

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.*, *Muraena* 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-canal 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 Siluroideæ, 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*, *Synodontis*, 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 *Urano-scopus 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 corpuscles, 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, yolk, 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 *Tania*, 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 Chimærae 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 *Chimæra*.

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 "seapurses," 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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