CHAPTER XIV

PHYLUM — CHORDATA — PART I

General Characteristics. This phylum includes such familiar forms as fishes, frogs, lizards, snakes, birds, cats, dogs, horses and men. The embryology of chordates exhibits blastula and gastrula stages. The diploblastic embryo becomes triploblastic and from the three germ layers — ectoderm, mesoderm and endoderm — the various specialized tissues and organs of the adult develop. A coelome is present and there are indications that the body is segmented. Chordates are bilaterally symmetrical and possess definite antero-posterior and dorso-ventral differentiation. A wide variety of animal forms is included in this phylum, but all possess three characteristics in common.

First: *Notochord.* The body at some period of life is supported by a longitudinal rod-like structure called a notochord. It extends the length of the body dorsal to the intestinal tract, which, beginning with a mouth at the front end, extends the length of the body, terminating in a posterior anus. The phylum is named after the notochord.

Second: *Gill Slits.* A portion of the digestive tract behind the jaws is called the *pharynx.* This possesses a series of vertical openings on each lateral wall of the pharynx. Membranous *gills* usually may border these openings, called *gill slits.*

Third: *Dorsal Nervous System.* The central nervous system is a hollow cylindrical tube of nerve cells and fibers, dorsal to the intestine and dorsal to the skeletal axis. In most chordates, the anterior end is organized into a large and chief nerve center, the *brain.*

We divide the Chordata into two sub-phyla, namely, the Prevertebrata and the Vertebrata.

SUB-PHYLUM I — PREVERTEBRATA

These are small animals which have little apparent similarity to the more common and larger Vertebrates. Nevertheless, they have chordate characteristics. Three classes are noted.

Class I. Hemichorda. This class is illustrated by Balanoglossus (Fig. 223), a worm-like form, about 15 cm. long and 0.5 cm. in diameter. It lives in the sand or mud along the seashore. Three body regions are evident: (*a*) *proboscis,* (*b*) *collar,* (*c*) *trunk.* It has a long alimentary tract. The obvious claim to relationship with the Chordates is the many pairs of gill slits and gills at the anterior end of the alimentary tract. The nervous system is a diffuse network under the epidermis with thickenings along the mid-dorsal and mid-ventral line. Finally, a forward rod-like prolongation from the anterior end of the mouth, extending dorsally from the mouth into the proboscis, is said to be a notochord. Balanoglossus possesses a larval form called a *Tornaria.* Because of the resemblance of the Tornaria to certain Echinoderm larvae, some authors believe that Balanoglossus indicates a genetic relationship between Echinoderms and Chordata. But in other respects Tornaria resemble certain larvae of Annelids, and because of this it is believed by other investigators that Balanoglossus had an annelid ancestor. This seems the more plausible theory. The adult is annelid-like in a number of respects.

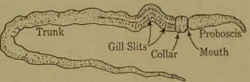

FIG. 223. — Balanoglossus.

Class II. Urochorda or Tunicata. Tunicates live in the sea. They were classified with mollusk-like animals until 1866, when Kowalsky showed their chordate characteristics. They are free-swimming, or attached sac-like forms, and are called Tunicates because the soft internal parts are protected by a tough outer *tunic.* They are sometimes called sea squirts because the animal squirts water through two tubes at the free end when irritated (Fig. 224). A common form along the Atlantic Coast is *Molgula manhattensis.* Water normally enters the animal through one of these tubes and leaves the body by the other. Oxygen and food is obtained from incoming water, and carbon dioxide, excretions, feces and reproductive cells are discharged through the other tube.

The mouth leads into a large pharynx which is perforated with a great many gill slits. Water coming into the pharynx passes out through these gill slits into the atrial chamber and thence out through the exhalent or atrial opening. At the base of the pharynx is the opening to the rest of the alimentary canal, which is bent laterally onto the pharynx, ending in the anus in the atrial cavity near the atrial opening. The simple tubular heart is located near the lower end of the pharynx. The blood is colorless. The animals are hermaphroditic, and simple sex organs lie in the loop of the intestine. Testis and ovary mature at different times. Gonaducts pass alongside the intestine and open near the anus.

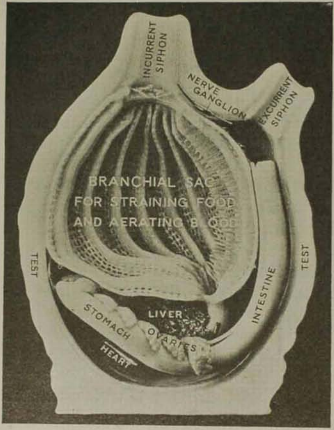

Fig. 224. — Anatomy of adult tunicate. Photo of model. (Courtesy American Museum of Natural History.)

Tunicates in their adult condition do not appear to be Chordates. The sessile adult condition is preceded by a larval free-swimming *tadpole* form. This has an enlarged anterior end behind which is a laterally compressed tail. The tadpole has bilateral symmetry, antero-posterior differentiation and shows plainly all three chordate characteristics. First, the mouth leads into a pharynx with perforated gill slits. Second, an elongated notochord extends back to the tip of the tail. Third, above the notochord is the nerve chord.

There are some compound Tunicates, *i.e.*, many individuals are surrounded by a common tunic. In some forms the individuals have a connecting circulatory system. Tunicates also reproduce asexually by budding.

Class III. Cephalochorda. Some authors regard these as offshoots from old vertebrate ancestors, others regard them as degenerate early and very simple Vertebrates. *Amphioxus* is a common form (Fig. 225). It is bilaterally symmetrical, it has antero-posterior and dorso-ventral differentiation, a body cavity and tubular intestine. It is two inches more or less in length.

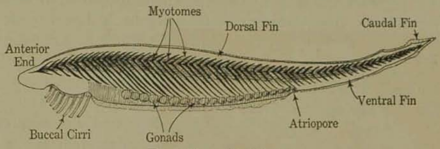

FIG. 225. — Amphioxus.

Alive, it is whitish in color, and on the side of the body can be plainly seen the segmented " V "-shaped muscle masses or *myotomes*. Just back and under the pointed front end of the body is a circular fringe of soft appendages called *cirri*. At the base of these is the mouth (Fig. 226). The mouth leads into a large laterally compressed *pharynx* which is perforated with many *gill slits*. Water comes into the mouth, passes out through the gill slits into the *atrial chamber* (Fig. 227) and out from this through the *atriopore*, somewhat back of the middle on the ventral side and just in front of the ventral fin. Back of the pharynx is the

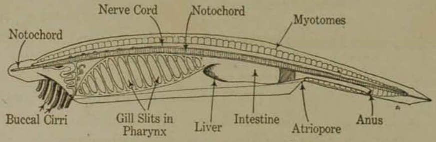

FIG. 226. — Anatomy of Amphioxus.

intestine, which passes back from the pharynx, ending in the *anus* on the left side behind the atriopore. Near the beginning of the intestine is a forward-directed blind pouch, the *liver*, running along the side of the pharynx.

Amphioxus possesses a *dorsal blood vessel*, in which the blood flows posteriorly (as in Vertebrates), and a *ventral vessel*, in which the blood flows forward. From the ventral vessel, blood flows through *afferent branchial arteries* to the gills, thus insuring oxygenation of the blood, thence from capillaries of the gills to *efferent branchial arteries*, to the *dorsal vessel.* The dorsal and ventral vessels have branches. The *notochord* is a cylindrical axis extending from the front end to the rear of the animal. There is a central nervous system, a cord-like structure, lying above the notochord, and hence above the intestine as in the Vertebrates and not under the intestine as in Annelids and Arthropods. It is slightly enlarged at the anterior end (brain). The sexes are separate. There are twenty-six pairs of gonads along the wall of the atrial cavity, from segments ten to thirty-five, lateral to the pharynx and intestine. Eggs or sperm are liberated into the atrial cavity and pass out through the atriopore into the water, where fertilization takes place.

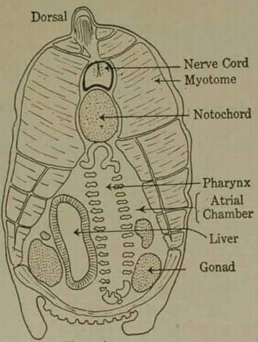

FIG. 227. — Cross-section of Amphioxus.

Amphioxus is a classic form to the biologist. The tadpole of Tunicates and the adult Amphioxus resemble each other in that both possess a much perforated pharynx, an atrial chamber, an elongated notochord and dorsal nervous system. It is thought that they have a common ancestry.

Lamarck in 1797 emphasized the marked differences between the *Vertebrates* or backboned animals and the *Invertebrates* which have no backbone. This division of the Animal Kingdom into Vertebrates and Invertebrates is not advisable because of the *number* of distinct types of body plan in the Invertebrates. But the influence of this early division of Lamarck is still felt, possibly because Man is a Vertebrate. According to the theory of evolution, the Vertebrates must have had some kind of invertebrate ancestry. Kowalsky in 1866 showed the vertebrate characteristics of Amphioxus; the resemblance of the tadpole stage of a

Tunicate to Amphioxus and later the vertebrate characteristics of Balanoglossus. Amphioxus is a simple Chordate. Tunicates, and the Hemichordate, Balanoglossus, have more invertebrate characteristics than Amphioxus. The Prevertebrates form a connecting link between Vertebrates and the Invertebrates. Some zoologists have linked Vertebrates with Annelids because of similarity in segmentation, for example.

SUB-PHYLUM II — VERTEBRATA

Characteristics. All of these forms are larger and more highly organized than the Prevertebrates. The embryos possess a notochord which is later displaced by an axial, segmented backbone composed of separate pieces called vertebrae. In the lowest groups the vertebrae are composed of cartilage and in the higher groups of bone. Vertebrates, of course, possess the other chordate characteristics, namely, dorsal nervous system and pharyngeal gill slits.

The Vertebrates may be dividėd into six classes: (1) *Cyclostomata,* (2) *Pisces,* (3) *Amphibia,* (4) *Reptilia,* (5) *Aves,* (6) *Mammalia.*

Class I. Cyclostomata (round mouth). An example is Petromyzon (Fig. 228). These animals resemble eels in form. They

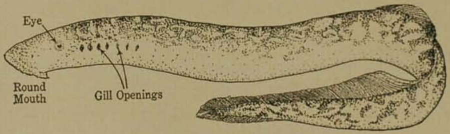

FIG. 228. — Petromyzon. (U. S. Bur. Fish.)

have no jaws or paired appendages. The notochord is retained even in the adult. The head and gills are supported by a cartilaginous framework; in fact the whole skeleton is cartilaginous. There is no atrial cavity. On the sides of the pharynx are external gill openings. The skin is soft and very slimy. The animals possess eyes, an olfactory sac and internal ears. The skin is provided with tactile sense organs. There is a heart behind the head on the ventral side, and there are arteries, veins and capillaries present. The brain resembles that of embryos of higher

Vertebrates. There is no distinct stomach present. There is a liver but often no bile duct connecting it with the intestine. The muscular system consists of serially repeated myotomes. Kidneys are alongside the mid-line of the dorsal body cavity. An excretory duct carries urine back into a common urino-genital chamber. The sexes are separate with hermaphrodite tendencies. The sex cells break out of the gonads into the body cavity and from this through a pair of genital pores into the urino-genital sinus and thence into the water by the urino-genital aperture. Some authorities consider Cyclostomata not as primitive, but as degenerate forms.

Class II — Pisces — Fishes

Characteristics. Fishes consist of a vast number of Vertebrates adapted for life in water. In most, the organs of respiration are gills. The organs of locomotion are fins of which there are two kinds, the unpaired and the paired fins. The surface of the body is usually protected by scales. The embryonic notochord is replaced by cartilaginous vertebrae, which in a large number of cases are, in turn, replaced by bone. The skull is well developed and consists of a part which incloses the brain and another part which forms the jaws and supports for the gills. The nasal sacs do not, as a rule, open into the mouth. We will consider three sub-classes of Pisces.

Sub-Class I — Elasmobranchii

These are sharks, skates, dogfishes (Fig. 229), etc. The skeleton is entirely of cartilage. The skin is covered with placoid scales,

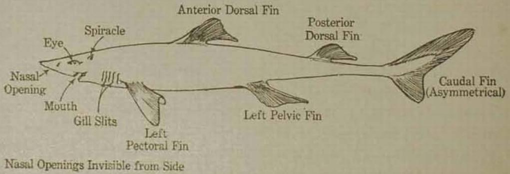

FIG. 229. — Squalus, the spiny dogfish. (U. S. Bur. Fish.)

sometimes called skin-teeth. The gill slits open to the outside and are uncovered.

External Features of the Dogfish. The study of a dogfish (*Squalus*) illustrates the general features of these animals. The body is fusiform in shape, larger in the anterior region. In front is the projecting snout. Just behind and underneath this is the mouth. At the posterior end, the body is laterally compressed and ends in the caudal fin, which is asymmetrical. The dorsal lobe is much more elongated than the ventral. This type of fin is called *heterocercal.* It is correlated with the ventral mouth. Propulsion by this type of fin would send the animals downward toward the bottom where they feed. The tail and caudal fin form the principal means of locomotion. The body is covered with *small placoid scales* (Fig. 230), which have a round, flat base from which rises a curved tooth-like spine pointing posteriorly. The body of a placoid scale is composed of dentine. Inside is a pulp cavity. The pointed tip is covered with enamel. In all these respects, the placoid scale is like a tooth; they might be called skin teeth. It is believed that the teeth of all Vertebrates are modified placoid scales, which in Elasmobranchii were found all over the external surface and inside the mouth, but which in higher animals became limited to the mouth during the course of evolution. On the lateral surfaces of the head are the *eyes.* The eye has a third lid in addition to the two usually found. This lid, the nictitating membrane, can be drawn across the eye from the inner corner. The eye of all Vertebrates is quite similar to that of the dogfish. Back of the eyes on either side are pairs of openings: (*a*) just behind each eye is a spiracle which opens into the pharynx. (*b*) Just in front of the anterior paired fins are found the five pairs of lateral gill slits.

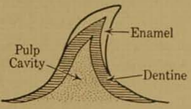

FIG. 230. — Placoid scale.

Associated with the gill slits are the membranous gills. Water for respiration comes *into* the pharynx through the mouth and probably at times through the spiracles. The water passes out from the pharynx through the gill slits, bathing the gills. In this process the blood in the capillaries of the gills takes in oxygen from the water and gives out CO_2 to the water. The nostrils are openings leading to blind sacs just in front of the mouth.

Two kinds of fins are present in fishes, paired and unpaired. The latter are median, dorsal and ventral projections. They are more primitive and they alone are found in Amphioxus and Cyclostomes. In Squalus they are the two dorsal and one caudal. Two pairs of lateral fins (limbs) are present. The forward pair are called *pectoral* fins, while the posterior are the *pelvic* fins. Each pair is attached to a cartilaginous ring inside the body; the pectorals being attached to the *pectoral girdle* and the pelvics to the *pelvic girdle*. The paired fins are strengthened by small bars of cartilage. The theory has been advanced that these cartilage bars are the fore-runners of the bones of the higher vertebrate limbs. Between the bases of the pelvic fins is the *cloaca*, terminating in the *anus*, the slit-like external opening of the alimentary tract.

Muscles. Underneath the skin are the segmentally repeated muscles or *myotomes*, showing similarities to those of Amphioxus and Cyclostomes, and recalling the segments of the earthworm. In the region of the paired fins the body muscles are modified to move the fins.

Skeleton. The skeleton is cartilaginous. It is divided into the *axial* and the *appendicular* portions. The axial skeleton consists of the skull and the segmented vertebral column. The embryonic notochord still persists in spaces between the centra of the hourglass-shaped vertebrae. The skull consists of a cartilaginous box-like *cranium* inclosing the brain, and the *visceral skeleton*. The latter consists of a series of cartilaginous bars forming the jaws and supporting the gills. The embryonic skeleton of higher animals is in many general respects similar to that of the adult dogfish. The bony skeleton of higher Vertebrates is preceded by a cartilaginous skeleton. The *appendicular skeleton* is the cartilaginous framework of the girdles and paired fins described above.

Intestine. The digestive tract (Fig. 231) is a little longer than the body. Behind the jaws with their rows of teeth is a large space, the *pharynx*, from which open out the *spiracles* and *gill slits*. The pharynx leads into the short, wide *oesophagus* which opens into the "V"-shaped *stomach*. At the intestinal end of the stomach is a valve (*pyloric sphincter*) which controls the discharge of food from stomach to intestine. The *small intestine* is very short. Behind it is the *large intestine*, inside of which is a central axis from which a spiral membranous shelf runs to the outer wall. This is called a *spiral valve*. Thus the internal surface of the intestine is increased. Attached to the hinder end of the intestine is the *rectal gland.* The intestine opens into the *cloaca* at the posterior end of which is the cloacal aperture, or *anus.*

The *liver* consists of two large lobes. Ducts from these lobes carry the liver secretions into the common *bile duct* and so into the intestine. A side branch leads to the *gall bladder,* in which bile is stored. The gall bladder is imbedded in the liver. Along the left bend of the stomach is the dark red *spleen.* Farther on and

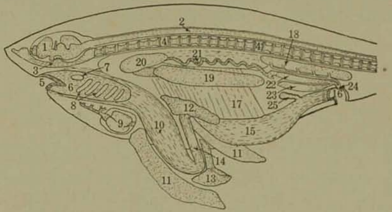

FIG. 231. — Anatomy of dogfish. 1, Brain; 2, Spinal cord; 3, Floor of skull; 4, Spinal column; 5, Mouth; 6, Pharynx; 7, Spiracle; 8, Gill slits; 9, Heart; 10, Stomach; 11, Liver; 12, Pancreas; 13, Spleen; 14, Small intestine; 15, Large intestine; 16, Cloaca; 17, Mesentery; 18, Kidney; 19, Testis; 20, Epididymis; 21, Vas deferens; 22, Seminal vesicle; 23, Sperm sac; 24, Urino-genital papilla; 25, Rectal gland.

extending between the pyloric end of the stomach and the intestine is the whitish *pancreas.*

Urino-genital Organs. Lying against the dorsal wall of the body cavity are the gonads. These are elongated white *testes* in the male. In the mature female the developing eggs, some quite large, may be seen in the *ovary.* The *oviducts* are long tubes lying against the dorsal wall of the body cavity. They join anteriorly under the intestine and there is a common opening here through which the eggs enter. When ripe, they are discharged from the ovary into the body cavity and from this pass into the opening common to both oviducts. Fertilization takes place in the oviduct. Here the eggs develop and *young dogfish are born, i.e.,* they pass down into the cloaca and out into the water, where they are capable of leading an independent life. The kidneys are narrow elongated organs which lie on each side of the dorsal midline covered with peritoneum, the membrane which lines the body cavity. Urine passes from the kidneys through ducts called ureters to the cloaca.

The testes of the male are connected with the cloaca by *sperm ducts.* Connected with the pelvic fins of the male dogfish are a pair of processes called *claspers* used in mating. Copulation takes

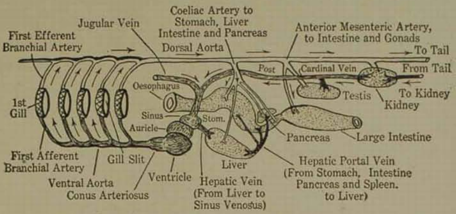

Fig. 232. — Plan of circulation in dogfish.

place, *i.e.*, fertilization is internal. The cloaca receives undigested matter from the intestine, excretion from the kidneys and reproductive cells from the gonads (*i.e.*, ovaries or testes).

Circulatory Apparatus. The *heart* is ventral to the pharynx. It is located in the pericardial cavity just above the ventral portion of the pectoral girdle. A canal connects the pericardial chamber with the abdominal cavity. The heart consists of a single *auricle* and *ventricle.* The course of circulation is briefly as follows (Fig. 232): The venous blood, collected from all over the body by the veins, is emptied into a large, thin-walled sac, the *sinus venosus,* posterior and dorsal to the auricle and thence into the auricle. This contracts and pumps the blood into the more muscular ventricle. When this contracts, a valve closes between auricle and ventricle. From the ventricle the blood passes forward through the *conus arteriosus* and thence into the *ventral* aorta under the floor of the mouth. From this ventral aorta the blood flows through *afferent branchial arteries* to the capillaries of the gills. Here the blood is oxygenated and also gives out CO_2 to the water. From the gill capillaries the blood passes up through *efferent*

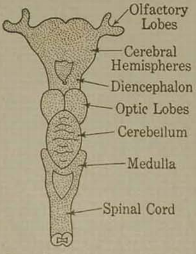

Fig. 233. — Brain of dogfish, dorsal view.

branchial arteries to the *dorsal aorta* and from this is distributed to all parts of the body. The afferent and efferent branchial arteries are called *aortic arches* because they form arches around the pharynx and form a dorsal aorta.

Nervous System. The dogfish has a well-developed nervous system. There is a brain, spinal cord, cranial or brain nerves and spinal nerves. The brain consists of (Fig. 233) two large olfactory lobes, a pair of cerebral hemispheres, a small diencephalon, a pair of optic lobes, a cerebellum, and a medulla, similar in fundamental respects to the brain of higher Vertebrates.

General Account of Elasmobranchs. They have a cartilaginous skeleton with traces of notochord still persisting, placoid scales, spiral valve in the intestine, claspers in the male. They have a heterocercal tail and ventral mouth. The heart contains venous blood. Fertilization is internal. Some forms, as the skate, lay eggs (*oviparous*) protected by horny egg cases. Others, as the dogfish, bring forth living young (*viviparous*). The eggs generally are large and well stocked with food (yolk). In *Mustelus* there is a *placenta-like* connection between the yolk sac of the embryo and the uterus of the mother. Some zoologists call such forms ovi-viviparous since there is no true placenta present (see page 276).

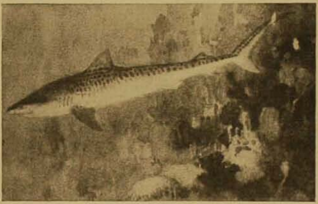

Fig. 234. — Galeocerdo — Tiger shark. From painting by Charles Knight. (Courtesy Amer. Mus. Nat. Hist.)

The word " shark " (Fig. 234) is a general name which includes forms like the dogfish, which are sometimes called dogfish sharks. True sharks have large, triangular-shaped teeth with notched edges adapted for grasping and cutting. Dogfish and skates have rows of small teeth. Sharks live more in the open sea than skates and rays, which are shore-dwelling forms.

Skates (Fig. 235) and rays dwell on the sea bottom and are flattened dorso-ventrally, with greatly developed pectoral fins. The food of these animals consists of fishes, squid, crabs, lobsters. Dogfish and sharks cause great damage to the nets of fishermen.

It is believed that they are responsible for the decrease in numbers of lobsters. Skates, dogfish, and sharks are used to a certain extent as food. The livers of all the Elasmobranchs are valuable as a source of oil, and formerly the outer layer of skin containing the placoid scales was used as an abrasive. Watch cases and sword handles were covered with this *shagreen*. Methods have been discovered of separating the scale-bearing part of the skin from that underneath and the deeper layers tan into good leather. The only obstacle to the development of this industry is the difficulty in securing skins.

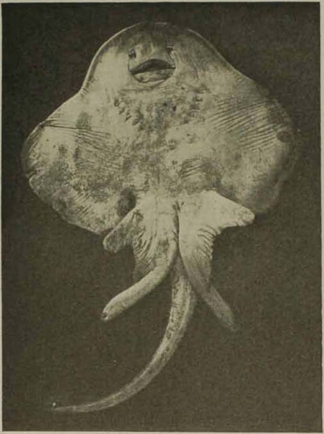

Fig. 235. — Ventral view of male skate. (Amer. Mus. Nat. Hist.)

Sub-Class II — Teleostomi

These are the common fish such as trout, perch, bass, cod (Fig. 236), mackerel, salmon, *i.e.*, types comprising the "harvest" of the world's fisheries and many others. They have many of the characteristics of the Elasmobranchs — in fact, the latter are regarded as ancestral to the Teleostomi, which, in turn, are regarded as a specialized *offshoot* from the line of evolution leading from Elasmobranchs to Amphibia.

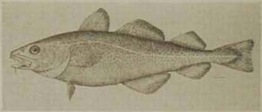

Fig. 236. — Gadus, the cod fish. (U. S. B. F.)

General Characteristics. Let us consider some of the peculiarities of the Teleostomi.

(1) Skeleton. The cartilaginous skeleton of the embryo is replaced by bone.

(2) The mouth, as a rule, is terminal, and not underneath as in Elasmobranchs.

(3) The tail is symmetrical, that is, the dorsal and ventral lobes are equal. The type of tail indicates a straightforward mode of swimming and the terminal mouth is adapted to feeding during swimming.

(4) Though some, such as eels, have a slimy, naked skin, yet most *teleosts* have flat scales covered with a thin integument.

(5) The gills are covered with a flap called the operculum.

(6) The fins are generally supported by jointed fin rays.

(7) Most teleosts have a membranous sac in the body cavity along the dorsal mid-line. This is called a *swim bladder*. It is connected with the gut in some forms and not so connected in others. It is, in some species, filled with gas by the secretion of the cells which line it. The contents of the bladder can also be absorbed. It is a hydrostatic organ, since the buoyancy of the fish is increased when the swim bladder is inflated; when deflated, the opposite condition is attained.

(8) The eggs are smaller and greater in number than those of Elasmobranchs. There is great variation in the number of eggs produced. For example, the marine cat-fish, *Felichthys*, produces as few as fifty eggs at a time, while the cod may spawn over nine million. *Most* of the cod eggs do not mature. In most cases both eggs and sperm are discharged into the water, where fertilization takes place.

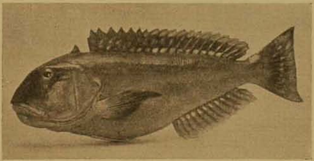

Fig. 237.— Lopholatilus — Tile fish. (U. S. B. F.)

(9) Associated with the act of spawning are the remarkable migrations of such forms as the salmon and the eel. The eel which spends most of its life in fresh waters will travel great distances to very deep waters of the ocean to breed and from these ocean depths the young eels retrace the watery highways of their parents. The salmon overcomes great obstacles, and to spawn may travel over a thousand miles to the headwaters of the lake or stream

in which it was born some years before. After spawning the parents die. Many unexplained phenomena connected with the migration or distribution of fishes occur from time to time. The *tile-fish* (Fig. 237), an important large deep-sea food fish, was abundant off the coast of New England for many years, then absolutely disappeared, only to reappear several years later.

The Fisheries. It is estimated that the annual value of fishery products amounts to about a billion dollars yearly. The most important food fishes are herring, salmon, cod, haddock, hake, pollock, mackerel and tuna. Fish constitute the main source of protein food of many maritime peoples. Fishery products are preserved by refrigeration and cold storage, by salting, by smoking, drying and canning. Among the by-products are oils used in making paints and soaps. The medicinal properties of cod-liver oil are well known. (See Vitamins, Chapter XXIII.) Glue can be extracted from fish wastes, and then the residue can be made into fish meal, a food for poultry, or as part of fertilizer for the soil.

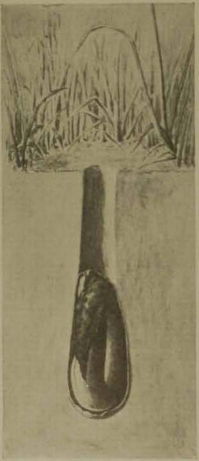

Fig. 238. — Protopterus, African Lung Fish in mud nest. (Courtesy Amer. Mus. Nat. Hist.)

Sub-Class III. Dipnoi

There is also another small though distinct group of fishes called *Dipnoi* or Lung Fishes (two kinds of breathing apparatus). They are large, fresh-water, mud-dwelling forms. They breathe by means of gills, while under certain conditions the modified swim bladder acts as a lung. The *external nares communicate with the mouth cavity*. There is a *partly divided auricle, i.e.*, it has a *right* and *left* portion. *Neoceratodus* is found in Australia; *Protopterus*, in Africa; and *Lepidosiren*, in South America. They are highly specialized and are *not* to be regarded as the ancestors of the Amphibia. They can live out of water to a certain extent and at that time the air-bladder functions as a lung. According to one theory the fin skeleton of Neoceratodus is the forerunner of the limb skeleton of Amphibia and higher Vertebrates.

During the dry season Protopterus (Fig. 238) burrows into the mud, forming a sort of slimy case in which it remains dormant, *i.e.*, *aestivates*. The specialized swim bladder functions as an organ of respiration. The energy for living functions comes from the metabolism of food stored in its tissues.

Evolutionary Significance of Cyclostomata and Pisces. The Cylostomes are regarded by many zoologists as degenerate and specialized survivors of some primitive ancient form. The Teleostomi are certainly specialized forms and this is true of the Dipnoi also. Each has developed along its own particular line and neither can be considered ancestral to the Amphibia. It is the Elasmobranchs which have remained the most primitive of the fish-like forms, and so in our geneological tree of organisms we have placed ‘ ancient sharks ’ *on* the line of evolution leading to the Amphibia.

Selected References

Cambridge Natural History, Vol. VII. Macmillan Co., N. Y.

Hegner, R. W. *College Zoology*. Macmillan Co., N. Y.

Jordan and Everman. *American Food and Game Fishes*. Doubleday, Page & Co., N. Y.

Parker and Haswell. *Text Book of Zoology*, Vol. II. Macmillan Co., N. Y.

Pratt, H. S. *Manual of Common Vertebrate Animals*. A. C. McClurg Co., Chicago.

Thomson, J. A. *Outlines of Zoology*. D. Appleton Co., N. Y.