LOCOMOTION IN FISHES

Fishes are perfectly adapted for swimming in water.

The body is generally spindle shaped and fusiform for efficient swimming, but variations occur in species which have become adapted for specialized mode of life.

Some species are elongated and eel-like, others have a laterally compressed body as the clupeids and solefish, while some others have a dorso-ventrally flattened body as the skates and rays.

Fishes swim by the following methods:

(a) By alternate contraction and relaxation of the muscles of the body called the myomeres. Thus, during swimming the fish oscillates from side to side showing lateral undulations.

(b) By various movements of the fins.

(c) By sudden expulsion of water as jet the gill aperture.

The tail and the caudal fin are the chief locomotory organs of fish and are used for rapid swimming during which tail is lashed from side to side by alternate contraction and relaxation of the myomeres on the two sides of the vertebral column.

Slow movement takes place with the help of fins only.

According to the Breder (1926), locomotion is fishes can be of three types.

(a) *Anguilliform*, seen in highly flexible fishes with elongated body as the eel.
(b) *Carangiform*, in which the undulations of the body are confined to the caudal region, as in trout, rohu, mrigal, etc.
(c) *Ostraciiform*, in which the body is inflexible being enclosed in a hard box-like protective sheath, and locomotion is due to undulations of the caudal fin, as in *Ostracion*, *Tetraodon*, *Diodon*, etc.

Muscles in Locomotion

Locomotion in fish is the result of coordinated action of muscles of the body and those of the fins.

The muscles of the body are divided into segmental myomeres by connective tissue septa (myocommata).

The myomeres alternate with the vertebrae and are of   shape.

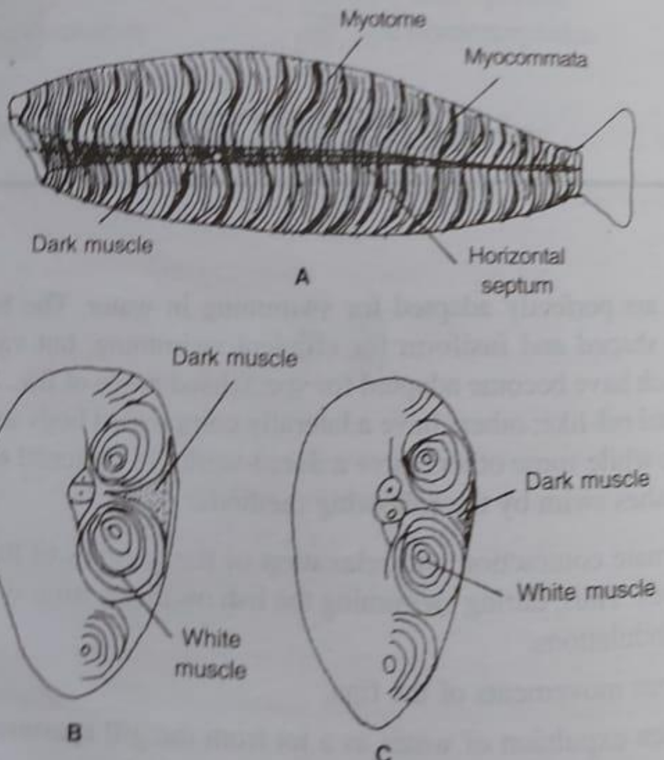
The successive segments fit tightly in a complex manner.

Fish having a larger number of myomeres have a more flexible body (e.g., eel) than others.

Repeated contraction and relaxation of the myomeres on the opposite sides, produces undulatory waves originating in the head region and going down to the tail end.

This produces a ‘thrust’ causing forward propulsion of the body in water.

produces undulatory waves originating in the head region and going down to the tail end. This produces a 'thrust' causing forward propulsion of the body in water.



26.1. **A.** Diagrammatic representation of orientation and proportion of white and dark muscles; **B.** T.S. tail of an active swimmer, **C.** T.S. tail of less active swimmer

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Fin muscles

Movements of the median fins during swimming for propulsion or steering is brought about by paired muscles attached to the base of the fin rays.

These are erector / protractor dorsalis, depressor / retractor muscles and inclinator muscles.

These bring about erection or bending of the fin. The caudal fin has some additional muscles at the base of the fin.

Muscles develop between the fin rays to bring about expansion and contraction of the caudal fin.

Paired fin posses abductors and adductor muscles for outward and inward movement of fin.

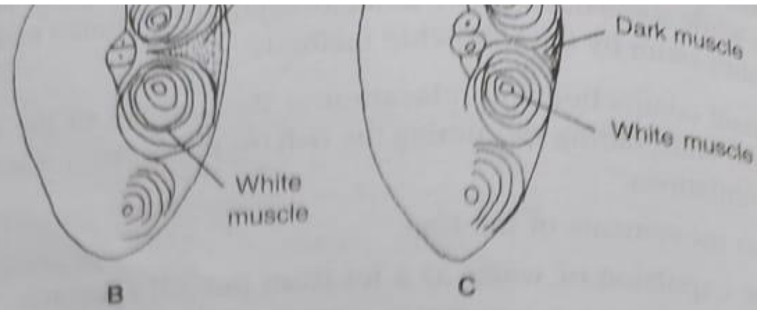

Fig. 26.1. **A.** Diagrammatic representation of orientation and proportion of white and dark muscles; **B.** T.S. tail of an active swimmer, **C.** T.S. tail of less active swimmer

Fin Muscles

Movements of the median fins during swimming for propulsion or steering is brought about by paired muscles attached to the base of the fin rays (Fig. 26.2). These are erector/protractor dorsalis, depressor/retractor muscles and inclinator muscles. These

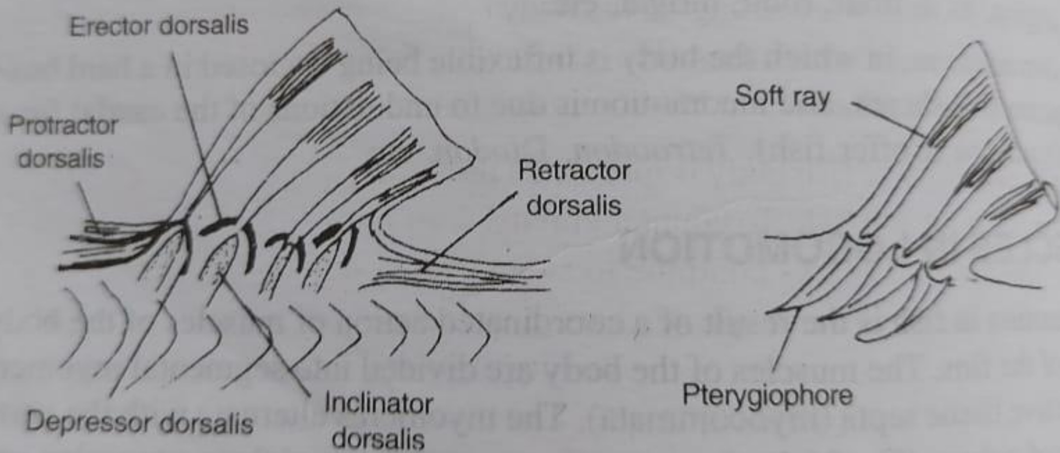

Fig. 26.2. Muscles and skeletal support in the median fin of a teleost.

Dark and White Muscles

The myotomal muscles of teleosts are of two kinds, white (light colour) and dark (red) muscles.

The white muscles form a very large part of the body muscles, and the two kinds vary in proportion, depending upon the habit of the fish.

Thus, fast pelagic swimmers like the herrings and the mackerel are reported to possess a larger proportion of dark muscles than the relatively less active fishes as the carps and cod.

White muscles usually constitute 80-90% of the myotomal muscles in a fish and are comparable to the striated muscles of other vertebrates.

They possess fewer mitochondria, lack haemoglobin and thin Z-lines.

They are ‘fast muscles’ and are used by the fish for a sudden dash to escape from a predator or to catch a prey.

Dark muscles are brown or red in colour due to the presence of myoglobin.

These from a thin superficial layer under the skin, thickening into a triangle along the side of the body at the lateral line region.

In some very active species, extra bands of dark muscles may be present near the neural spine.

Fin muscles are mostly dark muscles.

In species which swim only by the movement of fins (e.g. *Ostraction*, *Tetraodon*, *Diodon*) dark muscles are found only in fins.

They are called ‘slow muscles’, and differ from the white muscles in having a large number of mitochondria and broad Z-line.

They constitute 5-10% of the total muscle mass and need large amount of oxygen during active swimming. For this they have better vascularisation in the form of rete mirabile.

Types of Locomotion

In the carangiform type of locomotion, the fish shows undulating movements of the body and actual forward thrust is produced by the pressure of the tail against water.

In anguilliform type of locomotion, the movement is of serpentine type and the fish looks like crawling snake.

The forward thrust is generated by the pressure of the fish body against the water and the tail or caudal fin has little role in it.

Hence, the caudal fin is reduced in eel-like fishes.

Instead, the caudal region is laterally compressed, forming a blade-like structure and provides a large thrust of the body.

In the trunk fish (Ostracion), the head and body are enclosed in a rigid bony case, while the tail with caudal fin projects behind.

Slow movement takes place by the dorsal and anal fins, while the lashing movements of the tail cause rapid swimming. This is called ‘Ostraciform’ locomotion.

Some species of fish seldom flex the body for swimming, and move forward by undulating movements of the median fins.

Usually complete waves are seen along the fins.

This is called ‘balistiform’ locomotion. Certain species as the catfish, parrot fish, surgeon fish do not oscillate the body or median fins.

These fish use pectoral fins for locomotion and this is called ‘labriform’ swimming.

Some species like the globe fish (Tetraodon), porcupine fish (Dindon) and the sea-horse (Hippcocapus) swim with the help of dorsal and anal fins. Besides , pectoral fins are also used for slow movement. Water expelled from the gill aperture during respiration also helps in slow progression.

When the fish is at rest, the pectoral fins are moving constantly to overcome the forward thrust produced by the respiratory current.

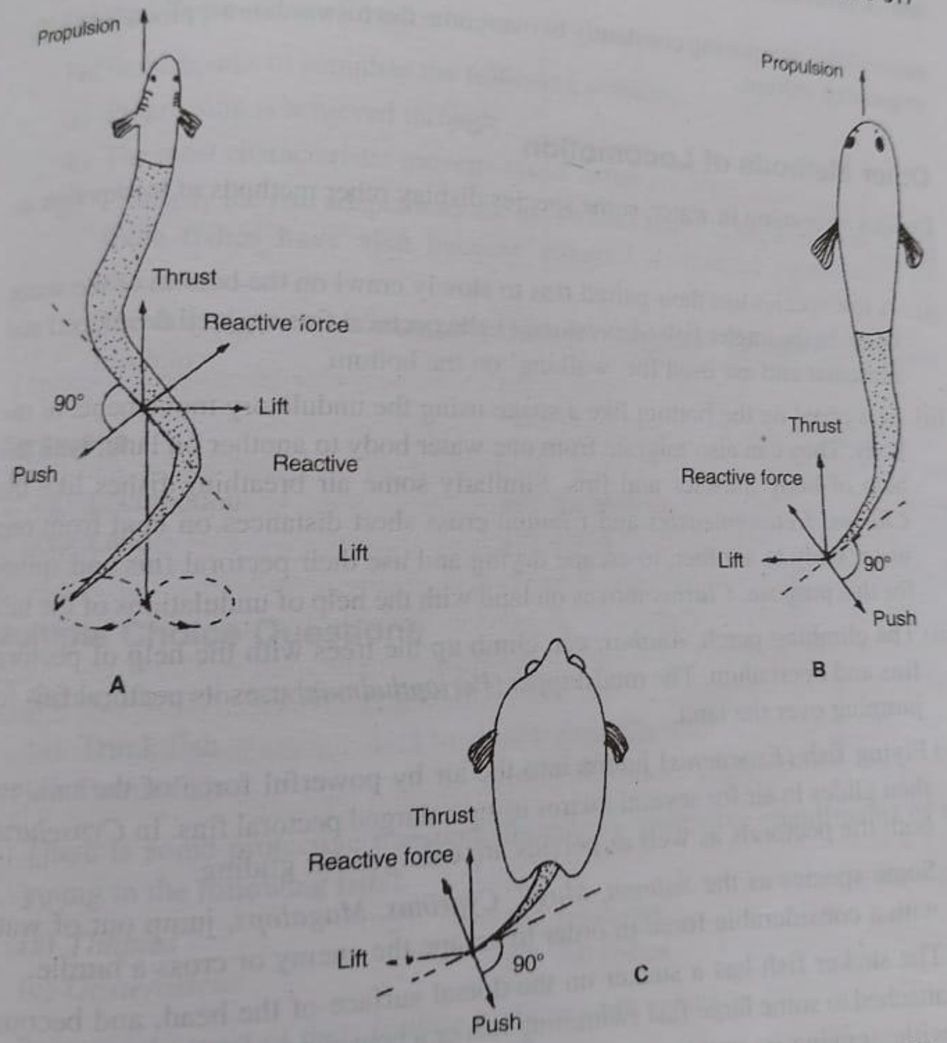

Fig. 26.4. Showing Swimming types in teleosts (after Pough et al., 1996); **A.** Angulliform, **B.** Carangiform, **C.** Ostraciiform.

Some species of fish seldom flex the body for swimming, and move forward by ... of the median fins. Usually complete waves are seen along ... species as the catfish,

Other Methods of Locomotion

Besides swimming in water, some species display other methods of locomotion as below:

(i) A few species use their paired fins to slowly crawl on the bottom of the water body. In the angler fish (Antennarius), the pectoral fins are well developed and muscular and are used for 'walking' on the bottom.

(ii) Eels crawl on the bottom like a snake using the undulatory movements of the body. They can also migrate from one water body to another on land, with the help of body muscles and fins. Similarly some air breathing fishes like the Clarias, Heteropneustes and Channa cross short distances on hand from one water body to another, to escape drying and use their pectoral fins and spines for this purpose.

Clarias moves on land with the help of undulations of the tail.

(iii) The climbing perch, Anabas, can climb up the trees with the help of pectoral fins and operculum. The mudskipper (Periopthalmus) uses its pectoral fins for jumping over the land.

(iv) Flying fish (Exocoetus) jumps into the air by powerful force of the tail, and then glides in air for several metres using enlarged pectoral fins. In Cypselurus, both the pectorals as well as pelvics are enlarged for gliding.

(v) Some species as the Salmon, Mugil, Cyprinus, Magalops, jump out of water with a considerable force in order to escape the enemy or cross a hurdle.

(vi) The sucker fish has a sucker on the dorsal surface of the head, and becomes attached to some large fast swimming fish or a boat and travels for long distances without using its own energy.

MIGRATION OF FISHES

Migration can be defined as seasonal movement of a large number of fish belonging to a species from one area to another, for feeding or breeding.

Generally, species remain confined to a small home territory, but a few species are known to travel long distances in search of food or for spawning.

Migration may occur in vertical direction as from the deeper to surface water, or may be in a horizontal direction either upstream or downstream.

True migration is seasonal movement that occurs regularly, and implies a return to the starting point.

According to Jones, migration is “a class of movement which impels the migrants to return to the region from where they have migrated”.

But Baker is of the opinion that there is no need of return journey.

Dingle has defined migration of fishes as a "special behavior evolved for the displacement of the species in space".

Accidental or unintentional movements are not included in the definition of migration.

Species that migrate have developed several morphological, physiological and behavioral adaptations but no single species show all of these adaptations.

Hence, a single complete definition of migration is not possible.

Migratory Species: Mature adults of several species of fishes undertake migration for breeding or feeding purpose. These are:

1. Gadus morhua (the cod)
2. Salmo spp. (the salmon)
3. Oncorhynchus spp. (the Pacific salmon)
4. Clupea harengus (the herring)
5. Thunnus thynnus (the Tunas)
6. Anguilla anguilla (the Europaen eel)
7. Anguilla rostrata (the American eel)
8. Anguilla japonica (the Japanese eel)

9.Anguilla australis (the Australian eel)

10.Hilsa ilisha (Hilsa)

11.Gasterosteus aculeatus (the three-spined stickleback)

12.Pleuronectes platessa (the flat fish)

13.Scomber spp. (the mackerel).

14.Petromyzon marinus (the Lamprey)

15.Lampetra fluviatilis (the Lamprey)

Types of Migration

Migration can be of anyone of the following types

(a) Climatic migration, undertaken to search better climatic and environmental conditions.
(b) Gametic migration is undertaken for spawning.
(c) Alimental migration is undertaken in search of food and water.
(d) Osmoregulatory migration.

Periodicity of Migration

Migration of fishes occurs at regular intervals, which varies in different species and even within a species.

Migration may be undertaken daily, monthly, seasonally, yearly or after a long gap, depending on biotic and abiotic factors. For example, larvae of Petromyzon may live in the mud for several years before undergoing metamorphosis and migrating to sea.

Similarly, eel remain in fresh water for several years before undertaking migration to sea for spawning.

Pacific salmon also lives for several years at sea and then returns to the spawning grounds in fresh water.

Clupea (herring) undertakes daily vertical migration for feeding, and annual migration to the spawning grounds for spawning.

Gadus (the cod) and Hilsa also undertake annual migration when adult.

Distance, Speed and Duration of Migration

There is no uniformly in the distance covered, speed and duration of migration by different species and this depends on the environment through which journey has to be undertaken to reach the desired location. Some species cover very long distances to reach the suitable location as in salmon, tuna, eel, etc. The time taken to cover the distance depends on whether the species has to gather food also during the journey. Some time may also be spent in testing the water and its suitability.

Methods of Migration

Several methods can be used by a species for migration. These are:

(a) By drifting: Fishes travel passively with the water current and do not make any effort. This is called ‘drift’ and results in ‘directional movement’ by the fish.
(b) Random Locomotory movement: In a uniform environment, fish released at a point spread out in all directions by random

locomotory movements. This results in uniform distribution or dispersal of the species.

(c) Orientated swimming: This involves swimming in a particular direction, which may be either towards or away from the source of stimulation. This can also be at an angle between the fish and the source of stimulation.

PATTERNS OF MIGRATION

The following terms are used to describe the patterns of migration:

Diadromous Fishes

These are truly migratory fishes which love between sea and freshwater and can be of three types:

Anadromous:

These species have feeding areas in the ocean and spend a major part of their lives in the sea but migrate to fresh water rivers of spawning.

Thus, many marine fishes like the Salmon (trout), Oncorhynchus (Pacific Salmon), Salvelinus, Hilsa, show various degrees of anadromous migration.

The trout (Salmo gairdneri) and Hilsa travel long distances to reach feeding areas in the oceans.

They return to the breeding grounds in the rivers for spawning.

Salmon and Hilsa are known to travel several thousand km in the sea, and then several thousand km in rivers to reach spawning grounds.

After egg laying the spent fish return to the feeding places in the sea.

The brown trout (Salmo trutta) and cut-throat trout (S.clarki) migrate for short distances only.

The three spined stickleback (Gasteroseus aculeatus) lives in the sea for considerable part of its life, but returns to fresh water for spawning.

Among the cyclostomes, the sea lamprey, Petromyzon marinus and Lampetra fluviatilis, are anadromous and migrate to fresh water for spawning.

The adults usually die after spawning, but the larvae remain there, metamorphose to adults, and migrate to sea, where they feed on fish.

After two years these adults return to fresh water for spawning.

Catadromous:

These fishes spend part of their lives in fresh water but migrate long distances at the sea for spawning.

The fresh water eel, Anguilla, is the best example of catadrornous fishes.

It travels several thousand km starting from the rivers reaching spawning ground in the sea.

After spawning the adults die, and the young larvae drift and swim back towards the rivers taking three years to reach there.

Here, they undergo metamorphosis to become the adults, and on reaching maturity return to the sea again.

The eel is represented by about 16 species, which are widely distributed throughout the world.

Anguilla anguilla, the European eel, and A. rostrata, the American eel, spawn in the western North Atlantic (Sargasso sea).

Anguilla japonica spawns in the North Pacific, while A. australis spawns east of Australia in the South Pacific.

Potamodromous Fishes

These are truly migratory fishes, but the movement is confined to freshwater e.g., the carps and trout.

These species travel long distances in rivers to locate suitable spawning grounds.

After egg laying, the parents return to the feeding area.

Some species migrate upstream for spawning and return to the feeding area. However, a few species migrate down to breed.

Many cyprinids, clupeids, catfishes, salmon, trout, etc show migration entirely within freshwater.

It appears that the spawning areas provide most suitable environmental conditions for the developing eggs, and are free from predators.

Food is available for the young ones, but these areas cannot support the adults, who return to their feeding areas.

Besides spawning needs, migration within freshwater may also be due to interspecific and intraspecific competition.

When the population increases, scarcity of food may force some fishes to migrate to other places, where food is abundant.

Oceanodromous Fishes

These are truly migratory marine fishes which travel long distances in the sea to spawn, and later return to the feeding areas. Example of oceanodromous fish are cod, herrings, mackerels and the tunas.

During migration these species visit spawning areas, nursery areas, feeding areas, winter area, etc, and stay in an area as long as it is necessary.

A brief account of the oceanodromous fishes is given below:

Herrings (Clupea)

Herrings are found in abundance in the North Atlantic and North Pacific Oceans, and exhibit seasonal migration covering a large area.

The herrings also undertake vertical migration daily.

This is for short distance and is related to food. The Atlantic herrings live in deep ocean during day time and move to the surface at sunset.

At midnight, the fishes go down, but again migrate to the surface at dawn, before going to the deep water for the day.

They feed on zooplankton, which show vertical diurnal migration, hence the herrings also undertake daily vertical migration to feed, and remain protected from the predators during the in deep ocean.

These fishes also undertake annual migration to the spawning ground near the coast, and do not exhibit vertical migration during this period.

After spawning, the larvae drift along the water current to wintering area near the coast, where they feed and grow.

On becoming adult, they join the older fish in the migration cycle and return to the spawning area when sexually mature.

This takes 4-6 years.

The Cod (Gadus morhua)

These fishes are widely distributed in the N.Atlantic ocean, and generally spawn from February to June near the bottom of the sea in cold water.

Hatching takes place in 2 weeks, and the young ones feed on zooplankton in mid water, for about 6 months.

Later, the young ones move to the bottom and feed on crustaceans and fish.

On becoming older, they join the mature fish and start the migration cycle, which is completed before spawning at the age of five years.

After first spawning, they continue to spawn annually for several years.

The Flat Fish (Pleuronects platessa)

This species inhabits coastal water of Europe.

The eggs and larvae are pelagic and drift with the current from the spawning to nursery areas.

Metamorphosis is completed in about two months, and they young ones migrate to the bottom to feed on invertebrates.

They attain sexual maturity in 3-4 years, and return to the same spawning grounds.

The migration cycle is repeated several times.

Tunas (Thunnus spp.)

These are warm-blooded fishes, and are widely distributed in the Atlantic and Pacific oceans.

The fish becomes sexually mature in 3-5years and is known to cover upto 10,000 km.

One race of tunas spawn in May and June in the Mediterranean Sea.

The spent fish begin the migration cycle within the Mediterranean, and majority of them migrate through migrate throung the Strait of Gibraltor, northward as far as Norway.

During winter, the move southward and reach the Mediterranean to spawn again.

CAUSES OF MIGRATION

Fish appear to migrate

(i) To avoid unfavourable conditions,
(ii) To enhance the chances of survival of the offsprings, and
(iii) To exploit the available food in feeding areas.

(iv) Population pressure is also considered a possible cause of migration. The fish migrate in search of new suitable areas where food is abundant and competition is minimum.

ADVANTAGES OF MIGRATION1

Migration is considered to be an adaptation towards abundance, as it ensures reproductive success of the group.

The spawning or nursery grounds may not have enough food, and therefore, both mature and young individuals of a large population cannot be maintained there.

Therefore, separate spawning and feeding area is advantages to the species. Most of the commercially important species are migratory.

This supports the view that migration is an adaptation towards abundance.

There appears to be some advantages to a species whose adults return to spawning area where favourable conditions exist.

By exploiting these favourable conditions, a better survival of eggs and larvae is ensured.

Moreover, fish are widely distributed in the feeding areas, but collect in large numbers at the spawning grounds almost simultaneously.

The presence of a large number of spawners of both the sexes at the spawning grounds ensures reproductive success and survival of the species.

Integumentary system–Scales, type of Scales

Scales are hard plates covering the body. The scales of fishes are developed from the dermis of skin.

Hence, fish scales are termed as dermal scales.

Based on Lagler et al.,1977 and Weichert, 1970.

The scales are of two types, namely placoid and non-placoid.

The non-placoid scales are of four types, namely cosmoid, ganoid, cycloid and ctenoid.

Cycloid and ctenoid scales are bony-ridge scales.

Placoid Scales

Placoid scales are also called dermal denticles.

They are found in elasmobranch fishes.

They are dermal in origin. These are closely set but do not overlap each other.

Each scale consists of two parts, namely a rhomboidal basal plate embedded in the dermis and a flat trident spine, projecting outward through the epidermis.

The basal plate consists of calcified tissue. According to Weichert (1970), it is a bony plate, which indicates the remain of ancestral bony armour.

It is anchored into the dermis by connective tissue fibres called the Sharpley’s fibres.

The trident spines are curved and directed towards the tail end.

This is to minimize friction with water. Each spine consists of dentine.

This is covered with a hard layer of Vitrodentine.

The dentine encloses a pulp cavity. This opens below through the basal plate.

Through this opening, blood vessels and nerves enter the pulp cavity.

The pulp contains many odontoblasts (dentine forming cells). Fine canaliculi arise form the pulp cavity and reach the dentine.

Cosmoid Scales (G.Kosmos, ornament + oide, like)

Cosmoid scales means ornament-like. They are found in extinct Crossopterygii, extinct Dipnoi and Latimeria. It is dermal in origin.

Each cosmoid scale consists of three layers as follows:

1.Isopedine: This is the inner (deepest) layer consisting of layered bone. It is pierced by channels for blood vessels.

2.Vascular layer: This is the middle layer consisting of spongy bone. It contains numerous vascular spaces.

3.Cosmine: This is the outer layer consisting of dentine containing pulp cavities.

Ganoid Scales (G.Ganoi, brightness+oide, like)

Ganoid scales are found in Lepidosteus, Polypterus, Amia etc. It is a modified cosmoid scale. It is formed of four layers, namely an inner isopedine, a vascular layer, a cosmine layer and an outer ganoine layer.

There are two types of ganoid scales

1.Palaeoniscoid ganoid scale

In this type.

(i) The layered bone isopedine is present.
(ii) The vascular layer is absent.
(iii) The cosmine layer is reduced.
(iv) Above the cosmine layer is a hard multilayered ganoine.

This gives a lustrous metallic sheen (shining)

2.Lepisosteoid ganoid scales

In this type, both spongy bone and cosmine layers are absent, so that ganoine contains many tubules. Such scales are arranged closely together, like tiles on a floor in diagonal rows.

Cycloid Scales

Cycloid scales are circular in shape. They are found in all teleost fishes.

They are dermal in origin. They are arranged in an overloading fashion like the tiles on the roof of a house.

It is made up of two layers, namely an outer isopedine and inner fibrous layer.

The central part of the scale is called nucleus (focus). It is the first develop. The focus is surrounded by concentric bony ridges called lines of growth (growth rings).

Some growth lines are thick and they are called annuli.

A number of grooves radiate from the centre to the margin. They are called radii.

The anterior border is free, rounded and is exposed. The posterior border has numerous longitudinal grooves for sucking nourishment.

Ctenoid Scales

Ctenoid means comb-like scales. They are found in teleost fishes.

Some fishes contain both cycloid and ctenoid scales.

They are dermal in origin.

They are arranged in an overlapping fashion like the tiles on the roof of a house.

It is made up of two layers, namely an outer isopedine and inner fibrous layer.

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Uses of Scales

1.Scales are useful for the classification and identification of fishes.

2.Scales are useful for the determination of age of fish.

3.Scales are useful for the estimation of the number of spawnings.

Gill respiration-Types of Gills, Structure, Mechanism of Gill respiration

Respiration can be defined as a physiological process in which oxygen from the medium is taken up by blood while the metabolic waste as CO_2 (carbon dioxide) is released off at the same time.

This oxygen in turn is made available to active tissues through the blood stream.

As a result of the oxidative and non-oxidative reactions in the tissues, the CO_2 and energy is released for biological activities.

This energy is consumed for various anabolic and catabolic processes while the CO_2 is carried away by the blood stream back to the respiratory surface where it is eliminated.

The Gills

Gill are feather-like organs, richly vascularised by capillaries bed for the exchange of O_2 and CO_2.

The gills lie within gill clefts and appear in the form of vascular and filamentous lamellae like outgrowths from the anterior walls of the gills clefts.

Gill clefts

The gill (pharyngeal gill slits) on each side open internally into the pharynx, by wide internal branchial apertures and to outside by narrow external branchial apertures.

The gill clefts on each side remain separate from the one another by inter-branchial septa.

Each septum consists of a central core of mesodermal tissue covered externally by the ectodermal layer and internally by the endodermal layer of pharynx.

It is supported either by a cartilaginous or by a bony rod like skeletal arch.

An afferent and one or two efferent branchial vessels course through the septum to constitute its blood supply.

The anterior and the posterior wall of each gill slit is raised in the form of vascular filamentous outgrowths to form the gills where exchange of dissolved O_2 and CO_2 takes place.

Respiration

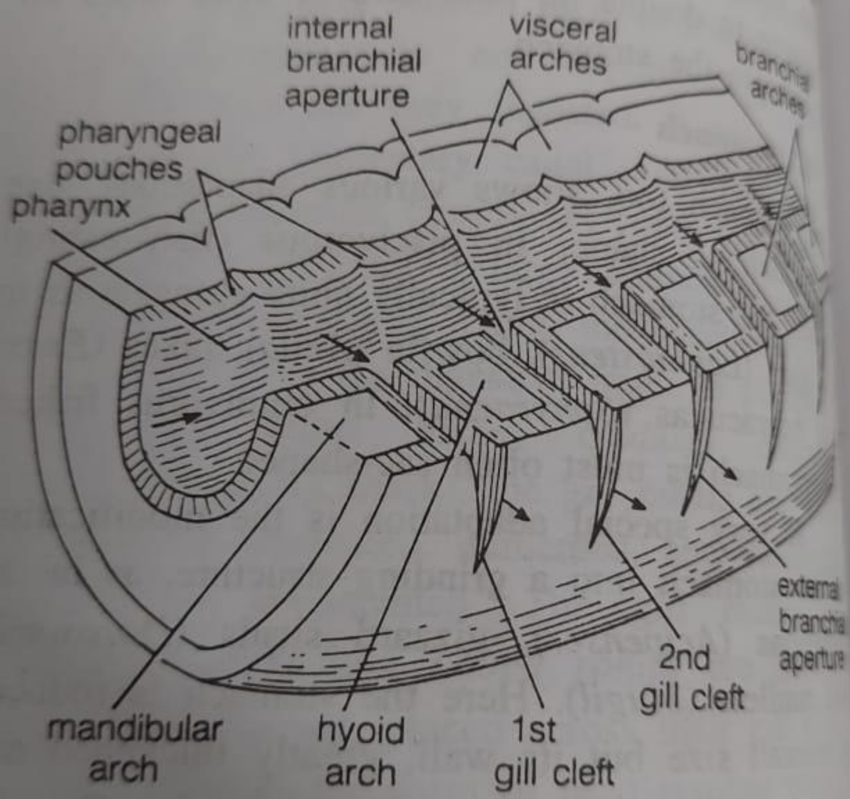

Fig. 1. Diagrammatic H. L. S. of the pharyngeal region of a [illegible] right half showing visceral grooves and visceral pouches, and [illegible] half gill clefts.

The gill clefts on each side remain separate from one another by inter-branchial septa. Each septum consists of a central core of mesodermal tissue covered externally by the ectodermal layer

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Types of Gills

In general gills are of two types: (i) External gills and (ii) Internal gills.

External gills are the filamentous outgrowths of the integument covering the visceral arches. This form is only found in the larvae of Dipnoi viz; Protopterus and Lepidosiren.

Internal gills are found in all the fishes and develop within the pharyngeal pouches and line the gills clefts in adults.

On the basis of position and function, gills may be classified as:

(I)Pseudobranch

The first gill cleft generally closes off in adults to form the spiracle.

In certain fishes only the external branchial aperture gets closed, while the internal branchial aperture remains open into the pharynx.

The filamentous gills of such clefts are called pseudobranchs which develop quite early in the embryonic stage and may have a respiratory function in this stage only but does not continue in the adult, e.g. Catla Catla. Psesudobranchs are found in Amia, Lepidosteus, Acipensor, Polydon etc. it is said to be absent in those fishes in which a choroid gland of the eye is absent viz., Notopterus, Channa, Wallago attu, Mystus aor, etc.

The pseudobranch may be free or covered with a layer of mucous membrane.

It receives oxygenated blood directly from the dorsal aorta and has a vascular connection with the internal carotid artery.

It may serve to increase the O_2 concentration in the blood going to the brain and the eye through the internal carotid artery.

Histologically, the pseudobranch contains a large number of acidophilic secretory cells which probably produce carbonic anhydrase enzyme.

The pseudobranch may also be useful in filling of gas bladder and in the regulation of intraocular pressure. However, it is non respiratory in function.

	—	14 pairs
	—	7 pairs
	—	6 pairs
	—	5 pairs
	—	never more than 5 pairs

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s open into the
such clefts are
p quite early in
ve a respiratory
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udobranchs are
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Mystus aor,

e or covered
. It receives

Histologically, the pseudobranch contains a large number of acidophilic secretory cells which probably produce carbonic anhydrase enzyme.

The pseudobranch may also be useful in filling of gas bladder and in the regulation of intraocular pressure. However, it is non respiratory in function.

[II] Complete gill (holobranch)

A complete gill or a holobranch consists of an inter-branchial septum supported by cartilage or

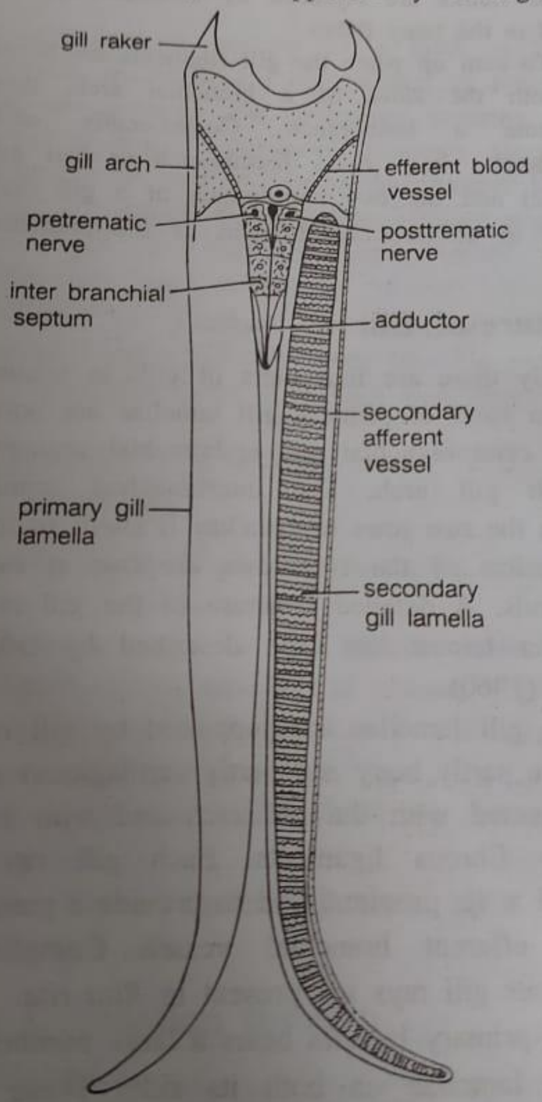

Fig. 2. Single gill arch with details of one hemibranch gill lamella.

(II)Complete Gill (holobranch)

A complete gill or a holobranch consists of an inter-branchial septum supported by cartilage or bone.

The anterior and posterior walls each septum are produced into vascular plate-like filaments. Each series of these filaments forms a hemibranch or a demibranch.

Two such hemibranchs together form a complete biserial gill or a holobranch.

In elasmobranchs, usually five pairs of branchial clefts are present, while the bony fishes posses only four pairs of gill slits. The spiracle is also absent.

Teleosts have a single external brancial aperture on each side of the head due to development of an operculum covering the gills.

The interbranchial septum is highly reduced in all teleosts and the paired efferent branchial arteries of the sharks are replaced by a single efferent vessel in the bony fishes.

To sum up when the gill filaments are borne on both the sides of a branchial arch, they constitute a holobranch.

Consequently each holobranch has two hemibranch or half gill and the two hemibranch of a gill cleft belong to different holobranchs or the branchial arches.

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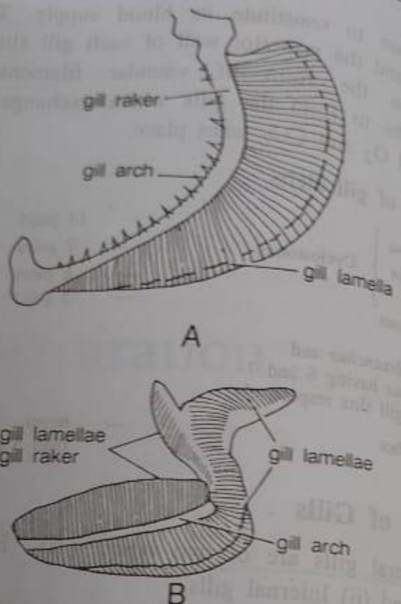


Fig. 3. A. Gill of *Cirrhinus mrigala*, B. Gill of *Hilsa ilisha*.

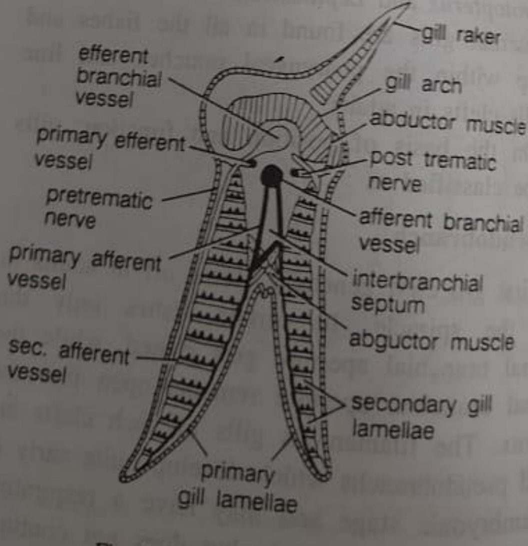


Fig. 4. T. S. gill of a teleost.

Each secondary lamella consists of a central vascular layer composed of pillar cells ... by
basement ...

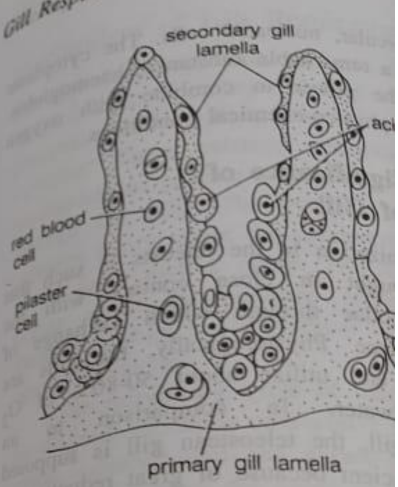


Fig. 5. Structure of secondary gill

Histology of Gill Filaments

The gill filaments are the functio
gill and are thin, delicate and gor
These are arranged in two row
posterior, on the gill arch.

The mode of arrangement o
over gill arch may vary but in
filament contains a richly vascular
type of Pilaster cells enclosed wit
sheet of the epithelial cells
epithelium, covering the gill arch
large number of mucous
eosinophilic cells and the taste bu

Each branchial arch is suppo
element called the skeletal arch.
parts, viz., the epibranchial an
parts. The epibranchial part is pl
supports the pharyngobranchial e
ceratobranchial is placed ventrall
hypobranchial elements. In addit
a third basibranchial part is
certain fishes.

Structure of Gill

Typically there are four pairs of gills in teleosts and two rows of primary gill lamellae are borne by the ceratobranchial and epibranchial segments of each gill arch. The interbranchial septum between the two rows of lamellae is short, so that the lamellae of the two rows are free at their distal ends. A detailed structure of the gill in a freshwater teleost has been described by Dutta Munshi (1960).

The gill lamellae are supported by gill rays which are partly bony and partly cartilaginous and are connected with the gill arch and with each other by fibrous ligaments. Each gill ray is bifurcated at its proximal end to provide a passage for the efferent branchial vessel. Completely cartilaginous gill rays are present in Rita rita.

Each primary lamella bears a large number of secondary lamellae on both its side. These flat leaf-like structures are the main seat of gaseous exchange.

Each secondary lamella consists of a central vascular layer composed of pillar cells covered by basement membrane and an outer epithelial layer. The pillar cells from the blood channels of secondary gill lamellae.

Air Bladder in Fishes

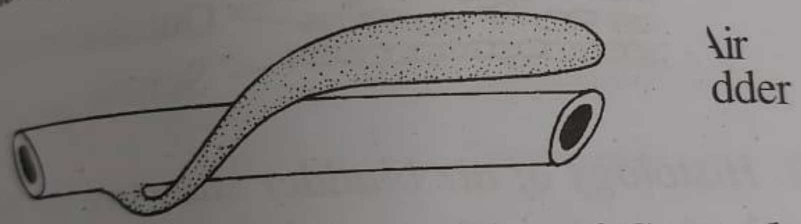
Air bladder may be defined as a gas filled sac, arising as a dorsal outgrowth from the gut in most of the ray-finned fishes; it regulates buoyancy at different depths. Hence, it is aptly called swim bladder.

15. Air Bladder in Fishes

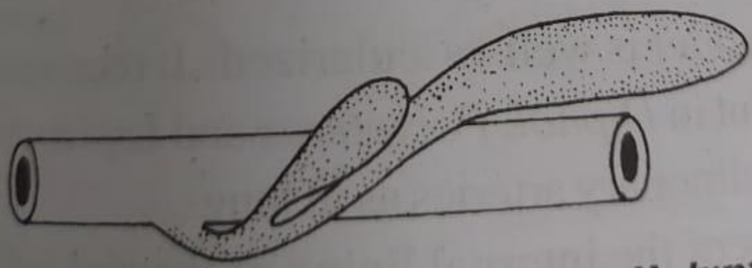
ir bladder may be defined as a *gas filled sac, arising as a* *outgrowth from the gut in most of the ray-finned fishes*; it ...ates ***buoyancy*** at different depths (***Romer***, 1962). Hence, it is ...alled ***swim bladder***.

The gases in the bladder are O_2, CO_2 and N_2. Hence, it is also ...ed as ***gas bladder.***

The air bladder lies between the gut and the vertebral column. It ...mologous to the lungs of tetrapods. It occupies the same posi- ...s the lungs.



Air bladder of Ceratodus



Air bladders of Polypterus

Fig.15.1: Air bladder in fishes.

The air bladder develops as an outgrowth from the dorsal sid... ...the oesop... ...dorsal aorta. But th...

The gases in the bladder are O_2, CO_2 and N_2. Hence, it is also termed as gas bladder.

The air bladder lies between the gut and the vertebral column.

It is homologous to the lungs of tetrapods. It occupies the same position as the lungs.

The air bladder develops as an outgrowth from the dorsal side of the oesophagus.

It receives an artery from the dorsal aorta. But the lungs develop as an outgrowth from the ventral side of the pharynx.

It receives blood from the sixth aortic arch.

In embryo, the air bladder is always connected to the gut by a pneumatic duct.

This duct is either lost in the course of development or retained throughout life.

Fish air bladder having a pneumatic duct is said to be physostomous type.

A fish contains one or two air bladders. In physostomous air bladder, the air bladder is connected to the oesophagus by a pneumatic duct.

The air bladder has two chambers, namely an anterior chamber and a posterior chamber.

The two chambers are inter connected by an opening called ductus communicans.

The inner lining of the air bladder may be smooth or folded to form as sacs called alveoli as in lungs.

The air bladder is well vascularized. It receives arteries from dorsal aorta. But in Dipnoi, Polypterus and Lepidosteus, the blood is supplied by pulmonary arteries as in lungs.

Some areas of the internal lining of the air bladders are highly vascular and modified into secretary area called gas gland.

Underlying each gas gland is a network of blood vessels called rete mirabile.

Gas gland and rete mirabile ae called red body. Red body is concerned with respiration and gas secretion.

The histology of bladder wall is similar to that of gut wall. Consists of mucosa, lamina propria, submucosa, muscularis (collagen) and serosa. In addition, it contains guanine crystals embedded in the collagenous muscle fibres. These give silvery appearance to the air bladder.

Physostomous Bladders

The air bladder having a pneumatic duct is called a physostomous bladder.

The pneumatic duct connects the air bladders with the oesophagus.

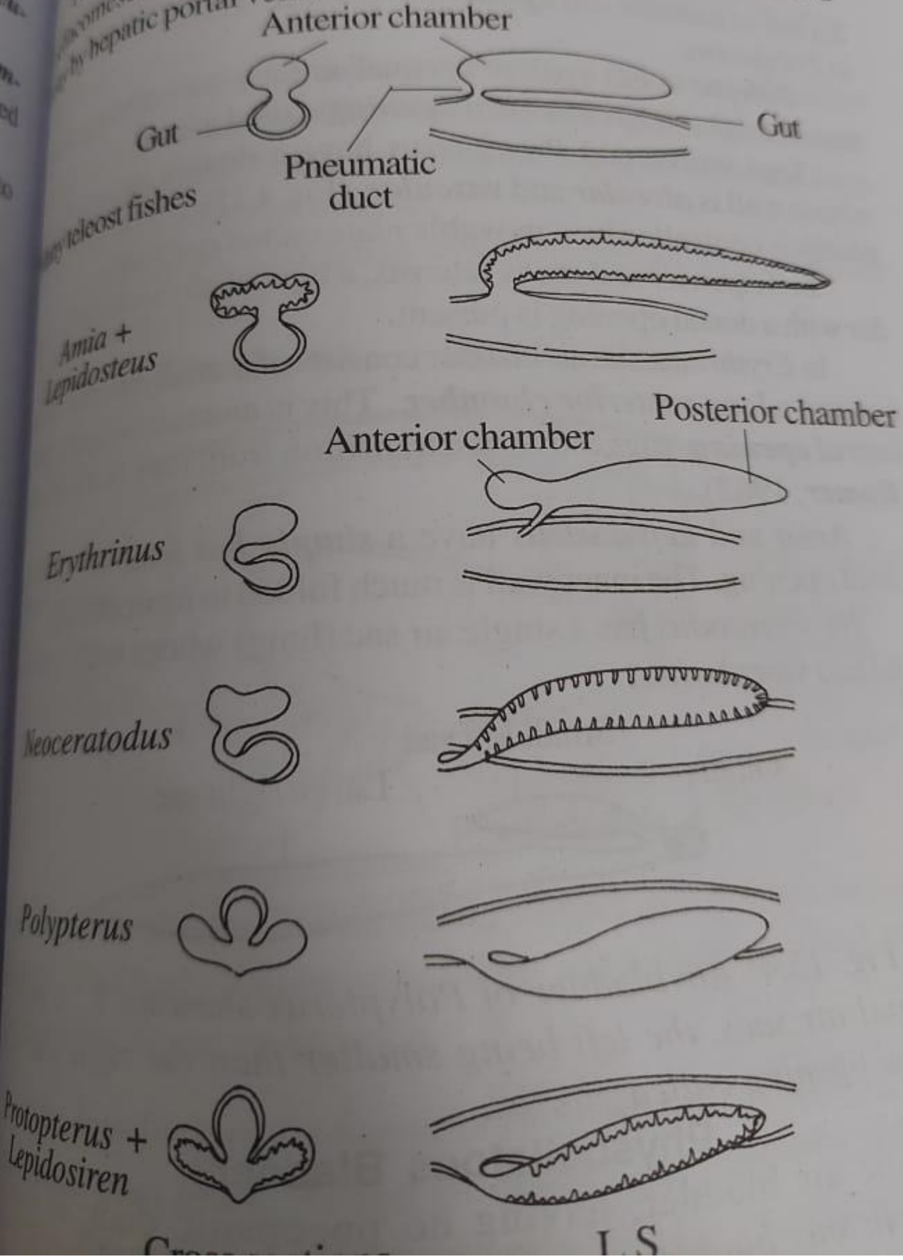
The physostomous air bladder receives an artery from coeliacomesenteric artery of dorsal aorta and the blood is carried away by hepatic portal vein.

Physostomous Bladders

The air bladder having a pneumatic duct is called a ...mous bladder.

The pneumatic duct connects the air bladder with the oesopha-

The physostomous air bladder receives an artery from ...omesenteric artery of dorsal aorta and the blood is carried ...by hepatic portal vein.



Cross section... L.S ... of air

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...g.4.172).
...ysostomous air
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Physoclistous Bladders

The air bladder, having no pneumatic duct, is called physoclistous bladders.

The physoclistous bladder develops first as physostomous air bladder. But only later in development, the pneumatic duct degenerates.

The fishes having physoclistous bladder is called ***physoclisti.***

Completely closed physoclistous air bladders are found in perch, haddock and toadfish (***Weichert***, 1970).

It is a ***closed sac.*** It has two chambers, an ***anterior chamber*** and a ***posterior chamber.*** The two chambers are interconnected by an opening called ***ductus communicans.***

The posterior chamber develops as the enlargement of the pneumatic duct.

The posterior chamber has a network of blood vessels called rete mirabile (***retia mirabilia***) and a gas secreting area called ***gas gland.*** The rete mirabile and gas gland are together called ***red body.*** ...innervated by the vagus nerve.

The red body is concerned with the secretion of gas into the bladder from the blood.

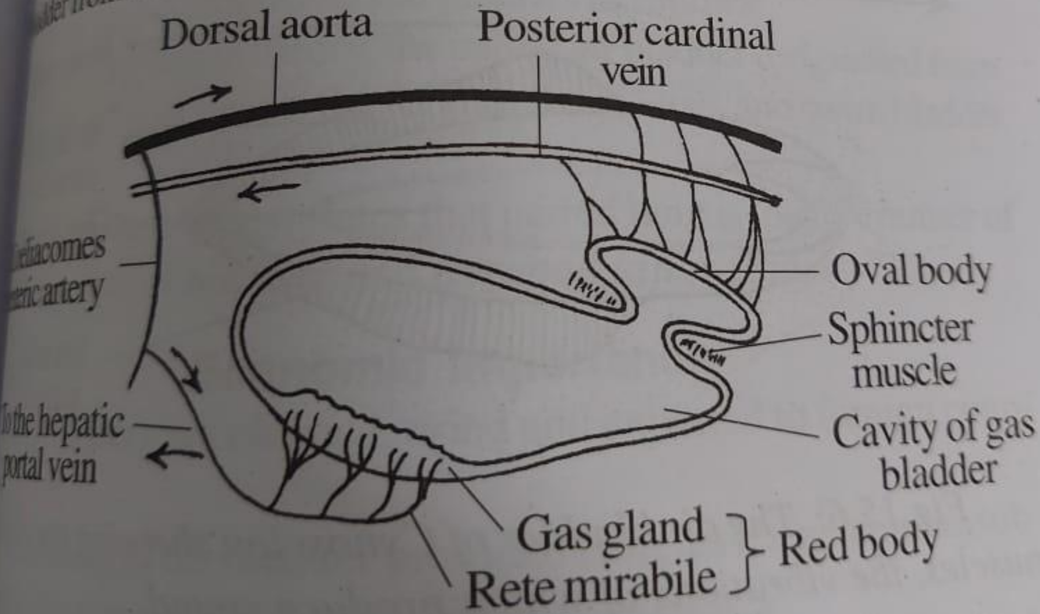

Fig.15.5: Structure and blood supply of a physoclistous gas bladder. Red body is concerned with gas secretion. Oval body is concerned with gas resorption.

... pocket-like struc-

Weberian Ossicles

A remarkable chain of small bony bead like structures connecting the internal ear i.e. membranous labyrinth with the air bladder in a number of fishes is termed Weberian ossicles or Weberian apparatus.

Structure of Weberian ossicles

The Weberian apparatus may consist of either four or three bony ossicles.

1. Claustrum
2. Scaphium
3. Intercalarium and
4. Tripus.

The last three form an articulated chain while the first piece of ascending order the claustrum, lies in front of the scaphium and is smallest anterior most piece.

The claustrum either articulates with forms a part of the neural arch of the first vertebra.

The second piece scaphium is slightly larger, broad and compressed structure.

A ventral peg-like process of the scaphium may be present and articulates with a depression in the centrum of the first vertebra.

The scaphium is connected to the interclarium by means if an interossicular ligament.

The interossicular also shows variation in the degree of its development.

It may be a small nodule of bone in the ligament, not connected with the vertebral column, as in the siluroids (Wallago attu, Mystus seenghala) or it may be in the form of a rod-like piece, reaching upto the centrum of the second vertebra, as in the carps (Labeo, Cirrhina, Tor tor). One end of the interclarium may be bifurcated.

The intercalrium is connected to the tripus by means of another ligament.

The tripus is the largest piece and consists of three processes, i.e. anterior, middle and posterior.

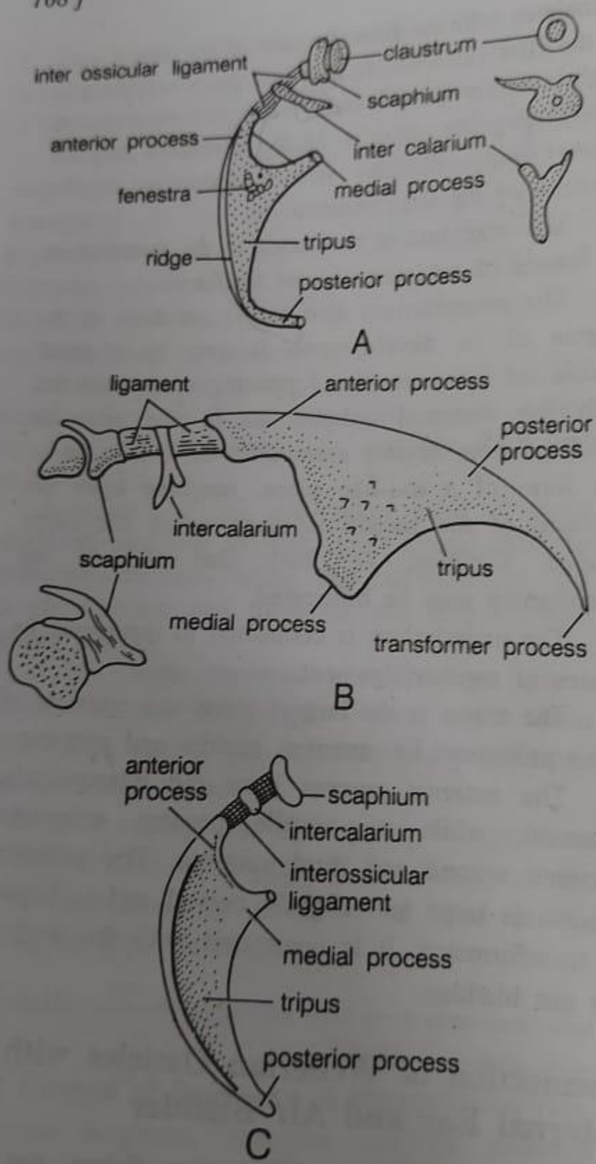

Fig. 10. A. Weberia ossicles of *Labeo*, B. Weberia ossicles of *Tor*, C. Weberia ossicles of *Wallago*.

blind diverticulum, the sinus endolymphaticus, projects ...

Types of Ear-Air Bla

Till now, four types of ea have been reported in fish described by **Weber** wh **Srivastava, P.N.**

First type connection

According to **Weber**, in duct or diverticulum is bladder which simply app capsule. Such a connec fishes belonging to No some species of Serrani added two more group Berycidae.

In *Notopterus not* anteriorly the air b sub-spherical sac, whi auditory caecae, one o these proceed ant corresponding auditory c

This type of ear-ai be regarded as the most the lack of intimate a possibly of low function

Second type connection

In this type, the anteri bladder forms a minute extends into head on ea has been found in c (Fig. 12) and *Gudusia* such type of connection Srivastava ...