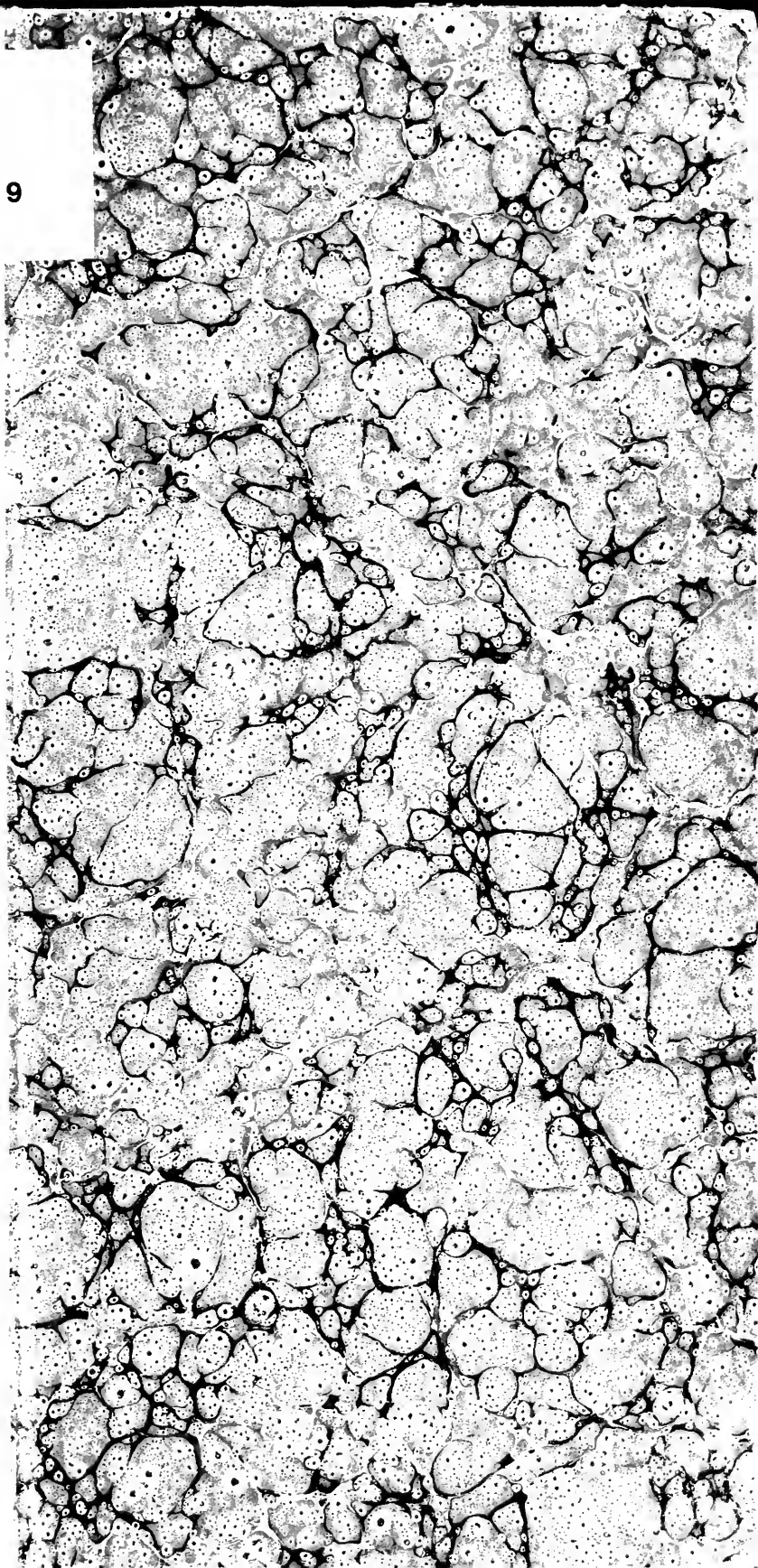

A

GUIDE

TO THE

ZOOLOGICAL COLLECTIONS

EXHIBITED IN THE

FISH GALLERY

OF THE

INDIAN MUSEUM.

Calcutta:

PRINTED BY ORDER OF THE TRUSTEES OF THE INDIAN MUSEUM.

1899.

Price eight annas.

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PREFACE.

The new Fish Gallery of the Indian Museum, which in old times was the Library of the Geological Survey, has been modelled on Dr. Günther's well-known *Introduction to the Study of Fishes*, and to that admirable work I have much pleasure in acknowledging my essential obligations.

In a country, like Eastern Bengal, where damp and mould, as well as moth and rust, take hold of everything in a way inconceivable by those whose experience is confined to happier climates; in a country where even japan-varnished labels of seasoned teak get mildewed: specimens can only be safely exhibited as specimens, without any of those attractive accessories that are needed to transform them into studies of Nature. So that the only attempt that has been made to lend verisimilitude to the exhibits in this Gallery has been, as far as possible, to hang the specimens by wires, instead of fixing them on boards or stands, and to paint them in their natural colours.

The limitations imposed by climate have led me to seek to add interest to the Gallery in other directions; as, for instance, by exhibiting dissections, maps of geographical distribution, and models of characteristic deep-sea fishes.

These models are principally the work of the Museum modeller, Panch Cowry Chatterjee. The colouring of the specimens has been done by the Museum draughtsman Abhoya Charn Chowdry.

A. Alcock, *Major*, *I.M.S.*,
Superintendent of the Indian Museum.

Calcutta, 1899.

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A GUIDE

TO THE

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FISH GALLERY OF THE INDIAN MUSEUM.

The Fishes are one of the five main divisions, or Classes, of the Craniate Vertebrates, that is, of the Vertebrates in which there is a brain, lodged in a skull, or capsule of cartilage or bone.

With the Fishes proper it is usual to include the *Cyclostomata* (typified by the Lampreys) which agree in most respects with the Fishes, but differ from them and from all other Craniate Vertebrates in having no true jaws.

It has also been usual to include with the Fishes the singular form *Amphioxus*, although, beyond the facts that it lives in the sea and breathes through its mouth and pharynx, it has no special resemblances with a fish.

Amphioxus, besides many other peculiarities, is distinct from the Fishes and from all other Vertebrates in having neither brain nor skull, and will here, therefore,

in accordance with the classification of Ray Lankester, be regarded as an independent branch of the Vertebrate stock.

It is convenient to exhibit in the Fish Gallery certain more or less degraded marine animals in which the vertebrate affinities are, at least in adult life, obscured. These are the Ascidians (*Tunicata*) and *Balanoglossus*. They have not the slightest external resemblance to ordinary vertebrate animals, and in the case of the worm-like *Balanoglossus* the vertebrate affinities are not undisputed; but the *Tunicata* are very reasonably considered to belong to the Vertebrate phylum principally on the grounds (1) that their larva—though not usually the adult—has a notochord or primitive foundation of a backbone, (2) that at least the main mass of the nervous system lies to the dorsal side of the level of the notochord, and (3) that the front part of their digestive tube is peculiarly modified for breathing.

It must be remembered that *Balanoglossus* and the Ascidians are exhibited in the Fish Gallery simply for convenience: they would be out of place in either of the Galleries of Invertebrates, and they are not, from a Museum point of view, important enough to have a gallery to themselves among the Vertebrates; although from many other points of view they are among the most important and most interesting of all animals.

BALANOGLOSSUS.

[Case 1.]

In external appearance, as in mode of life, the adult *Balanoglossus* resembles certain marine worms. Its larva in certain species, of which much enlarged figures are shown in Case 1, resembles certain Echinoderm larvæ.

It has been classed both with the Worms and near the Echinoderms, but certain very suggestive peculiarities of its structure have lately led the most advanced zoologists to remove it to the Vertebrate phylum.

It is not possible to discuss all these peculiarities here, but one of the chief of them, namely the essentially vertebrate ground-plan of the breathing-mechanism, is seen in the diagrams, specimens and model in Case 1. The general correspondence of the plan of the breathing arrangements of *Balanoglossus* with those of certain branchiate vertebrates is remarkable. This correspondence would not of itself justify the inclusion of *Balanoglossus* in the Vertebrate phylum, were it not that the essentially vertebrate notochord and dorsal nerve-tube are also represented, though obscurely and imperfectly, in *Balanoglossus*.

The enlarged drawings and diagrams in Case 1 will explain the structure of the animal.

No species of *Balanoglossus* has been found in these seas.

TUNICATA.

Sea-Squirts.

[Cases 2-3.]

Owing to the fact that in the more familiar members of the group the body wall forms a muscular mantle and secretes a thick protective test, the Tunicates were originally classed with the *Mollusca*.

But the knowledge that the larva of many Tunicates has a notochord in the posterior part of its body, or tail, and a dorsal nervous system (brain, etc.), formed on the Vertebrate plan; and that there are certain small free-swimming Tunicates that keep the larval tail and brain, though somewhat changed, throughout life; added to the

fact that breathing is effected in Tunicates, as in Amphioxus, by special modifications of the pharynx, has now led to the advancement of the *Tunicata* to the Vertebrate phylum.

In Ray Lankester's classification they stand as an independent branch of that phylum, under the name *Urochorda*, which expresses the fact that the embryonic and larval notochord is confined to the tail.

The *Tunicata*, or Ascidians, or Sea-squirts, occur to ordinary observation under two forms: namely, fixed Tunicates that are found encrusting rocks, etc., in shallow water near shore, and free-swimming Tunicates that float at and near the surface of the open sea. Some of the latter are very brightly phosphorescent, *e.g.*, the colony of *Pyrosoma* in Case 2.

In both forms the animal is usually encased in a thick gelatinous or leathery tunic (hence the name *Tunicata*), in which there are two openings: namely, one at the fore-end, leading into the body, and corresponding to the mouth of Vertebrate animals; the other either on the dorsal side, or at or near the after end, and leading out of the body.

In the fixed Tunicates the test is either semi-transparent or opaque, either gelatinous or leathery, and often coloured, and has its two openings rather close together: it often resembles a small leather bag—hence the name ascidian, from ἀσκος a leather bag, and εἶδος form.

In the free-swimming Tunicates the test is transparent and gelatinous, and has its two openings either at or almost at the opposite ends of the body.

There is another form of free-swimming *Tunicata* that, on account of its small size, needs careful searching for with a drift-net. In this form, enlarged drawings

of which are shown in Case 3, there is a tail for locomotion.

As the *Tunicata* of these seas have never been named, our exhibits are chiefly intended to illustrate some of the more important anatomical modifications of this most interesting group of animals.

The structure of the typical adult Ascidian is shown in the series of drawings, dissections and enlarged models in Cases 2 and 3.

The vertebrate affinities of the Ascidian larva are represented by a series of enlarged drawings, chiefly after Ray Lankester, in Case 3.

1. THE TYPICAL SIMPLE FIXED ASCIDIAN.

[Case 2.]

Nos. I and I in this Case are simple fixed Ascidians preserved in spirit. Observe the form and orientation of the body, the incurrent opening, or mouth, and the excurrent or *atrial* opening, shown by labels.

Nos. II and III are simple fixed Ascidians in which the whole of the right side of the test has been removed. Observe the animal lying completely enveloped in its mantle, which is the outer layer of the body wall; thus enveloped it appears to hang almost free within the test. Notice also the *siphons*, or processes of the mantle which open at the mouth and at the atrial orifice.

Nos. IV. V. VI. are simple fixed Ascidians of which the left side of the tunic has been removed, and more or less of the left side of the mantle also. We now see that beneath the mantle there is a space. This space is the *atrial* or *peribranchial cavity*: it opens directly to the exterior by the atrial or excurrent orifice of the test *only*. The pointer in No. V shows the passage from the

peribranchial cavity, through the atrial orifice, to the exterior.

In some of the dissections the whole of the left side of the mantle, as well as of the tunic, has been removed, to expose the whole of the large *branchial sack*. This branchial sack is the pharynx: it almost fills the peribranchial or atrial cavity, and it opens directly to the exterior by the mouth or incurrent orifice *only* as is shown by the pointer in No. V: its walls, however, are pierced with rows of pores, like a sieve, and through these pores the branchial sack also communicates with the peribranchial cavity. At its lower part, on the dorsal side, (to the extreme right hand side of the observer), it also leads into the alimentary canal: this forms a double loop, the open end of which (anus) hangs free in the peribranchial cavity at the bottom of the atrial orifice.

We can now understand how the Ascidian feeds and breathes. Seawater, carrying Oxygen and minute particles of food, is drawn into the capacious pharynx or *branchial sack*, at the mouth or incurrent orifice. The *food* finds its way into the intestinal tract, and the undigested waste ultimately escapes into the peribranchial cavity near the atrial orifice. The *water* passes through the pores in the wall of the pharynx, also into the peribranchial cavity, whence it escapes through the atrial orifice, carrying with it, as it sweeps through the atrial siphon, the waste from the intestine. As the water runs through the pores in the very vascular wall of the pharynx, it gives up its oxygen to the blood.

The other organs of the Ascidian can be seen in the dissections and in the explanatory drawing beside them.

It is necessary to explain how the particles of food

that enter the branchial sack with the water of respiration find their way into the gullet.

The mechanism by which this is effected is shown in dissection No. VII. Case 2.

In this dissection the right wall of both test and mantle have been cut away and the right wall of the branchial sack split open longitudinally and flapped back, so as to show the whole interior of the branchial sack.

We can now see, (1) running along the ventral wall of the sack (right hand side of the observer) a groove called the *endostyle*, and (2) running along the dorsal wall of the sack (left hand side of the observer) a projecting fold called the *dorsal lamina*.

Where the dorsal lamina ends, the opening of the gullet (marked by a silver wire) is seen.

The particles of food, washed into the branchial sack, are caught by the secretion of the endostyle and are carried forwards along the endostyle to the dorsal lamina. They then pass backwards, matted together, along the dorsal lamina to the opening of the gullet.

The enlarged and coloured clay models in Case 3, which have been made from the dissections, show plainly the organs of respiration and digestion of the typical Ascidian and their relations to the mantle and test.

The dissections enable us to realize that the breathing organ of the Ascidians is on the same plan as that of *Amphioxus*; but the other vertebrate affinities of the Ascidians can only be illustrated here by drawings. These, which are exhibited in Case 3, show that the larva of the kind of Ascidian that we are considering has a considerable resemblance to a frog's tadpole. It has a head and a tail. In the tail there is a notochord,

corresponding, so far as it goes, with that of *Amphioxus* and Vertebrate embryos, and—dorsal to the notochord—a nerve tube with the same general correspondences. In the head there is a hollow swelling of the nerve-tube having a fundamental identity with the brain of higher Vertebrates.

Some of the steps by which the free-swimming larval "Ascidian tadpole" changes into the degenerate fixed Ascidian are shown in a series of enlarged drawings after Ray Lankester.

2. LARVACEA .

[Case 2.]

As has been already mentioned, there are certain very small Tunicates that swim freely through the open seas, and that keep the tail, though not quite in the tadpole form, throughout life.

Enlarged drawings and models of some of these are shown in Case 3. They have no peribranchial cavity, and the branchial sack therefore opens directly to the exterior,—by two pores or gill-slits.

3. COMPOUND ASCIDIACEA.

[Case 2.]

Certain Ascidians that resemble in their general anatomy the form shown in our dissections, are able to form colonies by budding. They are represented here chiefly by glass models. Some of these compound Ascidians, as the *Pyrosoma* in Case 2, are free-swimming inhabitants of the open seas.

4. THALIACEA.

[Case 2.]

Salpa, of which glass models and spirit specimens, and *Thalia*, of which stained glycerine specimens are

exhibited, are types of free-swimming Tunicates that differ considerably from the simple fixed Ascidian. In *Salpa* the branchial sack and the peribranchial cavity form one continuous space, and the branchial and atrial openings are at opposite ends of the body. This is a special modification for locomotion, the animal being propelled forwards by the forcible expulsion, from the atrial opening, of the water that has been drawn into the peribranchial cavity: this is effected by the contraction of muscular bands in the mantle. *Thalia* moves through the water in the same way.

AMPHIOXUS.

Lancelets.

[Case 4.]

This curious little fish, of which spirit specimens are shown in Case 4, is so small that its structure can only be illustrated in a Museum by enlarged drawings and diagrams.

No. 1 is a drawing of an Amphioxus enlarged 18 times, No. 2 is a much more enlarged diagrammatic drawing of a cross-cut through the fore-end of an Amphioxus. No. 3 represents the mode of life of Amphioxus.

The species are of world-wide distribution in tropical and temperate seas, one species being common enough in shallow water along the Madras coast. They prefer sandy bottoms into which they can burrow, leaving only the fore-end of the body exposed. In this position they breathe and feed almost exactly in the manner of the Ascidians, drawing through the mouth, into a capacious pharynx, currents of water that contain oxygen and minute particles of food. The water passes through slits in the wall of the pharynx into a special

peribranchial or atrial cavity, whence it is discharged by a special opening, situated in the middle line some way in front of the anus, known as the atrial opening or *atriopore*; while the food is caught and carried, by structures corresponding with the endostyle and dorsal lamina of the Tunicates, into the alimentary canal, whence the undigested waste escapes at the anus.

The atriopore is indicated by a pointer in one of the specimens, the anus by a red circle.

Drawing No. 1 shows (1) the long smooth compressed lancet-like body tapering to a sharp point at both ends (whence the name *Amphi-oxus*) and showing no distinction whatever of head, trunk, and tail: (2) the long fold of skin, or dorsal fin, running from the right side of the mouth all along the middle line of the back, and its gelatinous fin-rays; the short fold, or ventral fin, running between the atriopore and the anus, and its fin-rays; and the caudal fold or fin, connecting the other two round the end of the tail: (3) the V-shaped muscle-segments extending in a chain from one end of the body to the other, but leaving exposed, at either end, the tip of the (4) notochord. [This, which is seen in section in Drawing No. 2, is a solid elastic rod of semi-cartilaginous consistence that extends all along the middle of the back, and is all that Amphioxus possesses in the way of a true skeleton]: (5) the mouth, at the fore-end of the body, encircled by small stiff oral tentacles: (6) the anus, which lies a little to the left of the middle line, near the after end: (7) the atriopore, some little way in front of the anus: (8) the series of reproductive organs, or gonads, showing through the semi-transparent body-wall.

Drawing No. 2 is meant to show specially:—(1) the position and form of the notochord: (2) the posi-

tion and form of the central nervous system: (3) the pharynx and gill-clefts, with the endostyle and hypopharyngeal groove: (4) the peribranchial or atrial chamber (coloured pink) into which the water is swept after it has been used in breathing: (5) the metapleural folds, or hollow folds of skin that run on either side of the body, right and left, from the mouth to the region of the atriopore.

As previously stated, Amphioxus has no place among the Fishes, and is now generally regarded as the representative of a separate branch of the Chordate phylum.

It differs from all the true vertebrates (1) in having no brain or skull of any sort, and hence no true paired eyes: (2) in the form of the liver, which persists as a hollow pouch of the gut; and in the absence of a pancreas; (3) in having no true heart and no red blood corpuscles; (4) in the curious primitive form of the renal organs, which recall the Annelid type; (5) in the large number of paired reproductive glands; (6) in the curious asymmetry, not merely of the body, but also of the muscles, nerve-trunks, olfactory organ, and anus.

It further differs from all true vertebrates except the Lampreys in having no true jaws and no branchial bars. And it further differs from all Fishes in having a vast number of gill-slits.

CYCLOSTOMA.

Lampreys and Hag-fishes.

[Case 5.]

The Cyclostoma have usually been included among the Fishes, but they differ from all true fishes in having no branchial bars and no jaws, in this last respect

differing also from all vertebrates above the level of *Amphioxus*.

The specimens and dissections of *Petromyzon* (Lamprey) exhibited in Case 5 show that the body is worm-like, without paired fins, but with unpaired dorsal and caudal fins supported by fin-rays, and without scales.

The mouth is a funnel, the walls of which are studded with strong conical horny teeth, and, with the piston-like tongue, forms an adhesive sucker. It is supported by plates of cartilage, and is surrounded by fleshy lips.

The gills are enclosed in pouches, which lie in a row on either side of the gullet. The pouches—one of which has been cut open to show the gill-leaves—open on one side, indirectly, into the gullet, and on the other side directly to the exterior: they are supported by a cartilaginous basket-work, which has been dissected off in the exhibited preparation.

Immediately behind the gills is seen the heart, which is of the ordinary fish type described further on. The branchial artery is seen running from the heart between the two rows of gill-pouches, and sends a branch to each pouch.

The skeleton is very imperfect. Instead of a back-bone there is a simple elastic rod-like notochord: this is enclosed in a sheath, from which a series of cartilaginous arches arise to cover in the spinal cord (dorsal nerve-tube) that lies immediately above the notochord. The relative positions of these organs are well seen in the cross-slice of the body of a Lamprey in Case 5. The skull is a mere capsule of cartilage.

The eyes are small and are more or less embedded in the skin. The nostril is a single pore placed in the middle line of the head.

The Lampreys are found in rivers and shallow seas

in temperate regions. They are predaceous, attaching themselves to their living prey—a fish—by their adhesive mouth, in the manner of a parasite.

The Hag-fishes are found in the seas of the colder parts of temperate regions: they feed in much the same way as the Lampreys, but often bore their way right into the abdominal cavity of their living prey.

FISHES.

[Cases 6-64.]

The Fishes constitute one of the five main divisions, or Classes, of the Craniate Vertebrates.

The Vertebrata are defined, in the most general way, as Coelomate § Metazoa † possessed of the three following characters :—

(1) A dorsal axial skeleton, which, in a few of the lowest and in the earliest embryonic stages of the higher Vertebrata, consists of a simple unsegmented soft rod (notochord), but which in the great majority of Vertebrata is gradually replaced, in the course of development, by a firmly-jointed chain of bones (vertebræ), known as the vertebral column, or backbone.

(2) A central nervous system lying to the dorsal side of the axial skeleton (notochord, backbone) in special processes of which it is usually enclosed. This dorsal nervous system is at first tubular.

§ *Metazoa* are animals that consist of a multitude of reciprocally-interdependent cells of various form function and arrangement: in contra-distinction from *Protozoa*, or animals that consist either of one single independent cell, or of a small mass of cells quite similar to one another in form and function, and independent of one another.

† Coelomate *Metazoa* are those that possess a body-cavity, or *coelom*, in which the digestive tube is suspended and the viscera are lodged: in contra-distinction from Coelenterate *Metazoa*, in which the only hollow of the body *is* the digestive cavity.

(3) A digestive tube of which the fore end is in part modified for breathing purposes.

In addition, almost all Vertebrata are bilaterally symmetrical, and most have a heart, placed towards the ventral side of the body, and a closed system of vessels in which red blood circulates: also in a great majority there are two pairs of limbs suspended from the vertebral column.

The Vertebrata are arranged by Professor Ray Lankester in four branches, namely, *Craniata*, *Cephalochorda* (Amphioxus), *Urochorda* (Tunicata), and *Hemichorda* (Balanoglossus).

The three last have been already treated, so that we are now concerned only with the *Craniata*.

The Craniate Vertebrates are divided by the same authority into two "Grades," namely, *Cyclostoma* or jawless Craniates, and *Gnathostoma* or Craniates with jaws and with (persistent or transient) branchial bars. The Cyclostomes have just been spoken of, so that we now are left with the Gnathostome Craniates alone.

These are grouped in five great Classes :—

Fishes, Amphibia, Reptiles, Birds and Mammals.

All the members of these five classes possess jaws and, at some time of life, a series of bars, known as branchial arches, suspended behind the jaws.

In the Reptiles, Birds and Mammals, the branchial arches, except the first which becomes the hyoid bone, disappear as independent structures early in embryonic life, as they do in adult life in many Amphibia: but in the Fishes, as well as in most Amphibia during larval life at least, they are important structures, most of them bearing gills for breathing air dissolved in water.

The Fishes and Amphibia are thus most closely related to one another, and they further agree with one

another, and differ from the three higher Classes, in being without an amnion and allantois during embryonic life. [An amnion is a special envelope formed for the protection of the growing embryo. An allantois is a special outgrowth of the hinder part of the gut of the embryo, carrying with it blood-vessels, for the primary purpose of respiration.]

Fishes however differ from Amphibia in the form of the limbs, which in Fishes—when they are present—are fins, while in Amphibia—when present—they are segmented limbs ending in digits. In Fishes again the respiration is more completely aquatic; for though there are a few fresh-water fishes that have lungs in addition to gills, the immense majority of fishes breathe, throughout life, exclusively by gills: and though most Amphibia when they leave the egg breathe entirely by gills, and though some Amphibia keep their gills throughout life, yet a majority of Amphibia, in the adult stage, completely lose their gills, and even those that do not lose them have lungs in addition.

The Fishes, like the Amphibia and Reptiles, are "cold-blooded;" that is to say, there is no nervous mechanism for controlling the temperature of the body, which therefore rises and falls with the temperature of the environment.

THE FORM OF THE BODY among Fishes is generally that of a spindle, a form that is admirably adapted for cleaving a way through a resistant medium like water. This form, which is almost universal among active-swimming species, has necessarily become profoundly modified, in various ways, to suit various other modes of life.

[A considerable series of preparations in Cases 6, 7, 8, is meant to illustrate some of the most striking of these modifications of form.]

For instance, in the Flat-fishes (see *Pleuronectes*) which live and feed on the bottom, and lie on one side, the body is strongly compressed and leaf-like, and the eye of the underside has travelled round to the upper-side, so that both eyes are on one side of the head.

In the Pomfret (see *Stromateus*) which, however, is a fish that swims free, the body is almost as much compressed as it is in many Flat-fishes.

In the Skates and Rays, (see *Trygon*) which generally live and feed on the bottom, the head and trunk are depressed,—giving the body a disk-like form, and the tail is a lash-like organ of defence.

In the Pediculati or Frog-fishes (see *Halieutæa* and *Lophius*) which also, usually, live on the bottom, the head and body are enormously enlarged and are depressed like a disk.

In the Eels (see *Muraena*) which are able to creep under rocks and into holes and crevices, the body is long cylindrical and snake-like.

In the Hairtails (see *Trichiurus*) the body is strap-shaped and the tail is long tapering and lash-like.

In the Pipe-fishes (see *Gastrotoceus*) many of which live in brackish water among weeds, the body is long, thin and rigid, very much like a stalk or a blade of grass.

In the Sea-horses (see *Hippocampus*) the body has a most singular resemblance to the conventional knight of the chess-board.

In the Box-fishes (see *Ostracion*) the form of the body is coffer-like.

In the Hammerhead Sharks (see *Zygæna*) the name well expresses the curious abnormality of form.

THE TOPOGRAPHY OF THE BODY of a typical fish may be studied from the lettered preparation of a Sea-perch (*Lates calcarifer*: Bekti) in Case 8.

The *head* is delimited from the trunk by the gill-opening, the slit by which the water that has been used in breathing ultimately escapes from the pharynx. In the head we see (1) a wide mouth, (2) eyes without true eyelids, and (3) nostrils, which do not, however, open into the pharynx. There are no external signs of an ear, because the organ of hearing in fishes is lodged within the bones of the head.

The *trunk* is delimited from the tail by the vent: the *tail* is the tapering part behind the vent.

In the middle line of the back is a fold of skin supported by rays: this is the *dorsal* fin, which may either be entire or be cut into two or three pieces. In the middle line of the under surface of the tail, occupying part or all of the space behind the vent is a similar fold of skin supported by rays: this is the *anal* fin. Extending vertically round the tail is a third similar fold of skin supported by rays: this is the *caudal* fin, which is very often forked. These three series of fins are known as the *vertical* or *unpaired fins*: the manner in which their rays are loosely articulated with the skeleton may be studied in the labelled skeleton of the Cod-fish in Case 9.

Besides these vertical unpaired fins, there are, in the specimen we are examining, on the trunk, two symmetrically *paired fins*. The front pair, placed immediately behind the gill-opening on either side, are the *pectoral* fins: they correspond with the fore-limbs of higher Vertebrates. The hind pair, which stand out on either side of the belly behind the level of the pectorals, are the *ventral* fins: they correspond with the hind limbs of higher Vertebrates.

The pectoral fins may be altogether absent, as they are in some eels. However they are far more constant than the ventrals, and although the height at which they stand varies a little, their position is always constant immediately behind the gill-opening. Their extreme of development is found in the Flying-fishes. In the Paradise-fishes (*Polynemus*: "*Topsi*") some of their rays are of prodigious length and form organs of touch. The same thing is seen in *Bathypterois Guentheri* a fish that lives in great depths of the ocean where little sunlight penetrates and where therefore eyes, being probably useless, are liable to degenerate. Degeneration of the eyes *has* occurred in *Bathypterois* and, in compensation, some of the rays of the pectoral fins have become long "feelers," by means of which the animal probably feels its way in the perpetual gloom, in much the same way as a blind man feels his way with a stick.

The ventral fins are far more variable in position than the pectorals and are usually smaller. In some fishes, for instance in all eels, they are altogether absent. In others, as in the whole Order of Physostomes they are, when present, placed far back on the belly. In others, as in the Perch we are considering, they are placed far forwards under, or just behind, the pectorals. In others, as in the Cod-fishes they are placed on the throat, well in front of the pectorals.

Although the paired fins of Fishes correspond with the limbs of higher Vertebrates, and although they are of some use as motors, they are not the principal means of locomotion; for locomotion in most fishes is effected by the pliant muscular tail and the caudal fin.

In most fishes the SKIN, as in the specimen of Sea-perch that we are examining, is covered with scales, which are often imbricate. Scales are of four principal kinds, namely:—(1) *Cycloid* scales, which are thin horny plates with a thin smooth edge; (2) *Ctenoid* scales, which are thicker horny plates with sharp spines on the hinder edge and often also on the exposed surface; (3) *Ganoid* scales, which are hard bony plates covered with a layer of still harder enamel: they do not overlap, but

often interlock with one another; (4) *Placoid* scales, which are either bony granules or tooth-like bony plates with a covering of enamel: placoid scales are, in fact, often not different, either in form or composition, from the *teeth* of the fishes that possess them.

In most fishes (see the labelled Sea-perch in Case 8) a row of scales along either side of the body is specially modified to form what is known as the *lateral line*. This is a subcutaneous groove that usually extends from the back of the head to the tail, and the scales that cover it are channeled and perforated and are specially provided with nerve-endings, so that the lateral line is an organ of sense.

A series of specimens of the various sorts of scales is to be found in Case 7.

The scales of fishes are usually imbedded in distinct pockets of the skin, and are protected (as also is the skin of those fishes that have no scales) by a copious layer of slime, or mucus, secreted by small cutaneous glands.

The integument of Fishes is almost always coloured. The colours fade both in dried and spirit specimens, but in this Gallery an attempt has been made, as far as possible, to represent the natural colours by painting.

The tints are commonly dull with a metallic sheen, but many marine species are most gorgeously coloured.

Fishes that live on sandy and shingly bottoms are often speckled and marbled in various shades of yellow and brown on the upper surface (or, in the case of Flat fishes, on the upper side); while those that haunt reefs encrusted with a variety of sea-weeds and zoophytes are often most wonderfully mottled, or else have the skin decorated with frond-like tags and tassels and fringes. By thus harmonizing with the colour and form of surrounding objects they escape the notice of their enemies and avoid scaring their prey.

Moreover, many fishes can, within certain limits, temporarily change colour to suit changes in their surroundings: this is brought about by varying the amount of contraction and expansion of the special cells—known as *chromatophors*, or colour-carriers—in which the colouring-matter is contained. For instance a fish may, as in the case of several species of *Platycephalus* be dependent for its colouration on two pigments—yellow and dark brown, which in ordinary circumstances are arranged in bands across the body. If, however, the fish be resting on a dark surface, the yellow cells

may contract and the dark cells expand to such an extent that the prevailing colour of the fish may be dark brown; but if, on the other hand, it be resting on a light surface, the dark cells may contract and the yellow cells expand until the fish appears almost yellow.

Or, as in the case of *Balistes maculatus*, the ordinary colouration is blue-black with light blue spots, somewhat resembling that of certain unpleasant sea-urchins of the reefs among which this fish is found. If, however, the fish be resting against a very dark surface (as, for instance, a piece of discoloured drift-wood) the light-blue cells may contract until they are almost invisible.

One of the most "chameleonic" fishes of Indian Seas is *Pterois miles* (Case 7) which, when creeping among the encrusted rocks of coral reefs, presents almost every intermingled shade of red and brown, but which, when forced by pursuit into the blue water of the open lagoon, can become almost blue.

In connexion with the integument it must be mentioned that in some fishes its mucous secretion may be poisonous. In Indian waters there are many such "poisonous" fishes. The commonest are the Sting-rays, which by means of a huge barbed spike on the dorsal surface of the base of the tail can inflict a poisoned wound that may even prove fatal.

Plotosus anguillaris is a Siluroid fish that with its large barbed dorsal spine—and perhaps also with the similar spine of the pectoral fins—inflicts a wound as painful as the sting of a hornet.

In neither of these cases have any special poison-glands been discovered, so that we must suppose that the secretion of the skin in the neighbourhood of the spines is poisonous. In *Synanceia verrucosa* (Case 53), however, each spine of the dorsal fin supports a cutaneous poison-bag, the spine itself being grooved to carry the poison into the puncture made by its sharp point.

In connexion with the integument, too, it must be mentioned that some fishes—especially among those species that either live habitually at great depths to which no sunlight penetrates, or that live at a considerable depth of the open sea and only come to the surface at night—have luminous organs imbedded in the skin. Specimens of several such species, that inhabit the Indian Seas, are shown in the gallery.

THE SKELETON among Fishes occurs under two principal types of form,—the BONY skeleton characteristic of the large Order of Bony Fishes, and the CARTILAGIN-

OUS skeleton characteristic of the Sharks and Rays. Although there are also several modifications of these two types, some of which are more or less intermediate between them, it is here sufficient to consider these two common types, as illustrated by the labelled skeletons in Case 9 of the Cod-fish and Dog-fish.

The skeleton of the Cod is of the well-ossified or BONY type, and as all the bones are named, the present description refers only to its general composition.

It consists of two portions, namely: (1) the *axial skeleton* including the jaws, hyoid bone, branchial arches proper, and ribs, and (2) the *skeleton of the appendages.*

The Axial Skeleton consists of (1) the *skull*, or brain-case, and (2) the *backbone*, which replaces the notochord, and in which the remains of the notochord are imbedded.

The skull includes (1) the segmented brain-case, or cranium, (2) the bones that enclose the organs of the special senses—nose, eye, and internal ear, (3) the bones of the palate and jaws, and (4) the bones that support and cover the gills or breathing-organs. Observe (1) that the cranium forms much the smaller part, and that the bones of the mouth and breathing-organs form much the larger part, of the skull; (2) that the bones of the mouth and gill-cover are slung from the skull, on either side, by a large *hyomandibular*; (3) that the five pairs of branchial-arches (of which only the first four bear gills) are slung from the base of the skull.

The backbone consists of a chain of rather simple vertebræ, to some of which, behind the first, a pair of ribs are attached. Those in front that bear ribs are known as *abdominal vertebræ*, those behind that have no ribs are known as *caudal vertebræ*. Observe that the backbone appears to end abruptly at two large plates of bone of nearly equal size that support the caudal fin, forming what is known as a *homocercal tail.*

The form and composition of the individual vertebræ can be learnt from the labelled specimens of abdominal and caudal vertebræ mounted alongside the skeleton. Each of these consists of an hour-glass-shaped body or *centrum*, hollowed at both ends. From the dorsal surface of the *body* two *neural plates* arch up and meet above the spinal cord (which they encircle), to form a *neural spine*.

From the ventral surface, also, of the body of the caudal vertebra a pair of *haemal plates*, almost exactly like the neural plates, descend and meet to form a *haemal spine*: in the haemal arch, or space between the haemal plates, the main artery of the body runs.

In the case of the abdominal vertebra the haemal arch is replaced by a pair of ribs.

Besides the neural and haemal processes and spines there are *articular facets* by means of which (1) the neural processes of the different vertebræ are articulated together, and (2) the ribs, when present, are articulated with the vertebra that carries them.

The Appendicular Skeleton relates to the paired fins. The pectoral fins are suspended from the head by means of a very complicated shoulder-girdle, from which the fin-rays radiate without the intervention of any bones corresponding to an arm. The ventral fin-rays are attached in the same way to a pair of simple pubic bones.

[The rays of the unpaired fins are loosely connected with the neural or haemal spines of the vertebræ by a series of interspinous bones.]

The skeleton of the Dog-fish represents the CARTILAGINOUS type.

The skull is an unsegmented cartilaginous capsule, of which the roof is often in places incomplete, and to it the cartilages that protect the organs of special sense are firmly attached,—the snout, or parts enclosing the organ of smell, being often enormously developed. The jaws, which are much less complicated than they are in the bony fishes, and the hyoid bone, are also of cartilage; as also are the branchial arches proper, which further differ from those of the bony fishes (1) in being suspended from the anterior part of the "backbone," (2) in having cartilaginous *branchial rays* for the support of the gill-chambers, and (3) *in not having a gill-cover.*

The backbone consists of a chain of cartilaginous vertebræ and is prolonged into the upper lobe of the caudal fin, forming a *heterocercal tail.*

The appendicular skeleton consists of two cartilaginous arches—one for the pectoral fins the other for the ventral fins—to which plates of cartilage are attached, and from these the cartilaginous fin-rays radiate.

The typical cartilaginous skeleton, above briefly described is not found, unmodified, in *all* the members of the large Order (of Sharks and Rays) to which the Dog-fish belongs. For instance, there are Sharks in which the vertebræ, and even some of the bones of the head, are more or less calcified; there are Rays in which the vertebræ are partly ossified; and there is one small section of the Order in which rudimentary gill-covers are present.

The essential difference between the skull of a Shark and that of any of the higher Vertebrates is, that in the latter the primitive skull is not only ossified, but also becomes roofed-in by large bones (dermal bones) formed in the original integumentary covering of the skull. In the Shark the primitive skull remains unossified and unconnected with any ossifications in its integumentary covering.

It has been stated that the rays of the paired fins of Fishes are not connected with any stem representing the axis of the limb of higher Vertebrates. An exception to this statement must now be made.

In the small but highly interesting Sub-class of Dipnoi (Case 23 & 24) the skeleton of the paired fins is comparable to that of the limbs of higher Vertebrates; for it consists of a long *segmented* cartilaginous rod to which the rays, when present, are articulated. The dissection of the fore-limb of *Ceratodus* in Case 23 displays this.

The DIGESTIVE SYSTEM of Fishes is illustrated by two dissections in Case 10, of a Sea-perch (*Pristipoma*) and of a Ray (*Trygon*) in which the abdominal cavity has been completely laid open and all the viscera labelled, with the exception of the liver, which has been removed for the sake of clearness.

In the Sea-perch (*Pristipoma*) observe the large mouth, the small tongue, the capacious pharynx with four wide gill-slits on either side, the short gullet, the **Y**-shaped stomach, the *pyloric appendages*, the single loop of the small gut, and the straight large gut opening at the vent. [The pyloric appendages are narrow pouches that surround the intestine at its junction with the stomach. Their microscopic structure does not differ essentially from that of the neighbouring intestine, into which they open].

In the Ray (*Trygon*) observe the **U**-shaped stomach, the absence of pyloric appendages, and the very short and wide intestine, which has been cut open to show how its absorptive surface is increased by the broad spiral pleating of its mucous membrane, known as the *spiral valve*. Observe that the intestine opens into a pouch common to it and the urinary and generative organs, called the *cloaca*.

The pancreas and spleen are left in their natural position, but the liver, which is a large oily organ that fills a large part of the abdominal cavity, has been removed.

The mouth of Fishes is generally large, and teeth are generally present not only in the jaws, but often also on several bones of the palate, and even on the tongue and on parts of the branchial arches. It would almost need a special gallery to exhibit the various forms of teeth that are found among Fishes: they all, however, agree in being impermanent structures that are shed and replaced throughout the life of the animal, and in being more usually fixed to the bone than sunk in sockets; and although in certain Fishes that feed on hard substances such as mollusks and living coral they are adapted for crushing, they are never organs of mastication, but are merely used for prehension,—for the majority of fishes are predaceous and bolt their prey whole.

The gullet is short and wide, and the stomach is large and capable of enormous distension, especially among the highly predaceous deep-sea fishes, some of which can swallow prey actually larger than themselves.

The general nature of the BREATHING-ORGANS and HEART in Fishes is illustrated by dissections of a Ruhu (*Labeo*) and of a Sting-ray (*Trygon*) in Case 10, in which the pericardial cavity that contains the heart has been opened, and the main arteries and the gills have also been laid bare.

In both these fishes the breathing-organs, or gills, consist of rows of leaf-like vascular folds of mucous membrane, attached to the branchial arches like the barbs of a feather, in which the blood gets rid of its gaseous impurities and absorbs Oxygen from the surrounding water.

In both, also, the heart lies immediately behind the gills and consists, from behind forwards, of the following parts: (1) a thin walled *venous sinus*, into which the

great veins of the body open ; (2) a thin-walled *auricle* that receives the blood—valves preventing regurgitation—from the venous sinus ; (3) a thick-walled muscular ventricle, which receives the blood—valves intervening—from the auricle and propels it to the gills.

The *Gills of the Sting-ray* exemplify the type of the Sub-class Elasmobranchii. They are contained in separate *gill-pouches*, of which there are five pairs, arranged in two rows, one row on either side of the pharynx. Each gill-pouch has a separate opening, not only into the pharynx but also to the exterior. The gill-pouches are supported by the hyoid and branchial arches and their "branchial rays" before mentioned. Each pouch contains two half-gills, except the last, which contains only one half-gill. Besides the five pair of gill-pouches, there is a pair of *spiracles* which open into the pharynx, and also to the exterior just behind the eyes: they do not bear functional gills, but they are of use in respiration by admitting water into the pharynx: they are homologous with gill-clefts, being in fact the pair of clefts between the jaws and the hyoid bone, that is to say between the first two *primitive* branchial arches.

In the *Heart of the Sting-ray* (Elasmobranch type) the ventricle ends in a muscular, pulsatile, many-valved *arterial bulb*, or *arterial cone*, from which a single large *branchial artery* issues and runs forward between the two rows of gill-pouches, giving off a branch to each pouch. These branches of the branchial artery break up and ramify in the gills for the purification of the blood. The purified blood is collected by a corresponding series of arteries, which finally unite to form a single large blood-vessel—the *dorsal aorta*—that runs

beneath the backbone and supplies the whole body with pure oxygenated blood.

The *Gills of the Ruhu* exemplify the type of the Sub-class Teleostei. There are four pairs of them, attached to the convexities of the first four pairs of branchial arches, and they lie in a gill-chamber on either side of the pharynx. Each gill-chamber is protected by a gill-cover, and opens into the pharynx by four wide branchial clefts, but opens to the exterior by a single *gill-slit.* Special processes known as *gill-rakers* are generally present along the concavities of the branchial arches—especially of the first—to strain the water as it passes from the pharynx into the gill-chamber.

In the *Heart of the Ruhu* (Teleostean type) the ventricle gives of a single branchial artery, which has the same course and distribution as that of the Sting-ray, but has no muscular pulsatile arterial cone at its base but only a fibrous thickening known as the *aortic bulb.*

The mechanism of breathing in Fishes is as follows. Water containing oxygen in solution is drawn into the pharynx either through the mouth alone, or, when spiracles are present, through the spiracles also. The water passes, through the branchial clefts in the walls of the pharynx, into the gill-pouches or into the gill-chamber. There it is acted on by the gills, which exchange their carbonic acid for its oxygen, and thence it flows away through the external gill-clefts or through the gill-slit.

In the circulation of the blood in Fishes venous blood is carried to the heart whence it is propelled, by the strong pulsations of the ventricle, to the gills, to be arterialized. From the gills the arterial blood flows into the dorsal aorta to be distributed to the body.

Although the great majority of Elasmobranch Fishes have only five pairs of gill-pouches, there are a few that have six or seven pairs. Again there is one small section of the Elasmobranchs, namely, the *Holocephali*, in which the external openings of the gill-pouches are concealed by a fold of skin that encloses a rudimentary gill-cover.

Again, although the Teleosteans generally have four pairs of gills, there are some, such as several of the Frog-fishes *(Pediculati)* that lead an inactive life at the bottom of the sea, that have only two-and-a-half, or even only two pairs.

Accessory Breathing Organs of Fishes. Gills are essentially organs for aquatic respiration, but there are some fishes that, living under peculiar conditions where the supply of water may periodically run short, or where it may suit them to take short journeys on land, are provided with accessory organs that enable them to breathe out of water. Several such fishes are found in the jheels of India. The so-called Climbing Perch (*Anabas scandens*) and the Singhi fish (*Saccobranchus fossilis*), dissections of both of which are exhibited in Case 10, are good examples of these.

Observe in *Anabas* the frilled and pleated mass of thin bone, covered by vascular mucous membrane, that lies in a special prolongation of the gill-chamber, on either side of the head. Observe in *Saccobranchus* the lung-like extensions, into the muscles on either side of the backbone, of the gill-chambers.

By these curious structures, if only they are kept moist, the fish is able to breathe out of water, and it is a well known fact that both these fishes will live for days after they have been removed from water, if only they are kept damp.

The *Air-bladder* or *Swim-bladder of Fishes*, a series of dissections of which have been placed in Case 10, can hardly be spoken of as an accessory breathing-

organ; but yet, since it is strictly homologous with the lungs of air-breathing Vertebrates, and since in one Sub-class of Fishes—the *Dipnoi*—it acts as a true lung, a short account of it may be most naturally introduced here.

The air-bladder (which does not exist in all Fishes and is unknown among the Elasmobranchs) is a sack, with tough walls and a pearly lustre, that lies in the abdomen beneath the backbone and kidneys but above the peritoneum or lining membrane of the abdominal cavity. Its walls yield isinglass, and its cavity, in life, is filled with gas, the amount and density of which can be regulated in such a way as to make the organ an adjustable float.

It originates as an outgrowth of the gullet, exactly in the same way as do the lungs of higher vertebrates, but in a large number of fishes its connexion with the alimentary canal becomes completely obliterated.

The dissections in Case 10 show (1) an air-bladder of a fresh-water eel that retains an open communication with the gullet by means of a *pneumatic duct;* and (2) various air-bladders that are mere closed hydrostatic organs.

In the *Dipnoi* (Cases 23-24) the air-bladder is a true lung that receives a special supply of venous blood and returns it—arterialized—to the heart. In respect of their breathing-organs and circulation the Dipnoi resemble certain Amphibia.

In many freshwater fishes the air-bladder (or special processes of it) is connected with the internal ear.

The relations of the KIDNEYS in Fishes are seen in the dissections in Case 10. In the dissection of *Trygon* (Elasmobranch type) they lie in the after portion of the

abdominal cavity on either side of the vertebral column and their ducts open into the cloaca. In the dissections of *Pristipoma* and *Lates* (Teleostean type) they adhere to the backbone and open behind the vent.

The NERVOUS SYSTEM of Fishes, portions of which are illustrated by labelled dissections of an Indian Carp, of a Bekti, of *Lamprogrammus* and of a Shark, in Case 11, corresponds with that of higher vertebrates.

The *Brain* is small and is divided into five regions none of which conceal any of the others in the Carp and *Lamprogrammus*, though some of them do in the Shark. The five regions are (1) the paired *olfactory lobes* which are relatively large, (they have been removed in *Lamprogrammus* to show the crossing of the optic nerves); (2) the paired *cerebral hemispheres*, which are small, though larger in the Shark than in the others; (3) the paired *optic lobes*, which in the Carp and *Lamprogrammus* are the largest lobes of the brain, though in the Shark they are small and are completely hidden by the cerebellum; (4) the unpaired *cerebellum* which is small in the Carp, but large in the Shark; (5) the *medulla oblongata*, which is continued without a break into the spinal cord.

Immediately behind the cerebellum there is seen, in a dorsal view, a hollow or groove, called the *fourth ventricle:* this can be followed forwards into the brain and backwards into the spinal cord, betokening the tubular origin of the central nervous system.

The olfactory lobes are prolonged to form the so-called olfactory nerves, which expand where they meet the olfactory sacks: observe the large size of these sacks

in the Shark. The olfactory nerves are really outgrowths of the brain.

From the under surface of the optic lobes the optic nerves pass: they too are really outgrowths of the brain. In the Carp and *Lamprogrammus* the optic nerves cross, so that the nerve of the right side goes bodily to the left eye and *vice versâ*: but in the Shark they fuse where they cross each other.

Eight other pairs of nerves emerge from the under surface of the brain. They supply the muscles that move the eye-balls; the skin and muscles of the head, face, jaws, gill-covers and hyoid; the organ of hearing; the mouth, tongue, gills and throat; and the gullet, stomach, heart, air-bladder and lateral line.

The *Spinal cord* is continued from the medulla oblongata along more or less of the canal formed by the neural arches of the vertebræ, and it gives off a pair of spinal nerves between every vertebra.

The dissections of brains in Case 11 also display some of the organs of special sense—namely the organs of smell and hearing and the eye.

Except in the case of the *Dipnoi*, in which the nostrils open into the mouth, the organ of smell in Fishes consists of a pair of closed sacks of considerable size, the lining membrane of which is pleated.

Except in certain fishes that inhabit subterranean pools or ocean depths to which no light can penetrate (*e.g.*, *Tauredophidium Hextii* in Case 15), eyes are present in Fishes and are peculiar in having the cornea flat and the lens spherical.

The organ of hearing in Fishes is enclosed within the bones of the head, and consists, on either side, of the labyrinth or "internal ear" only. The cavity that corresponds with the tympanum or "middle ear" of

higher vertebrates is either absent, or (as in Sharks) is a functional part of the breathing apparatus; and the bones that correspond with the auditory ossicles of higher vertebrates are in Fishes important parts of the suspensorium of the jaws and hyoid.

The MUSCULAR SYSTEM of Fishes is comparatively simple. The eye-balls, the jaws and gill-apparatus, and the fins, all have their own special muscles, but the principal part of the muscular system is massed along the sides of the trunk and tail. Each lateral mass of muscles is longitudinally divided into a dorsal and ventral band, and each of these again is split up, vertically, into a close-fitting series of conical flakes or segments known as *myocommas*.

The ELECTRIC ORGANS possessed by certain Fishes are probably peculiar modifications of muscular tissue, by means of which voluntary nervous impulses give rise to powerful electric outbursts instead of to ordinary tetanic contractions. A dissection of one of the electric organs of an Indian Torpedo, or Electric Ray, showing the great nerves that ramify in its substance, is exhibited in Case 11. The electric organs are weapons of defence and may also be useful in disabling prey.

The phenomena of REPRODUCTION in Fishes are varied.

The form and position of the ripe organs of reproduction are shown in the dissection of *Trygon* and *Pristipoma* in Case 10, each representing a different type.

In the majority of Fishes the female lays eggs which are fertilized by the male after their extrusion; but in

the Sharks and Rays, as well as in a few species of Bony fishes, the eggs are impregnated by the male before they are laid, as in the manner of Birds and Reptiles. Moreover there is a considerable number of Sharks and Rays in which not only are the ova fecundated internally but the embryos also complete their development within the body of the parent, much as in the manner of Mammals.

In the first case (external fertilization) the eggs are small and shell-less and the embryo, of course, developes, from first to last, quite independently of the parent. The series of preparations in Case 12 illustrates the developmental history of the common Salmon from the egg to the free-swimming larva.

In the Stickleback (of which a pair with nest and eggs are shown in Case 12) the male builds a nest in which he induces certain females to lay their eggs, and these eggs he guards jealously until they are hatched.

In the Sea-horse (of which a brooding male with the nursing-pouch laid open is shown in Case 12) the male has an abdominal pouch into which the eggs are received and in which they remain until development is complete and larval growth well advanced.

And there are several other species of fishes in which one of the parents, usually the male, watches over the developing offspring.

Where impregnation is internal, as among the Sharks and Rays, the eggs are large, and they may either be encased in a tough leathery shell, or they may be shell-less: in the latter case they are not laid as eggs, but undergo development within the oviduct, so that the young are born alive.

In Case 12 the eggs and development of two species of Dog-fish are exhibited: the eggs are enclosed in a curious shell and are hatched quite independently of the mother.

In the same Case (12) is shown a specimen of the unborn young of a Hammerhead Shark. Here the

embryo developes in the mother's oviduct, and when all the yolk is used up by the growing embryo, the large empty yolk-sack adheres to the wall of the oviduct so that the blood-vessels of the two structures—yolk-sack and oviduct—come into close contact and allow nourishment to pass from the mother to the embryo.

In the same Case (12) a specimen of the unborn young of a Sting-ray (*Trygon*) is shown lying in the mother's oviduct. Here too the embryo developes within the oviduct, of which the lining membrane is shaggy with glands that secrete a kind of milk. When all the yolk is used up by the embryo, the yolk-sack, which is small, shrivels, and then the embryo lives on the milk which passes into its mouth through the spiracles. In the exhibited specimen clusters of milk-glands are seen to pass deep down into the spiracles.

There are certain Bony Fishes (see *Saccogaster*, *Diplacanthopoma*, and *Hephthocara*) in which impregnation is internal and the young do not leave the mother until their development is complete. Here the eggs are small, as in all Bony Fishes, and the growing embryos appear to be nourished by simple absorption from the wall of the ovary.

In some fishes the sexes differ considerably in appearance, and it is generally the male that differs from the female, either in being more brilliantly coloured or in possessing special ornaments. Numerous instances of these "secondary" sexual differences have been brought together by Darwin, in the *Descent of Man*. In Case 13 two good examples are shown; in one of them (*Brachypleura*) the male has the first few rays of the dorsal fin greatly lengthened to form an erectile plume: in the other (*Callionymus*) the male alone has both the dorsal and the caudal fin-rays much prolonged.

Observe also in Case 12 how the adult male alone of the common Stickleback has the throat and belly coloured bright red during the breeding-season.

Of the *Habits* and *Uses* of Fishes little can here be said.

As to *Uses:* in every civilized country that has a sea-board, the sea-fisheries are a recognized source of the country's wealth and an acknowledged factor in its commercial importance, besides often giving—as in the case of Norway—a determining impulse to its scientific, no less than to its industrial, activities. In India, unfortunately, the sea-fisheries, although they are of incalculable value, are almost entirely neglected by capital, so that instead of contributing largely—as they ought—to the national prosperity, they do little more than furnish a contemptible living to the meagre population of the coasts.

As regards *Habits*, these, as far as they have any peculiar interest, will be referred to in the sequel.

A few words have yet to be said (1) as to the geographical relations of the Indian fish-fauna, and (2) on the fishes that inhabit the great depths of the Indian Seas.

THE GEOGRAPHICAL RELATIONS OF THE FRESH-WATER FISHES OF INDIA.

Exclusive of some marine forms that ascend tidal rivers, the true fresh-water fishes of India number about 400 species, of which considerably more than half (nearer two-thirds) are Carps (*Cyprinidæ*), and about three-tenths are Cat-fishes (*Siluridæ*.)

The Carps form an enormous dominant family and are widely spread, in fresh waters, in Europe, Asia, Africa, and North America: there is little difficulty in explaining their presence and abundance in India.

The *Siluridæ* also form a very large family; they are not exclusively inhabitants of fresh-water, for some species live in estuaries and in the sea, but always near coasts. Though some species occur in North America, in Europe, in Central Asia China and Japan, and in Australia, the great bulk of the family are found in Tropical America, Tropical Africa, and Southern and Tropical Asia. Sometimes (*e.g.*, *Arius*) the same genus is represented in Tropical America, in Tropical Africa, and in India.

The other true fresh-water fishes that are found in India are

(3) the *Cyprinodontidæ*, little carp-like fishes that also occur in Tropical America, in Tropical Africa, and in some of the countries bordering on the Mediterranean:

(4) the *Chromides*, a family of which most of the members inhabit Tropical America, a considerable number are found in Africa and Syria, and 2 species only occur in India and Ceylon:

(5) the *Symbranchidæ*, a small family of fresh-water eels occurring only in Tropical America, in the Indian region, and in Australia:

(6–9) the *Notopteridæ*, the *Labyrinthici*, the *Ophiocephalidæ* and the *Rhynchobdellidæ*—all small families that occur only in Africa and the Oriental region:

(10) the *Nandina*, a small subfamily of Perch-like fishes peculiar to India.

The fresh-water fishes of India thus show a curious connexion with those of Tropical Africa and Tropical America—a connexion that, if we can find other confirmatory evidence, would incline us to suppose that the ancestors of the fresh-water fishes of India were inhabitants of a great tropical sea that formerly extended from Central America eastwards across Africa far into Southern Asia.

Besides the fresh-water families, there are a few species belonging to the under-mentioned marine families that have become adapted to fresh-water in this country, namely: some species of Eels, Herrings, Garpikes, Perches, Gobies, Grey-mullets, Parrot-fishes. These fresh-water immigrants from marine families show us one of the ways in which, in Delta-lands especially, the fresh-water-fauna is being re-inforced from the sea.

THE GEOGRAPHICAL RELATIONS OF THE MARINE FISHES OF INDIA.

Excluding the estuarine and brackish forms that are passing into the fresh-water-fauna, the marine fishes of India number about 1200 *species*. Most of them are shore-fishes, a few inhabit the surface-waters of the open sea, and a considerable number live in the great depths.

The total number of Indian *genera* is (allowing for different opinions as to the limits of a genus) between 330 and 350, of which 54 per cent. are also found in the Atlantic, and chiefly (though not entirely) in tropical or subtropical latitudes of that ocean that embrace the American shores and islands between 40° N. and 10° S. and the African shores and islands between the somewhat similar parallels.

Of the 54 per cent. that are common to the Atlantic and the Indian Oceans, half—that is to say, 27 per cent. of the total Indian genera—are also present in the intervening Mediterranean Sea, and a certain number (seventeen genera) that are absent from the Mediterranean are present in the intervening Red Sea. Ten more Indian Ocean genera that do not occur in the Atlantic are found in the Mediterranean, so that the number of genera that the Indian Seas have in common with the Atlantic and Mediterranean combined is more than 54 per cent. of the total.

Not only so: but a respectable number of *species* are common to the two areas, and that not only in the case of wandering species that may live in the surface drift, or of widely-ranging deep-sea species, but also in the case of shore-keeping forms. For instance, *Lobotes surinamensis*, a Sea-perch that lives in brackish water and estuaries, is found on the Atlantic coasts of Tropical America and on the shores of the Indian Ocean from Africa to China, and has once been taken in the Mediterranean, off the Sicilian coast. *Hoplostethus mediterraneum* has a somewhat similar distribution, and there are at least a dozen other species which, though not found in the Mediterranean, are common to the Atlantic approaches of that Sea and the Indo-Pacific.

The conclusion therefore seems irresistible that a large part of the present fish-fauna of the Indian Seas is derived from a great tropical Mediterranean Sea, of a former geological period, that stretched from the Gulf of Mexico, eastwards, halfway round the globe.

THE FAUNA OF THE DEEP SEA.

More than 150 species of fishes are known to live in the depths of the Indian seas, down to 1500 fathoms. Some of them undoubtedly live at the bottom, but the great majority probably swim about in the middle depths.

The conditions under which many of them must live are most peculiar. In the first place, the direct heat and light of the sun are cut off—as in a much minor degree they are cut off to our own daily observation by clouds and fogs—by the overlying volume of water, so that the bottom of the sea, at great depths, is cold and quite dark: at a depth of 200 fathoms it is supposed to be quite dark, and the temperature in these seas, is about

50° Fahr.: at 2000 fathoms there can be no doubt about the absolute darkness, and the temperature, in these seas, is constant at less than 2° above freezing-point.

As a result of the absence of sunlight, plants (except perhaps microbes) do not exist.

Again the barometric pressure at the bottom of the sea is something enormous: at 200 fathoms it must be over 500 lb. on the square inch, at 2000 fathoms it must be considerably over 2 tons on the square inch.

The effects of the pressure can only be inferred. Deep-sea fishes when brought to the surface by the dredge and released from the accustomed pressure, are—only in a very highly intensified degree—somewhat in the condition of a man who has been carried into the uppermost regions of the atmosphere by a balloon. They are dead: their bodies are distended and ruptured by the expansion of their gases and by the extravasation of their fluids, and their eyes are blown out of their sockets.

The ultimate effects of the darkness are as curious as varied. Some deep-sea fishes are quite blind, their eyes being hidden rudiments: *Tauredophidium hextii* shows this. In others, the eyes are rudimentary and some of the fin-rays have become long organs of touch—a compensation on the principle of the blind-man's stick: *Bathypterois Güntheri* is a good instance. Others have evolved their own means of illumination, and possess organs that—like the luminous glands of fire-flies—secrete a fatty substance that burns slowly with a cold phosphorescent light: these have their eyes well developed, and several examples of them are shown in Cases 15–18 in which a series of typical deep-sea fishes are exhibited.

Ravenous as most fishes are, deep-sea fishes surpass

all others in this respect. Some of the models and specimens in Cases 15–18 show the marvellous developments of teeth and maw.

The model of the deep-sea Torpedo, *Benthobatis moresbyi* needs a special explanation, since it appears to upset our calculations. It has been implied that *Tauredophidium* has lost its functional eyes because it lives in the dark, and that certain other fishes although they live in darkness, or, at any rate, in deep gloom, have retained their eyes because they have acquired their own means of illumination. But here is a fish *Benthobatis moresbyi*, which undoubtedly lives at the bottom and at a depth to which sunlight does not penetrate, and which—as we should therefore expect—is blind, but which yet has, in the skin of its back, numerous little luminous pores.

The probable explanation of this apparent anomaly is that the pores are lures to attract prey—the prey being then instantly killed or disabled by the powerful electric organs which *Benthobatis* possesses.

The following is the classification of fishes proper adopted in this Gallery :—

Subclass I. **Chondropterygii :—**

Order i. PLAGIOSTOMA :—

Suborder 1. *Selachoidei* (*Sharks*).
„ 2. *Batoidei* (*Rays*).

Order ii. HOLOCEPHALA (*Chimæras*).

Subclass II. **Dipnoi** (*Lepidosirens*), not represented in India.

Subclass III. **Teleostomi :—**

Order i. GANOIDEI (*Sturgeons*), not represented in India.

Order ii. TELEOSTEI (*Bony fishes*) :—

Suborder 1. *Physostomi.*
„ 2. *Acanthopterygii.*
„ 3. *Anacanthini.*
„ 4. *Lophobranchii.*
„ 5. *Plectognathi.*

We shall begin with the Bony-fishes, as they are, from the systematist's point of view, the latest, highest, and most specialized developments of the fish type. It must be remembered, however, that from the morphologist's point of view, this very specialization has brought the Bony-fishes to a lower or rather more aberrant grade of organization, compared with the central ideal Vertebrate standard, than the *Chondropterygii* and *Dipnoi*.

For the same reason we shall begin with the *Acanthopterygii* among the Bony-fishes.

Subclass **TELEOSTOMI.**

Order I. TELEOSTEI [Cases 42–75].

In the Bony-fishes the skeleton is completely ossified and the tail is homocercal: the gills are free, and lie, on each side, in a gill-chamber, which is closed by a gill-cover and opens to the exterior by a single gill-slit: the bulbus arteriosus is non-contractile: the intestine has no spiral valve: the optic nerves cross each other. The skin is usually, but not always, scaly: the scales are usually either cycloid or ctenoid, but bony scutes resembling ganoid scales occur in some species, and granules something like placoid scales are occasionally met with.

Suborder ACANTHOPTERYGII [Cases 43–59].

The Bekti is a good type of this suborder. Some of the dorsal, anal, and ventral fin-rays are spines. The air-bladder, when it is present, rarely has a pneumatic duct.

There is really no hard and fast boundary line between the *Acanthopterygii* and the *Anacanthini* and *Physostomi*.

The Indian species of Acanthopterygian Fishes are grouped in 42 Families.

Family I. *Percidæ* [Cases 56–59].

The Perches are a large family to which about one-tenth of all the Indian fishes at present known belong. The Indian Perches are for the most part marine, a few only—and those but small species—live exclusively in fresh-water. The Bekti (*Lates calcarifer*) is the best known of the many edible fishes of this family.

There are 31 genera of Indian Perches, of which three—namely *Chelidoperca*, *Synagrops* and *Brephostoma*

—have been discovered since the publication of the *Fauna of British India.*

Brephostoma (Case 57) is a true deep-sea fish. *Lobotes surinamensis* (Case 56) has a most curious and suggestive range, being found along the Atlantic coast of Tropical and Temperate America, in the Mediterranean, and in the seas of India and China.

So far as is known, the *Percidæ* first made their appearance in Tertiary times. They are carnivorous.

Family II. ***Squamipinnes*** [Case 55].

The *Squamipinnes* are practically Perches with a compressed and greatly elevated body. They owe their name to the fact that the dorsal and anal fins are so thickly covered with scales that the usual boundary beween the body and the fins is lost.

Most of them haunt coral-reefs and are gorgeously coloured. Like the Perches they are carnivorous. They are not much used as food, though *Drepane punctata* is fairly good to eat.

The Indian species are arranged in nine genera. *Scatophagus argus* enters estuaries and backwaters, and is even found in freshwater tanks that have long ceased to be connected with any channel leading to the sea: it thus illustrates the way in which the freshwater fauna is continually being augmented from the sea.

Toxotes, which resembles *Scatophagus* in habitat, is said to be able to shoot insects from plants overhanging the water, by means of a jet forcibly ejected from its mouth. An even more important interest attaches to *Toxotes*, because although the species are now confined to Oriental Seas, a fossil species has, according to Zittel, been found in the Tertiary deposits of Monte Bolca near Verona in Northern Italy.

Family III. ***Mullidæ*** [Case 55].

The Red Mullets are marine carnivorous fishes, the great majority of which are confined to tropical seas. Fourteen species, belonging to three genera that are separated by very slight differences of dentition, occur in Indian limits. They are all very good to eat.

Family IV. ***Sparidæ*** [Case 54].

The Sea-breams are Perciform fishes that possess curious specialized teeth for stripping and crushing the shell-fish (*Mollusca*) upon which they largely feed. They inhabit tropical and temperate seas, and twenty species, belonging to seven different genera, are found in Indian waters. They are all esteemed as food.

Sargus noct and *Crenidens forskalii*, two of the Indian species, also occur in the Mediterranean. The genera *Sargus*, *Pagrus*, and *Chrysophrys* are all found off the Atlantic coasts of North America, in the Mediterranean, and off the coasts of India.

Family V. ***Cirrhitidæ*** [Case 53].

These are Perch-like fishes which are distinguished by having the lower pectoral rays thickened and unbranched, so as to form either auxiliary organs of locomotion or organs of touch. Four species, belonging to two genera, are found in the seas of India.

Family VI. ***Scorpænidæ*** [Case 53].

The *Scorpænidæ* are a largish family of marine, carnivorous, Perciform fishes, and are characterized by having a bony stay or buttress across the cheek, and the bones of the head and gill-covers usually armed with spines.

Many of them live among coral-reefs and have the fin-rays curiously lengthened and fringed, and the skin

studded with tags and tassels, to resemble the fronds of sea-weeds and zoophytes. By this means they avoid scaring—if they do not actually allure—prey, and also escape the notice of their enemies. *Minous inermis* (Case 14) has no such tassels, but has the body encrusted with small Hydroid Zoophytes which make an even better disguise.

Synanceia verrucosa (Cases 14 and 53), which in form and coloration resembles a lump of encrusted rock, is another instance of disguise for protective and offensive purposes. This fish is also remarkable in having a series of poison-glands connected with the spines of the dorsal fin.

The majority of the *Scorpænidæ* are of small size.

Family VII. ***Nandidæ*** [Case 54].

In accordance with the arrangement followed in the *Fauna of British India*, this family is allowed to stand here. It is represented by *Plesiops*, which is really a sea-perch; and by three genera of small freshwater fishes very distinct from *Plesiops*.

Plesiops haunts the pools of coral-reefs in the Indo-Pacific region.

Badis, *Nandus*, and *Pristolepis* are found in freshwater in the East Indian region.

Family VIII. ***Teuthididæ*** [Case 53].

This small family contains the single genus *Teuthis*, easily recognized (1) by the structure of the ventral fins, each of which consists of two spines with three soft rays between them, and (2) by the incisor teeth, which are adapted for cutting sea-weed and coral. *Teuthis* is confined to the Indo-Pacific region, where it is found among coral-reefs.

Family IX. ***Berycidæ*** [Case 52].

This is one of the most ancient of all the families of Bony-fishes (*Teleostei*) and was abundantly represented in the seas of the Cretaceous period. It therefore, as might be expected, is less sharply marked off than are its fellows from some of the other suborders of *Teleostei*: for instance, one genus, *Melamphaes*, was at first placed near the Physostomous family *Scopelidæ*; and another genus, *Bathyclupea*, was at first ranked among the Herrings. Several members of the family, in fact, have the air-bladder connected with the gullet by a pneumatic duct, as in the typical *Physostomi*.

The antiquity of the family is also, in all probability, the explanation of the fact that—the family being entirely marine—most of its existing members are confined to deep water.

The family being of exceptional interest, the Indian genera may be noted in detail.

Genus 1. *Monocentris*. In this genus, which contains but one species, *M. japonicus*, the scales form a bony mail, or carapace, and the ventral fins consist each of a huge spine with a few rudimentary rays. *M. japonicus* occurs in Japan, in Australian waters, in the Andaman Sea, and off Mauritius.

Genus 2. *Hoplostethus*. This genus is only found at depths of about 150 to 400 fathoms. *H. Mediterraneum* has a remarkable range, being found off the West Indies and neighbouring coasts of America, in the Atlantic, in the Mediterranean Sea, in the Arabian Sea and Bay of Bengal, and in the Japanese Seas.

Genus 3. *Trachichthys*. *T. Darwinii* has been found, in deep water, off Madeira, in the Bay of Bengal, and off Japan.

Genus 4. *Bathyclupea*. *B. Hoskynii* is peculiar to the

Andaman Sea and Bay of Bengal, at considerable depths. In form it much resembles a Herring, a resemblance that is further increased by the presence of a perfect pneumatic duct.

Genus 5. *Melamphaes.* This is a curious form, which is found only in very deep water. One species occurs in the Bay of Bengal at a depth of over 1,300 fathoms.

Genus 6. *Polymixia.* The single species of this genus bears a considerable resemblance to the Red Mullets, since it has a pair of strong fleshy barbels. *P. nobilis* has almost the same wide range as *Hoplostethus mediterraneum*, but has not been found in the Mediterranean Sea.

Genera 7 and 8, *Myripristis* and *Holocentrum*, are both shallow-water fishes, and are common enough to be used as food.

Family X. *Kurtidæ* [Case 53].

This is a very small family of small marine Acanthopterygian fishes which have a thin body, one short dorsal fin and a long anal fin.

Two genera, *Kurtus* and *Pempheris*, are known, and they are only found in the Indian Ocean and Tropical parts of the Pacific.

Family XI. *Polynemidæ* [Case 53].

A small family of marine and estuarine fishes of much economic value.

Polynemus paradiseus, the Topsi or Mango fish, may be taken as the type. In this fish there are two short dorsal fins, remote from one another, and some of the lower rays of the pectoral fins are isolated and prolonged into independent tactile filaments of great length. The "Topsi," although a marine fish, is seldom found far

from great estuaries, which at certain seasons it ascends, even into freshwater limits. The eye is small and the fish probably relies more on its tactile filaments than upon its sense of sight. The use of the "Topsi" as food is well known: equally estimable is the Silli fish, which is also valuable for its isinglass.

Polynemus occurs in the West Indies, in the seas of India, and in the tropical seas of the Western Pacific.

Family XII. ***Sciænidæ*** [Cases 51–52].

In this family, the members of which share the habitat of the "Topsi," there is a short spinous dorsal fin and a very long soft dorsal fin.

It is a large family and is represented in Indian seas by four genera—*Sciæna*, *Scienoides*, *Umbrina*, and *Otolithus*, all of which are very good to eat, besides being capable of furnishing isinglass. All four genera range from the Gulf of Mexico and neighbouring coasts of America to the Atlantic and Mediterranean and eastwards to the Indo-Pacific.

The Indian species are very common at the mouths of the estuaries of big rivers, and several of them are able to make a croaking sound: none of them appear to be confined to freshwater, though several enter freshwater freely.

Family XIII. ***Xiphiidæ*** [Case 51].

The "Sword-fishes" are characterized by having the bones of the upper jaw prolonged to form a long sword or lance of great sharpness and strength, and a very formidable weapon of offence. By means of it they are able to attack whales successfully; and in the Indian Museum there is a piece of ship's timber that has been perforated by a sword-fish.

In most of the species the dorsal fin is greatly elevated and is said to be capable of acting as a sail.

They are the largest of all Acanthopterygians, and they occur in the Atlantic, the Mediterranean, the Indian Ocean, and the Pacific.

They must not be confused with the "Saw-fishes" which belong to the same Order with the Sharks.

Family XIV. *Trichiuridæ* [Case 50].

A small family of highly rapacious marine fishes, known as "Hairtails" and "Scabbard-fishes." The body is low, compressed, and extremely elongate, and the tail sometimes ends in a long filament. Scales are absent or rudimentary. The dorsal and anal fins consist of a very large number of rays.

Two genera—*Trichiurus*, with three species, and *Thyrsites*, with one species—are represented in Indian Seas. *Trichiurus* occurs in the West Indies and Atlantic and in Eastern Seas from India to Japan. *Thyrsites* occurs in the West Indies and North and South Atlantic, in the Mediterranean, and in the Indian and Western Pacific regions: the Indian species comes from the depths.

Family XV. *Acronuridæ* [Case 50].

The "Surgeon-fishes" are a small family, the members of which occur in shoals among coral-reefs. They are recognized (1) by their rough leathery skin, (2) by the presence of sharp-edged plates or spines on the sides of the tail, and (3) by their incisor teeth, which are adapted for browsing on coral. The plates on the tail are capable of inflicting severe injury, and I have seen a man's palm slashed right across, down to the blood-vessels, by the tail of one of these fishes.

The species found in Indian Seas are 16 in number and belong to two genera, *Acanthurus* and *Naseus*.

Acanthurus is found in the West Indies and Tropical Atlantic coasts of America, in the Red Sea, and in the tropical parts of the Indian and Pacific Oceans. *Naseus* is not found west of the Red Sea. Both genera, however, are known as fossils in the Tertiary deposits of Monte Bolca in Northern Italy.

Family XVI. ***Carangidæ*** [Cases 48, 49].

The "Horse-Mackerels" and their relatives are a large family of active, predaceous, marine fishes, many of which are used as food.

They are distinguished from the true Mackerels, which they closely resemble in form and habit, by having fewer vertebræ.

Many of them being inhabitants of the open seas, have a very wide range in tropical latitudes. For instance, *Micropteryx chrysurus*, *Naucrates ductor*, and *Trachynotus ovatus* are all three found in the West Indies and Atlantic and in the East Indies and Pacific, *Naucrates ductor* also occurring in the Mediterranean and in temperate seas. This fish is known as the Pilot-fish, "from its habit of keeping company with ships and large fish, especially Sharks."

The Indian genera *Caranx*, *Trachynotus* and *Platax* occur fossil in the Tertiary deposits of Monte Bolca in Northern Italy.

Family XVII. ***Cyttidæ*** [Case 50].

The Dories are a small family of marine fishes which is represented in Indian seas by a single species—*Antigonia capros*. Besides occurring in these seas, this species is found in the West Indies, off Madeira, in the East Indian Archipelago, and off Japan—generally at a considerable depth.

Family XVIII. ***Stromateidæ*** [Case 48].

A very small family of marine fishes allied to the Mackerels. The only Indian representatives are the Pomfrets, justly celebrated for the table.

It is not generally known to the inhabitants of Calcutta that Pomfrets abound off the Sandheads.

Other species of Pomfrets are found off the West Indies and neighbouring coasts of America and in the Mediterranean.

Family XIX. ***Coryphænidæ*** [Case 48].

The so-called "Dolphins" are predaceous fishes of the open sea, allied to the Mackerels. Two species occur in Indian Seas. One of these, *Coryphæna hippurus*, ranges from the Atlantic to the Indian and Pacific Oceans and is also found in the Mediterranean.

Family XX. ***Scombridæ*** [Case 47].

The well-known family of Mackerels has seventeen representatives in Indian waters, several of which, known as "Seer-fish," run the Pomfrets very close in estimation for the "equal feast."

Like the "Dolphins" they are inhabitants of the open sea and are among the most active and predaceous of all fishes. To see and hear a shoal of Tunnies in pursuit of a shoal of flying-fish—as may be done in the neighbourhood of the Laccadive Islands—is one of the sights and sounds of the sea.

The following species range through the tropical parts of the Atlantic and Pacific:—*Thynnus thunnina*, *Thynnus pelamys*, *Elacate nigra*, *Echeneis naucrates*, *Echeneis remora*, *Echeneis brachyptera*. All of these, with the exception of *Elacate nigra*, are said to occur in the

Mediterranean also. The species of *Echeneis* also range into temperate seas.

Echeneis, known as the Remora, or "Sucker-fish," has the spinous dorsal fin most curiously modified to form an oval cross-pleated disk, or sucker. By means of this sucker, which is placed on the upper surface of the head and neck, the fish can firmly attach itself to other objects, such as fish, turtles, ships, and can thus be carried about without exertion.

Family XXI. ***Trachinidæ*** [Case 46].

This is a rather small family, the members of which commonly have a long low body and a rather large head, and mostly live on the bottom of the sea, in shallow water or in moderate depths. They are rapacious, and they do not grow to any great size.

To the Indian genera recorded in the *Fauna of British India* three more have to be added, namely, *Champsodon*, *Bembrops*, and *Chiasmodus*, each represented by one species.

Bembrops caudimacula (known to American naturalists as *Hypsicometes gobioides*) has a most curious geographical distribution: it is not uncommon in the Caribbean Sea and off the neighbouring coasts of America at depths varying from 68 to 324 fathoms, and in the Andaman Sea and Bay of Bengal at 107 to 194 fathoms, and it also occurs in Japan.

Chiasmodus niger is one of the most voracious fishes known, being able to swallow prey of greater bulk than itself. It is an inhabitant of great depths, and has been found off the West Indies, in the mid-Atlantic and off Madeira, and in the Bay of Bengal.

The *Trachinidæ* in this Gallery include the *Uranoscopidæ* and *Pseudochromides* of Day's *Fauna*.

Family XXII. ***Malacanthidæ*** [Case 46].

This little family contains but one genus and three species, one of which has been found off Ceylon. Another species belongs to the West-Indian fauna.

Family XXIII. ***Batrachidæ*** [Case 46].

A small family represented in Indian Seas by two species of *Batrachus*. They are of no great size and have a broad thick head and a compressed tail, something like the *Trachinidæ*, which family they also resemble in habit. The ventral fins are peculiar in consisting each of a spine and only two soft rays. The other species of *Batrachus* extend from the Atlantic coasts of America, through Indian and Pacific waters to the Pacific coasts of Central America, one species occurring in the Mediterranean.

Family XXIV. ***Pediculati*** [Case 46].

The "Frog-Fishes" or "Fishing-Frogs" are characterized (1) by their enormous head; (2) by the curious modification of the spines of the dorsal fin, which are commonly transformed into tentacles; (3) by the elongation, to form a sort of "arm," of the bones on which the pectoral fins are supported; (4) by the small size of the gill-opening and the reduced number of gills. This reduction of the breathing organs is, in all probability, a consequence of the inactive life of the "Fishing-frogs," which either lie in wait for their prey on the bottom of the sea, or—as in the case of several species of *Antennarius*—adhere to drift sea-weed.

The Indian genera of this remarkable family may be reviewed in detail.

Genus 1. *Antennarius*. The species of this genus are pelagic and are often remarkably coloured to harmonize

with the colours of the sea-weeds, encrusted rocks, etc., to which they cling with their arm-like pectoral fins. They are the only Indian Pediculates that possess an air-bladder.

Genus 2. *Lophius.* The Fishing-frogs proper live on the bottom. They have a large disk-like head and a cavernous mouth with numerous sharp teeth sloping inwards. The first dorsal spine is very long and ends in a tassel; and it can be bent forwards so that the tassel hangs in front of the mouth. This long modified spine and its tassel form, in fact, a fishing-rod and bait. The fish lies concealed in the mud at the bottom of the sea, the concealment being assisted not only by the colour of the fish but also by the curious frond-like tags of skin with which its body and fins are fringed: in this position it "plays" its fishing-rod, and, when other fish are attracted to the bait, has only to open its enormous mouth. Four species of *Lophius* are found in Indian waters, at depths between 25 and 400 fathoms. The other species of *Lophius* occur in all parts of the Atlantic, in the Mediterranean, and in the seas opening into the Western Pacific.

Genus 3. *Ceratias.* One species of this genus is found in Indian waters. It lives at great depths, and its habits are probably the same as those of *Lophius*; but, as there is no daylight at these depths, the lure at the end of the "fishing-rod" is a luminous organ, which, in all probability, is extremely efficacious, as fishes are known to be readily attracted by a light. The other species of *Ceratias* occur at great depths off the coast of Greenland, in the Atlantic, and in the seas of the Western Pacific system.

Genus 4. *Onirodes.* One species is an inhabitant of the great depths of the Bay of Bengal. It chiefly differs from *Ceratias* in having a smooth skin. The only other species known was taken off the coast of Greenland.

Genus 5. *Chaunax*. In this genus the modified first dorsal spine, or tentacle, is short. One species is known and has been found at depths of 130 to about 400 fathoms, off the West Indies and neighbouring American coasts; off Madeira, Cape Verde and the neighbouring African coasts; in the Arabian Sea and Bay of Bengal; in Japanese Seas; and off the Fiji Islands. Like many other deep-sea animals, *Chaunax pictus* is of a beautiful red or pink colour.

Genus 6. *Halieutæa*. In this genus the form of the body is much like that of *Lophius*, but the modified dorsal spine, or tentacle, is situated on the snout, where it can be retracted into a bony cavity. Four species are found in Indian waters, three of them at considerable depths.

Genus 7. *Dibranchus*. This genus is distinguished from *Halieutæa* by having only two pairs of gills instead of two and a half pairs. Two species occur in Indian seas, both at depths of about 200 to about 400 fathoms. Another species is found in the Atlantic.

Genus 8. *Malthopsis*. This genus differs from *Dibranchus* in little but dentition. In habit it resembles *Lophius* and other forms. The type species occurs in Indian seas at depths similar to those at which *Dibranchus* is found. A second species has lately been found off the Sandwich Islands.

Genus 9. *Halicmetus*. This form differs from *Malthopsis* only in having no soft dorsal fin. Only one species is known, which shares the bathybial habitat of *Malthopsis* and *Dibranchus*.

Family XXV. ***Cottidæ*** [Case 46].

A small family of Fishes, resembling the *Trachinidæ* in form and habit. Some of the bones of the head are

armed with spines, and there is a bony buttress across the cheek, as in the *Scorpænidæ*. In the Gurnards (*Trigla* and *Lepidotrigla*) some of the rays of the pectoral fins are thickened and isolated from the rest of the fin to serve partly as organs of touch and partly as organs for creeping along the bottom of the sea.

The Indian genera are *Platycephalus*, *Trigla*, and *Lepidotrigla*.

Family XXVI. ***Cataphracti*** [Case 45].

The Mailed Gurnards differ from the Gurnards in having the head and body protected by bony plates. When the head alone is thus protected the scales of the body are keeled. The Indian genera are *Peristethium*, *Dactylopterus* and *Pegasus*. In *Dactylopterus* the pectoral fins are prolonged, as in the true Flying-fishes, to form organs of flight.

Family XXVII. ***Gobiidæ*** [Case 45].

This is a very large family, the Indian species alone numbering 91. None of them grow to any size, most of them are littoral, and some inhabit freshwater. Some of the Gobies construct nests. The species of *Periophthalmus* and *Bolcophthalmus* live among tidal creeks, and are as much at home on land as in water, hopping about with great activity by means of their strong ventral and pectoral fins. One of the most curious sights of the estuary-land of this country is to see *Periophthalmus* sitting up on its arm-like pectoral fins and gazing in all directions with its large protruding swivel eyes. The Dragonets (*Callionymus*) are often beautifully coloured, and in several species the male is much more brilliant than the female, and has the rays of the spinous dorsal and of the caudal fin greatly prolonged.

Family XXVIII. ***Blenniidæ*** [Case 45].

A large family of fishes much resembling the Gobies in form, and, like them, inhabitants of the littoral and of brackish and fresh water. Thirty-seven Indian species are known, and none of them attain any great size. One of the European species of Blennies brings forth its young alive. *Tripterygium* occurs in the Mediterranean Sea, in East Indian waters, and in New Zealand. In several respects the *Blenniidæ* illustrate the transition from the *Acanthopterygii* to the *Anacanthini*.

Family XXIX. ***Trichonotidæ*** [Case 45].

Two species of this small family, which is allied to the *Blenniidæ*, occur in Indian Seas, namely, *Trichonotus setiger* and *Tæniolabrus cyclograptus*.

Family XXX. ***Cepolidæ*** [Case 45].

This family contains a single small genus, *Cepola*, of which two species are found in the seas of India. On account of their elongate compressed body they are known as Band-fishes. The other species occur in the Eastern North Atlantic, the Mediterranean, the East Indian Archipelago, and the seas of China and Japan.

Family XXXI. ***Mastacembelidæ*** [Case 45].

The "Spiny-eels" live chiefly in fresh, but also in brackish water, in West Africa, Syria, India, Ceylon, and Further India. Several species are common in the jheels of Bengal, where they are known as *Gonchi* and *Bámmi*. They are eaten by the people of the country, their flesh being said to be tough but good.

Family XXXII. ***Sphyrænidæ*** [Case 45].

This small family includes a single genus, *Sphyræna*,

of which four species live in Indian Seas. They are large, active, and extremely rapacious fishes. The other species are found in the West Indies and Atlantic, in the Mediterranean and Red Seas, and in the Indo-Pacific.

Family XXXIII. *Atherinidæ* [Case 44].

A small family allied both to the *Sphyrænidæ* and to the Grey Mullets. They are marine, but also ascend rivers. Four species of *Atherina* occur in India, the other species of the genus being found in the North and South Atlantic; the Mediterranean, Black, and Red Seas; and the seas of the Indo-Pacific region

Family XXXIV. *Mugilidæ* [Case 44].

The Grey Mullets are numerous in temperate and tropical seas, occurring in shoals. They are particularly fond of brackish water and tidal pools, and some of the species are entirely fluviatile, living far above the reach of the tides. They feed to a large extent by sifting the organic matter out of mud and sand, and their digestive canal is singular, not only for its great length, but also in having the stomach provided with a muscular chamber much like the gizzard of birds. In correlation with their method of feeding, the gill-rakers, or structures for straining the water before it passes over the gills, are remarkably developed. They are good eating when perfectly fresh.

Family XXXV. *Fistulariidæ* [Case 45].

The Tube-fishes have the anterior bones of the head produced to form a long tube, at the end of which the mouth is placed. One species is found, often in back-waters of the sea, in India.

Family XXXVI. ***Centriscidæ*** [Case 45].

A very small family, represented in Indian seas by a single species. The anterior bones of the head are produced to form a long tube, with the mouth at the end, as in the *Fistulariidæ*. In the Indian species the back is enclosed in a cuirass formed not by scales, but by modifications of the backbone. The existing species of *Amphisile* are confined to the Indo-Pacific; but a fossil species has been found in the Tertiary deposits of Monte Bolca in Northern Italy.

Family XXXVII. ***Ophiocephalidæ*** [Case 44].

This is a small family of freshwater fishes, most of which belong to the Oriental region, one or two species only occurring in Africa. They are common in the jheels and tanks of Bengal, where they are known as *Murral*. The gill-chamber is connected with a cavity in the head which acts like the pulmonary sack of a snail, so that if the air is only kept moist the fish can breathe out of water. Some of the species that live in jheels and tanks undoubtedly, during the dry season, exist, buried in the mud, in a state of suspended animation, from which they recover when the tank fills up again in the rains. They are largely eaten in Bengal.

Family XXXVIII. ***Labyrinthici*** [Case 44].

In habit, the fishes of this family resemble the *Ophiocephalidæ*, and like them can bear removal from water, and can stand being dried up in the mud of jheels and tanks during the hot weather. The gill-chamber also is connected with a cavity in the skull; but this, in place of being a simple cavity, is filled by a coiled and pleated plate of very thin bone, by which the respiratory surface is much increased. The *Koi*, or "Climbing-perch,"

Anabas scandens, is a good example of the family. The climbing-perch is said to be able to climb trees: it certainly can and does escape from a tub half-full of water unless means are taken to prevent it. The "Koi" and its congeners are popular as food, their flesh being believed to be very strengthening.

Family XXXIX. ***Trachypteridæ*** [Case 15].

The Ribbon-fishes have a long, low, thin, tape-like body, at the end of which the caudal fin sticks up almost at a right-angle. The only Indian species known is *Regalecus Russellii*. The other species of *Regalecus* come from the North and South Atlantic, the Mediterranean, and the seas of New Zealand.

Family XL. ***Glyphidodontidæ*** [Case 44].

A largish family of fishes that, for the most part, live among coral-reefs and are gorgeously coloured. They have a considerable resemblance to some of the Sea-perches and *Squamipinnes*, but are distinguished from them by having only $3\frac{1}{2}$ pairs of gills and the lower pharyngeal bones fused. Of the six Indian genera three, namely *Pomacentrus*, *Glyphidodon* and *Heliastes*, range throughout the tropical parts of the Indo-Pacific and are also found off the Atlantic coasts of Tropical America, *Heliastes* also occurring in the Mediterranean. They are carnivorous and feed largely on the polyps, etc., of the reefs.

Family XLI. ***Labridæ*** [Case 43].

The Wrasses are a large family, the members of which are found in all tropical and temperate seas, not far from the shore. They resemble the members of the previous family in having $3\frac{1}{2}$ pairs of gills and the pharyngeal

bones fused, but differ from them in the form of the scales, which are cycloid, and in having very strong teeth for crushing the shells of the mollusks upon which they largely feed. Many of the species have very thick lips. Like the *Glyphidodontidæ* many of them are coloured in patterns of startling brilliance. The Indian species number nearly sixty. Of the 20 Indian genera, eight (namely, *Cossyphus*, *Platyglossus*, *Novacula*, *Julis*, *Coris*, *Scarus*, *Callyodon*, *Pseudoscarus*) range through tropical seas from the Atlantic coast of America through the Pacific, *Novacula*, *Julis*, *Coris*, and *Scarus* also occurring in the Mediterranean.

Family XLII. ***Chromides*** [Case 44].

The *Chromides* are a small family of fishes inhabiting rivers and lakes in Tropical America, Tropical Africa, Madagascar and Palestine, and three species are found in India, two of which also occur in Ceylon. In the structure of the pharyngeal bones they agree with the Wrasses and Glyphidodonts. They are, for the most part, small.

Suborder ANACANTHINI [Cases 42, 43].

None of the fins have spines. The ventral fins, if present, are often jugular. The air-bladder, if present, has no pneumatic duct.

This suborder is divided into two sections (1) the *Gadoidei*, or Cod-fishes, and (2) the *Pleuronectoidei*, or Flat-fishes.

ANACANTHINI GADOIDEI [Cases 42, 43].

The *Indian* Gadoidei are, for the most part, but not entirely, inhabitants of the depths, where the

temperature approaches that of temperate, or even of Arctic, seas; and they are grouped into four families.

Family I. ***Gadidæ*** [Case 42].

Three species of the Cod family inhabit Indian Seas, namely *Bregmaceros Macclellandii*, *Physiculus roseus* and *Physiculus argyropastus*.

The first is common enough in Indian waters at fifty to about a hundred and fifty fathoms, but also occurs at less depths: the second has been found in the Andaman Sea at about 200 fathoms, where the temperature is about 56° Fahr.: the third has been taken in the Bay of Bengal and Gulf of Manár between 100 and 200 fathoms, where the temperature is between 60° and 50° Fahr.

Another species of *Bregmaceros* occurs in the Caribbean Sea; and other species of *Physiculus* occur in the West Indian and Madeiran regions of the Atlantic, in the Mediterranean, and in Japanese Seas.

Family II. ***Ophidiidæ*** [Case 42].

The great majority of the Indian representatives of this family live in the cool depths of the sea. The body is generally long and somewhat eel-like: the ventral fins are reduced to one or two rudiments attached to the throat, or are altogether absent. The genera may be noticed in detail:—

Genus 1. *Brotula*. The species, which occur in the Caribbean Sea, the Indian Ocean and Japan, have small barbels on the chin.

Genus 2. *Dinematichthys*. A species has been found in the pools of the coral reefs of the Andamans. It has a distinct caudal fin.

Genus 3. *Neobythites*. This is a deep-sea genus, of

which six species are found in the seas of India between 100 and 1700 fathoms. The head and body of all are covered with small scales.

Genus 4. *Dicrolene.* Also a deep-sea genus, differing from *Neobythites* only in having some of the lower rays of the pectoral fin isolated and greatly prolonged to form organs of touch something like those of the Topsi fish. Three Indian species are known, of which one, *Dicrolene intronigra*, also occurs off the West Indies and neighbouring American coasts and off the Atlantic coasts of north-west Africa.

Genus 5. *Bassozetus.* Another deep-sea genus, differing from *Neobythites* chiefly in being more eel-like in appearance. The only Indian species comes from the Bay of Bengal in 1310 fathoms of water.

Genus 6. *Dermatorus.* Another deep-sea form, differing from *Bassozetus* chiefly in having the bones of the head armed with spines. Three Indian species are known from depths between 900 and 1800 fathoms.

Genus 7. *Glyptophidium.* Two species belong to the Indian fauna, living at depths between 150 and 400 fathoms. In both, the bones of the head are curiously crested and frilled.

Genus 8. *Lamprogrammus.* In this curious form there are no ventral fins and the scales of the lateral line are much enlarged,—each scale also carrying a gland that probably secretes light. Two species are known and they have only been found between 400 and 700 fathoms.

Genus 9. *Tauredophidium.* This is a true deep-sea form of which only one species is known, occurring in the Bay of Bengal at a depth of 1310 fathoms. It has no eyes, and the bones of the gill-covers are armed with enormous spines which can be erected in defence.

Genus 10. *Diplacanthopoma.* Also a member of the

deep-sea fauna. The head is covered with a thick glandular scaleless skin. Of the three Indian species one is known to be, and all are believed to be, viviparous, and one also occurs in the Atlantic off the coast of Brazil.

Genus 11. *Saccogaster*. Another deep-sea genus, viviparous like *Diplacanthopoma*, from which it chiefly differs in dentition.

Genus 12. *Nephthocara*. Another deep-sea and viviparous form, resembling the two previous genera in having the head covered by a peculiarly thick glandular scaleless skin, but differing from them in being destitute of ventral fins.

Genus 13. *Fierasfer*. A curious eel-like shallow-water genus of peculiar habits. In the Case containing the *Holothuroidea*, in the Invertebrate Gallery, is a dissection of a Holothurian with a fish of this genus in its body-cavity. In life the *Fierasfer* is semi-parasitic on the Holothurian, entering and leaving its host's body through the cloaca, the wall of which it appears to rupture. One species occurs in these seas, other species being found in the Atlantic, the Mediterranean, and in other parts of the Indo-Pacific.

Genus 14. *Bleekeria*. Allied to the "Sand-eels" of Europe. One species has been found on the Madras Coast.

Family III. ***Macruridæ*** [Case 42].

Like the majority of the *Ophidiidæ*, the *Macruridæ*, whether of India or elsewhere, are all inhabitants of the cold waters of the deep sea. Their body ends in a long lash-like tail, and in most of the species the scales are keeled, or spiny, or both. The ventral fins are well developed. Two genera are represented in Indian seas,

namely *Macrurus* with 16 species, and *Bathygadus* with 2 species. *Macrurus cavernosus*, which is not uncommon in the Andaman Sea and Gulf of Manár at 180 to 405 fathoms, also occurs in the Gulf of Mexico, and is very probably identical with the Mediterranean *Macrurus italicus*. *Macrurus lævis*, of which several specimens have been taken in the Andaman Sea at 188 to 419 fathoms, and in the Arabian Sea at 719 fathoms, also occurs in all parts of the North Atlantic system, off the coast of Brazil, off Madeira and its neighbourhood, in the Mediterranean, and off the Sandwich Is. *Bathygadus longifilis* is another Indian species that is found off the Atlantic coasts of America, and in the Madeiran neighbourhood.

Family IV. ***Ateleopodidæ*** [Case 42].

Two closely similar species, one from the depths of the Indian seas, the other from Japan, make up this family. The body is shaped like that of *Macrurus*, but there are no scales and the ventral fins are reduced each to a single stiff filament. In the Indian species, *Ateleopus indicus*, the mouth looks as if it were adapted for suction: this species has been found in the Andaman Sea, at 188 to 405 fathoms, and off the Malabar coast, at 224 to 284 fathoms.

Anacanthini Pleuronectoidei.

This section includes the single large family of Pleuronectidæ or Flat-fishes.

Family V. ***Pleuronectidæ*** [Cases 42, 43].

In the Flat-fishes the head and part of the body have departed from the bilateral symmetry that characterizes all the Craniate Vertebrates.

The Flat-fishes have the body compressed like a leaf, and lie habitually on one side—either the right or the left—both eyes being placed on one side of the body, namely on the side opposite to that on which the individual lies. Except in a few deep-sea species the side upon which they rest is colourless ; and in all but a few pelagic forms the side upon which the eyes are situated is coloured, the colouration being, for protective purposes, very similar to that of the sand or mud or shingle on which the fish rests.

In the very youngest stages of their existence Flat-fishes are bilaterally symmetrical, and swim in a vertical position, like other fishes ; but as soon as they begin to rest upon one side, which happens very early in life while the tissues are plastic, the eye and orbit of that side become twisted round towards the light, until both eyes come to be on the upper side of the body.

Flat-fishes occur in all seas : they always live on the bottom, preferably on a sandy bottom. A good many species live in estuaries, and a few live exclusively in fresh water. Sixty-four different species are found in Indian waters, but none of them reach any great size.

The Flat-fishes of Indian seas are very good to eat, but they are very seldom brought to market.

The Indian species belong to the following generic groups :—

(1) Shallow-water genera :—*Psettodes*, *Arnoglossus*, *Pseudorhombus*, *Rhomboidichthys*, *Psettyllis*, *Citharichthys*, *Samaris*, *Brachypleura*, *Solea* (including *Achirus*), *Synaptura*, *Plagusia*, *Cynoglossus*.

(2) Deep-water genera :—*Chascanopsetta*, *Lœops*, *Boopsetta*, *Aphoristia*.

Aphoristia, of which four species have been found at

moderate depths in Indian seas, is interesting because it is only known to occur elsewhere off the Atlantic coast of America.

Suborder PHYSOSTOMI [Cases 60–73].

The Ruhu, the Tengra and the Hilsa are good familiar types of this suborder. The rays of the fins, with the exception sometimes of the first dorsal and first pectoral rays, are not ossified. The ventral fins, when they are present, are placed behind the pectoral fins—usually a good long way behind them. The air-bladder, when present, is usually connected with the gullet, or with some part of the intestinal canal, by a pneumatic duct. (See the air-bladder and pneumatic duct of an eel in Case 10).

The fishes of this suborder are grouped into the following 14 families.

Family I. *Siluridæ* [Cases 60–63].

The Cat-fishes are a very large family, the Indian species alone numbering nearly 120. For the most part they inhabit fresh waters, but a few live in the sea—generally in the neighbourhood of estuaries, and never far from the coast. Many of them are used as food, except by Mahomedans. The Cat-fishes are so-called from the barbels, which are attached to the lips and jaws, and somewhat resemble in appearance the "whiskers" of a cat. These barbels are organs of touch, for Cat-fishes usually live in muddy water where the sense of sight is not of much use: for this reason also, their eyes are usually small. The skin is scaleless. In most of the species the first spine of the dorsal fin

and the outermost spine of each pectoral fin is enormously enlarged and thickened and dreadfully barbed, so as to form a formidable defensive weapon. In some species (*e.g. Plotosus*) the wound inflicted by these spines is as painful as the sting of a scorpion, and causes a hurt that may be dangerous. The neighbouring bones are specially strengthened for the support of these great erectile spines. In *Arius* and *Osteogeniosus* the males carry the fertilized ova in their mouths, probably in order that the developing embryos may benefit by the streams of fresh water as they pass into the gill-chamber of the parent. In *Exostoma*, which lives in rapid mountain streams, the lips form a sucker and the front part of the belly forms a sort of adhesive pad, by means of which the fish can attach itself to fixed objects. *Chaca*, which is not uncommon in the jheels of Bengal, has the mode of life and much the external appearance of a Frog-fish. In *Saccobranchus* (the Singhi) each gill-chamber is prolonged to form a respiratory sack that lies alongside the backbone, and enables this fish to breathe out of water. In *Glyptosternum* which lives in quick-flowing rivers, the pectoral fins are horizontally expanded, and the surface between their bases is pleated, to form an adhesive mooring apparatus. The curiously wide distribution of the Siluroids has already been commented upon.

Family II. ***Scopelidæ*** [Cases 70–71].

The members of this family are entirely marine, most of them being either pelagic or living in the depths of the ocean. One Indian species, the "Bummalo" or "Bombay Duck," has a certain repute as food. The genera may be noticed in detail.

Genus 1. *Scopelarchus*, known only from the depths of

the Arabian Sea: it is a generalized form, linking together several other genera that have usually been regarded as widely separated. It has a scaly body, a formidable dentition, and eyes with a strong upward cast, but it has no phosphorescent organs.

Genus 2. *Saurus:* a shore genus, ranging, in tropical and subtropical latitudes, from the West Indies, across the Atlantic, to the Mediterranean, and across the Indian and Pacific Oceans. It has a scaly body, lateral eyes, no barbed teeth, and no phosphorescent organs.

Genus 3. *Saurida:* only differs from *Saurus* in some particulars of dentition: it does not occur in the Mediterranean.

Genus 4. *Harpodon:* is singular in having a three-lobed tail: it has formidable barbed teeth. The "Bombay duck" belongs to this genus, which includes only three species. The body may be completely or only partly scaly.

Genus 5. *Chlorophthalmus:* a deep-sea genus, with a distribution similar to that of *Saurus*. It has enormous eyes and tiny incipient phosphorescent organs, and its scales are well developed.

Genus 6. *Bathypterois:* a scaly deep-sea genus of the Atlantic, Indian, and Western and Southern Pacific Oceans. It has very small, almost rudimentary, eyes, but in compensation for this, some of the fin-rays are wonderfully prolonged and strengthened to form organs of touch.

Genus 7. *Scopelus:* a large and very widely ranging oceanic genus, with a scaly body and with definitely-arranged phosphorescent spots. Most of the species are quite small.

Genus 8. *Neoscopelus*, differs from *Scopelus* only in having a flat snout and a smaller mouth, and in the

different position of the anal fin. One species is known, which occurs in the Atlantic, in the seas of India, and in the south-western Pacific.

Genus 9. *Scopelengys:* another deep-sea genus, of which only one species is known.

Genus 10. *Odontostomus.* This genus, which includes two species—one from the Mediterranean, the other from the Bay of Bengal and Andaman Sea—is alone among Indian *Scopelidæ* in having the body scaleless: its eyes have a very strong upward cast and its teeth are most terrible.

Family III. ***Cyprinidæ*** [Cases 64–67].

The Carps and Loaches are an exclusively fresh-water family of enormous size, and are widely distributed throughout the Old World and North America. The Indian species alone number over 230. The family being exposed to such wonderfully diversified conditions of life, its members exhibit a corresponding diversity of form. The widest departure from the typical carp form is seen among those species, such as *Orcinus*, *Schizothorax*, *Ptychobarbus*, and *Diptychus*, that live in the spating rivers of Tibet, Kashmir, and of the Oxus system. These forms, dwelling under conditions very similar to those that have, in other regions, produced the Trout, have come to, superficially, resemble Trout so closely that European travellers habitually call them "trout," though they are undoubted carps: this is particularly the case with *Ptychobarbus*, which is even spotted like a trout.

The famous "Mahseer" is a carp of the Barbel kind.

Most of the fishes eaten by Europeans up-country are carps.

The different kinds of "Gold-fish" are domesticated

varieties of a species of carp. In a state of nature all such varieties and monstrosities are—the conditions of life remaining unchanged—kept down by an inexorable competition; but when Man interposes, he can, within reasonable limits, preserve any variety or monstrosity that takes his fancy. Of course there are some animals that are not only more variable and plastic but also more amenable to domestication than others, and the Gold-fish appears to be one of these.

Family IV. ***Cyprinodontidæ*** [Case 67].

The interest of this family of fresh-water fishes—of which 5 species are found in India—has been noticed in the section on *Geographical Distribution*.

Family V. ***Scombresocidæ*** [Cases 70–71].

This family includes the Gar-pikes and Flying-fishes. The Gar-pikes are marine, but have a tendency to pass into estuaries and backwaters and so to furnish a complement to the freshwater fauna. The Flying-fishes are truly oceanic and are found in all the oceans in the tropical and temperate zones. The Indian Gar-pikes, *Belone* and *Hemiramphus*, also occur in all tropical and temperate seas, including the Mediterranean.

Family VI. ***Sternoptychidæ*** [Case 70].

These are oceanic fishes which live at a considerable depth below the surface. Their eyes are well developed and their phosphorescent glands are abundant. The genera that occur in Indian seas are *Argyropelecus*, *Sternoptyx*, *Polyipnus*, *Cyclothone*, *Photichthys*, and *Chauliodus*. Of these, all but *Polyipnus* and *Photichthys* are also found in the Atlantic; while *Argyropelecus* and *Chauliodus* are also Mediterranean genera. In *Polyipnus*

the number of phosphorescent organs is enormous: in *Chauliodus* the teeth are of the most cruel size and form.

Family VII. ***Stomiatidæ*** [Case 71].

These are also oceanic fishes, living in darkness at considerable depths, but furnished with phosphorescent organs, and having teeth of astonishing size and sharpness. They are easily distinguished by having a barbel attached to the hyoid bone, and this barbel may either hang down free, or may be attached to the inside of the chin. The Indian genera are three in number, namely, *Stomias*, *Malacosteus*, and *Photostomias*, all of which also occur in the Atlantic, *Stomias* being also found in the Mediterranean.

Photostomias and *Malacosteus* are perhaps, for their size, the most rapacious-looking fish of these seas: their mouth is so enormous that it forms one great cleft with the gill-openings, and almost separates the head from the body: the fangs are large and peculiarly sharp, and the lower jaw looks more like a hideous spring rat-trap than a jaw.

Family VIII. ***Clupeidæ*** [Cases 68–69].

The Herrings are a large family and are of the greatest use to Man. They live in shoals, generally near shores and estuaries; some, such as the Hilsa, enter rivers, and a few live entirely in fresh water. The Indian genera *Clupea* (Herring) and *Engraulis* (Anchovy) have a wide distribution in the Atlantic and Indo-Pacific, and also occur in the Mediterranean. The Indian genera *Pellona*, *Opisthopterus*, *Raconda*, *Chatoessus*, *Spratelloides*, *Albula*, *Elops*, *Megalops* all occur in the Atlantic: so that out of 14 genera of *Clupeidæ* that are represented

in India, only four are peculiar to the Indo-Pacific region. In the case of *Albula*, the same species (*Albula conorhynchus*) is found off the West Indies and neighbouring coasts, off Cape Verde and its vicinity, in the Red Sea, and off the coasts of the Oriental Region. In the case of *Elops*, the same species (*Elops saurus*) is found in the West Indian Region, at the Cape of Good Hope and off the shores of East Africa, and in Oriental seas. This distribution of genera of a family that dates from Cretaceous times, corresponding as it does with that of the *Berycidæ* and *Scopelidæ*, both of which are contemporary with the Herrings, is highly interesting. Among the existing Indian Herrings the most important is the Hilsa, the economic possibilities of which are enormous; for it is a true herrring (*Clupea*) and lends itself to capture in shoals, and is undoubtedly as fit to be salted and smoked as its congener of British seas.

Family IX. ***Chirocentridæ*** [Case 69].

This family contains a single genus and species, *Chirocentrus dorab*, peculiar to the Indian Ocean. It has a resemblance to a Herring, but the body is low and extremely long.

Family X. ***Alepocephalidæ*** [Case 68].

The members of this family are found only in the depths of the sea: they are closely related to the Herrings. The Indian genera are:—

(1) *Alepocephalus*, which also occurs in the Atlantic and Mediterranean: it has a scaly body but a scaleless head: three species are found in Indian seas, at 240 to 902 fathoms:

(2) *Bathytroctes*, which also occurs in the Atlantic: two species live in Indian seas, at 500 to 740 fathoms:

(3) *Narcetes*, which differs from the two previous genera only in dentition:

(4) *Platytroctes*, which has a curious high, compressed, body, and no ventral fins: the same species *P. apus* occurs in the Atlantic and in these seas:

(5) *Xenodermichthys*, which occurs in the Atlantic and in these seas at considerable depths: it has a black scaleless skin, with minute luminous organs, and a large eye:

(6) *Leptoderma*, which also occurs in the Atlantic: it has a black scaleless skin with a luminous epidermis, and an eye of enormous size.

(7) *Aulastomomorpha*, which has the bones of the head produced to form a tube-like snout, and the skin of the head brilliantly phosphorescent.

Family XI. ***Notopteridæ*** [Cases 68–69].

This small family contains a single genus (*Notopterus*) of fishes that inhabit freshwater of the Oriental and West African regions. They are related to the Herrings. The two Indian species are known in Bengal as *Chitala* and *Phola*.

Family XII. ***Halosauridæ*** [Case 72].

This is a small family containing one genus, *Halosaurus*, the species of which are found only in the depths of the Oceans. Five species occur in the seas of India, at depths of 500 to 1000 fathoms. They have a long tapering eel-like body, covered with scales, and in many of the species the scales of the lateral line are enlarged and grooved or perforated to lodge a luminous organ.

Family XIII. ***Symbranchidæ*** [Case 73].

The *Symbranchidæ* are freshwater eels, having neither pectoral nor ventral fins and only vestiges of vertical fins—thus, in external appearance, much resembling snakes. The gill-openings are confluent, and one of the Indian species has the gill-chamber produced to form a respiratory sack for breathing air, somewhat after the fashion of the Singhi fish. The curious geographical distribution of the *Symbranchidæ* has already been commented on.

Family XIV. ***Muræenidæ*** [Cases 72–73].

The Eels are a very large family, of wide distribution. Their body is snake-like, ventrals fins are never present, pectoral fins are often wanting, and vertical fins are sometimes quite rudimentary. They are abundant in tropical seas, especially in the neighbourhood of coral reefs, many inhabit the great depths of the sea, and some are found in fresh water. The Indian species belong to the following genera :—*Nemichthys* (deep-sea), *Gavialiceps* (deep-sea), *Dysomma* (deep-sea), *Dysommopsis* (deep-sea), *Synaphobranchus* (deep-sea), *Coloconger* (deep-sea), *Congromuræna* (chiefly deep-sea), *Uroconger* (chiefly deep-sea), *Promyllantor* (deep-sea), *Anguilla*, *Muræsox*, *Sauromuræsox* (deep-sea), *Saurenchelys* (deep-sea), *Nettenchelys* (deep-sea), *Xenomystax* (deep-sea), *Muræn-ichthys*, *Ophichthys*, *Moringua*, *Muræna* and *Gymno-muræna*.

Eels of the genus *Muræna* are particularly savage, especially when breeding; and I myself have several times been attacked by them, when collecting on coral reefs.

Suborder LOPHOBRANCHII [Case 75].

The gill-elements are not leaflets but little knobs, and the gill-cover is a simple plate. The integument consists of an armour of bony segments. The mouth is situated at the end of a long tube-like snout. There is no pneumatic duct to the air-bladder.

The Pipe-fishes of Indian seas fall into a single family.

Family ***Syngnathidæ*** [Case 75].

This family includes the Pipe-fishes and Sea-horses. These are marine, but generally live near shore, and many of them find their way into brackish and fresh water. They are all of small size, and are bad swimmers, locomotion being chiefly effected by rapid vibrations of the dorsal fin. In these fishes the male looks after the eggs, which he carries about with him—either in a special brood-pouch, or glued to the abdomen—until after they are hatched. In Case 12 a male *Hippocampus* (Sea-horse) is shown with the brood-pouch full of developing ova.

Most of the Indian genera, and even one species (*Hippocampus guttulatus*) are also found in the Atlantic and Mediterranean.

Suborder PLECTOGNATHI [Cases 74–75].

In this suborder of Bony-fishes the skin is usually covered either with prickles and spines or with bony plates, though it is sometimes naked. The ventral fins are either absent or are reduced each to a spine, which is sometimes large. A spinous dorsal fin is either present or absent: when present the spines are few, but the first one is often very large. The gills have the

usual form, but the gill-openings are narrow slits. The skeleton is incompletely ossified and the vertebræ are few in number. There is no pneumatic duct to the air-bladder. The suborder consists of two families.

Family I. ***Sclerodermi*** [Cases 74–75].

In this family there are distinct teeth in the jaws, there is generally a spinous dorsal fin, and the ventral fins are generally represented by a pair of spines. It is divided into three subfamily groups :—

1. Subfamily *Triacanthinæ*, of which three Indian genera are known, namely *Triacanthus*, which is a shore fish, and *Triacanthodes* and *Halimochirurgus* which belong to the deep-sea. *Halimochirurgus* has the snout produced to form a long tubular beak. In all the members of this subfamily the skin is covered with small prickly scales, there is a spinous dorsal fin, and a pair of very strong ventral spines which can be erected and fixed like bayonets.

2. Subfamily *Balistinæ*, of which three genera are known, all being represented in Indian Seas. They are *Balistes*, known as File-fishes, or Trigger-fishes, the species of which are very numerous round coral-reefs ; *Monacanthus* of which the species are abundant among coral-reefs but often also take to the open sea, swimming chiefly by rapid vibrations of the soft dorsal fin ; and *Anacanthus*, which resembles *Monacanthus* in form and habit, but has a barbel at the chin. The members of this subfamily have strong chisel-like teeth with which they bite off the pieces of coral and chip open the mollusks upon which they feed : their skin is covered either with granules or with hard rough bony scales, and the ventral spines are rudimentary or absent. Both *Balistes* and *Monacanthus* are also found in the tropical

parts of the Atlantic, *Balistes* being also represented in the Mediterranean. One species of this genus, *Balistes maculatus*, is found in the West Indian region, in the Oriental region, and in Japan.

3. Subfamily *Ostracionina*. In the Box-fishes, which include the single genus *Ostracion*, the body is angular and the integument forms a firm carapace of immovable bony plates, from which the end of the tail projects. There are no ventral fins. The species of *Ostracion* occur in all tropical seas and two species are also found in the Mediterranean.

Family II. ***Gymnodontes*** [Cases 74–75].

In the family of Globe-fishes the bones of the jaws form a beak something like that of a parrot, eminently adapted for crushing the coral and mollusks on which these fish feed, and there are neither spinous dorsal nor ventral fins. The family is divided into three subfamilies all of which are represented in India.

1. Subfamily *Triodontinæ:* contains the single genus and species *Triodon bursarius* in which the upper valve of the "beak" is divided into two halves by a median suture: it inhabits the Indian Ocean and Archipelago. Like the members of the next subfamily it can distend its abdomen with air. The skin is covered with rough scutes.

2. Subfamily *Tetrodontinæ:* contains the Indian genera *Xenopterus* and *Tetrodon* in which both jaws are cleft in the middle line by a suture, and *Diodon* and *Chilomycterus* in which neither of the jaws are so cleft. Most of the species are marine, but *Xenopterus* and several species of *Tetrodon* enter estuaries and ascend into fresh water. The skin, though often naked, is usually more or less spiny or spicular, and in *Diodon* and *Chilomycterus* the

spines are so numerous and so strong as to resemble those of a hedgehog. All the Tetrodonts can inflate their gullet, and so their abdominal cavity, like a balloon, and many of them can make a croaking sound. Both *Tetrodon* and *Diodon* occur in the Atlantic and Mediterranean as well as in the Indian and Pacific Oceans, and one species *Diodon hystrix* is common to all these regions. *Chilomycterus* belongs to the Atlantic and the Indo-Pacific.

3. Subfamily *Molinæ*. The Sun-fishes have a most singularly abbreviated, round or oval, disk-like body. They are pelagic fish and occur in all tropical and temperate seas, and they grow to a great size. One species is said to occur in Indian waters. The jaws of the Sun-fish, like those of the Triacanthines, are weak.

Order II. GANOIDEI [Cases 26–29].

The second order of the Subclass *Teleostomi* contains the Ganoid fishes, but as none of these fishes are known to occur in India we shall postpone their consideration: moreover, their position in the Class of Fishes will be better understood after we have considered the subclass *Chondropterygii*. It will be sufficient, for the present, to say that the Ganoids, in a general way, are remote cousins to the Sharks and are the ancestors of the Bony fishes, and that they are therefore, in this sense, intermediate between the Teleostei and the Chondropterygii.

Subclass **CHONDROPTERYGII** [Cases 30–41].

This subclass contains the Sharks, Rays and Chimæras, of which the first two groups are well represented in the seas and estuaries of India.

The skeleton is cartilaginous, though calcification may sometimes occur in parts of it, and the tail is usually heterocercal: the gills are attached to the skin by their outer margins, so that—with the exceptions to be noted—there are as many external as internal gill-openings and no gill-cover: there is a muscular *conus arteriosus* (see Case 10), with many valves, at the base of the aorta: the mucous membrane of the intestine forms a spiral valve (see Case 10): the optic nerves do not simply cross each other: impregnation is internal, and though eggs may be laid the young are often born alive (see Case 12): the ventral fins are placed far behind the pectoral fins: the skin may be naked, but more commonly it bears placoid scales, or granules or spines, which last are sometimes hardly distinguishable from small teeth. Geologically, the Chondropterygii are a very ancient order: "some of the earliest determinable fish remains are believed to be, or are, derived from Plagiostomes" (Günther).

Order I. PLAGIOSTOMA.

This Order is divided into two sections which grade into one another, namely: (1) the Sharks (*Selachoidei*) in which the gill-openings are lateral and the trunk gradually shades into the tail, and (2) the Rays (*Batoidei*), in which the gill-openings are on the ventral surface and the trunk is more or less disk-like.

Selachoidei (Sharks).

Six of the nine existing families of Sharks are represented in Indian Seas.

Family I. ***Carchariidæ*** [Cases 39–41].

These are the true Sharks, known of all. The eye has a nictitating membrane. They are common in all

seas. *Carcharias gangeticus* is the Shark that comes up the Hooghly in the hot weather and attacks bathers at the Calcutta ghâts. *Zygæna* is the Hammerhead Shark, of which two of the Indian species are also found in the Atlantic and Mediterranean. An unborn young of *Zygæna blochii*, with the placenta and curious placental cord attached, is shown in Case 12.

Family II. ***Lamnidæ.***

These are also large and formidable Sharks, found in all seas. There is no nictitating membrane to the eye: the first dorsal fin stands above the space between the pectoral and ventral fins. *Lamna spallanzanii* and *Alopecias vulpes* are found in the Atlantic and Mediterranean as well as in Indian seas.

Family III. ***Rhinodontidæ.***

This family contains a single species, *Rhinodon typicus*, found only in the Indian Ocean, and growing to a gigantic size—seventy feet, it is said. The snout is broad, short and flat, and the mouth is singularly situated at the end of it. Its teeth are very small and it is harmless.

Family IV. ***Notidanidæ.***

A small family containing the single genus *Notidanus*, with four species, three of which belong to the Mediterranean and Atlantic, while the fourth, *Notidanus indicus*, is found in the Indian and Pacific Oceans. This Indian shark can be recognized by its gill-openings, which are seven in number, instead of the usual five, and by the single dorsal fin. *Notidanus* is said to reach a length of about fifteen feet.

Family V. ***Scylliidæ*** [Case 38].

The Dog-fishes have no nictitating membrane, and their first dorsal fin is placed far back, above or behind the ventral fins. They are usually of small size and are not dangerous to man: they live chiefly on mollusks and crustaceans. The genera found in India are *Scyllium*, which occurs in all seas; *Ginglymostoma*, which also occurs in the Atlantic and the Red Sea; and *Chiloscyllium* and *Stegostoma*, which are restricted to the Indian and Western Pacific Oceans. *Stegostoma* is the "Tiger-shark," a common Indian form, which grows to a length of 10 or 15 feet. *Ginglymostoma* also grows to a large size.

Family VI. ***Spinacidæ*** [Case 37].

The Spiny Dog-fishes of these seas are recognized by the presence of a spine at the fore end of each dorsal fin. Only two Indian species are known, namely, (1) *Centrophorus Rossi* from 430 fathoms, and (2) *Centroscyllium ornatum* from 285 to 690 fathoms. Other species of *Centrophorus* are found in the Atlantic and Mediterranean, and of *Centroscyllium* near Arctic and Antarctic seas.

Batoidei (Rays).

All of the six known families of Rays are represented in Indian Seas.

Family I. ***Pristidæ*** [Cases 36–37].

The Saw-fishes resemble Sharks in form of body, but the gill-openings are like those of the Rays in being on the ventral surface. The snout is produced to form a long narrow flat blade, which is armed with strong teeth along both edges and is a formidable weapon of offence. Saw-fishes grow to a length of 20 feet. Of the four

known Indian species two occur in the Atlantic, one of these being also found in the Mediterranean.

Family II. ***Rhinobatidæ*** [Cases 35–36].

In this family the form of the body is still Shark-like, but the broadening of the pectoral regions, which is so characteristic of the Rays, is becoming manifest. The snout is produced, but not nearly to such an extent as it is in the Saw-fishes, and it has no teeth on the edges. Of the six known Indian species two, namely, *Rhinobatus halavi* and *R. columnæ*, also occur in the Atlantic and Mediterranean.

Family III. ***Torpedinidæ*** [Case 33].

In this family the form of the body is rather more Ray-like than Shark-like, the pectoral region being much broadened to form a disk, from which however the tail is not yet sharply delimited. On either side of the disk, between the head and the pectoral fins, is an "electric organ," the shock from which can disable enemies and, perhaps, can also overcome prey. A dissection of the electric organ of one of the Indian species is shown in Case 11: it is seen to consist of a multitude of vertically-placed hexagonal prisms, and to be supplied by several enormous nerve-trunks. Three Indian species of Electric Rays are known, namely, *Narcine timlei* and *Astrape dipterygia* from shallow water, and *Benthobatis moresbyi* from 430 fathoms. The skin of the Electric Rays is quite smooth.

Family IV. ***Rajidæ*** [Case 34].

In the true Rays the head, trunk, and pectoral fins together form a broad flat disk, from which the tail is sharply marked off. The skin may be almost smooth, but is more often furnished with prickles and definitely-

placed spines—these being more numerous in the female. The Rays live on the sea-bottom and progress by the undulations of their pectoral fins. The genera that are found in Indian Seas are *Raja* and *Platyrhina*. The Indian species of *Raja*, three in number, are only found in deep water.

Family V. ***Trygonidæ*** [Case 34].

The Sting-rays have a disk-like body and a long lash-like tail, which is even more sharply demarcated from the disk than is that of the true Rays. Moreover, near the base of the tail, in many species, there exists a great erectile barbed spine, which is capable of inflicting a severe and even dangerous wound. The spine is shed and replaced by reserve spines, like the poison fang of a snake. The Sting-rays, like the true Rays and Electric Rays, live on the bottom: they have pavement-like crushing-teeth for feeding on hard-shelled mollusks and crustaceans. They are particularly numerous in the muddy water at the mouths of estuaries, and, like so many fishes that have this habitat, they have a tendency to spread up the estuaries into freshwater and so, in some cases, to become incorporated in the freshwater fauna. Many Trygons bring forth their young alive, the embryo being nourished during its development, not by a vascular placenta, but by a milk-like secretion which is poured forth from a multitude of special glands in the uterine mucous membrane and finds its way into the gullet of the embryo through the latter's spiracles. Specimens in Case 12 illustrate this singular method of intra-uterine nutrition. Two species of Trygon, *T. bennettii* and *T. pastinaca*, are common to the Atlantic and Indo-Pacific, the latter also being found in the Mediterranean. *Pteroplatæa* also is found both in the Atlantic and in the

Indo-Pacific. Some of the Trygons grow to an enormous size.

Family VI. ***Myliobatidæ*** [Case 33].

The Eagle-rays or Sea-devils chiefly differ from the Trygons in having a thicker disk and a slightly different arrangement of the pectoral fins, which are more extended laterally and less extended forwards.

In their mode of life they much resemble the Trygons, and have a pavement-like arrangement of crushing-teeth even more perfect than that of the Trygons. Some of them resemble the Trygons in their mode of bringing forth their young. Some of them grow to an enormous size. All the four Indian genera of Eagle-rays also occur in the Mediterranean and Atlantic.

Order II. HOLOCEPHALA [Cases 30–32].

Of all the members of the subclass *Chondropterygii*, the *Holocephala*, or Chimæras, make the nearest approach to the Ganoids. They differ from all other members of their subclass, and resemble the Ganoids and their descendants, in having a gill-cover and so only a single external gill-opening on each side. But the gill-cover is a rudimentary one, and merely covers the four external gill-clefts, which resemble those of sharks: it does not cover a gill-chamber in which the gills lie free. Except in this respect and in certain skeletal characters, the Chimæras agree with the Sharks. The males have a singular erectile appendage on top of the head.

No actual specimens of *Chimæra* and *Callorhynchus* (the two genera that now constitute the Order) have been taken in Indian seas, but their empty egg-capsules have been dredged in the Bay of Bengal between 400 and 600 fathoms, so that specimens may be discovered any day.

We have next to consider, but more briefly, certain Orders of fishes that are not represented in India. They are the Ganoids and the *Dipnoi*.

Ganoid Fishes [Cases 26–29].

To the Order of Ganoids "belong the majority of the fossil fish-remains of palæozoic and mesozoic age, whilst it is very scantily represented in the recent fauna and evidently verging on total extinction." (*Gunther*).

Most of the Ganoids live in fresh water; some species of Sturgeons alone are found in the sea, but even they ascend rivers at the spawning season. Their Geographical Distribution is shown in the coloured map in Case 29, from which it will be seen that none occur in India, although some are found in Central Asia and China.

The Ganoids are, in a way, intermediate between the Bony-fishes and the *Chondropterygii*. As in the Sharks, the intestine has a spiral valve, though it may be rudimentary; the bulb of the aorta is muscular, and is provided with numerous valves; and the tail is commonly, though not always, heterocercal. As in the Bony-fishes, the gills are free and lie in a common gill-chamber on each side of the head—the gill-chamber being protected by a gill-cover and communicating with the exterior by a single opening. As in many Physostomous Bony-fishes, there is an air-bladder with a pneumatic duct. The skeleton may be cartilaginous and of the *Chimæra* type, or it may be bony. There are vertical and paired fins, and the ventral fins, when present, are placed far behind the pectorals. The scales may be either cycloid or ganoid.

The specimens in Cases 26–29 are merely meant to give a general idea of the Order. *Accipenser* comes nearest to the Chimaeras, *Amia* comes nearest to the Bony-fishes.

Subclass **DIPNOI** [Cases 23–25].

From the map in this Case, showing the Geographical Distribution of this small subclass of Fishes it will be seen that none occur in Asia and none north of the tropics. As a matter of fact, they are now restricted to the fresh waters of tropical and subtropical latitudes in South America, Africa, and Australia.

They differ from all other fishes, and approach Amphibia, in having (1) an air-bladder that functions as a true lung, and (2) an incipient pulmonary circulation. They are further remarkable among fishes in the form of their paired fins, which have a segmented axis foreshadowing the segmented limbs of higher vertebrates.

The skeleton is partly cartilaginous and partly bony, and, as in the Sharks, the intestine has a spiral valve and opens into a cloaca.

The gills resemble those of Teleosteans and Ganoids in lying free within a gill-chamber on either side of the head. The gill-chamber has a gill-cover, though a rudimentary one—and opens to the exterior by a single gill-opening.

The body is covered with cyloid scales.

By means of their lung the *Dipnoi* can live in water that is too impure for branchial respiration.

The subclass is represented in this Gallery by a stuffed specimen, a dissected pectoral fin, and a skull, of *Ceratodus*. In the skull notice the curious compound teeth. Similar teeth have been found, fossil, in Secondary strata in India and Europe.

The *Dipnoi* are generally regarded as a divergent branch of the stock from which the Ganoids descended. They are also connected, through the ancestors of the Chimæras, with the Chondropterygian stock.

Characteristic Fishes of the Deep Sea.

In Cases 15–20 are exhibited specimens of some fishes that are specially adapted for life under the peculiar conditions that prevail in the depths of the sea.

In Case 15 are specimens of fishes that, in all probability, live in constant darkness or gloom. The eyes show marked degeneration, but, so far as is known, there is no compensating overgrowth of any of the other organs of sense.

In Case 16 are specimens of fishes that undoubtedly live at the bottom, in depths to which no daylight penetrates. The eyes are completely-hidden rudiments, but, so far as is known, there is no compensating overgrowth of any of the other organs of sense.

In Case 17 are specimens of fishes that live in darkness and have very degenerate eyes, but have the sense of touch greatly developed in compensation.

In Case 18 are specimens of fishes that undoubtedly live at depths to which little, if any, daylight reaches. Their eyes are of enormous size to catch such light—whether faint gleams of daylight or phosphorescent light—as does exist.

In Case 19 are specimens of fishes that live in constant darkness or gloom, but possess their own independent means of illumination.

In Case 20 are specimens that illustrate in an extreme degree the extraordinary rapacity and voracity of certain deep-sea fishes.

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