected by vessels with the apex of the kidneys. In the Bony Fishes, which were previously denied to possess these organs, a pair of small reddish-white corpuscules, mostly placed behind the kidneys against the vertebral column, have been recently found, *e. g.* in Cyprinus,

Cyclopterus, Pleuronectes, and been interpreted as such. In the Sturgeon and Cyclostomi similar structures have not yet been met with.

SEXUAL ORGANS.

The organs of generation in Fishes present in general a very simple type of structure, and those of both sexes, at least in the Bony Fishes and Cyclostomi, are formed upon a very analogous plan. It may be here observed, that the opinion which was formerly held, that regular hermaphrodites occurred among Fishes, is equally incorrect with the assertion of genera of these animals existing in which the male sex was wanting, and only individuals with female organs could be found; it is true that the female sex occurs in disproportionately greater number than the male, as is the case also in many Invertebrate animals.

The *Ovaries* of the Osseous Fishes are in general double, rarely single, as in Perca fluviatilis, Cobitis, Blennius viviparus, though even in these instances the separation is usually indicated. In the majority of Fishes the ovaries consist of simple sacs formed of an external fibrous and internal mucous coat, which last usually presents transverse, more rarely longitudinal folds, and sometimes also interrupted papillæ that are frequently clavate in form. Thus we find longitudinal folds in Cottus, Gobius, and others, transverse in Pleuronectes, Belone, and Gadus Callarias; in Gadus Lota we meet with shaggy papillæ, in Blennius viviparus with tubercles. Upon these projections of the mucous membrane the ova are developed in great number; those which are nearly mature hang from a pedicle, and the less ripe have a shorter attachment; both kinds are invested by a thin membrane, by the dehiscence of which, or the rupture of the pedicle, the ova when ripe fall into the cavity of the ovarium. In the ovum itself we may distinguish a chorion, yelk, and a very large and distinct germinal vesicle, provided with scattered germinal spots. Each sacciform ovarium contracts posteriorly to form a short oviduct, which very soon coalesces with its fellow into a common duct, that opens usually within a depression, more rarely upon a tubercle, behind the anus, and in front of the urinary aperture. Such is the usual arrangement of these parts in the Osseous Fishes; but in some genera of the latter, as Salmo, Cobitis, and Tænia, in the Sturgeon also, and in the Cyclostomi, the ovarium, instead of being sacciform, is a flattened plate, from the lower or ventral surface of which folds

or laminated projections, shaped like a frill, as in the Eel and Petromyzon, take their rise, and in these the ova are developed. In such cases the oviducts are absent, and the eggs, having fallen into the ventral cavity, are expelled the body through a single or double slit lying between the anus and urinary opening, and more rarely through an aperture communicating with the ureter; the latter arrangement appears to occur generally in the Sturgeons, *e. g.* Acipenser Huso, stellatus and Ruthenus, but not in A. sturio, where we find the anal slits to be present; these, however, being absent in the other species, the ova, after having been freed from the ovaries, pass into two membranous infundibuliform tubes, which are united with and open into the two wide ureters about the middle of the kidneys; behind these apertures is a valve, to prevent the escape of the urine into the ventral cavity; the ova thus pass out of the female through the ureters.

The structure of the female sexual organs in the Plagiostomi and Chimæræ is more perfect, and analogous to that in Reptiles and Birds. The ovaria are here generally double, situated far forward, and each presents the form of a more or less considerable plate, rarely that of a sac, upon which the ova ripen in succession, the vitelline spheres gradually attaining a size equal to those of Birds. In some Sharks only a single ovarium is present. A common and wide abdominal opening conducts into the double oviduct, which is constructed like that of Birds, being wide, thick-walled, and lined with folded mucous membrane. The oviduct at its commencement is narrow, but dilates above the middle, and is generally surrounded in the Rays, Sharks, and Chimæras by a cordiform or reniform gland, which is sometimes, as in those Sharks, *e. g.* Mustelus and Galeus, that possess a nictitating membrane, and also a single ovarium, of a spiral form; it is in the majority of examples very compact, and formed of filamentary follicles, like the caudal gland of Birds. Further backward the oviduct expands considerably into a kind of uterus, to make room for the large ova that are provided with horny shells; within this the embryos are attached and developed, as will be described further on. The external sexual opening is situated behind the anus, and we find there a papilla, or rudimentary clitoris. In many Fishes the ovaries and oviducts are secured in their place by mesentery, in others they are free.

Two ovaria with free oviducts, thus essentially repeating the type of structure in the Plagiostomi, have been found in the Lepidosiren; the oviducts join the ureters and enter the cloaca; the ovaries are in

other respects very elongated, the oviducts tortuous, and thus these structures approximate those in the Ichthyic reptiles.

In Amphioxus we find, in the bladder-shaped ovaries that are situated against the sides of the body, vitelline spheres with distinct germinal vesicles and a single germinal spot.

The *Male sexual organs* of the Bony Fishes exhibit the same simplicity and type of structure as the female. The testes are sacs, mostly retained in place by mesentery, which, when in a turgid state, like the ovaries, frequently occupy the whole length of the ventral cavity. They are continued to form the seminal ducts, which soon unite into a short and common excretory duct behind the anus, where they frequently open upon a perforated conical projection or penis. The two testes are not always symmetrical; the right being often the largest, in others the left. In most of those fishes where the ovary is single, the testicle is also found under similar conditions; its division, however, into two halves is usually indicated. In Cobitis barbatula, however, the testicle is double though the ovary is single. The testicle is frequently plaited like a frill, as in the Eels and Petromyzon, and granular in texture; while in the Osseous Fishes it usually consists of slender cæcal tubes, that are occasionally subdivided. A glandular layer, that may be compared to the prostate, is very often developed, *e. g.* in Gobius and Blennius, at the end of the seminal duct. Conical and often elongated structures, resembling intromittent organs, are found in Syngnathus, Gobius, Lepadogaster, Blennius, and also Petromyzon. In the male species of Sturgeon we find similar infundibula to those of the female opening into the ureters.

Another type of structure for the male organs is furnished by the Rays and Sharks, and the structure, for example, of their testicles is of very great interest as regards the development of the spermatozoa. The structure of these glands, and their connexion with the epididymides, are best seen in the Thorny Rays (Acanthias). The testes consist of white, mostly reniform lobules, which present their convex edge externally. Within these lobules we may detect even with the naked eye a granular structure; the granules are round capsules about one fifth of a line in size, and contain the seminal animalcules in their interior. These spermatozoa are lodged, as in the other Plagiostomi, *e. g.* Raia oxyrhynchus, in very neat and regular parcels within the capsules. The spermatozoa are absent in the youngest or smaller capsules, which merely contain granular matter, and are

always surrounded by a circle of vessels. The delicate seminal canals proceed from the lobules of the testis, and from them arise nine to ten short, transverse, and parallel *vasa efferentia*, that run transversely toward the *vas deferens*; the latter is very much contorted, and continued superiorly into a dense epididymis, which was for a long time taken for a particular gland, its connexion with the testicle having been overlooked owing to its being concealed by a lobulated mass of white and granular fat, deposited upon the plexus of seminal canals, as in the Rays and Squalus canicula. The testicles and vasa deferentia frequently lie more close to each other, as in Scymnus, where the large convolutions of the vasa deferentia distinctly project above the much elongated cylindrical testes. Inferiorly the efferent ducts expand to form bladders or long sacs that are completely filled with semen. At the end of the cloaca we also find some short tubercles tolerably well developed, and reminding us very much of allied structures in the Tritons; the semen issues from their conical points, and a circular fold, surrounding them like a prepuce, completes their analogy with the penis. We find also peculiar auxiliary organs, belonging to the external generative apparatus, and consisting of long cartilaginous styliform appendages hanging to the anal fins or pelvic extremities, and channeled by a groove, along which the semen actually escapes from the male, and is probably brought by a kind of copulative act in contact with the female genitals. These parts are often seen to be red, turgid, and besmeared with a bloody slime. In their dilated or clavate extremities a number of interarticulated cartilages is recognised; these, like the whole organ, may be moved by adductor and retractor muscles.

The testes in Amphioxus consist of small bladders, similar to the ovaries.

The *Spermatozoa* exhibit a variety of forms; those of the Osseous Fishes are rounded and conical, with very long and delicate tails sometimes, as in Cobitis, they have a small appended nodule. In the Plagiostomi they are very generally long and linear, with delicate tails; sometimes they are spirally twisted at the commencement, as in the Passerine birds, but run to a finer point, or else they are stiff and straight; they are also spirally convoluted in the Chimæræ.

In Fishes, as in Reptiles, we find many viviparous as well as oviparous genera. Numerous diversities are visible in the form, size and structure of the ova, but these belong to the developmental

history of Fishes. In the Rays and Sharks the large vitelline spheres are frequently included in horny capsules, called "sea-purses," which project into cornua or cylindrical threads.

Certain Sharks (*e. g.*, Mustelus, Carcharias) attach themselves, after the manner of the Mammalia, by an umbilical chord to a placenta placed in the interior of the female genital organs, and thus constitute a very remarkable exception among the class of Fishes. In other Fishes, as in Syngnathus and allied genera, the young are developed in a peculiar cavity, or incubating organ, opening by a slit, and placed posterior to the anus beneath the tail. It is remarkable that these pouches are found only in the male Syngnathi, while in Scyphius it is the females who carry their eggs free in a mass adherent to the belly.

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APPENDIX.

A LIST is subjoined of the most useful works that treat upon the Development of the Vertebrata, this being a subject of the highest interest and importance when a general comparison is instituted between the several classes.

Baer, Rathke, and others, in Burdach's Physiol. 2d ed. 1837, have given a most complete and general survey of the development of the Vertebrata. Upon that of the *Mammalia*, consult Von Baer's Entwickelungsgeschichte der Thiere, Königsb. 1837. Bischoff, Entwickelungsgeschichte des Kaninchens, Braunschweig, 1842, and Rudolph Wagner's Elements of Physiology by Dr. Willis, part 1, on Generation, where copious bibliographical references are also given. *Birds*, Von Baer, über Entwickelungsgeschichte der Thiere, 1 ter Theil, 1828. Pander, Beiträge zur Entwickelungsg. des Hünchens im Ei., Wurzburg, 1817. Reichert Entwickelungsleben im Wirbelthierreich, Berlin, 1840. *Reptiles*, Baer, op. cit. Band 2, on Batrachia. Rathke, Entwickelung der Natter, Königsb. 1839. Reichert, op. cit. Vogt. Untersuch. über Entwickelungsg. der Geburtshelferkröte, Solothurn, 1842. *Fishes*, Baer, Untersuch, über Entwickelungsg. der Fische, Königsb. 1835, and Vogt. Entwickelungsg. der Forelle in Agassiz Hist. Nat. des Poissons d'eau douce de l'Europe, Neufchatel, 1841.

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NOTE to pages 49 and 61.

The *thymus gland*, according to Owen, trans. Zool. Soc., vol. 1, is absent even in the fœtus of the Marsupialia, but not in the Ornithorynchus. The *Cloaca* appears only to occur in the female Marsupials.

NOTE to page 100.

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NOTE to page 106.

Stannius, see Müller's Archiv f. 1843, has found true *Lymphatic hearts* in the Stork among the Grallatores, in the Ostrich and Cassowary among Brevipennes, and, in the Natatores, in the Goose, Swan, Diver, and Auk. He has as yet failed to detect them in the Fowl and Turkey. Panizza was previously acquainted with their existence in the Goose; these hearts lie near the sacral bone, are connected with lymphatic vessels, and a vein issues from them. As yet they have not been observed to pulsate, though they exhibit distinct fasciculi of transversely-striated muscular fibre.

NOTE to page 117.

Tschudi, in Müller's Archiv f. 1843, describes a remarkable structure of the *Trachea* and *Inferior larynx* in Cephalopterus ornatus, which seems to agree closely with that in the Duck; it consists of an expansion of the trachea below the superior larynx into a large elongated drum-like cavity; the inferior larynx is also similarly dilated; this structure is the more remarkable from its occurring in one of the order Passerinæ and family of Coracinidæ. The bird utters a loud and unpleasant howling cry, and occurs in the same latitudes, namely, S. America, as the Howling Apes.

NOTE to page 176.

Bachthold, über die Giftwerkzeuge der Schlangen, Tubingen, 1843, gives beautiful figures of the *Poison glands* of Hydrophis pelamys and Naija rhombeata. The length of the poison gland of the latter amounted, in a specimen eighteen inches long brought from the Cape, to three inches, or a sixth part of the length of the body; it is placed parallel to the vertebral column like a broad band, and surrounded by a strongly-attached muscle, which draws the gland forward or toward the head; the gland consists of six perfectly parallel tubes, or long cæca, two of which unite to form a common excretory duct. The poison tooth is not, however, of large size.

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THE END.