Dayanand Science College, Latur

Department of Zoology and Fishery Science

Class: B.Sc. I Year

Subject: Icthyotaxonomy and Ecological Adaptation (I)

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Icthyotaxonomy and Ecological Adaptation

Syllabus

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2) Classification of fishes (Berg, 1940) up to class level
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4) General characters of class Holocephali
5) General characters of class Dipnoi
6) General characters of class Teleostomi
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UNIT I Icthyotaxonomy

1) Scope and importance of fishery science

Fish is aquatic cold blooded, vertebrate, which respire with gills and locomote with the help of fins. The study of fish is called as Ichthyology. Whereas, culture of aquatic animals is called as 'Aquaculture' and culture of fishes is called as 'Pisciculture'. Fishes are gill bearing cold-blooded aquatic animals. The body temperature varies according to the environment. This helps fishes to keep their metabolic activity and food intake very low especially when they live in ice or frozen in north or in hot springs of volcanic region. These are most numerous of vertebrates (over 40000 species have been described so far). Fish meat contains protein, carbohydrates, minerals, water and fat which are most essential components of human food. Fishes are found in all three aquatic environment the freshwater, brackish water and the marine ecosystem. But they are more diverse and numerous in marine ecosystem, distributed from warm tropic to ice cold arctic region, from surface to deepest region. The group, fish exhibits a great variation in their shape and size. Some are torpedo shaped, fusiform, round, flat, angular, and laterally compressed. There are four classes of fishes, Elasmobrachii, Teleostomi, Holocephali and Dipnoi. Majority of the fishes belong to two common classes namely Elasmobranchii the cartilaginous fishes and Teleostomi the bony fishes.

For fishery purpose according to salinity water is divided into freshwater (salinity < 0.5 ppt), brackishwater (salinity 0.5 - 35 ppt) and marine water (salinity > 35 ppt). Freshwater resources include rivers, ponds, lakes, canals, etc. Brackishwater resources includes estuaries, creeks, backwaters, etc. whereas, marine water include ocean ans seas. Fishes inhabiting all the three aquatic ecosystems (The freshwater, brackish water and seawater) do not exhibit any distinguishing characters externally.

Fisheries, as the name suggests is an organized effort which is related to the capturing of fish including inland and sea or other aquatic species. This industry involves catching, processing, marketing and conservation of fish. Fisheries Science is an academic discipline of managing and understanding fisheries. This is a multidisciplinary subject that includes the biological study of life, habits and breeding of various species of fish. 5. It also involves farming and husbandry of important fishes and aquatic organisms in fresh water, brackish water and any marine environment. Fisheries aims at developing and maintaining sea wealth. Fisheries are estimated to provide 16% of the world population's protein and India holds the seventh position in the world as regards to the value of fish exports. Around 14 million people of India are directly or indirectly dependent on the fisheries sector. The rapidly developing fishery industry, provides employment not only to the traditional fishermen, but also to the highly skilled personnel engaged in the scientific breeding and management of fisheries. The scope in the field of fishery science is increasing with the development of brackish water and freshwater aquaculture. Because of the country's expansive natural resources, dynamic entrepreneurial skills, this profession is advantageous to the Indian economy also. A career in fisheries science can create an aqua culturist, farm managers, exporters, traders, breeders and modern fishermen's, etc. The main objective of fisheries science is to make available the much needed technically competent extension personnel for transfer of technology. It helps a person to assist the research and development; to develop and execute fisheries development plan.

Economic Importance of Fish

1. Fish as Food: The fish flesh is an excellent source of protein, has very little fat, carries a number of minerals and vitamins A and D, and is rich in iodine.
2. Employment Generation: Fisheries sector creates enormous employment directly or indirectly. About 14 million people in India are engaged in fisheries sector. Beside this, fisheries plays very vital role in socio economic upliftment of women.
3. Fish for Controlling Diseases: Diseases like malaria, yellow fever, and other dreadful diseases that are spread through mosquitoes can be controlled. Larvivorous fish eat mosquitoes.
4. Scientific Value: Some fish, like the lungfish, are of zoological importance because of their discontinuous distribution and anatomical features. E.g. Lung fishes found in Africa, America and Australia.
5. Aesthetic Value: A large number of fish are cultured in aquariums for their beauty and graceful movements. The important aquarium fish are Gold fish, Angel fish, Neon tetra, Guppy, Molley, etc.
6. Fishery By-products:

   a. Fish oil: It is extracted from the liver of the sharks, sawfishes, etc.
   b. Isinglass: It is high-grade collagen produced from the air bladder or swim bladder of certain fishes like catfishes & carps. The isinglass prepared in Russia is of the best quality.
   c. Fish oil: Dry oil is obtained from Salmon & Herring. Semi-dry oil from carps. Liver oil contains vitamin A,D,E.
   d. Fish meal: It is prepared from wastes of fish oil. The Waste of the cod industry is called “Whitefish meal”.
   e. Fish meal contains Calcium 5.36%,5.36%, phospholipids 3.42%,3.42%, and iodine. For younger animals, it has proved to be a good nutritious diet.
   f. Fish Protein: Used in the preparation of ice cream, pharmaceuticals, paints, varnishes, textile, paper, and cosmetics.
   g. Fish Flour: It is a highly nutritious food prepared by solvent extraction process easily digested by infants of 3–43–4 months.
   h. Fish Skin: The skin of some fishes like sharks and rays are used for covering card cases, jewel boxes, scab boards, etc. The skin of cod salmon and other fishes is also tanned and converted into leather.

2) Classification of fishes (Berg, 1940) up to class level

Phylum: Chordata :

- Notochord present
- Bilateral symmetry
- Perforated pharynx
- A hollow tubular nerve chord
- Heart ventral to gut
- Tail is present

Acraniata (Protocraniata)
- No cranium (brainbox)

Craniata (Vertebrata)
- Cranium present
- Notochord is replaced by vertebral coloumn
- Few gill slits found in larvae and adult fishes
- Dorsal tubular nerve chord

Craniata

Agnatha
- Without jaw
- Single nostril (external)

Gnathostomata
- With jaw and teeth
- Two external nostril

Class

Ostracodermii
- Armoured fishes

e.g. *Cephalaspis* (extinct)

Cyclostomata (Hag fish)
- Circular suctorial mouth
- 5-16 pairs of gill slits
- Skeleton cartilaginous

e.g. *Petromyzon, Myxine* (Lamprey)

Gnathostomata

Super classess

Tetrapoda
- Two pairs of pentadactyle limbs

e.g. Amphibian, Reptiles, Aves, Mammals

Pisces
- Primarily aquatic
- Paired fins for locomotion
- Gills for respiration, upto 7 pairs
- With or without scales

Classes

1. **Elasmobranchii**
- Cartilaginous endoskeleton
- 5-7 pairs of gill arches opening seperately
- Without operculum
- Placoid scales
- Cloaca
- Claspers
- Tail heterocercal
- Exclusively marine

2. **Holocephali**
- 4 pairs of gill slits
- Without operculum
- No cloaca

e.g. *Chimaera*

3. **Dipnoi**
- Lungfishes
- Single gill slit
- Air bladder/lungs

4. **Teleostomi**
- Bony endoskeleton
- 4 pairs of gill arches covered by operculum
- Cycloid and ctenoid scales
- Tail mostly homocercal
- Freshwater, brackish as well as marine water species

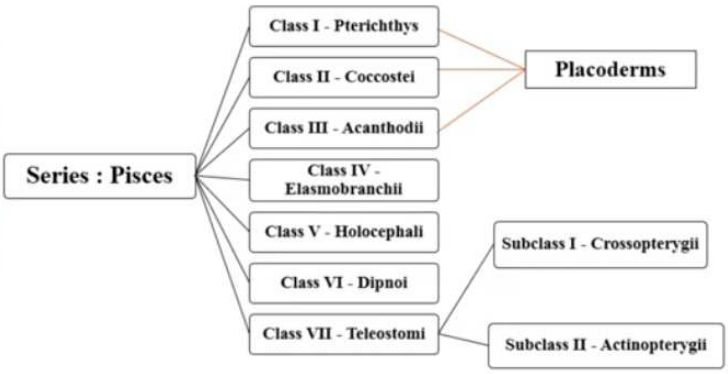
Teleostomi

sub classes,

1. Crossopterygii, 2.Dipneusti, 3. Brachiopterygii, 4. Actinopterygii (modern bony fishes)

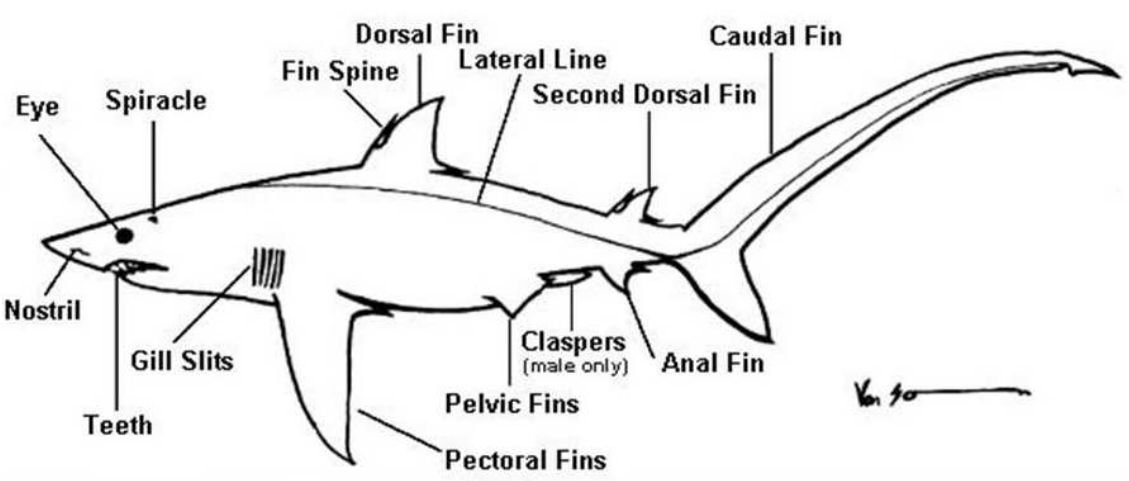
Berg Classification (1940):

Berg (1940) included all the living and the fossils fishes within a series – PISCES and subdivided the series into seven major classes.



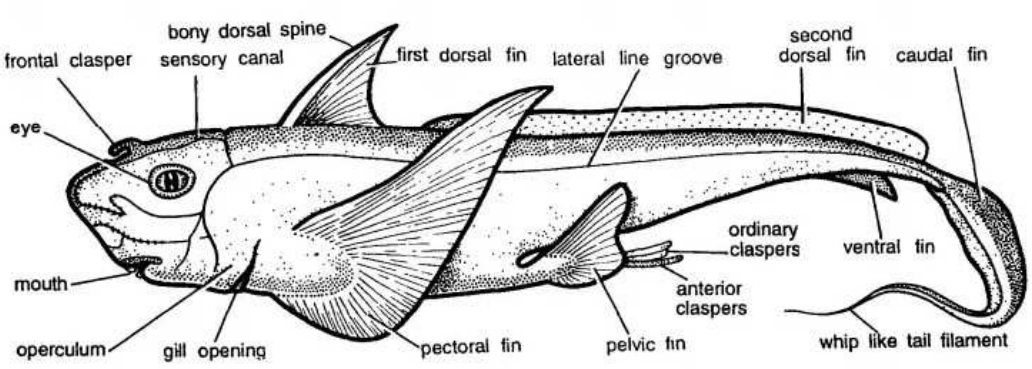
3) General characters of class Elasmobranchii

1. Endoskeleton is cartilaginous.
2. Exoskeleton is in the form of dermal denticles or placoid scales.
3. Five to seven pairs of gill slits are present.
4. Operculumn is absent so that gill slits open directly to the exterior.
5. Tail is heterocercal.
6. Air bladder is absent.
7. Male posses pair of claspers.
8. Cloaca is generally present.
9. Mouth generally inferior.
10. Fertilization is internal.
11. Mostly viviparous.
12. Exclusively found in marine water.
13. E.g. Sharks, Skates, Rays, etc.



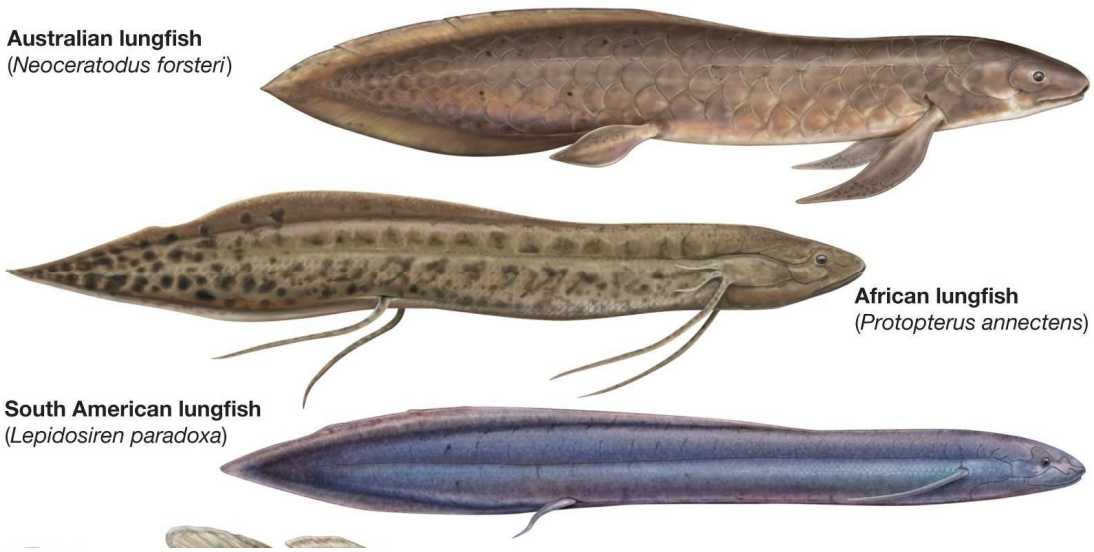
4) General characters of class Holocephali

1. Popularly known as 'Rat fish'.
2. Endoskeleton is cartilaginous.
3. Skin is smooth, silvery and placoid scales occur in patches.
4. Single external gill aperture.
5. Two dorsal and a ventral fin are present. The second dorsal fin is fairly ong in *Chimaera*. Pectoral fin fins are relatively large fan like and pelvic fins are smaller in size.
6. Tail is heterocercal, but in *Chimaera* it is diphycercal and in the form of whip-like structure.
7. A frontal clasper is present on the head of male *Chimaera* along with a pair of claspers at the base of pelvic fin.
8. A lateral line system is well developed. It is in the form of a groove in *Chimaera.*
9. Exclusively found in marine water found below 80 m depth.
10. Mouth generally inferior.
11. Fertilization is internal.
12. Mostly viviparous.
13. E.g. Rat fish - *Chimaera*



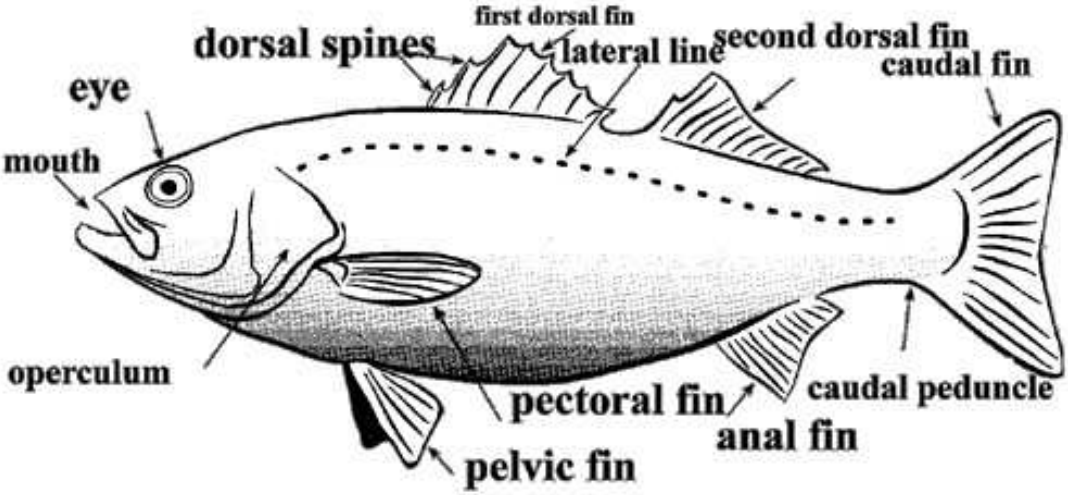
5) General characters of class Dipnoi

1. Popularly known as ‘Lung fishes’.
2. Body is covered with overlapping cycloid scales.
3. Lung fishes are unique in possessing both aquatic and aerial respiratory organ. Gills are present for aquatic respiration and lungs for aerial respiration.
4. Air bladder is modified as lung for aerial respiration.
5. During summer when water dries up the fish undergoes aestivation (summer slip), moving deeper waters parts and form a ‘cocoon’ made up of clay and mucus. During aestivation fish uses stored fat from the body.
6. Lung fishes show discontinuous distribution. i. e. Australian lung fish found in Australia, African lung fish found in Africa and South American lung fish found in South America.
7. E.g. Lung fishes



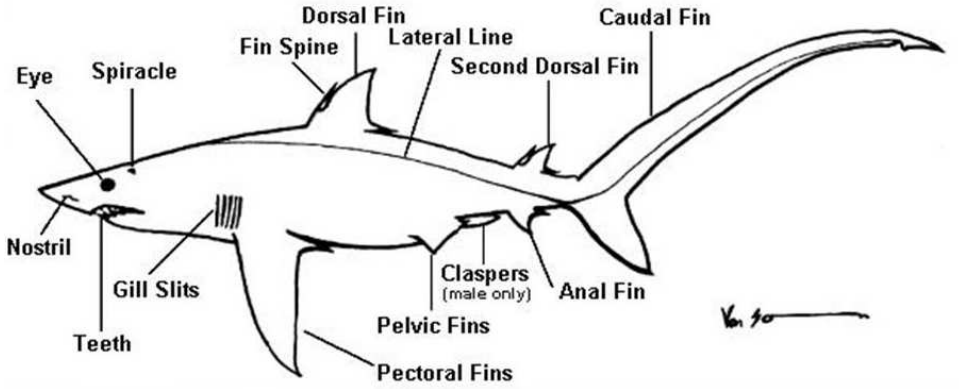
6) General characters of class Teleostomi

1. Endoskeleton is bony.
2. Exoskeleton is in the form cycloid scales.
3. Four pairs of gill slits are present.
4. Operculumn is present.
5. Tail is homocercal.
6. Air bladder is present.
7. Claspers and cloaca is absent.
8. Mouth generally terminal, sub-terminal.
9. Fertilization is external.
10. Mostly oviparous.
11. Found in marine, brackish and fresh water.
12. E.g. Catla, Rohu, Gold fish, Catfish, etc.

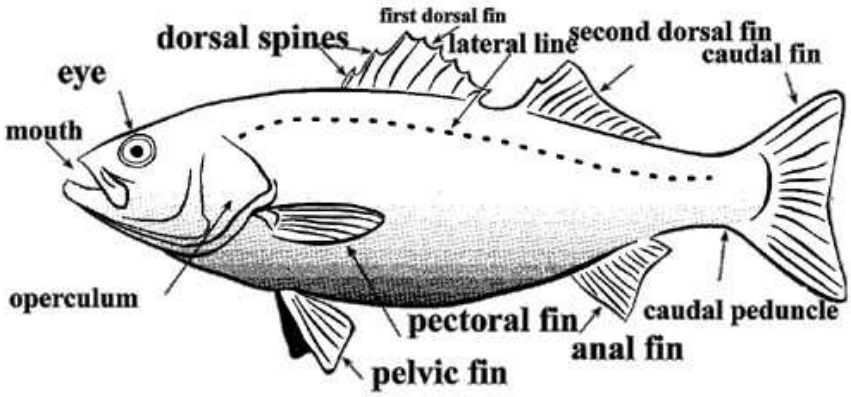


7) Difference between Elasmobranchii and Teleostomi fishes

Character	Elasmobranchii	Teleostomi
Common name	Cartilagenous Chondrichthyes	Bony Osteichthyes
Endoskeleton	Cartilagenous	Bony
Type of Scales	Placoid	Cycloid and Ctenoid
Fertilization	Internal	External
Type of reproduction	Mostly Viviparous	Mostly Oviparous
Tail	Heterocercal	Homocercal
Number of gills	5-7 pairs of gill slits	4 pairs of gills
Operculum	Absent	Present
Clasper in male	Present	Absent
Cloaca in female	Present	Absent
Air Bladder	Absent	Present
Habitat	Exclusively marine	Found in Marine, brackish and freshwater
Mouth shape	Mostly Inferior	Mostly terminal, sub-terminal
Example	Sharks, Skates, Rays, etc.	Catla, Rohu, Gold fish, Catfish



Elasmobranchii



Teleostomi

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13. E.g. Sharks, Skates, Rays, etc.

General characters of class Teleostomi

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2. Exoskeleton is in the form cycloid scales.
3. Four pairs of gill slits are present.
4. Operculumn is present.
5. Tail is homocercal.
6. Air bladder is present.
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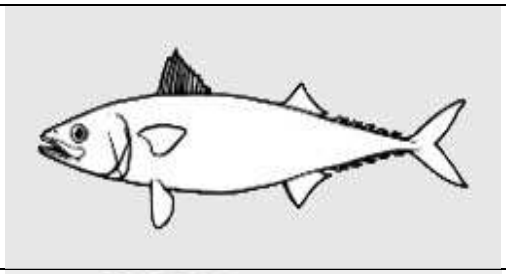
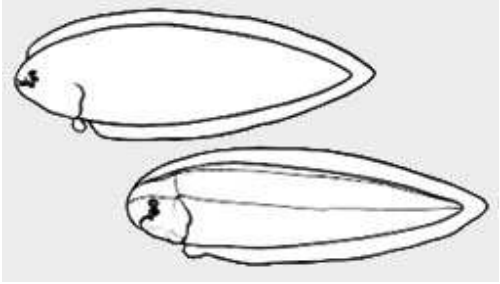
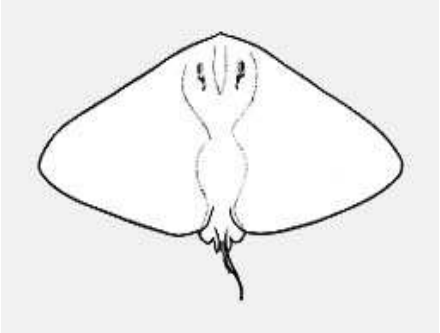
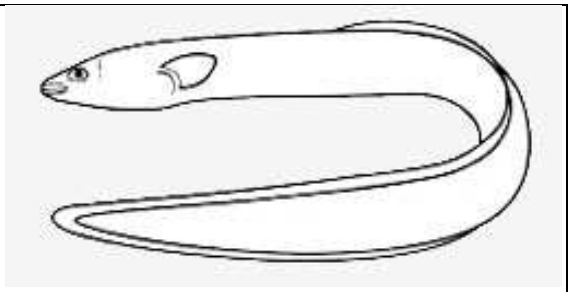
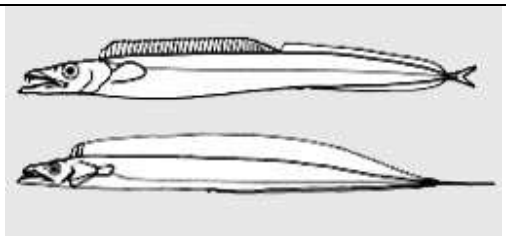
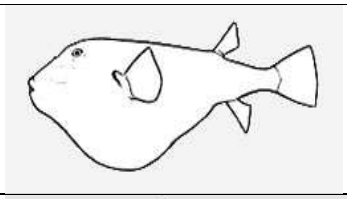
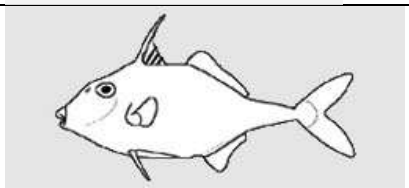
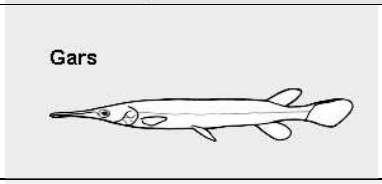
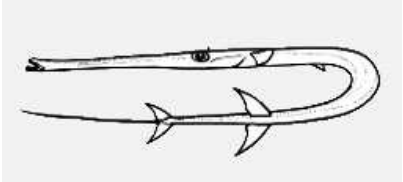
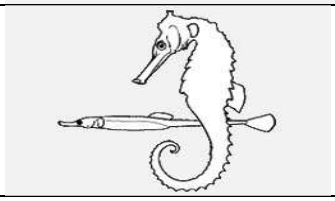
11. Found in marine, brackish and fresh water.
12. E.g. Catla, Rohu, Gold fish, Catfish, etc.

UNIT II

7) Body forms in fishes

The body form of a fish can give a quick assessment of the fish's way of life. In the diagram the different body shapes and forms are described. Different shapes allow some fish to be fast or slow, bottom dwellers or live in the pelagic zone, and others to survive the extremes of the ocean.

Sl. No.	Type	Characteristics	Example	Figure
1.	Streamlined / Fusiform	Pointed at both ends shaped like a plane fuselage; Fast swimming; open water fishes	Tuna, Mackerel	
2.	Compressiform	Body laterally compressed; not constantly moving. This shape is highly versatile	Flatfish; Filefish; Pomfret	 Flat fish
3.	Depressiform	Body dorsoventrally depressed allowing the fish to rest on the bottom and hide either using camouflage; Flight like swimming or by covering itself with a layer of sand.	Ray; Skate	

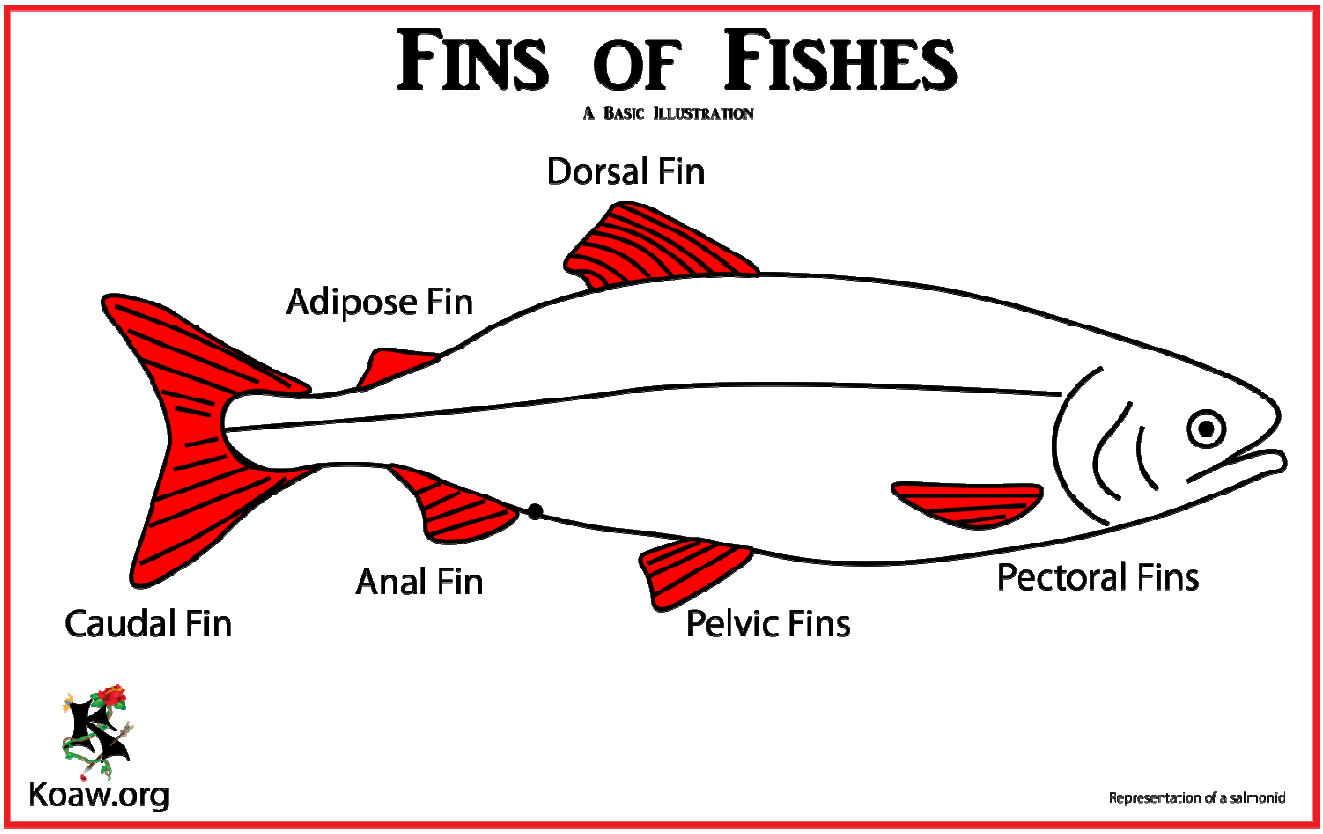
4.	Anguilliform	Body snake like or eel like; generally lack pelvic fins; dorsal, anal and caudal often confluent. It allows a fish to enter and hide in very narrow openings,	Eel	
5.	Ribbonform / Taeniform	Body elongate; ribbon like; dorsal, anal and caudal often confluent. This shape is good for hiding in cracks and crevices,	Ribbon fish	
6.	Globiform (combination of shapes)	Body globe like, round; live in deep or bottom water	Puffer fish	
7.	Box type (combination of shapes)	Body box type; mouth small; slow moving	Tripod fish; Box fish	
8.	Sagittiform (Arrow like)	Body elongate and arrow like;	Gars Pikes	
9.	Filiform	Body thin and elongate and thread like.	Snipe eel	
10.	Combination of shapes	Coiled tail; head bent downward,	Sea horse	

8) Different types of fins and their functions

Fins are one of the most distinguishing features of a fish and they have several different forms. Two types of fins are found in most of the fish: median and paired fins. Median fins are single in number which runs down the mid-line of the body. In fishes, median fins are dorsal, caudal and anal fins while paired fins are pectoral and pelvic which are arranged in pairs homologous to human arms and legs. Fins help to swim and maintain the balance of the body. Fins also help to identify the fish species. Different types of median and paired fins are described below:

Paired Fins: Pectoral fin & Pelvic Fin

Median Fins: Dorsal fin, anal fin and caudal fin



Pelvic Fin

In fishes, a pair of pelvic fins are present which are located ventrally below and behind the pectoral fins. In some fishes, they are situated in front of the pectoral fins (Cod family). This type of fin helps in stability and slowing down the fish. Generally, fish use pelvic fins for moving upwards and downwards in the water.

Pectoral Fin

Pectoral fins are located on both sides usually just behind the operculum. It is homologous to the tetrapod`s forelimbs. It provides supports during swimming. It creates dynamic lifting force and also helps the fish to turn left or right.

Dorsal Fin

This type of fin is located on the top or back of the fish which help the fish in quick turns or stops. It also helps the fish against rolling. In fish, there are three distinct dorsal fins such as proximal, central or middle, and distal dorsal fins. Some fish have two dorsal fins where the central and distal fins are combined together.

Adipose Fin

They are soft fins and located between the dorsal and caudal fins, usually very near to the caudal fin. It is mainly found in catfishes. This type of fin help to navigate the fish in rough water.

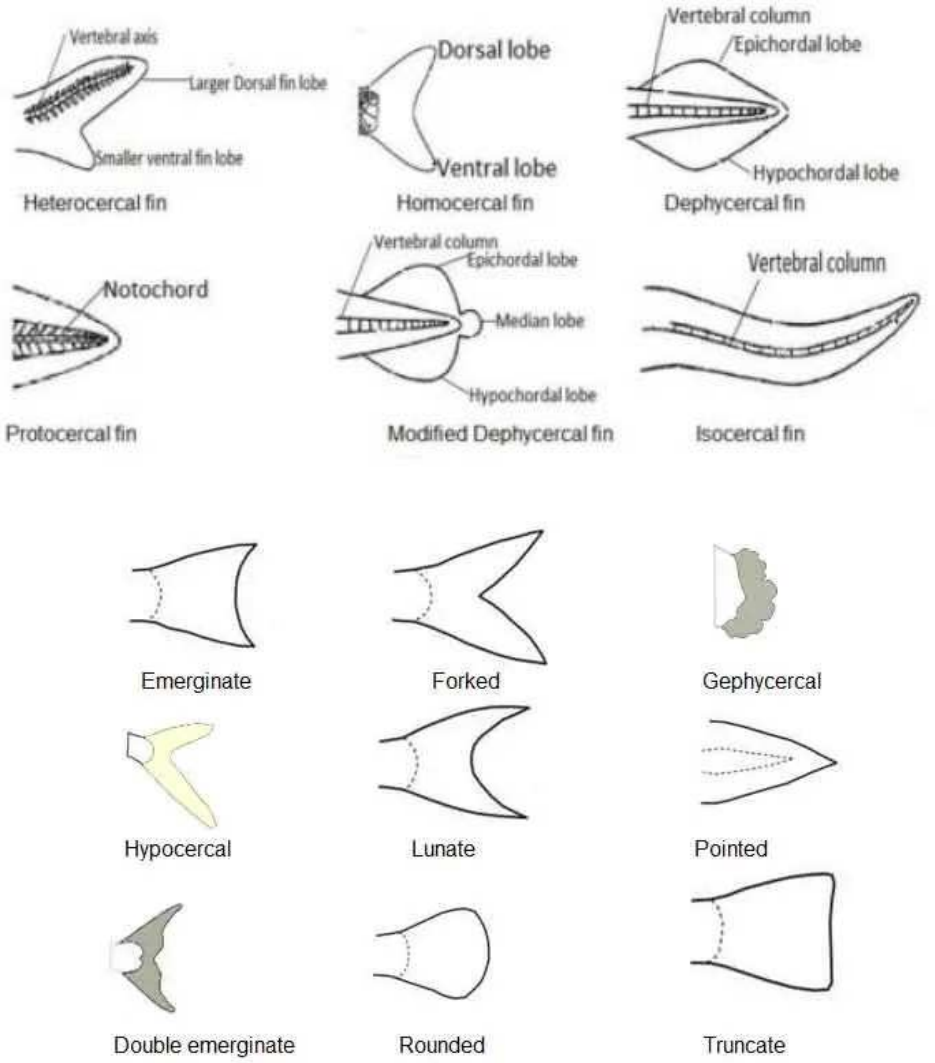
Anal Fin

The Anal fin is also known as cloacal fin which is located on the ventral side just behind the anus. It supports the dorsal fin and stabilizes the fish during swimming and contrinols the rolling motion.

Caudal Fin

The caudal fin is the primary appendage which is used for locomotion in many fishes. The caudal fin is also known as tail fin or a median fin which is usually homocercal or heterocercal. Generally, it is a vertically expanded structure which is located at the caudal end of the body. The base of the caudal fin is known as caudal peduncle with strong swimming muscles. In general, caudal fin acts like a propeller while the caudal peduncle functions as a motor.

The caudal fin has two lobes such as dorsal epichordal and ventral hypochordal lobe which are supported by the modified last three caudal vertebrae. The shape of the caudal fin may vary in different species from rounded to pointed, notched, emarginated, truncated, etc. It is used to identify the fish species. Generally, fish use it for forwarding propulsion and speed. The caudal fin of the adult fishes may be grouped into three categories:

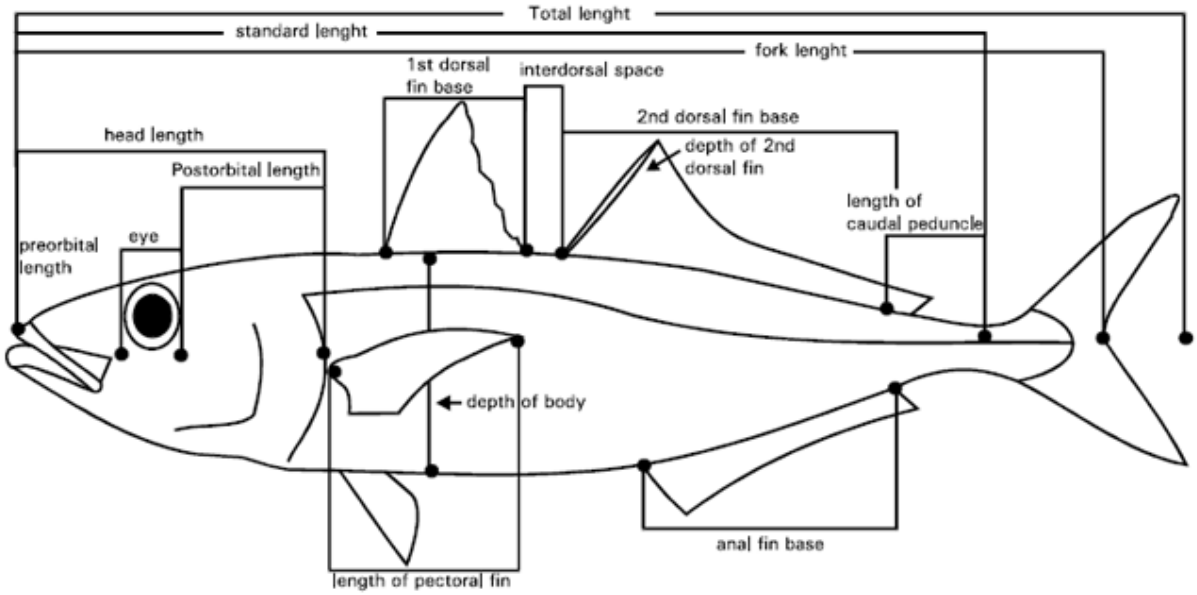

Vertebral axis
Larger Dorsal fin lobe
Smaller ventral fin lobe
Heterocercal fin
Dorsal lobe
Ventral lobe
Homocercal fin
Vertebral column
Epichordal lobe
Hypochordal lobe
Dephycercal fin
Notochord
Protocercal fin
Vertebral column
Epichordal lobe
Median lobe
Hypochordal lobe
Modified Dephycercal fin
Vertebral column
Isocercal fin
Emerginate
Forked
Gephycercal
Hypocercal
Lunate
Pointed
Double emerginate
Rounded
Truncate

9) Fish identification techniques

i. **Study of morphometric characters in fishes**
ii. **Study of meristic characters in fishes**
iii. **Study of descriptive characters in fishes**

i) Study of morphometric characters in fishes

Total length	Length of the fish from anterior most tip of the snout to the posterior-most tip of the longest lobe of the caudal fin
Fork length	Length from the tip of the snout to the bifurcation of caudal fin
Standard length	Length from the tip of the snout to the posterior end of the last vertebrae
Head length	Length from the tip of the snout to the posterior most margin of the operculum
Pre-orbital length	Length from the tip of the snout to the anterior most margin of the eye orbit
Post-orbital length	Length from the posterior most margin of eye orbit to the posterior most part of the operculum
Eye diameter	Diameter of the eye orbit along the body axis
Inter-orbital length	Distance between the two dorsal most orbits of the eye
Pre-dorsal length	Length from the tip of snout to the origin of the dorsal fin
Pre-pectoral length	Length from the tip of snout to the origin of pectoral fin
Pre-pelvic length	Length from the tip of snout to the origin of pelvic fin
Pre-anal fin length	Length from the tip of snout to the origin of anal fin
Pre-anal length	Length from the tip of snout to the anal pore
Dorsal fin base length	Length of the dorsal fin from the origin of the fin to the insertion point of the fin
Height of dorsal fin	Length from the base of origin of dorsal fin to the tip of the longest fin ray
Inter dorsal space	Distance between insertion point of 1st dorsal fin and origin of 2nd dorsal fin
Pectoral fin length	Length from the origin of the pectoral fin to the posterior most tip of the fin
Anal fin length	Length from the origin of 1st anal fin ray to the origin of the last anal fin ray
Caudal fin length	Length from the origin of the caudal fin to the posterior most part of the caudal fin (total length- standard length)
Body depth	Maximum width of the body (deepest part of the body)
Caudal peduncle depth	Minimum vertical distance across the caudal peduncle



ii) Study of meristic characters in fishes

Meristic characters which are countable have been widely used in studies of fish population and species. Unlike the body proportions or colouration, meristic characters are fixed usually at or before metamorphosis and remain constant throughout the life of an individual. All the meristic characters should be treated separately and the frequency distribution of meristic characters must be given so as to find out any variation between species or between population of a species. The following abbreviations are used in fins, scales and gill rakers of a teleost:

D – Dorsal fin A – Anal fin P 1 – Pectoral fin P 2 or V 2 – Ventral fin C – Caudal fin L1 – Lateral line scales Ltr – Lateral transverse row of scales O – Adipose dorsal fin Gr – Gill rakers

Dorsal fin count and anal fin count includes spines and rays. Among two dorsals one spinous and other ray type, then the formula may be given as D1 and DII where, DI stands for spinous first dorsal and DII stands for rays of second dorsal fin. If 3 spines and 7 branched rays are present in a single dorsal fin, then the formula may be given as DIII, 7.

The anal fin count includes spines and rays. If two spines and 5 rays are present, the formula may be given as AII, 5. Pectoral fin count can be made on the left side. However, counts can be made on both sides in a few number of specimens to permit estimation of bilateral variations. Pelvic fin count includes both spines and rays if present.

Fin count formula is given as below:

D1, I, VII-VIII - This denotes first dorsal fin with one spine separated from the rest of spines (VII-VIII).

D2, I, 15-16 - This denotes second dorsal fin with one spine followed by 15-16 rays.

AII, I, 10-15 - This denotes anal fin with two spines separated from one spine followed by 10-15 rays.

Gill raker counts are for lateral gill rakers on the first arch, normally on the left side. The raker at the junction of the upper and lower limbs (epibranchial and ceratobranchial) is included in the lower limb count as the major part of the base of the raker is over the ceratobranchial. Rudimentary gill rakers, with the base width (lateral) of the raker equal to, or less than the raker length, occur at the anterior ends of the upper and lower limbs and these are included in the counts, though differentiated as ii, 7+19, iv=32.

Laterial line scales (L1) are scales along the lateral line from its origin to its posterior most part of the lateral line. In some teleostean fishes as in clupeids lateral line is absent. In such case scales will be counted along the row where the lateral line normally would have been present.

Predorsal scales are scales on the midline in front of the dorsal fin origin. These scales are counted as the scale rows which intersect the midline from the anterior point of the dorsal fin to the orbit.

Scales above and below the lateral line (Ltr) – A transverse series below of scale rows; below the lateral line scales are counted from the origin of the anal fin, not including the median ventral scale row, along a forward diagonal to the lateral line; above lateral line scales are counted from the origin of the dorsal fin, not including the median dorsal scale row, on a diagonal backward to the lateral line; the lateral line row is not included in these counts.

iii) Study of descriptive characters in fishes

Descriptive characters of fish refer to the qualitative traits or features used to describe the physical appearance, coloration, body shape, and other observable characteristics of fish species. These traits provide important information for species identification, taxonomy, and ecological studies. Descriptive characters can include details about the shape of the body, presence or absence of certain fins, colors patterns, scales, and other distinctive features

10) Locomotion in fishes: Types of locomotion, special mode of locomotion, locomotion due to the movement of appendages

Fishes do locomotion in many forms like Jumping, Flying, Climbing, swimming, walking, etc. Fins are known as the primary organ of locomotion. There are five types of fins commonly found in fishes – (1) Dorsal fin (2) Pectoral fin (3) Pelvic fin (4) Anal fin & (5) Caudal fin. Apart from fins muscles fibers and gills play important role in locomotion.

Types of locomotion

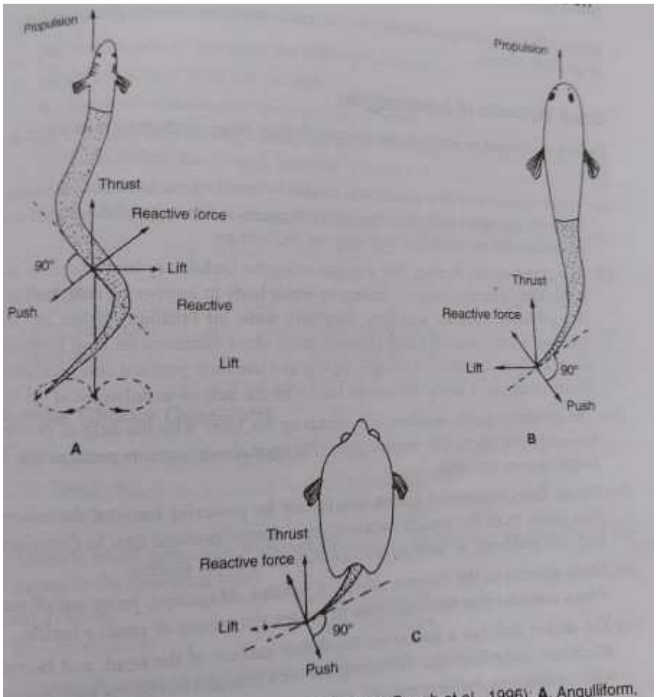
There are mainly three types of locomotion –

1. Anguilliform locomotion
2. Ostraciform locomotion
3. Carangiform locomotion

(1) Anguilliform locomotion – this is also known as eel-like locomotion because This type of locomotion mostly ell like fishes. This type of locomotion is the result of alternative contraction and relaxation of myomeres. Propulsive force is generated by most of the body.

(2) Ostraciform locomotion – This kind of locomotion is found in trunk-like fishes and this kind of locomotion is also known as wig-wag motion. The alternative contraction and expansion of myomere muscles take place in the locomotion of fish. The propulsive force is generated by only caudal or tail region.

(3) Carangiform locomotion – this type of locomotion is found in Jaw-like fishes. The contraction and expansion of myomere muscle take place on this process and propulsive force is genereted by posterior half of the body.



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

and move forward by

Locomotion due to contraction and expansion of myomere muscles

Alternative contraction and expansion creates a type of wave which helps the fish to go forward or in general term these alternative contraction and expansion helps the fish in locomotion. In the initial of this process, One side of myomere muscles contract and form a curve in the direction of the contraction and the opposite muscles expanses. In the next step the muscles which were expanded, contacts and contracted muscles expanses. This process is all about alternative contraction and expansion of myomere muscle on each side of body. In the result of contraction and expansion of myomere continuously waves are formed in backward direction and fish moves forward. This type of locomotion is known as Anguilliform locomotion and generally found in eels.

Locomotion due to fins

Fins are known as one of the most important in locomotion. Fishes have different types of fins like – Dorsal fin, Pectoral fin, Pelvic fin, anal fin and caudal fin. These fins help in locomotion of fish. Every fin play different role in locomotion like balancing the body, forward thrust, going deeper or upper in the water. These movements are controlled by different fins.

The role of fins and two type of motions (1) rolling or yawing and (2) pitching movement. Here yawing movement mean left and right turn during swimming and pitching movement mean diving and rising movement. The caudal fin gives forward thrust to fish and fish move forward but some time it produces negetive pitching effect cause diving head to caunter balance this paired fins are used. In the use of all fins fish can move and don't face balancing problem. The role of pelvic fins are less because of backward positioning.

Acting forces on fishes

(1) Gravity – gravitation force work on all living and non organism on earth. Gravitation force attract the fish toward the earth.

(2) Upliftment – the fins are used to uplift the fish in opposite of gravitational force so fish can swim on water.

(3) Yawing/Rolling – some fishes body are flat or roll, if we put this kind of any object on water which doesn't use etra force then object will roll on water. Same force also work on fish but fins counterbalance this force.

(4) Pitching – pitching mean diving deep and rising or going up in water. This force is mainly generated by caudal fin and muscle fibers.

(5)Forward thrust – caudal fin gives forward thrust force.

Form of locomotion in fishes

(1) Jumping – Some fishes jump to capture prey and run away from predators. This is common type of locomotion in fishes. They use their caudal fin to jump from water. Eg – Mullet Fish.

(2) Flying – fishes don't fly like birds but some fishes can glide on air for few seconds or minutes. For gliding their fins are specially adapted. Their pectoral fin works like a parachute. Eg – exocoetus and Dachylopterus.

(3) Climbing – some fishes can climb on trees or in surface. They use their opercular spines to climb on trees. Eg – Climbing Perch.

(4) Walking – in this type of locomotion pectoral fin is modified into 3-4 finger like rays which is used to walk as insects. Eg – Cephalocanthus.
(5) Crawling – Some fishes crawl at the surface of bottom sea. Their pectoral fins are modified for this type of locomotion. Eg – Lophius.
(6) Tetrapod like walking – some fishes move slowly like mud puppy or salamander. They look like walking like tetrapod. Eg – Neoceratodus.
(7) Burrowing – fishes burrow on the beach or edge of the river and pond. Eg – eel.

11) Structure and functions of skin in fishes

The integument or skin is an outermost covering or wrapping of the body, hence it is the most exposed part of the body to the environment. For this reason, it plays an important role of first line of defence in a number of ways. In fishes, the skin is well-adapted for protection from injuries and diseases. It also serves for respiration, excretion and osmoregulation.

In some fishes, special colouring devices and phosphorescent organs are present in the skin, which either conceal the organism or make it present or used for sexual recognition. In addition, some species have special structures like electric organs, mucous glands and poison glands.

Structure of Skin of Fishes:

The skin of fish is made up of two distinct layers, viz. an outermost layer, the epidermis and an inner layer dermis or corium. The epidermis originates from ectoderm and the dermis derives from mesoderm layer.

1. The Epidermis layer of skin in fishes:

It is composed of many layers of flattened and moist epithelial cells. The innermost layer is called stratum germinativum. This layer is made up of active columnar cells that continuously divide by mitotic division. The newly formed cells occupy the lowermost stratum and the older cells move outside and are worn off time to time and maintain growth. These migrating epithelial cells fill the superficial wounds.

Epidermal glands:

The epithelium of epidermis is modified into a variety of glands, which are:

(i) Mucous gland:

The epidermis is provided with a number of mucous glands, which open at the surface of the skin by minute pores. These glands are flask-shaped or tubular extending to the dermis. The mucus glands secrete slippery mucus, which contain a lipoprotein, known as mucin.

The slimy mucus reduces drag on fish while swimming in the water. Continuous secretion and sloughing of mucus wash away micro-organism and irritants, which may cause disease if accumulated. In some species (Protopterus and Lepidosiren), the mucus forms a cocoon-like structure around the body to avoid dry condition of weather, especially during aestivation. The mucus gives a characteristic fish odour.

Among some fishes, mucous is used for chemical communication. Many teleosts feed their young ones on the mucus, secreted in large quantity on the surface of the body. Some species like Macropodus and Gasterosteus use their sticky mucus for preparation of nest for laying eggs.

The mucus also helps in regulating to some extent, the osmotic exchange of water and ions between the body-fluids and the water. The number and size of mucus gland cells vary with species. Generally, fishes with no scales, have large numbers of mucus cells.

(ii) Poison glands:

Venom or poison glands have evolved in different families of fishes. Glandular cells of epidermis are modified into poison glands. These glands secrete poisonous substance to protect themselves from the enemy for defence.

They are also used for offence as well. The poison glands are generally present at the base of certain structures like sting, spine of dorsal fin and tooth. Poison glands open at the tip of these structures to inject poison by penetration into the prey.

The most common example is the stingray, which is provided with venomous caudal sting. Similarly, Chimaeras possess venom glands in spine of the dorsal fin. The poison glands are present in the grooves of spines of dorsal, pelvic and anal fins of the Scorpion fish (Scorpionidae). In Sturgeon fish (Acanthuridae), the poison glands are found at each side of the caudal peduncle.

(iii) Photophores:

In many marine species of fish, special multicellular glands are developed from stratum germinativum of epidermis. These glands are deeply seated into dermis and produce light. These

light producing luminous organs are mostly found in deep-sea elasmobranches and in some teleosts inhabiting total darkness in sea.

Each gland has an apex consisting of mucus cells that helps to magnify light, produced from the basal glandular part of the gland.

2. The Dermis layer of skin in fishes:

The dermis lies beneath the epidermis (Fig. 3.2). This layer contains blood vessels, nerves, connective tissues and sense organs. The upper layer of dermis is made of loose connective tissues and is known as stratum spongiosum, while the lower part is occupied by thick and dense connective tissues, called the stratum compactum.

This layer generally has proteinaceous collagen fibres and mesenchymal cells. The dermis is well supplied by blood vessels, hence it also provides nourishment to the epidermis.

Functions of Skin

- It support and protect soft tissues against abrasion, microbes. Mucous glands secrete copious mucous which forms a thick slimy layer all over the body and protect it from parasite, fungi and bacteria.
- The mucous lubricates the body of fish so as to reduce the friction in water enabling the fish to swim with greater speed.
- The mucous helps in repair and healing of the wounds of fish.
- Some fishes like Betta, Gasterosteus and Macropodus use their mucous for preparing the nest.
- Integument receives the external stimuli like, heat, cold, chemical change in water quality etc.
- It helps the fish to regulate the exchange of water and ions between the body fluids and external medium.
- It helps in heat regulation.
- It helps in cutaneous respiration. In some fishes like Anguilla and Periopthalamus, integument acts as an accessory respiratory organ. In these fishes the dermis becomes highly vascular.
- Scales, plates, spines etc. are the derivatives of integument and protect the body of fish.
- Poison gland of scorpion fish and toad fish are the modification of mucous gland and are useful organ of offence and defence.

12) Study of different types of scales

There are few type of scales based on their structure and shape. The different types of scales are often characteristics of the species. On the basis of scales' origin they are of two types:

(i) Plate like or **placoid scales**, which develop from epidermis and dermis and commonly found in Elasmobranches.

(ii) **Non-placoid scales**, which develop from the dermis. These scales are following deifferent types: a) Cycloid scales (found in carps) b) Ctenoid scales (found in perches) c) Ganoid scales, common among gars and sturgeons d) Cosmoid Scales (Found in fossil some fishes).

Placoid scales

Placoid scales are present in sharks and other Elasmobranches. They are small dermal denticles that remain embedded in the skin. The placoid scales do not overlap each other and are closely arranged in the skin. Like the teeth of vertebrates, they are partly dermal and partly epidermal in origin and resemble teeth in basic structure.

Each scale consists of two parts: (i) an upper part, known as ectodermal cap or spine. Outer most covering of the spine is made of enamel, like substance, known as vitrodentine, it is hard and transparent, similar to human tooth. The inner layer is the dentine that encloses a pulp cavity follows the vitreodentine. (ii) The lower part of placoid scale is a disc-like basal plate, which is embedded in dermis with cap or spine projecting out through epidermis. The basal plate has a small aperture through which blood vessels and nerves enter into pulp cavity.

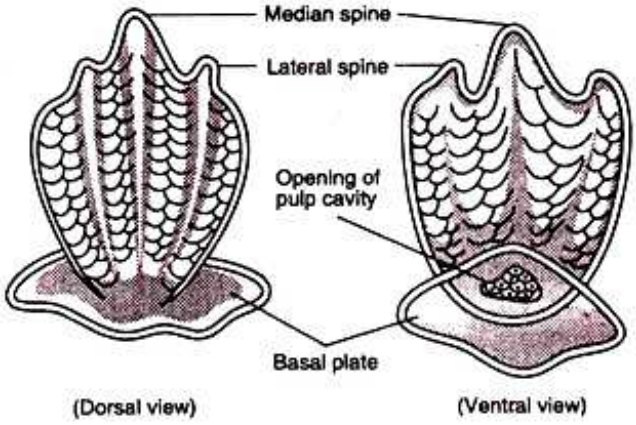


Fig. 3.3(a) : Placoid

Cylcoid Scales

The cycloid scales are thin, flexible, transluscent plates, rather circular in outline, thicker in the centre and marked with several concentric lines of growth which can be used for determining the age of the fish. They are found in a large number of teleostean fishes having soft

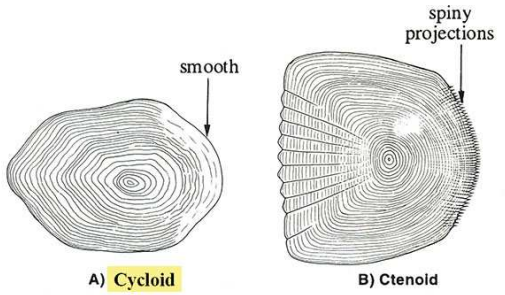
rayed fins, such as Labeo, Catla, Barbus, Cirrhina, etc. The central part of the scale is called the focus and is the first part to develop. In many species, oblique grooves or radii run from the focus towards the margin of the scale.

They form a protective covering over the skin and project diagonally in an imbricating pattern. The part of the scale which is exposed to view in situ condition (posterior area) generally shows less distinct ridges or circuli and chromatophores are also sometimes attached to it. The anterior area lies embedded in the skin.

Ctenoid Scales

The ctenoid scales are also circular and can be distinguished from the cycloid scales by having a more or less serrated free edge. Moreover, several spines are present on the surface of the posterior area of the scale. These scales are characteristic of modem higher teleosteans such as perch, sunfish, etc.

They are more firmly attached and their exposed free hind parts which are not overlapped, bear numerous small comb-like teeth or spines. Intermediate types between cycloid and ctenoid scales are also found on different parts of the body. Certain fishes, such as flounders, may bear both types, ctenoid scales dorsally and cycloid scales ventrally.



Uses of Scales

1. Scales play very important role in the identification and classification of fish.

2. Scales are used in calculating the age of fishes and rate of their growth. The age of fish could be determined by measuring space in annual rings of the scales.

3. In some species like Atlantic Salmon, the scales exhibit the presence of spawning marks on them. These marks indicate how many times the fish has spawned and the time of first spawning also.

4. Scales provide important information about extinct fishes and are useful in identifying food habits of piscivorous animals.

Unit III: Ecological adaptation in fishes

1) Migration in fishes - general account of migration, types of migration, advantages of migration, factors influencing migration

General account of migration

In ecology, migration is an animal behaviour of mass movement of animals from one place to another. The purposes for migration varies accordingly with the types of animals. Migratory behaviour of fish is a regular phenomenon. Their journey is purposed mainly for feeding and reproduction.

Generally fishes restrict their movements within small territorial limits and do not go out of their home ranges. However, a few species travel long distances moving from place to place in search of food or for breeding. This movement of a large number of fishes for the purpose of feeding or spawning is known as migration. It may take place in vertical direction, as from the deeper to the surface water, or it may be in horizontal direction, either upstream or downstream.

Causes of Migration

Feeding or alimental migration: This kind of migration takes place in fishes for feeding. In high populations fishes use up the food resources quickly in a given particular area and therefore they must migrate constantly in search of new food resources for the population. This type of migration is called as feeding migration or alimental migration. The best examples of feeding migration are Salmons, cods and sword fish. These fishes constantly migrate from one place to another in the sea in search of food source.

Gametic or Spawning migration: Spawning migration takes place in breeding season in fishes which have spawning places far away from feeding places. The best examples of spawning migration are eels and salmons. Also a large number of riverine fishes spawn in tributaries of river in hills.

Climatic or Seasonal migration: This kind of migration takes place in fishes that inhabit arctic areas where in summer climate is favorable and food abundant but as winter approaches temperatures fall below zero and food becomes scarce. So these fishes must migrate towards subtropical and tropical areas to escape extremes of weather and food scarce conditions.

Osmoregulatory migration: This kind of migration takes place fishes for maintaining the salt-water balance when the salinity of water changes especially during rainy seasons.

Types of migration

The migration of some fishes is a regular journey and is truly an innate animal behaviour. Fish migration are classified into following types:

1. Diadromous migration:

- it is the migration of fish between sea and fresh water.
- As we know, most of the fishes are restricted to either fresh water or sea water. Changes in habitat may causes osmotic imbalance in those fishes. However some fishes regularly migrate between sea and fresh water and have perfect osmotic balance, they are the true migratory fish.

- This migration is of two types-

a. Anadromous migration:

- It is the migration of marine fishes from sea to fresh water for spawning.
- Fishes spend most of their life living and feeding in sea.
- They only migrate during breeding season to the river for spawning ground.
- Eg. *Salmon, Hisla, Lamprey* etc.
- Salmon migrate for breeding during winter from sea to river. While migrating, some physiological changes occurs:
- – stops feeding during journey
- – changes colour from silver to dull reddish brown
- – gonads mature
- They select suitable spawning ground and make a saucer-like nest in which female lays eggs and male releases smelt over them. Juvenile larva hatched out from the egg known as Alevins. Alveins then transform into parr and metamorphosed into adult when return to the sea.

b. Catadronous migration:

- It is the migration of fresh water fishes from river to sea during breeding season for spawning. Eg. Eel (*Anguilla* spp)
- Both European eel *(Anguilla anguilla* or *Anguilla vulgaris)* and the American eel *(Anguilla rostrata)* migrate from the continental rivers to Sargasso Sea off Bermuda in south Atlantic for spawning, crossing Atlantic Ocean.
- Before and during migration some physiological changes occur in their bodies:
- – deposit large amount of fat in their bodies which serves as reserve food during the journey
- – Colour changes from yellow to metallic silvery grey.
- – Digestive tract shrinks and stops feeding
- – Eyes get enlarged and vision sharpens. Other sensory organs also become sensitive.
- – Skin serves respiratory organ.
- – Gonads get matured and enlarged.
- The lay eggs in suitable spawning ground and are fertilized by males. After spawning they die. The larva hatch out and develop into young ell and finally return to river.

2. Potamodromous migration:

- It is fresh water migration of fresh from one habitat to another for feeding or spawning.
- Eg. Carps, catfish

3. Oceanodromous migration:

- It is the migration of fish within sea in search of suitable feeding and spawning ground.
- eg. *Clupea, Thummus, Tuna*

4. Other Types

a. Latitudinal migration:

- It is the migration of fish from north to south and vice-versa.

- It is a climatic migration.
- Eg. Sward fish migrate north in spring and south in autumn.

b. Vertical migration:

- It is a daily migration of fish from deep to the surface and vice-versa for food, protection and spawning.
- Eg. Sward fish usually move vertically downward to greater depth for food.

c. Shoreward migration:

- It is the migration of fish from water to land. However it is a temporary migration.
- Eg. Eel migrate from one pond to another pond via moist meadow grass.

Advantages of migration

Migration is an adaptation towards abundance. The spawning or nursery grounds may not have enough food to maintain both the mature and immature members of a large population. Hence, it would be an advantage to have separate spawning, nursery and feeding grounds. The fact that many commercial species are migratory, supports the view that migration is an adaptation towards abundance.

Further, there appears to be some advantage to a species whose adults return to spawn in an area where the environmental conditions were similar to those under which they themselves survived when young. A return to the parent spawning ground provides a means by which these favourable conditions may be exploited. Thus, a better egg and larvae survival would lead to a greater number of spawners on a particular ground.

Fish are often dispersed widely over large areas while feeding, but congregate at specific spawning grounds to enhance reproductive success. Precise timing of spawning migration ensures simultaneous arrival of sufficient members of both the sexes at one place to ensure reproductive success of the group. Collectively following are the advantages of fish migration.

- Abundance of fish population is maintained.
- Maintaining the continuity of reproduction.
- Favorable environment is ensured.
- Ensuring embryonic development with egg protection.
- It helps to find suitable environment for breeding.
- Ensuring the safety of fish from enemies or predators.
- Ensuring adequate food supply.
- The tendency for making shoaling and schooling among the fish occurs.

Factors influencing migration

Migration is affected by physico-chemical and biotic factors. Physical factors include water depth, pressure, temperature, light intensity, currents, etc. Biotic factors, on the other hand, include sexual maturity, blood pressure, diet, memory, endocrine gland, consumers and predators.

Numerous fish migrate to the feeding ground in search of food. In summer, due to the increase in the temperature of the surface of the sea, the salmon is stimulated in the sea. As a

result, when water temperatures in the river continue to rise, then fish migrate against the water current.

The salinity of water is another important issue. Most freshwater fish cannot tolerate major changes in salinity. Therefore, their migration is confined to a limited range. So they migrate in its fresh water. On the contrary, fish like Salmo, Anguilla, Hilsa etc. are accustomed to migrate to any level of salinity.

The factors that directly or indirectly contribute to the control of fish migration are:

(A) Physical factors: The physical factors that influence the movement of fish include water temperature, light, and pressure, nature of the bottom of the water bodies, tides and currents. The depth of the water bodies, the turbidity and the penetration of light into the water also affect the movement of the fish.

(B) Chemical factors: Fish migration is affected due to excess or deficiency of various chemical substances dissolved in water. Chemical factors include water salinity, pH, various contaminants and gaseous substances (O_2, CO_2) dissolved in water. In addition, the taste and smell of the water also affects the movement to some extent.

(C) Biological factors: Fish can adapt to the aquatic environment. Fish migrate in the interest of adaptation. Notable biological factors that stimulate fish migration are blood pressure, sexual maturity, competition, search for food, secretion of endocrine glands and appetite. These biological factors interact with physical and chemical factors to stimulate the migration of fish.

2) Colouration in fishes – Source of colour, colour changes in fishes, regulation of colour changes, significance of colour changes

Majority of fishes are vividly and brightly coloured. Colouration is one of the most common phenomena found among the fishes. The enormous range of colours and patterns that produced in fishes are generally related to their habits. Normally fishes are darker on the dorsal and lighter on sides or ventral side. This gives them protection from above and below.

However, some fishes have uniform colouration as found in the gold fish, Carassius, which has brilliant colour all over the body. The bottom dwellers are often strongly and intricately coloured above and pale below. Variation in colour may be seen in a single fish. The trunk fish (Ostracion) has green body, orange tail and yellow belly with blue bands on the body.

The pipe fish, Sea horse and angler living in weeds, often exhibit colour and pattern similar to weeds. Sometimes they also develop leaf like or filamentous processes on the body. Mahasheer (Tor tor) has dark grey colour on the back with golden or reddish on sides and silver on the abdomen.

However, paired fins are yellowish or reddish. Colour differences in both sexes are quite marked in fishes. The males are generally brighter. Males of small million fish, Lebistes, are variously coloured while females are of a single colour. The variation of colours in males is due to genetic factor of Y-chromosome.

Another important feature is lack of pigment causes transparency in pelagic, free- swimming young's of many species. Similarly cave fishes living in total darkness, do not possess pigment and are colourless.

Sources of Colour:

There are two main sources of colour production in fishes. These are chromatophores or bio-chromes and iridiocytes or iridiophores.

The Chromatophores:

They are large and branched specialized cells. They are mostly present in the dermis, just beneath the epidermis or scales. They are also present around the brain and spinal cord. Chromatophores may be monochromatic, viz., and possess only one type of pigment, di or polychromatic.

Cytoplasm of chromatophores contains different pigment granules, which are responsible for colour. These are flavines (yellowish green), carotenoides (yellow, red) and melanin (black and brown). Amalgamation of different chromatophores produces a wide range of colour, thus yellow and black.

Chromatophores inter-spread among one another to produce green or brown colour. Many fishes are able to change their colour of the body because of the migration of the pigment within the chromatophore.

The pigment granules may disperse throughout the cell or aggregate in the centre to give different tone and pattern to the fish. There are four basic types of chromatophores based on colour of pigment granules present therein.

These are erythrophores (red and orange), xanthophores (yellow), Melanophores (black or brown) and leucophores (white). The red and orange pigment granules of erythrophores and yellow pigment of xanthophores mainly consists of carotenoids.

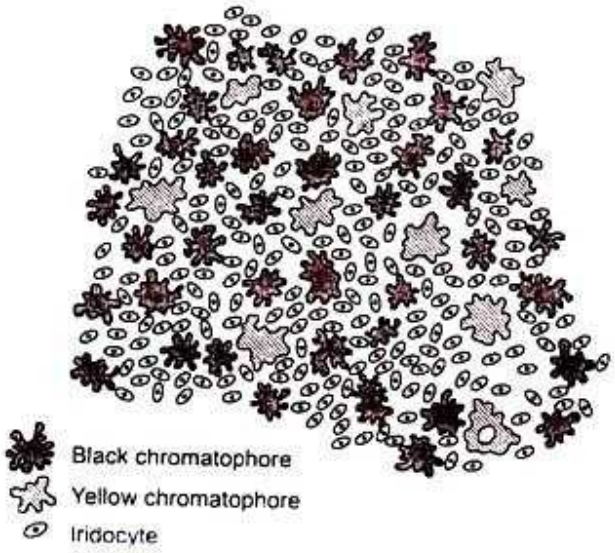


Fig. 16.1 : Coloration elements in the skin of the upper side of a flounder *(Platichthys)* (After Norman)

Fish obtain carotenoids through plant food. However, the black pigment of melanin is synthesized from amino acid tyrosine, under the influence of enzyme tyrosinase. Sometimes a brown pigment called eumelanin is also found in the chromatophores

Pigments of Chromatophore:

Fish chromatophore contains following types of pigments.

Melanins:

The melanin is the brown or black pigment derived from amino acid tyrosine. Melanin is synthesized usually in young melanophore and sometimes in adult melanophore. The first step of melanin synthesis is the oxidation of tyrosine to Dopa (3, 4-di-hydroxy-phenylalnine) under the influence of enzyme tyrosinase.

Dopa further oxidized to Dopa quinone, which is polymerized to synthesized melanin. It is generally considered that higher tyrosinase level causes higher pigmentation in fishes.

Carotenoids:

These are highly unsaturated hydrocarbon compounds containing carbon chain with ring structure at one or both ends. Carotenoid is found in xanthophores or erythrophores causing red or yellow colour.

Carotenoid is insoluble in water but soluble in organic solvents, hence called as ‘lipophores’, the term widely used to denote xanthophores and erythrophores. It is reported that carotenoids cannot be synthesized in body of fishes and it is derived from food. In some species it comes from the pigment found in the yolk.

Ptridines:

This is a similar compound to purines and flavins. Fishes are reported to have both coloured and colourless ptridines. Drosopterines including drosopterin, isodrosopterin and neodrosopterin are responsible for red colour. However, sepiapterins and iso-sepiapterins are yellow.

Purines:

Guanine is a purine and is responsible for white or silvery tone in fishes. It is found in iridiocytes.

The Iridiocytes:

They are also called as reflecting cells or mirror cells because they reflect light. The iridiocytes contain crystals of guanine, making them opaque and able to reflect light so as to produce either white or silvery appearance.

This material is used in the manufacture of artificial pearls. Iridiocytes when present outside the scales, produce an iridescent appearance and when they present inside them, forming a layer called argenteum produce a white or silvery appearance.

Colour Changes in fishes:

Colour change is both short and long term phenomenon due to pigment change. It is both physiological and morphological phenomena. A morphological change is a slow process as it involves formation of pigment granules in cells.

Physiological change is rapid (for a short period within a few minutes) and exhibits rearrangement of pigment granules in the chromatophores. Both of these changes occur due to visual and non-visual stimuli. The later involve nerve and hormones.

Physiological or Rapid Colour Change:

In some fishes rapid change in colour occurs to match the changing surroundings. This type of colour adaptation is done by redistribution of pigment granules within the chromatophores. This type of colour change makes the fish inconspicuous over different backgrounds. The rapid colour change in fishes is known as cryptic or concealing colouration and may be of two types.

Assimilation with Background:

In this type of colouration the fish harmonizes its colour to the background. The most common example of this type is pelagic laptocephalus larvae of eel, which is devoid of pigment. Sea horse and pipefish often have the colour that resembles the seaweeds. The green colour of 'tench' resembles to that of surrounding by assimilation.

Another interesting example of rapid colour change is seen in the flat fish (Pleuronectiformes). These fishes have remarkable matching power. When they are kept on checkerboard, they will, after a short period, develop almost same colour and pattern as that of background.

Disruptive Colouration or Breaking Up the Outline of the Fish: The disruptive colouration is beneficial for concealment of fish. This is a sort of camouflage. In this type of colouration the

continuity of body adapting different colour and tone disrupts surface or shape. The disruptive outline of the body helps fish to conceal. Various types of spots, stripes, lines and bands of brilliant colours on fish body, break up the outline making the animal less conspicuous.

Sometimes disruptive colouration is used as a special camouflage, in which different parts of the body is concealed. Thus that particular part of the body is prevented from recognition on sight. In Nassau grouper a horizontal coloured line is present in continuation with the body, which makes the eye inconspicuous. Similarly, a vertical line is present in the head of Jack-knife fish, to conceal the eye.

Sematic or Warning Colouration:

Besides concealing, another kind of colouration is sematic or warning colouration. In this type fish is usually adopt striking pattern and colour that reveals the animal then top conceal. This is of special significance for defence, as animal likely to attack are able to resemble the pattern and harmful effects previously associated with it.

Torpedo ocellata has a prominent spot on electric organ for this purpose. In some fishes obliterating colouration is adapted for concealment. The body of fish is counter shaded so that observer gets third dimension of the fish body, which reduces the visibility of fish.

Regulation of colour changes

The colour change is also controlled by the action of posterior lobe of pituitary. It is evidently observed in the Atlantic minnow *Fundulus* that hypophysectomy result in the lighter body colour than normal individual, due to contraction of chromatophores.

The injection of pituitary extracts causes expansion of the chromatophores resulting dark colour of the body. It is believed that the two hormones of pituitary are responsible for colouration.

The melanin dispersing hormone (MDH), i.e., intermedine causes darkening and the melanin-aggregating hormone (MAH) or W-substance causes paling of the body. It is evidently seen in Scyllum. Although the presence of MDH is found in many teleosts like *Anguilla* and *Fundulus.*

In addition to pituitary hormones, adrenaline is also considered to control the action of chromatophore. It has chromatophore aggregating effect. Thyroxin is also believed to be responsible for colour change by effecting chromatophores.

Significance of Colouration:

Colouration in fishes provides them power of adjustment with surroundings and also enables them to survive. The colour of fishes is used for concealment, communication, camouflage, sexual recognition and advertisement, warning or threat. Colouration also has taxonomic value.

Different colour pattern in fish is often considered as character for distinction among species and subspecies. The specific pattern due to exact distribution of chromatophores is under genetic control. The colour pattern is also used in distinction of genera of some species like Channa and Mystus.

Factors Affecting the Colouration:

There are various factors like temperature, light and stimuli which affect the functioning of the chromatophores. At low temperature chromatophores disperse causing darkening of the body while increase in temperature concentrates the chromatophores with substantial paling of the body.

The light exerts its effect in two manners. In primary response the light affects the chromatophores by other sources then eyes. By secondary response chromatophores are affected by light through eyes.

External stimuli like tactile or psychic type also influence colouration of fish. The psychic type also influences colouration of fish. The psychic type of stimuli contribute much for change in colour during mating behaviour of some fishes, when excited, shows psychological colour change in a short time, for example Tilapia.