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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*, *Muraenophis*, 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 laminae 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

\* Class PISCES.

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, Tetradon, Orthogoriscus, Ostracion, Balistes, &c.*

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

Sub-class 2. Pisces Cartilaginosi s. Chondropterygii.

V. PLAGIOTOMI.—Ex. *Rays and Sharks.*

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

VII. CYCLOSTOMI.—Ex. *Petromyzon, Ammocetes, Myxine, Bdellostoma.*

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

VIII. AMPHIBIOIDEI.—Ex. *Lepidosiren.*

IX. HELMINTHOIDEI.—Ex. *Amphioxus, s. Branchiostoma.*



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, unless the latter is injured, it is impossible for the scales to come off. The layers, which cover the scales, are as follows: 1st. 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. 2d. 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. 3d. The *cutis*, consisting of a fibrous tissue, within the areolæ of which is a deposit of fat. 4th. 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 corpuscles 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 corpuscles. 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 merluccius*, 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. 1st. The *Placoidians* (πλαξ, 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. 2d. 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. 3d. *Ctenoidians* (κτεῖς, 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. 4th. *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*, *Gobioidæ*, 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 ar-

ticated 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 corpuscles 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 immovably by means of firm ligaments, like the other vertebrae. 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 found, *e. g.* in *Muraena* and *Muraenopsis*, 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.* *Muraenopsis*, 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 *Orthogoriscus* 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 *Sciaena 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 *Muraena*, *Muraenopsis*, 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 orbital 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 *Muraena*, *Muraenopsis*, *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-*