

Agnatha

- ✍ Jawa are absent in these animals (lowest grade vertebrates).
- ✍ Notochord persistent. All developed vertebrae are found at notochord.
- ✍ Mouth at the anterior end of body, **round, Funnel shaped** and **subtorial**.
- ✍ Paired fins are absent
- ✍ Genital ducts are absent.
- ✍ **Two semi - circular** canals are found in **internal** ear.
- ✍ One median **pineal eye** is found along with two lateral eyes on head.

Group Agnatha is divided into two classes.

[A] **Ostracodermi** [B] **Cyclostomata**

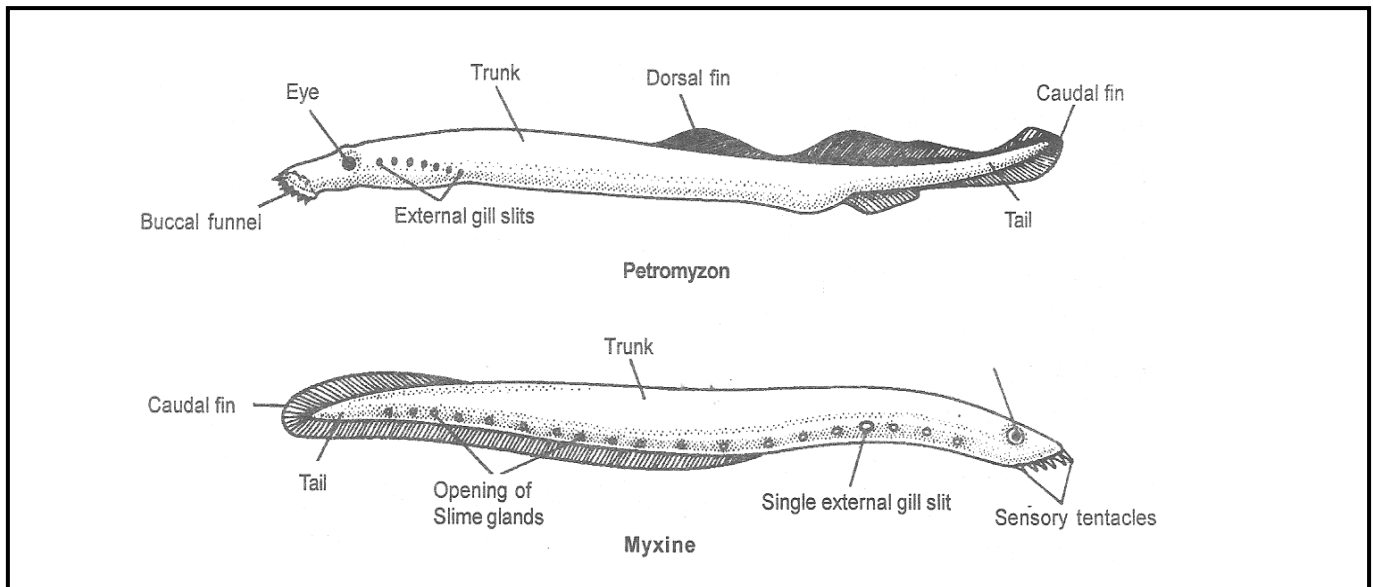
Class [A] - Ostracodermi

- ✍ All the members of this class are extinct. These **were freshwater fishes** which are **first vertebrates**.
- ✍ Two semicircular canals in internal ear.
- ✍ Their body was covered by protective covering made up of hard scales.

e.g. - **Cephalaspis**. (Primitive vertebrate of Ordovician period)

- **Drepanaspis**

Class [B] Cyclostomata :



- ✍ Most of the members of this class are marine, except some fresh water species.
- ✍ These fishes are **parasite** as well as **scavenger**.
- ✍ This class included **Jaw less fishes (false - fishes)**.
- ✍ Body long, thin, tubular, tail is flat.
- ✍ Skin soft, smooth and scaleless.
- ✍ **Mouth** is rounded, sucker like and biting -eating type.
- ✍ Three eyes are found on the head, one median **pineal eye** and two lateral eyes.
- ✍ Only one Nostril (**Monorhynchous**).
- ✍ Internal ear contains **one** or **two semicircular canals**. Internal ear works as **statoreceptor** only. i.e. organ of balance.

- ✍ Gill clefts are **5 16 16 pairs**
- ✍ Digestive system is without stomach. Intestine has spiral typhlosole.
- ✍ Notochord and vertebral column both are present. Vertebral column is made up of cartilage. Bones are absent.
- ✍ Heart is two-chambered, It is called **Benous - heart**.
- ✍ Kidneys are **protonephric** or **mesonephric** type.
- ✍ Paired fins absent. Dorsal median and tail fin is present.
- ✍ Tail is **protocercal type**. In this type of tail, notochord is extended at the last end and tail and tail fin is divided into two equal dorsal and ventral lobes.
- ✍ Animals **unisexual**, fertilization **external**, larval stage absent. Except **Ammocoete** larva is found during development of **Petromyzon**.

e.g. -:

- **Petromyzon or Lamprey** : It is a **living fossil**. It is an ectoparasite (Sanguivorous) on true fishes. Many teeth are found in mouth and it shows **Anadromous** migration.
Larva Ammocoete is considered as **connecting link** between Cephalochorada and Cyclostomata.
- **Myxine or Hag fish** :it has wrinkled lips just like an old woman. It usually remains attached with gills of host. It has **Archaeonephric kidney** in young ones i.e. which can filter blood and coelomic fluid.
- **Bdellostama**
- **Ichthyomyzon**

Gnathostomata

- ✍ Mouth is encircled by true jaws. These are developed vertebrates.
- ✍ Vertebral column well developed.
- ✍ Mouth is not rounded.
- ✍ Movement by paired fins or legs.
- ✍ Gonads are paired, genital ducts are present.
- ✍ 3 Semi circular canals are found in internal ear.
- ✍ Pineal eye is absent.
- ✍ Animals are unisexual.
- ✍ Gills or lungs are meant for respiration.

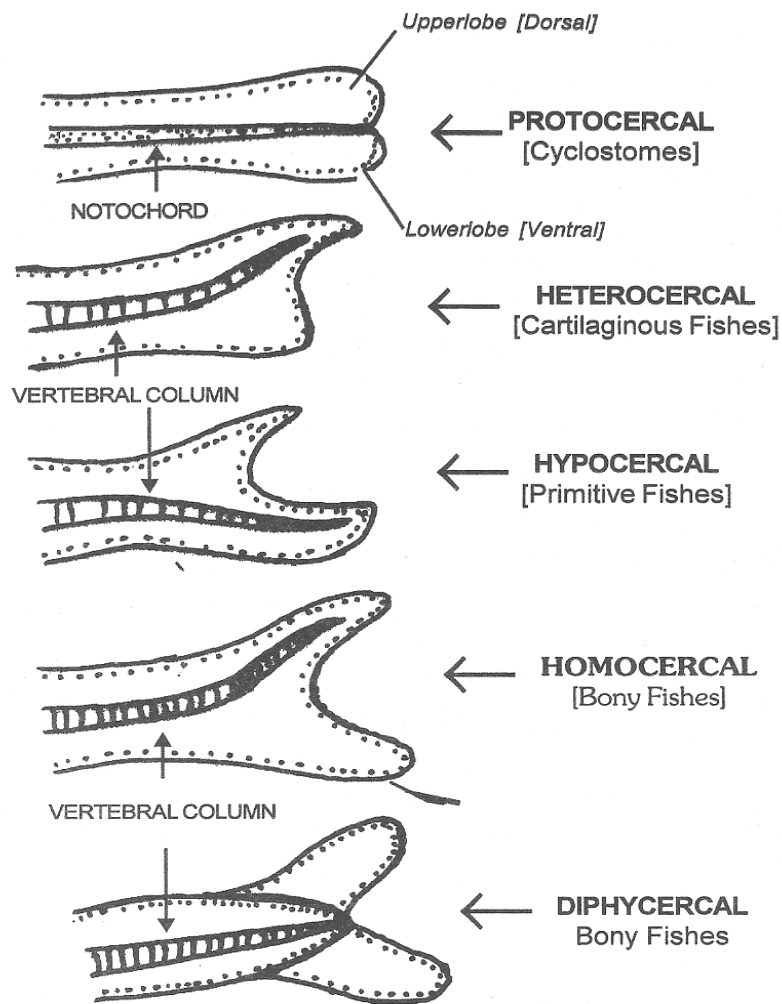
Gnathostomata is classified into two super classes on the basis of locomotory organs, respiratory organs, heart and blood vascular system

Super Class : [1] Pisces [2] Tetrapoda

Super Class – Pisces

- ✍ '**Devonian period**' is called "**Golden period of fishes**"
- ✍ Study of fishes is **Ichthyology**.
- ✍ This super class includes **true fishes**.
- ✍ Animals are **aquatic**, may be fresh water or marine.
- ✍ Body is long, boat shaped and stream lined, which is divided into **head, trunk** and **tail**. Neck is absent. Slim glands are present on the skin,
- ✍ Body is covered by **dermal scales**. But Cat fish, **Torpedo & Wallagone** fish are **scale less**. Colour in fish is produced by **iridocytes** present in the dermis.

- ✍ Paired fins are present for swimming. e.g. Pectoral and pelvic fins are paired. Along with these unpaired fins are also found on the body e.g. mid dorsal fin and caudal fin.
- ✍ External nares are one pair. This condition is known as **Diryhous conditiion**.
- ✍ External and middle ears are absent (No ossicle or Tympanum) only internal ear is present in which **three semi - circular canals** are present, which work as statoreceptor. Eyes are without lids.
- ✍ Respiration **by gills**, gills are **4 to 7 pairs** and **naked** or covered by **operculum**.
- ✍ “**Air bladder**” helps in respiration in lung-fishes (Group - Dipnoi)
- ✍ Heart two chambered known as “**Venous heart**”, because it contains only impure blood, which goes to gills for purification from heart, pure blood is then distributed to all parts of body directly from gills. i.e. circulation of blood is **unicircuit**.
- ✍ RBC (Present in blood) are **nucleated**. **Sinus venosus, renal** and **hepatic portal** system are found in circulatory system.
- ✍ Endoskeleton is made up of **cartilage** or **bones**.
- ✍ Vertebrae in fishes are **amphicoelous**, in which centrum is concave at both the surfaces.
- ✍ In the skull of fishes only one occipital condyle is present, so their skull is called **monocondylar type**. Cranial nerves are **10 - pairs**.
- ✍ **Lateral line receptor system** is present in the body fishes, which includes many receptor organs which can detect vibration (Rheoreceptor) and Electric field.
- ✍ Kidneys in fishes are **mesonephric** type.
- ✍ **Cartilagenous** fishes excrete **urea**, Marine bony fishes excrete **trimethylamine oxide** and fresh watered fish excrete **ammonia**. Urinary bladder is absent.
- ✍ Fishes are **unisexual**.
- ✍ Fertilization is **internal** or **external**.
- ✍ Eggs are **mesolecithal** or **megalecithal** type.
- ✍ **Extraembryonic membranes** are **absent** in fishes so all the fishes are placed under group **anamniota**.
- ✍ Metamorphosis is **direct i.e.** larval stage is lacking during development.
- ✍ These are **cold blooded**, poikilothermic animals (Exception - Tuna fish, Sword fish, endothermic).
- ✍ Small fishes (Baby fishes) are called **Fry or Hatchling**.
- ✍ Fishes show a **seasonal migration** in a particular season.
 - [A] **Catadromous migration** : Migration of fishes from fresh water to marine water
e.g. **Anguila**
 - [B] **Anadromous migration** : Migration of fishes from marine water to fresh water
e.g. (1) **Salmon**
(2) **Strugeon**
(3) **Hilsa**
 - [C] **Potamodromous migration** : Migration of fishes from Fresh water to fresh water
 - [D] **Oceanodromous migration** : Migration of fishes from Marine to Marine water
- **Stenohaline** : Fish which can tolerate a narrow range of salinity in water.
- **Euryhaline** : Fish which can tolerate a wide range of salinity in water.



Types of Tails of Fishes

Romer classified super class pisces into three classes :

[A] Placodermi

[B] Chondrichthyes

[C] Osteichthyes

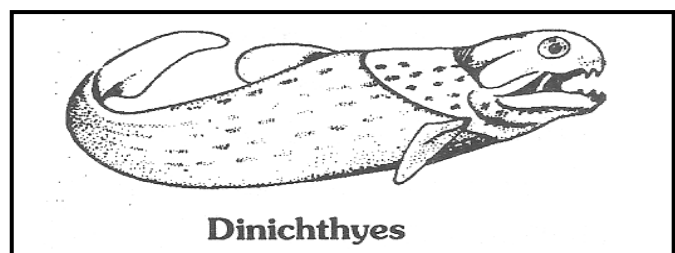
[A] Class – Placodermi

(1) In this class, **extinct** fishes (Fossil fish) are included, which used to live from devonian era to permian era. So these were the first fresh water true fishes.

(2) Their body was covered by **bony plates**, so these are called “**Armoured fishes**”

e.g. : - **Climacodus** - First jawed fish

- **Dinichthyes**



[B] Class - **Chondrichthyes or Elasmobranchi**

- ✍ This class includes cartilaginous fishes.
- ✍ Fishes are normally **marine** of this class.
- ✍ Endoskeleton is made up of **cartilage**.
- ✍ Exoskeleton over the skin is made up of **placoid** scales. These scales are like denticle and are originated by dermis of skin.
- ✍ In these fishes **4 - 7 pairs** of gills are present, which open direct outside the body by bill slits, operculum is normally absent in these fishes.
- ✍ Mouth is present at the **vental surface** of head. Jaws and teeth are present. **Suspensorium** of jaws is **Hyalostylic type**.
- ✍ Air - bladder or lungs are absent.
- ✍ **Spiracles** present.
- ✍ A **spiral valve** or **scroll valve** is found in intestine (To increase surface area)
- ✍ Cloacal aperture is present.
- ✍ There is a special structure at the dorsal surface of head in these fishes, which is called "**Ampulla of Lorenzini**" this works as **thermoreceptor**.
- ✍ Liver is **Bilobbed**
- ✍ Tail is **heterocercal** type.
- ✍ Genital ducts open into cloacal aperture.
- ✍ Fertilization is **internal** - male fishes have "**Claspers**" as copulatory organs, which are developed by the inner edges of pelvic fins.
- ✍ Fishes are **oviparous** or **viviparous** (few have yolk sac placenta).

e.g. :-

- **Scoliodon** : Dog - fish - Dog like sense of smell. It is also known as Indian shark viviparous
- **Sphyrna** - Hammer headed shark
- **Stegostoma** - Tiger Fish / Zebra shark
- **Carcharodon** - Great white shark
- **Rhinobatus** - Guitar fish
- **Pristis** : Saw - Fish
- **Trygon** : Sting ray - Its dorsal fin has poisonous spines.
- **Torpedo** : **Electric ray** - In this fish an electric organ is found which is a modified muscle, it can give shock of about 100 volts. It is exoskeletonless.
- **Rhineodon** : Whale shark - It is the largest true fish. Its length is 13 - 14 meters.
- **Chimaera** : - "Rat fish" or "King of herrings" or Ghost fish. Connecting link between body & cartilaginous fish. Operculum present. Cartilage fish with operculum is placed under **holocephali** group.

[C] Class - **Osteichthyes or Teleostomi**

- ✍ This class includes bony fish.
- ✍ Fishes of this class are found in fresh water as well as marine water.
- ✍ **Endoskeleton** of these fishes is made up of **bones**, so these fishes are called “**bony - fishes**”
- ✍ Their **exoskeleton** is made up of scales, which may be cycloid or **ctenoid** or **ganoid** type. **Placoid** scales are absent.
- ✍ Respiration by **4 - pairs** of gills. These gills are covered by **operculum** at each side of body.
- ✍ Mouth is normally terminal or subterminal, teeth are found in Jaws. Suspensorium of Jaw is **autostylic**
- ✍ Helping respiratory organs “**airbladders**” are present. Lung fishes respire through air bladders. In other fishes these air bladders are **hydrostatic** i.e. help in maintaining balance of body.
- ✍ Spiracle is absent.
- ✍ Scroll valve in intestine is absent.
- ✍ Cloaca absent, in place of cloacal aperture anus is present.
- ✍ No ampulla of Lorenzini
- ✍ Liver is **Trilobbed**
- ✍ Tail is normally **homocercal** type but sometimes it may be **diphycercal** type.
- ✍ Genital ducts open outside the body through separate apertures.
- ✍ Fertilization is **external**, **classpers** are absent in male fishes.
- ✍ Fishes are **oviparous** but may be **ovoviviparous** or **viviparous**.

Examples :-

- **Labeo** : “Rohu” or “Indian carp” - It is a fresh water fish.
- **Clarias** : - “Cat fish” or **magur**
- **Wallagonia** : Lachi (scale less)
- **Catla** - Catla (Fresh water)
- **Heteropneustis** - Signhi
- **Channa** - Lata Fish
- **Lophius** - Angler Fish
- **Hippocampus** - “Sea - horse” or “Pregnant male” :- It swims in water in its vertically position. A pouch like structure is present at the abdomen of male fishes known as “Brood - pouch” in this pouch male collects the eggs. Secondary vivipary and parental care is found in hippocampus.

- **Anada** - Climbing perch
- **Sardinella** - Salmon
- **Acipenser** - Sturgeon - Endoskeleton is cartilaginous
- **Betta** - Fighting Fish
- **Pterophyllum** - Angel Fish
- **Exocoetus** - Flying fish - Its dorsal fin is long, it can fly (glide) over 400 metre with the help of this fin.

- **Anguila** - Eel : -Snake like, migrate to sea for spawning. Young ell (Elver) migrate back to fresh water.
- **Solea** - Flat fish
- **Fistularia** - Flute fish
- **Harpodon** - Bombay Duck
- **Amia** - Bow fish
- **Echeneis** (Remora) - Suker fish. Shows commensalism with shark and whales. Dorsal fin modified into suker.
- **Mystus** - Sanghara
- **Sirrhina** - Mrigal
- **Latimaria or coelacanth** - Living fossil fish - It is the **oldest living vertebrate** known till now. Belongs to group **Crosspterygii**.
- **Chenocephalus** - Ice fish : Only vertebrate without haemoglobin.
- **Opsanus** - Toad fish
- **Synanceja horrida** - Stone fish : It is the most piosonuous fish.
- **Gambusia** (Top minnow) - Larvivorous fish.

Dipnoi Group:- Fishes of dipnoi group are caled **Lung - fishes** or “**Uncle of amphibia**’ because their **air bladder** help in respiration.

- ✍ Three chambered heart.
- ✍ External and internal both the nares are present.
- ✍ Their tail is **heterocercal** type. Scale is **pacoid** type.
- ✍ These are freshwater fishes.
- ✍ Fishes of dipnoi group are called **Lung - fishes** or “**Uncle of amphibia**’

e.g. :-

- **Protopterus** : African lung fish : It is living fossil fish.
- **Lepidosiren** : South American lung fish.
- **Neoceratodus** : Australian lung fish.

Shagreen is dried skin of Cartilaginous fish.

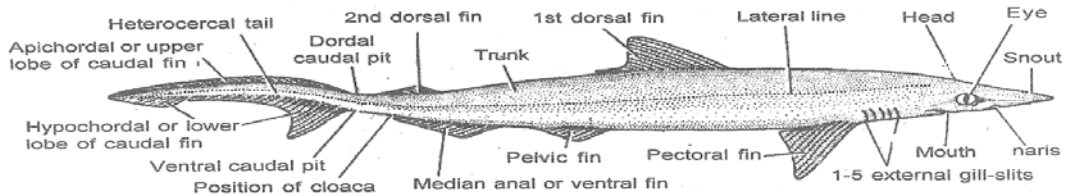
Cod liver oil is rich in Vitamin D, Shark liver oil is rich in Vitamin A

Maltase cross is found in vertebra of shark for supporting vertebrae.

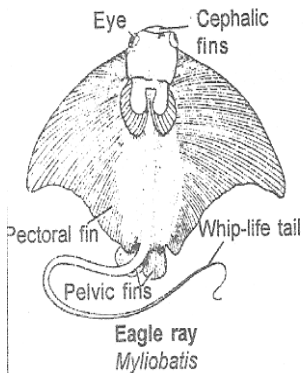
Mermaid’s purse refers to Egg capsule of shark.

Isinglass is a gelatinous product from air bladder of certain fish for making cement, Jelly & for charification of wine & beer.

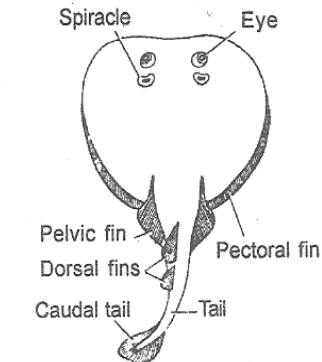
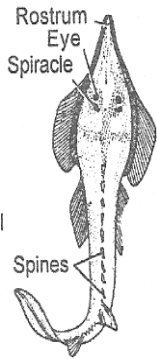
Smallest fish **Mystichthyes** - Goby fish - Pandaka (8 - 10mm)



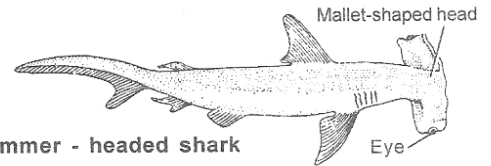
Female Indian dogfish shark (*Scoliodon sorrakowash*) in lateral view



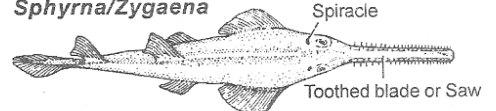
Guitar fish (*Rhinobatus*)



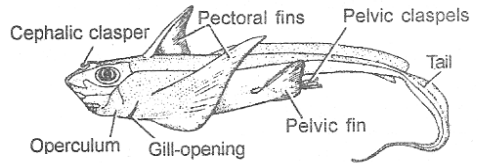
Electric ray (*Torpedo*)



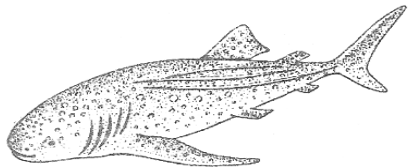
Hammer-headed shark *Sphyrna/Zygaena*



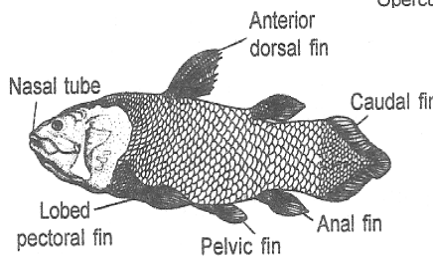
Sawfish *Pristis*



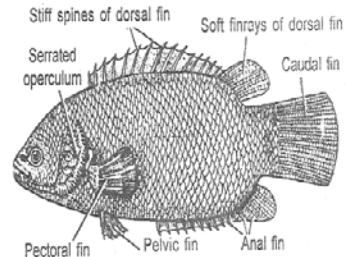
Rat fish = *Chimaera*



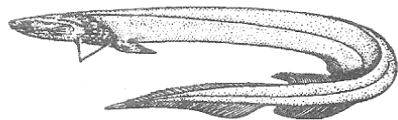
Whale shark (*Rhineodon typicus*)



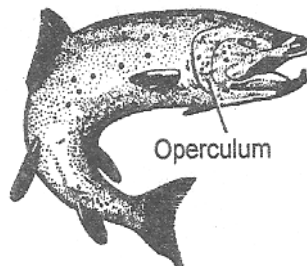
Latimeria



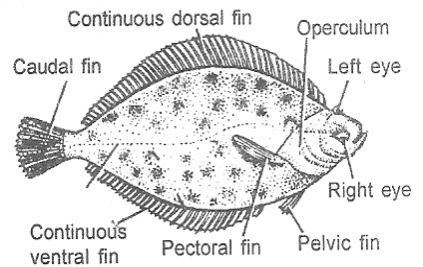
Climbing perch (*Anabas testudineus*)



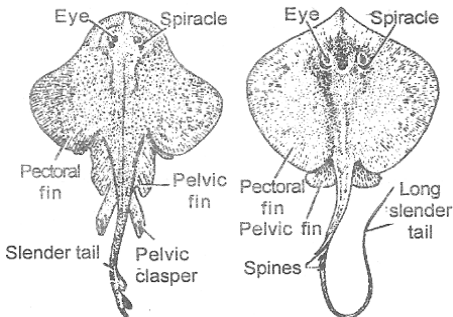
Frilled shark (*Chlamydoselachus*)



Atlantic salmon or Trout (*Salmo salar*)

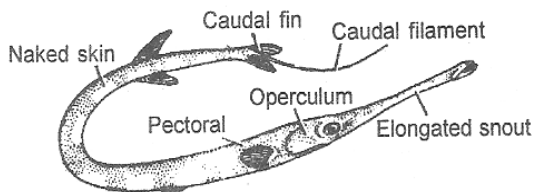


Flat fish (*Pleuronectes*)

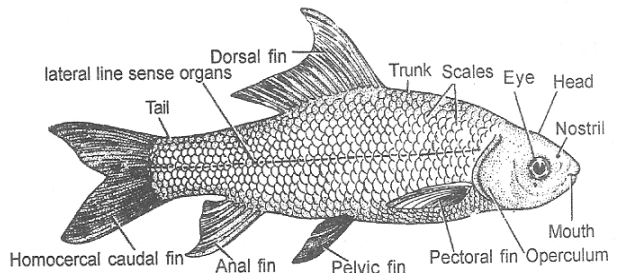


Common skate *Raja erinacea*

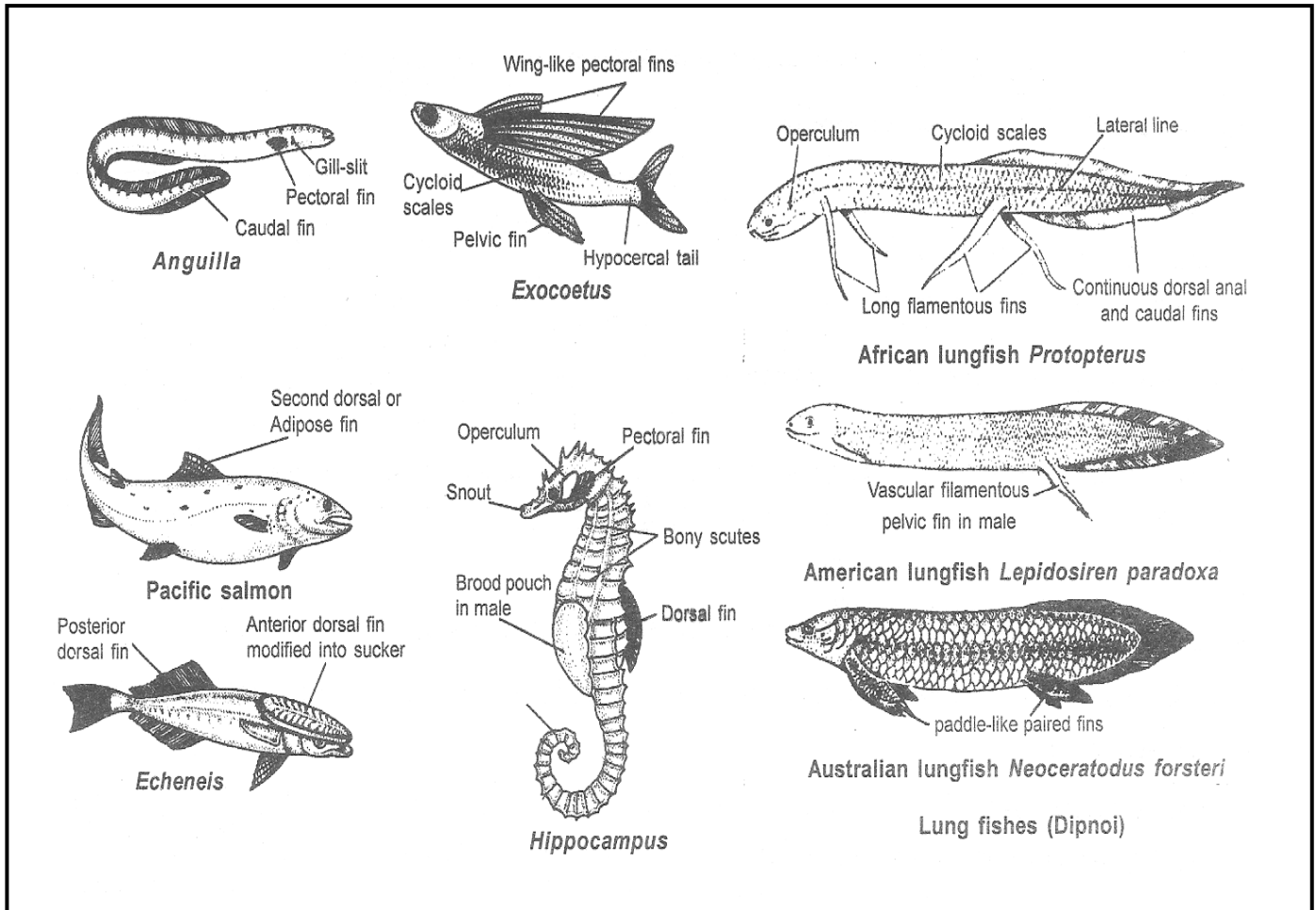
Sting ray *Trygon*



Flute fish (*Fistularia*)



Labeo rohita : External features in side view



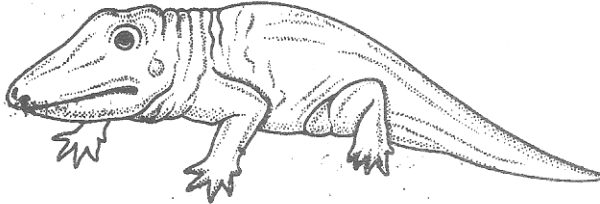
Superclass – Tetrapoda

- ✍ *Members of this superclass are found in water and on land*
 - ✍ Locomotion by 2 pairs of **pentadactylous** limbs.
 - ✍ Gills are present only in embryonic stages. Main respiratory organ in adults is **lung**.
 - ✍ Exoskeleton is made up of scales, **feathers** or **hair**.
 - ✍ Endoskeleton is made up of **bones**.
 - ✍ Heart is three or four chambered and **double circulation** is found in them.
 - ✍ Kidneys are **mesonephric** or **metanephric** type.
 - ✍ Middle ear is present. **Birds** and **mammals** have external into four classes
- Superclass - Tetrapoda is divided into four classes
- Class [A] - **Amphibia**
 - Class [B] - **Reptilia**
 - Class [C] - **Aves**
 - Class [D] - **Mammalia**



Class – Amphibia



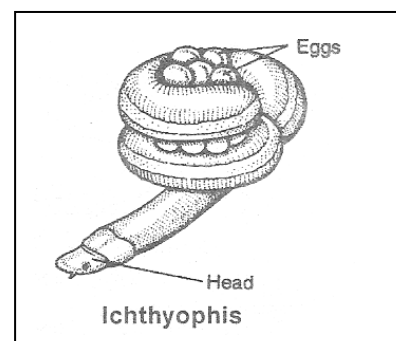
- ✍ **Devonian Origin & Carboniferous** is the age of Amphibians
 - ✍ Class amphibia includes amphibious animals which can live on both the places at ease **i.e.** – under water and on the land. No marine.
 - ✍ These are the first chordate animals which come out of water but these are not able to live on land permanently, these depend on water for their reproduction. Their eggs do not have protecting covering to check the evaporation.
- 

Stegocephalia (Amphibian Ancestor)
- ✍ Body is divided into head, trunk and tail. Some amphibians lack all e.g. frog toad etc.
 - ✍ Skin is smooth and mostly **scale less**, but whenever scales are present there are embedded in the skin e.g. **Ichthyophis**.
 - ✍ Numerous **glands** are found in skin which help in moistening the skin. So these animals respire through moist skin. Some poisonous glands are also found in the skin of some animals e.g. **Bufo**. Pigment cells are also found as chromatophores for colouration. Few amphibians have ability to change colour by expansion and contraction of pigment cells. This phenomenon is known as **Metachrosis**.
 - ✍ Two pairs of limbs help in swimming in water or moving on land. Forelimbs have four fingers and hindlimbs have five fingers.
 - ✍ Their digits do not have **nails** or **claws** at all.
 - ✍ Mouth is bigger in size. Upper or both the jaws have alike teeth. These are **pleurodont**, **homodont** and **polyphodont**. Suspensorium of jaws is **autostylic**. (Frog - Acrodont)
 - ✍ A well developed and **complete** alimentary canal along with digestive glands are present in digestive system (Salivary glands are absent in frog).
 - ✍ Alimentary canal, urinary bladder and genital ducts open into **cloaca**.
 - ✍ Respiration by **gills**, **skin**, **lungs** or **buccopharyngeal** cavity.
 - ✍ Two nostrils are found, this condition is called **dirhynous**.
 - ✍ Heart is **three chambered**, 2 auricles and 1 ventricle (arteriovenous). **Sinus venosus** and **Truncus arteriosus** is well developed.
 - ✍ R.B.Cs are **biconvex**, **oval** and **nucleated**.
 - ✍ In these animals **renal portal system** and **hepatic portal system** are found.
 - ✍ Endoskeleton is made up of bones, but **cranium** is **cartilagenous**.
 - ✍ Skull has two occipital condyles, with the help of these two condyles skull is connected by first vertebra of vertebral column i.e. Atlas, this type of skull is called **dicondylic skull**.
 - ✍ Ribs absent, but may be present in some animals, but **ribs** are not attached with **sternum**.
 - ✍ Vertebrae, in these animals are **procoelus** type, in which centrum is **concave** from anterior side and **convex** from posterior side.

- ✍ External ear absent, only one ear ossicle **columella (stapes)** is present in middle ear.
- ✍ Cranial nerves are **10 - pairs**.
- ✍ **Lateral line sensory system** is necessarily found in any stage of development. In frog it is found only in larval stage.
- ✍ 1 pair of kidneys work as excretory organs. These kidneys are **mesonephric** or **opisthonephric** type. These animals are **Ureotelic**. but tailed animals & larvae are **Ammoniotellic**.
- ✍ These are cold blooded or **poikilothermal** animals.
- ✍ These animals undergo **hibernation** or **aestivation** to prevent themselves from extreme cold and heat and to overcome unfavourable conditions.
- ✍ These are unisexual animals, males have copulatory organs sometimes. These animals return to water from land for their reproduction.
- ✍ Fertilization is **external** and in the **water** but some animals show **internal** fertilization.
- ✍ These are **oviparous**, which lay their eggs in water. Eggs are **mesolecithal**. Extraembryonic membranes are absent, so these are placed under **anamniota** group.
- ✍ Cleavage in eggs is **holoblastic** and **unequal**.
- ✍ Development is **indirect type** i.e. **Tadpole larva** - In Frog, **Axolotl larva** - In Salamander This class is divided into three orders.
 - (A) **Gymnophiona** or **Apoda**
 - (B) **Caudata** or **Urodela**
 - (C) **Anura** or **salientia**

[a] **Order - Gymnophiona or Apoda**

- ✍ Their body is **worm** like. These are **primitive amphibians** burrowing in nature.
- ✍ Their body is **limbless**.
- ✍ Skin is soft, and moist, with mucous glands, small scales (cycloid) are found on the skin.
- ✍ Their eyes are covered by opaque skin. (Blind)
- ✍ Middle ear and tympanic membrane absent. (Deaf)
- ✍ Protrusible **copulatory organ** is present in male.
- ✍ Fertilization **Internal**.
- ✍ Parental care is found in them.
- ✍ Tail ill developed or absent.



e.g. :-

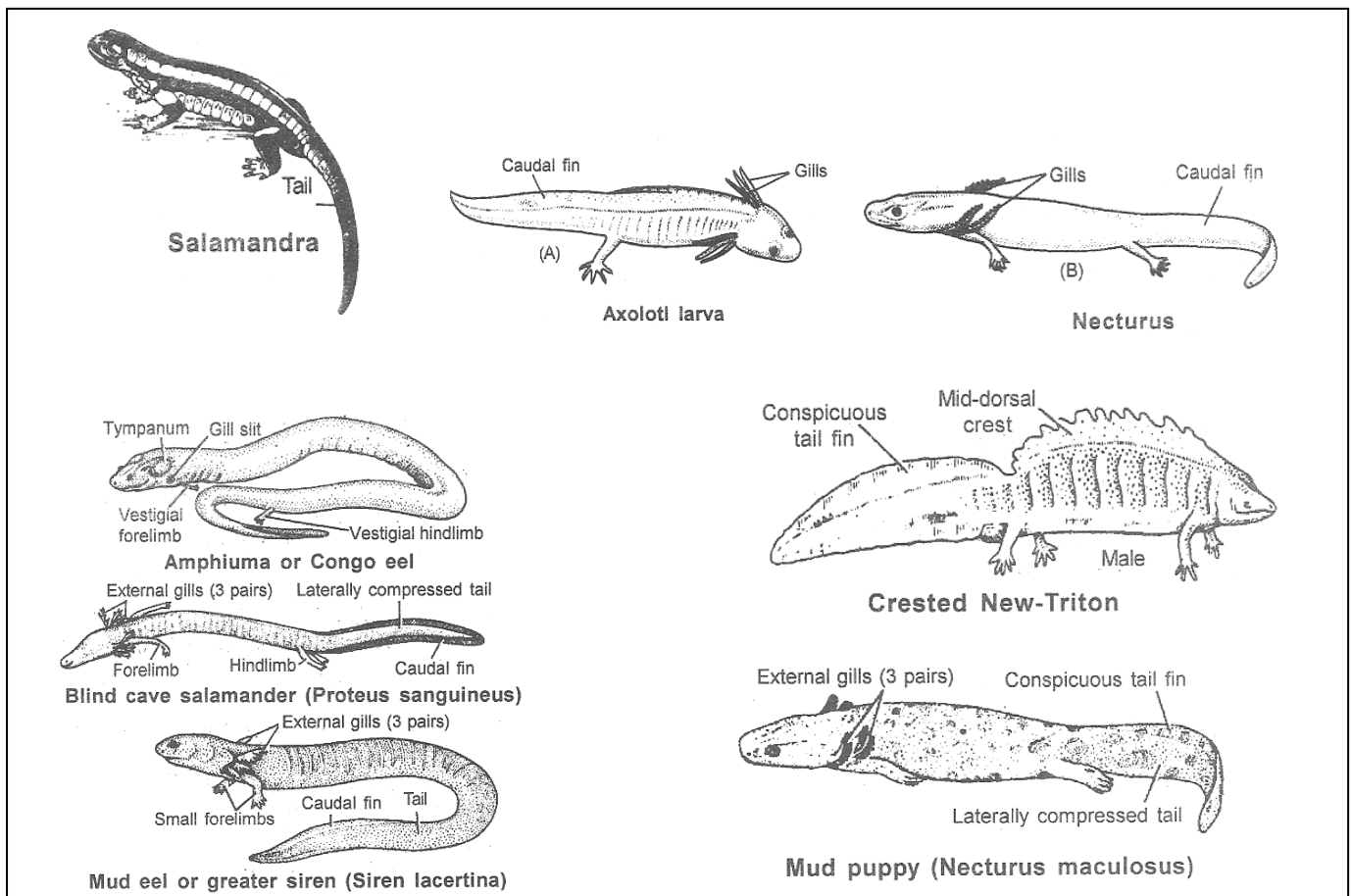
- **Ichthyophis (Caecilian)** : Blind worm without tongue.
- **Uraeotyphlus** : Dermal scales are found in the skin.
- **Gymnophis**

[b] **Order - Caudata or Urodela**

- ✍ Body is distinctly divided into **head trunk** and **tail**. Tail may have caudal fin.
- ✍ Normally two pairs of limbs are found which are of **equal** size. Sometimes hind limb is absent.
- ✍ Skin **scale less**.
- ✍ Middle ear and tympanic membrane absent.
- ✍ External gills are present only in larval stage.
- ✍ **Copulatory organ absent** in males.
- ✍ Fertilization **Internal**.
- ✍ Vertebrae are numerous their centrum is **amphicoelus** or **opisthocelus** type.
- ✍ Characteristic feature of this order is **Neoteny**. Larva attains sexual maturity without undergoing **Metamorphosis**, and starts reproduction.

e.g :-

- **Salamendra** : It is **viviparous**. Its larva is called **Axolotl** larva. It sometimes show neoteny. (Longest gestation period - 36 months)
- **Proteus** - Cave - salamender (Blind)
- **Ambystoma** - *Tiger salamender* (Axolotl larva)
- **Triton** - Newt
- **Necturus** - Water dog or mud puppy : Gills in adult also. It shows **permanent neoteny**.
- **Amphiuma** - Congo-eel : - Largest RBC is present.
- **Siren** - Mud-eel
- **Cryptobanches** - Hell Bender :- Largest Amphibian, Fully aquatic.



(c) **Order - Anura or salientia**

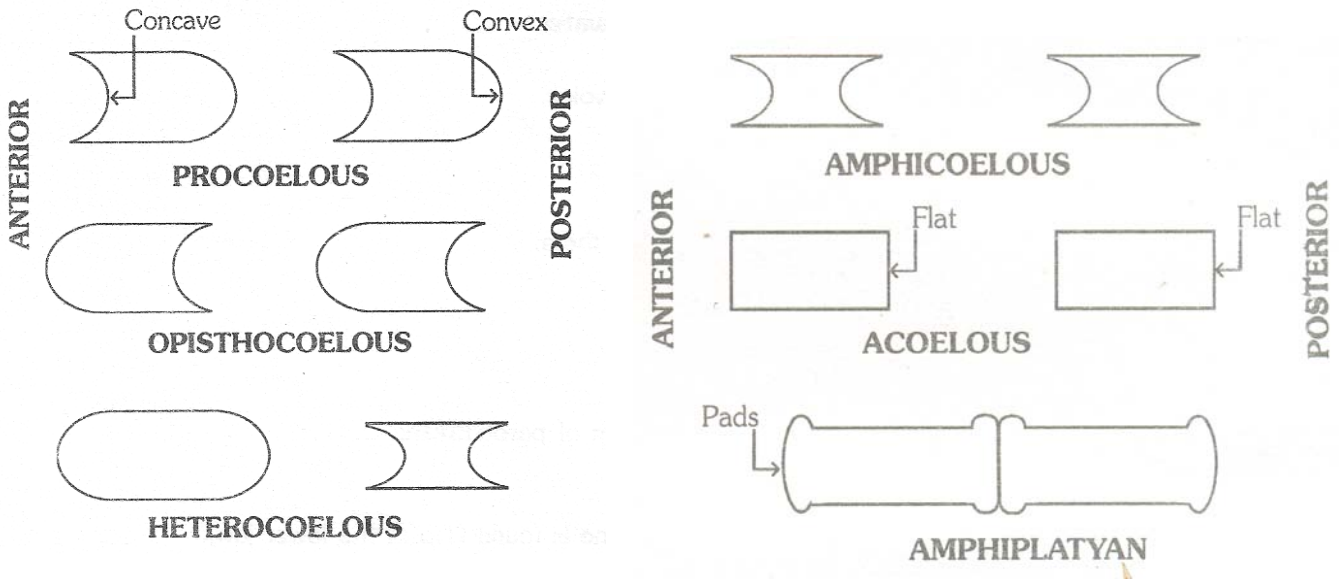
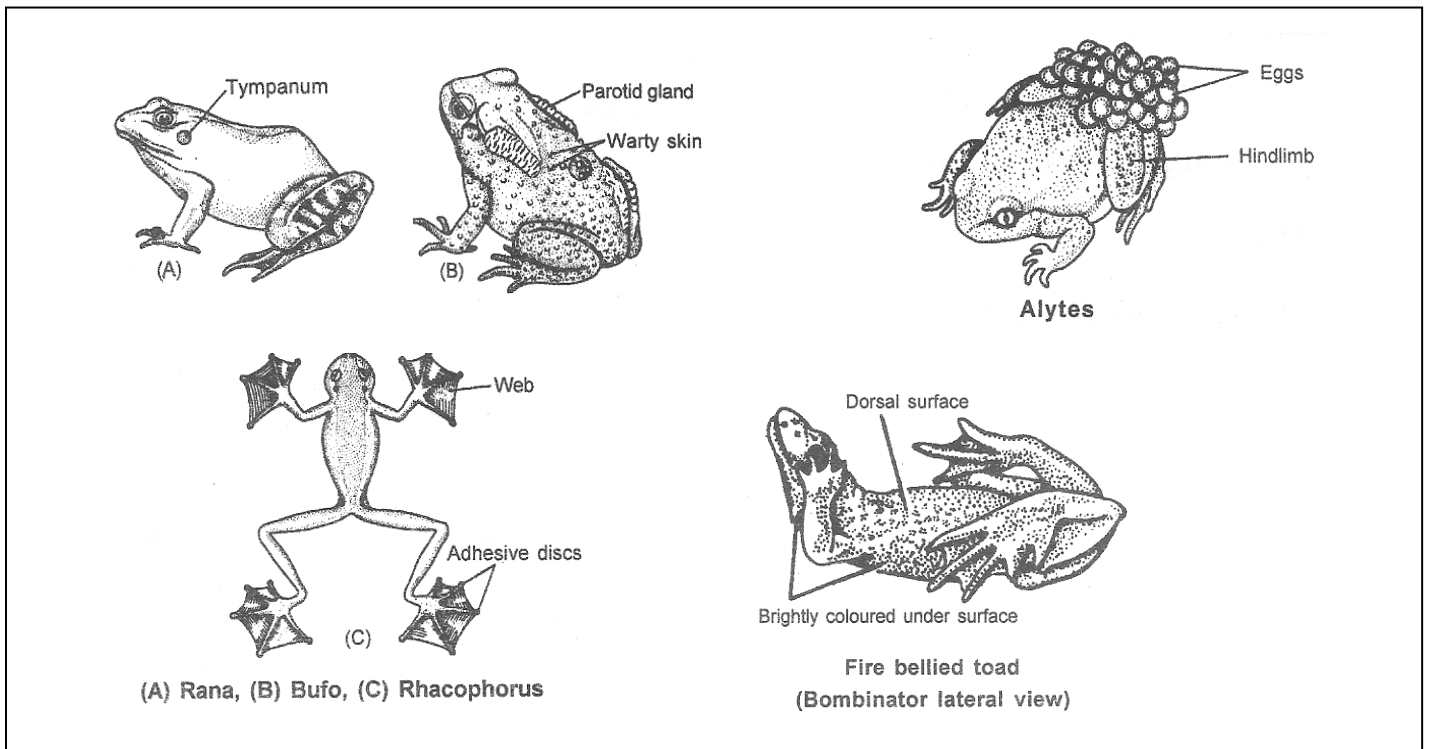
- ✍ These are specific animals, where tail is absent in adult stage.
- ✍ All the frogs and toads are include in this order.
- ✍ Skin is moist with **mucous**.
- ✍ 2 pairs of limbs are found. Fore limbs are short and hind limb are long. Digits of hind limbs are **webbed**, which help in swimming.
- ✍ Gills are absent in adults.
- ✍ Vertebral column small, in which only **5 - 9 vertebrae** are found. last vertbra is stick like urostyle.
- ✍ Eyes with **lids, tear** glands present. (Lower lid movable & upper immovable).
- ✍ Maxillary teeth are present in the upper jaw (absent in toad).
- ✍ Middle ear and Tympanic membrane present.
- ✍ Egg laying, fertilization and development is always in **water**.
- ✍ These have well developed vocal cords i.e. power of voice.
- ✍ Fertilization **external**.
- ✍ Development **indirect** i.e. **tadpole larva** is found in them.
- ✍ Metamorphosis **complete** :-

e.g. :-

- **Bufo** - Common toad [Pituitary glands are modification of parotid gland]
- **Hyla** - Tree -frog
- **Rana trigrina** - *Indian bull frog. mentomechanical bone is found* (Tip of the lower jaw).
- **Rhacophorus** - Flying frog
- **Alytes** - Widow toad - Reproductive organ is well developed in them. Male toads carry eggs in their limbs.
- **Rana goliath** - Largest frog
- **Phyllabates** - Smallest frog (found in Cuba)
- **Discoglossus** or **Bombinator** - Fire bellied toad
- **Xenopus** - African toad

REVIEW

Amphibia (amphibians) : first land vertebrates, evolved from lobe - finned bony fishes, skin naked and moist for respiration, have four limbs, digits without claws, sac-like lungs 3-chambered heart, undergoes metamorphosis, embryonic membranes not formed.



Types of CENTRUM of vertebrae