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-