S Y B Sc Semester III	S Y B Sc Semester IV
ANIMAL DIVERSITY –III	**ANIMAL DIVERSITY –IV**
ZOOLOGY (ZO-231): Paper –I	ZOOLOGY (ZO-241): Paper -I
(2 Credits)	(2 Credits)

e Book Animal Diversity (Chordates)

As Per SPPU New Revised Syllabus, CBCS Pattern From June 2020

E Book EDITOR

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Front page designed by Dr. Dhiraj V. Bhavsar

Learning Outcomes for the e Book – Animal Diversity

- The students will be able to understand, classify and identify the diversity of all vertebrates.
- The students will able to understand the complexity of all vertebrates
- The students will be able to understand different life functions of vertebrates.
- The students will be able to understand the linkage among different groups of vertebrates.
- The student will become aware regarding his role and responsibility towards nature as a protector, to understand his role as a trustee and conservator of life which he has achieved by learning, observing and understanding life

Course Title: Animal Diversity - III Course Code: ZO – 231,
Semester - III (2 credits – 30 Hours)

Contents…

Chapter 1 Introduction to Phylum Chordata –

Contents:

Objective:

By reading this chapter we will understand the origin and ancestry of chordates and difference between non chordates and chordates. After studying this chapter we will be also able to know the classification of phylum chordata upto the classes.

Introduction:

Animal kingdom is basically divided into two sub kingdoms:
I) Nonchordata- including animals without notochord.
II) Chordata- The phylum chordata comprises the animals having notochord or chorda dorsalis. All chordates have the following important features at some stage in their life (in the case of humans and many other vertebrates, these features may only be present in the embryos).

The most important features of chordates are:

- The notochord,
- The dorsal tubular nerve cord,
- The pharyngeal gill-slits
- A post-anal tail.

TOPIC NO.1 - INTRODUCTION TO PHYLUM CHORDATA

1.1 ORIGIN AND ANCESTRY OF CHORDATES

There was a controversy about origin of chordates, but most of the Zoologists accepted the fact that the chordates have originated from the invertebrate ancestors. The earlier ancestors of chordates were soft bodies; hence their fossil remains were not left. The only basis for finding out the origin of chordate is available from resemblance between chordate (protochordates) and the invertebrates. Some structural features exhibited by them may be considered as the basis of their common ancestry. These features were bilateral symmetry, antero-posterior body axis, triploblastic ceolomic condition and metameric segmentation. There are several theories put forth to explain the origin of the chordates. These theories postulate that the chordates originated either directly from some invertebrates or through the intervention of some protochordates. Only Echinoderm theory has received some attention and acceptance. This theory was considered and evaluated under denterostome line of chordate ancestry. Echinoderm Ancestry (Echinoderm Theory): On the basis of palaentological, embryological, anatomical, biochemical and serological evidences, many scientists tried to establish that chordates probably had originated directly from some primitive echinoderm or some echinoderm larva. Tornaria larva of Balanoglossus (Hemichordata) and larvae of echinoderms (bipinnaria or dipleurula) show close similarities.

1.1 Origin & Ancestry of Chordates

Chordates are evolved from some deuterostome ancestor echinoderms,hemichordates, pogonophorans etc.) as they have similarities in embryonic development, type of coelom and larval stages.

The following theories have been given to explain the origin of chordates:

1. **Echinoderm Origin.**

- Johannes Muller (1860) proposed this theory.
- It is based on the comparative studies of larval stages of echinoderms and hemichordates.
- Johannes Muller, W. Garstang and DeBeers proposed that echinoderm larvae gave rise to chordates by neoteny.
- The fossil echinoderms (**Calcichordata)** confirms echinoderm ancestry of chordates.

2. Hemichordate Origin.

- **According to Romer (1959) the ancestral deuterostomes were sedentary tentacle feeders whose mucous-laden ciliated tentacles served to trap planktons.**
- **By some mutation pharyngeal gill slits evolved in these ancestors.**
- **Extant pterobranchs possess both ciliated arms and pharyngeal gill slits.**

- **The hemichordates show affinities with chordates, its Tornaria larva shows phylogenetic relationship with echinoderm larvae.**

3. Urochordate Origin.

- W. Garstang (1928) and N.J. Berrill (1955) proposed tadpole-like larva of urochordates which carries typical chordate characters
- notochord in tail along with segmented myotomes, dorsal hollow nerve cord, sense organs and pharyngeal gill slits.
- Garstang (1928) suggested that chordates evolved from some sessile filter feeding urochordate by the larval stage evolving into adult by neoteny and by losing the sedentary adult stage.

4. Cephalochordate Origin.

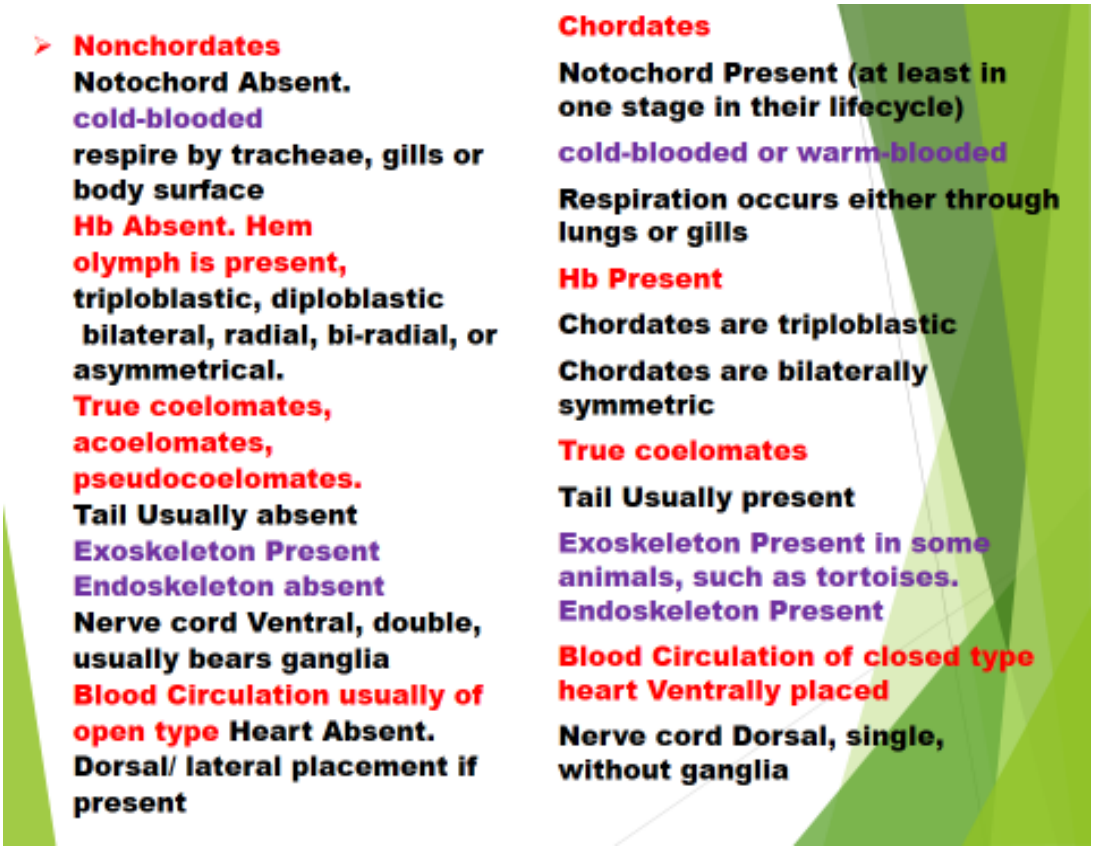
- Chamberlain (1900) proposed that cephalochordates possess all chordate characters
- some primitive features of non-chordates, such as, absence of heart, head, sense organs, respiratory pigment, filter-feeding mode of food capture and excretion by solenocytes.
- The Amphioxus-like fossils show streamlined, ribbon-shaped, 5 cm long body having notochord in the posterior two-third of body and myomeres.
- Other chordate-like fossils are: *Cathaymyrus* from early Cambrian sediments in China and *Palaeobranchiostomata* from early Permian from South Africa that appears to be more similar to Amphioxus.

5. Combined theory.

- **E.J.W. Barrington (1965) combined all the above theories and proposed that the common ancestor of echinoderms and chordates**
- **Modern Crinoidea (Echinodermata), Pogonophora and Pterobranch hemichordates evolved from a similar ancestor by retaining the original mode of feeding**
- **However, pharyngotremy (perforation of pharynx with gill slits) must have evolved in a large number of groups**
- **Hence, the sedentary Protoascidians of that time lost ciliated arm feeding and adopted pharyngeal filter feeding**
- **Sometime later, when the plankton population in water declined, free-swimming tailed larva of these urochordates did not metamorphose and became a neotenic adult**

Cephalochordate-like ancestors evolved by perfection and expansion of chordate characters that were already present in the ascidian tadpole larva.

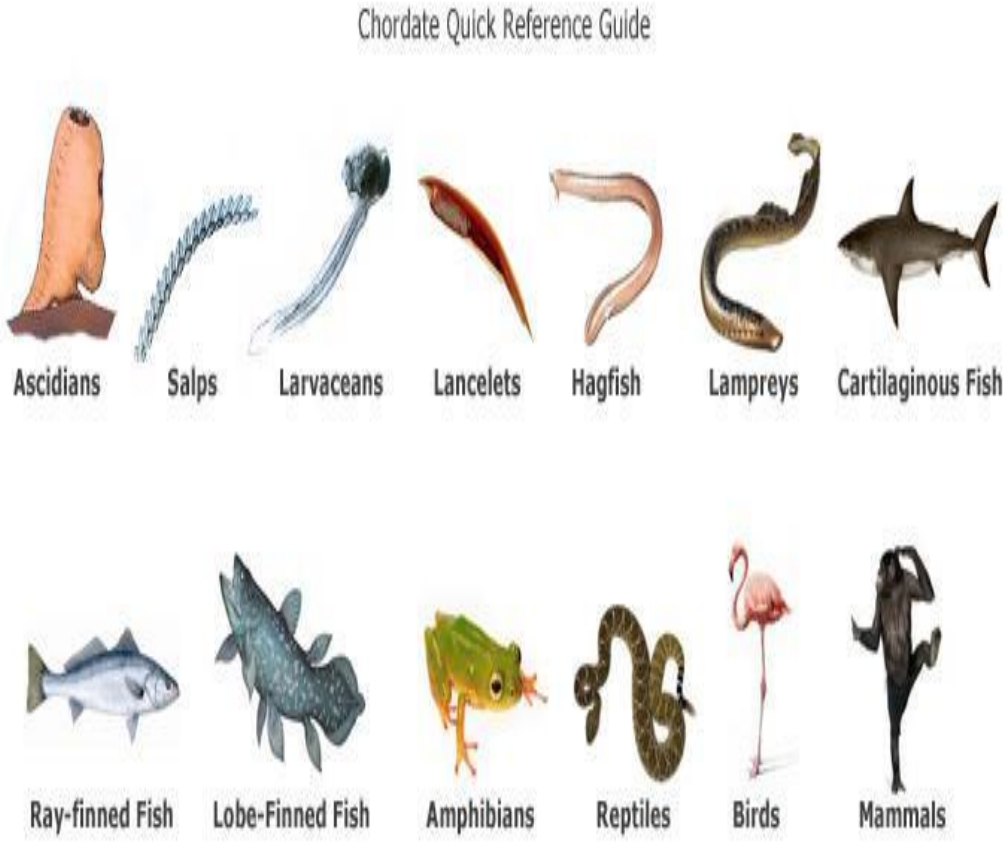
1.2 COMPARATIVE ACCOUNT OF FUNDAMENTAL CHARACTERS OF CHORDATES WITH NON CHORDATES



SALIENT FEATURES OF PHYLUM CHORDATA

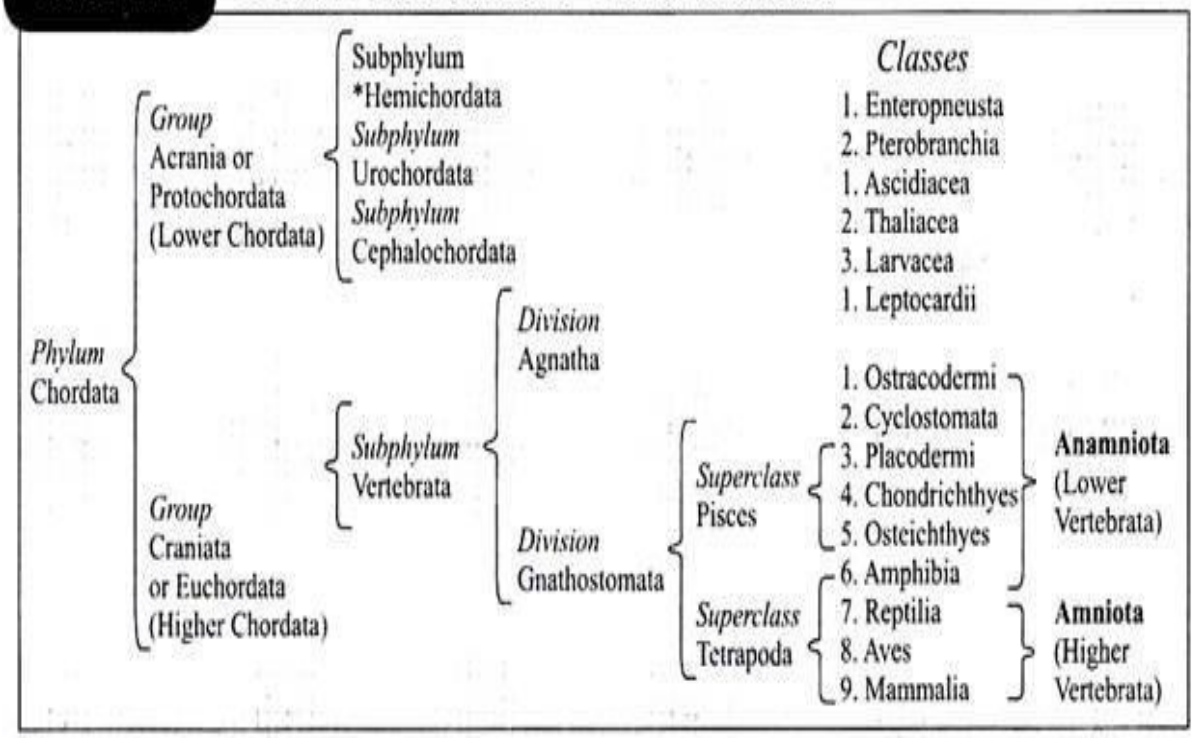
- Dorsal hollow, tubular nerve cord: The central nervous system of the chordates is located dorsally in the body. Nerve cord is tubular, hollow and longitudinal situated just above the notochord and extending lengthwise in the body. There is no ganglia
- Longitudinal supporting rod-like notochord: It is also called chorda dorsalis It is rod-like, flexible structure extending the length of the body. It is present beneath nerve cord and just above the digestive system.
- Pharyngeal gill slits: In all the chordates, at some stages of their life history, a series of paired lateral gill clefts or gill slits leading outward from the pharynx. They are also known by different names like pharyngeal clefts or pouches, branchial or visceral clefts. They are endodermal in origin.
- Cephalization: Formation of head by concentration of nervous tissue and sense organs at the anterior end. The posterior end is called tail. Thus, body shows antero-posterior axis.

- Bilateral symmetry: Right and left sides are mirror images of each other, thus called as bilateral symmetry. It is seen in all chordates and majority of non-chordates.
- Triploblastic condition: All chordates show triploblastic condition. They have germ layers, namely ectoderm, mesoderm and endoderm.
- Coelom: All chordates are coelomate animals because they have a true coelom lined entirely by mesoderm. A secondary body cavity or true coelom exists between body wall and the digestive tube.
- Closed circulatory system: Blood is circulated by arteries, veins and capillaries in chordates. Thus, chordates show closed circulatory system.
- Complete digestive system: Chordate digestive tract always has mouth for ingestion of food and anus or cloacal aperture for egestion of faeces.
- Skeleton: Endoskeleton is made up of bones and cartilage, which supports the body and give particular shape.



CLASSIFICATION OF PHYLUM CHORDATA UPTO CLASSES

TABLE 1.2. OUTLINE CLASSIFICATION OF PHYLUM CHORDATA.



Subphylum Hemichordata is now considered to be an invertebrate group.

CHAPTER NO.2 - INTRODUCTION TO GROUP PROTOCHORDATA SALIENT FEATURES OF PROTOCHORDATA (ACRANIATA)

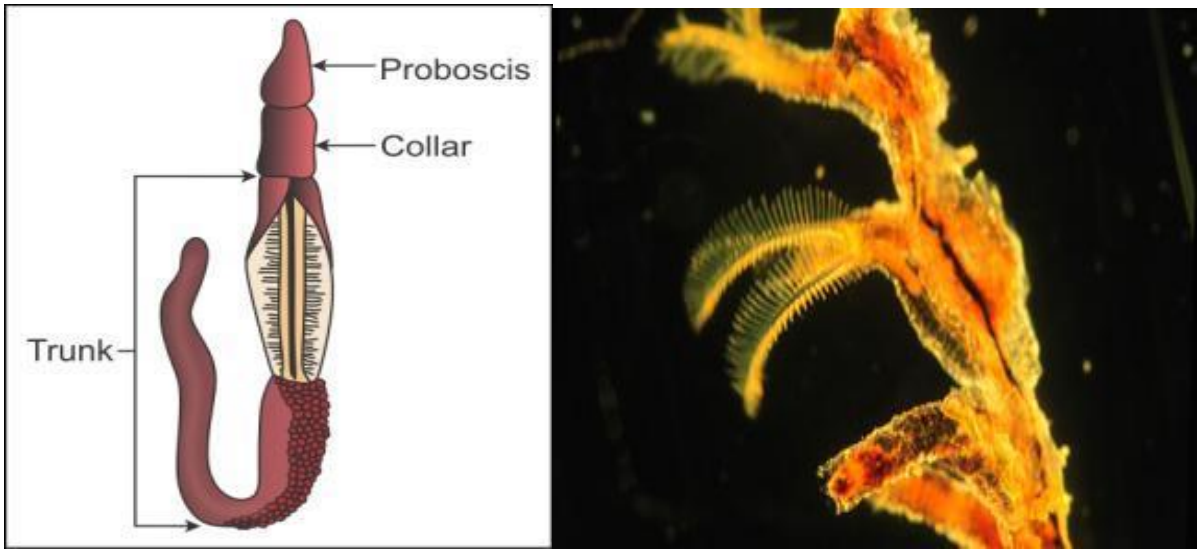
- They are exclusively marine and mostly of small forms.
- They lack head and cranium (Skull).
- Notochord in some forms is confined to the tail in the larval stage which disappears in adult stage.
- Vertebral column, jaws and paired appendages are absent.
- Dorsal tubular nerve cord, notochord, gill slits and myotomes are usually present.
- Mode of feeding is usually ciliary.
- Sexes may be united or separate.
- The group Protochordata is divided into three subphylums:

  Hemichordata, Urochordata and Cephalochordata.

SALIENT FEATURES OF SUBPHYLUM HEMICHORDATA

- They are marine, solitary or colonial.
- Body is soft, fragile, vermiform, unsegmented, bilaterally symmetrical and triploblastic.
- Body is divisible into three distinct regions: proboscis, collar and trunk.
- Body wall consists of a single layer of epidermis with mucous glands.
- The alimentary canal is complete, in the form of straight of U-shaped tube.
- Numerous pairs of gill slits are present on the dorso-lateral anterior part.
- They are ciliary filter feeders.
- The circulatory system is simple and well developed; closed type.
- Reproduction is mostly sexual. Sexes are separate or united, gonads one or many pairs.
- Fertilization is external. Development is mostly indirect through a free swimming tornaria larva.

Example: ***Balanoglossus and Rhabdopleura***



SALIENT FEATURES OF SUBPHYLUM UROCHORDATA

- They are marine, solitary or colonial, distributed from Arctic to Antarctic oceans.
- Mostly sedentary (fixed), simple, aggregated in groups.
- The body varies in shape and size. They have different colours.
- Adult body degenerate, sac-like, unsegmented without paired appendages and usually tailed.
- The body is covered by protective tunic or test.
- Notochord is present only in larval tail hence the name Urochordata.
- Digestive system is complete.
- They are ciliary feeders.
- Circulatory system is open. Heart is simple, tubular and ventral.
- Mostly these animals are hermaphrodite with external and cross fertilization.

Example: *Herdmania and Salpa*

Figure 2.21 Examples of Urochordata

SALIENT FEATURES OF SUBPHYLUM CEPHALOCHORDATA

- They are marine and widely distributed in swallow waters.
- Mostly sedentary and buried with only anterior body end projecting above the sand.
- They are small animals with slender and fish like body which is metameric and transparent. 4) Head is lacking. Body is with trunk and tail.

- Notochord and nerve cord are persistent and extend along the entire body, anteriorly right upto tip of the snout, hence called Cephalochordata.
- There is no exoskeleton, epidermis is single layered.
- Alimentary canal is complete.
- Well-developed closed type of circulatory system, but heart is absent.
- Sexes are separate. Reproduction is by sexual method.
- Fertilization is external in sea water.

Example: *Amphioxus and Asymmetron*

MCQs

1. What is the habitat of Protochordates?
   a) Marine b) Freshwater
   c)Terrestrial. d) Arborial

2…….. lack head and cranium (Skull).
   a) Ambhibia b) Reptiles c) Aves d) Protochordates

3. Vertebral column, jaws and paired appendages are absent in group……..
   a) Protochordates b) Birds c) Mammals d) Amphibians

4. The group Protochordata is also called as ……
   a) Invertebrates b) Vertebrates c) Craniata d) Acraniata

5. The group Protochordata is divided into sub-phylum Hemichordata, Urochordata and ……..
   a) Cephalochordata b) Echinodermata c) Vertebrata d) Invertebrata

6. In ……body is divisible into three distinct regions: proboscis, collar and trunk.
   a) Echinodermata b) Hemichordata c) Vertebrata d) Invertebrata

7. In Hemichordata body is unsegmented, bilaterally symmetrical and ……..
   a) Triploblastic b) Diploblastic c) Monoblastic d) Coeloblastic
8. In Hemichordata the alimentary canal is complete and in the form of…….tube.
   a) L-shaped b) J-shaped c) U-shaped d) V-shaped

9. To which sub phylum, *Balanoglossus* belongs?
a) Urochordata b) Hemichordata c) Vertebrata d) Cephalochordata

10. To which sub phylum, *Rhabdopleura* belongs?
a) Hemichordata b) Echinodermata c) Cephalochordata d) Urochordata

11. In Cephalochordata the circulatory system is of closed type but heart is …….
a) present b) absent c) well developed d) functional

12.In ……the Alimentary canal is complete.
a) Hemichordata b) Echinodermata c) Cephalochordata d) Urochordata

13. To which sub phylum, *Amphioxus* belongs?
a) Urochordata b) Hemichordata c) Vertebrata d) Cephalochordata

14. To which sub phylum, *Asymmetron* belongs?
a) Hemichordata b) Echinodermata c) Cephalochordata d) Urochordata

15. Which of the following is not Protochodate----------
a) Herdmania b) Amphioxus c) Salpa d) Petromyzon

16. Head and cranium is absent in ……
a) Fishes b) Protochordates c) Aves d) Reptiles

17. To which sub phylum, Salpa belongs?
a) Urochordata b) Hemichordata c) Vertebrata d) Cephalochordata

18. To which sub phylum, *Herdmania* belongs?
a) Hemichordata b) Echinodermata c) Cephalochordata d) Urochordata

19. To which sub phylum, *Amphioxus* belongs?
a) Hemichordata b) Echinodermata c) Cephalochordata d) Urochordata

20. Which of the following is not Protochodate----------
a) Petromyzon b) *Branchiostoma* c) *Rhabdopleura* d) *Asymmetron*

CHAPTER NO.3 - INTRODUCTION TO SUBPHYLUM VERTEBRATA SALIENT FEATURES OF VERTEBRATA (CRANIATA)

- Body is bilaterally symmetrical.
- Body is divided into head, neck, trunk and tail.
- Body covered by an integument, made up of two parts; outer epidermis and inner dermis.
- The endoskeleton is associated with a complex musculature.
- Presence of large coelom or body cavity, containing visceral organs.
- Presence of complete digestive tract ventral to the nerve cord.
- Lower vertebrates have paired gills and higher vertebrates have lungs as a respiratory organ.
- They have closed blood circulatory system with network of arteries, veins and capillaries.
- They have a large, highly complex brain and 10 to 12 pairs of cranial nerves.
- Sexes are separate. Single pair of gonads is present.

GENERAL CHARACTERS OF SECTION AGNATHA (Agnatha – Jawless)

- They are earliest vertebrates.
- The jaws are absent in these animals, hence called as Agnatha.
- They have a distinct head and skull but cephalization is of a low order.
- Skull is unique and difficult to homologize.
- Brain is present, but of primitive type.
- Paired appendages are absent.
- Vertebral column is poorly developed.
- Notochord persists permanently.
- Some are parasitic (blood sucking cyclostomes), while some feed on minute particles by producing food currents.
- Almost all are extinct cyclostomes.

Example***: Petromyzon* and *Myxine***

GENERAL CHARACTERSOF SECTION GNATHOSTOMATA

- They have a mouth with true upper and lower jaws.
- Olfactory organs and nostrils are paired.
- There is well developed endoskeleton.
- Three semicircular canals in each internal ear are present.
- There is closed blood circulation.

Example: ***Frog, Labeo, Catla, Snakes, Birds etc.***

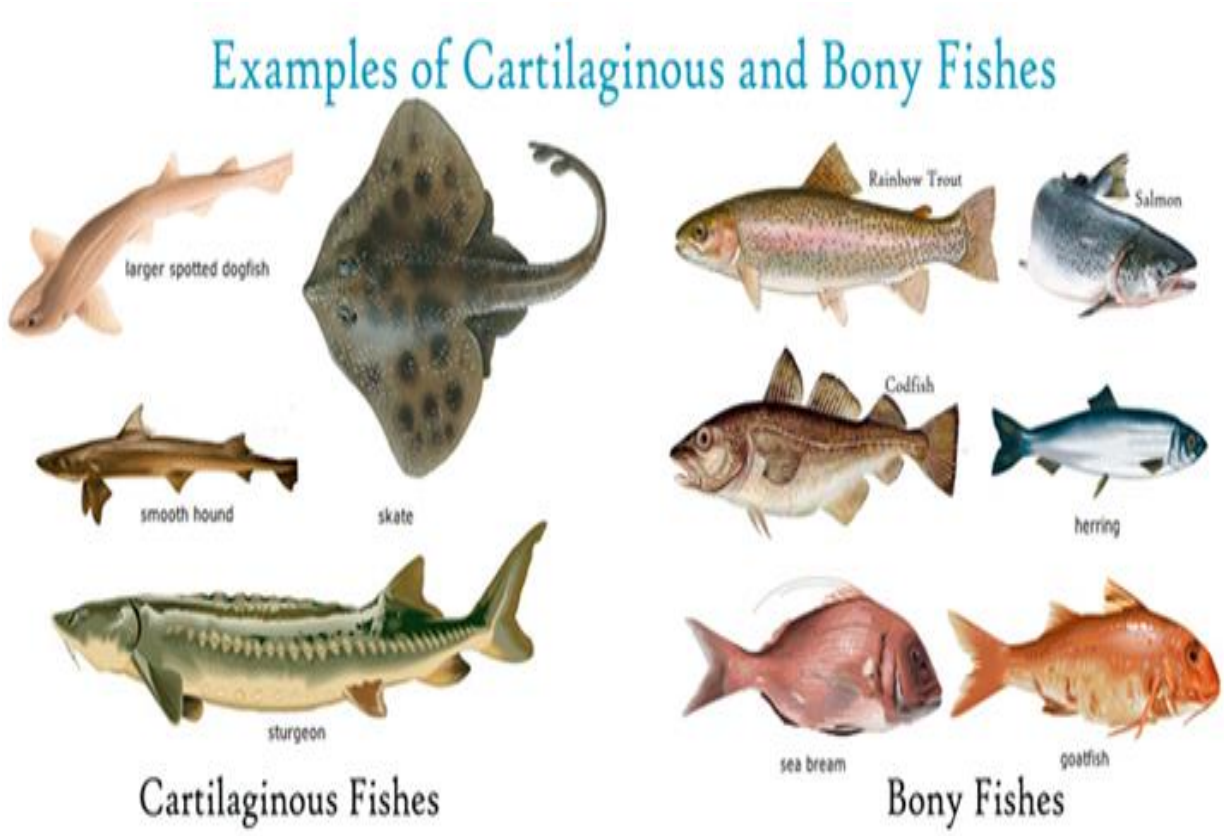
CHAPTER NO.4 - INTRODUCTION TO CLASS PISCES SALIENT FEATURES OF CLASS PISCES

- They are aquatic, either freshwater or marine.
- The skin is covered with scales, dermal denticles or bony plates.
- They possess paired and unpaired fins supported by spiny rays.
- The unpaired fins are dorsal, caudal and anal fins, while the pectoral and pelvic fins are paired.
- The endoskeleton is cartilaginous or bony.
- Respiratory organs are gills.
- These are cold blooded animals.
- Lateral line system is well developed.
- The heart is two chambered with one auricle and one ventricle.
- Presence of ten pairs of cranial nerves.
- The gonads possess true gonoducts.
- Sexes are separate and development is indirect.

SALIENT FEATURES OF SECTION CHONDRICHTHYES

- Most of the fishes are marine, some are fresh water and all are predaceous
- Body is spindle shaped, laterally compressed or dorsoventrally flattened.
- The skin is tough covered with minute placoid scales.
- Both median and paired fins are present and supported by horny fin rays.
- Endoskeleton is entirely cartilaginous, hence called as chondrichthyes.
- Five to seven pairs of gills are present for respiration.
- Heart is two chambered, hepatic and renal portal systems are present.
- Stomach is ‘J’ shaped, intestine is short with spiral valve.
- Brain is large, olfactory lobes and cerebellum is large.
- Sexes are separate, paired gonads and internal fertilization.

Examples: ***Scoliodon, Chimaera, Torpedo, Trygon Chimaera***



SALIENT FEATURES OF SECTION OSTEICHTHYES

- Body is spindle shaped and laterally compressed.
- Both median and paired fins are present and supported by bony fin rays.
- Body covered by ganoid, cycloid or ctenoid scales.
- Endoskeleton is partly or wholly made up of bony vertebrae.
- Mouth is usually terminal with numerous teeth.
- Four pair of gills is present covered by operculum.
- An air bladder is generally present
- Heart is made up of two chambers.
- Brain has small olfactory lobes and small cerebellum.
- Sexes are separate, paired gonads and fertilization is external.

Examples: ***Labeo rohita, Catla catla, Hippocampus, Mrigal***

TYPES OF SCALES IN FISHES

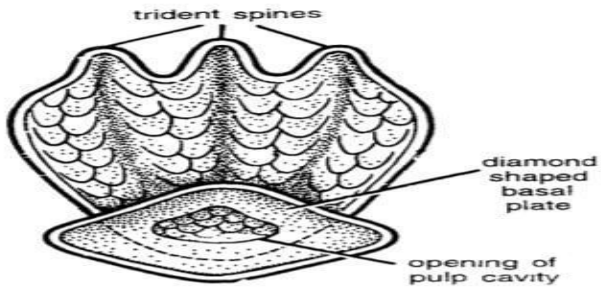
Fish scales Placoid Non placoid (from epidermis and dermis) (from dermis only) Elasmobranch Cosmoid Ganoid Bony plates Latimeria *Polypterus acipencer* Cycloid Ctenoid Amia Flounders Dipnoi

1) Placoid Scales:

These are found in Elasmobranch fishes only. These are also called as dermal denticles. These are closely set together but do not overlap each other giving sandpaper like appearance to the skin. Each placoid scale consists of two parts a rhomboidal basal plate embedded in the dermis and a flat trident spine, projecting outward and backward through the epidermis. 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 cavity contains many odontoblasts which are dentine forming cells. Fine canaliculi arise from the pulp cavity and reach the dentine.

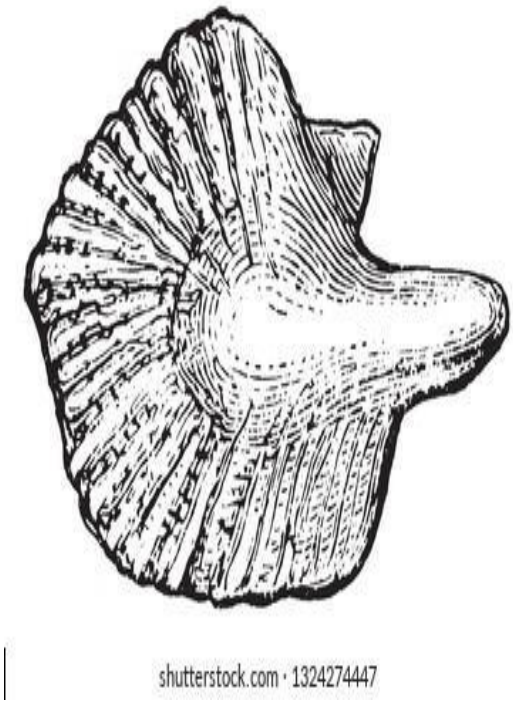
Example: ***Scoliodon***



2) Cosmoid Scales:

These are ornament like scales. These type of scales are characteristics of certain ostracoderms, placoderms and extinct sarcopterygians (lobe finned fishes and lung fishes but do not occur in living fishes). Each cosmoid scale consists of three layers as follows: Isopedine: This is the inner layer consisting of layered bone. It is pierced by channels for blood vessels. Vascular layer: This is the middle layer consisting of spongy bone. It contains numerous vascular spaces. Cosmine: This is the outer layer consisting of dentine containing pulp cavities.

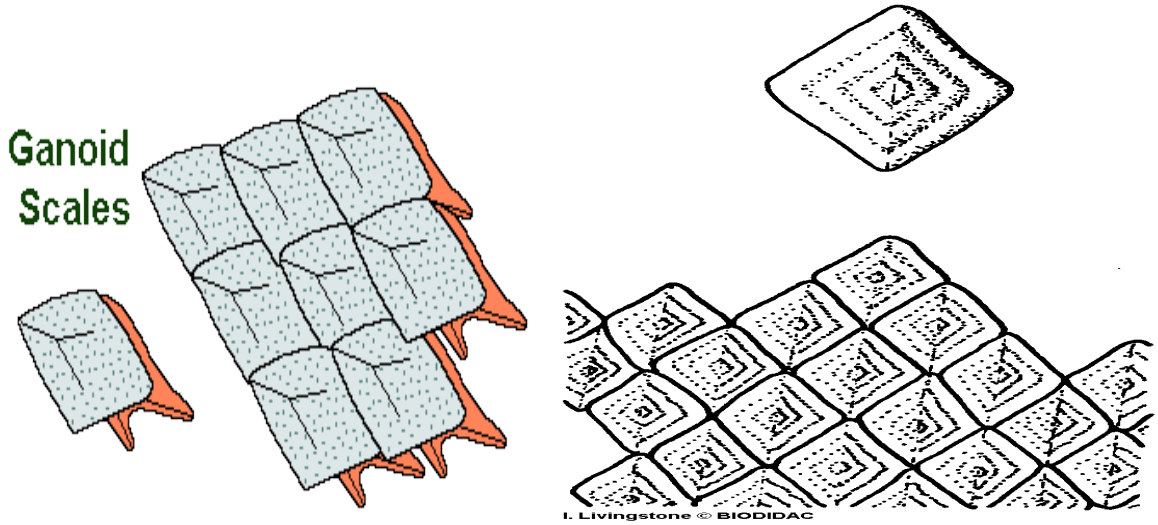
Example: ***Latemaria***



3) Ganoid Scales:

Ganoid or rhomboid scales are thick, usually diamond shaped plates closely fitted side by side, like tiles, providing bony armour to the fish. In some fishes they may be overlap. In this type, the layered bone isopedine is present. The spongy bone is absent and the cosmine layer is reduced. The cosmine layer is a hard multilayered ganoine. This gives a lustrous metallic shining.

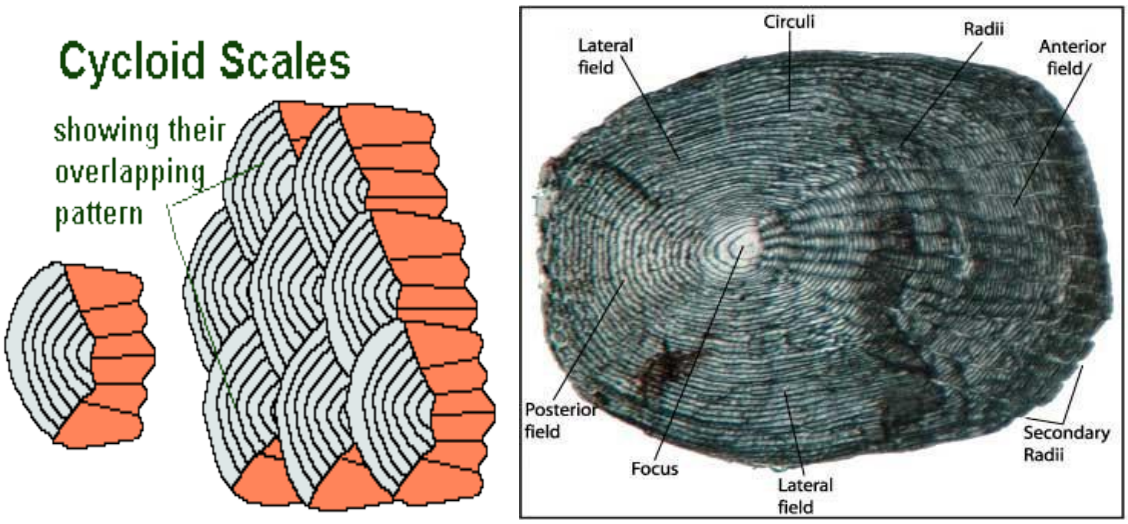
Example: ***Acipencer, Polypterus***



4) Cycloid Scales:

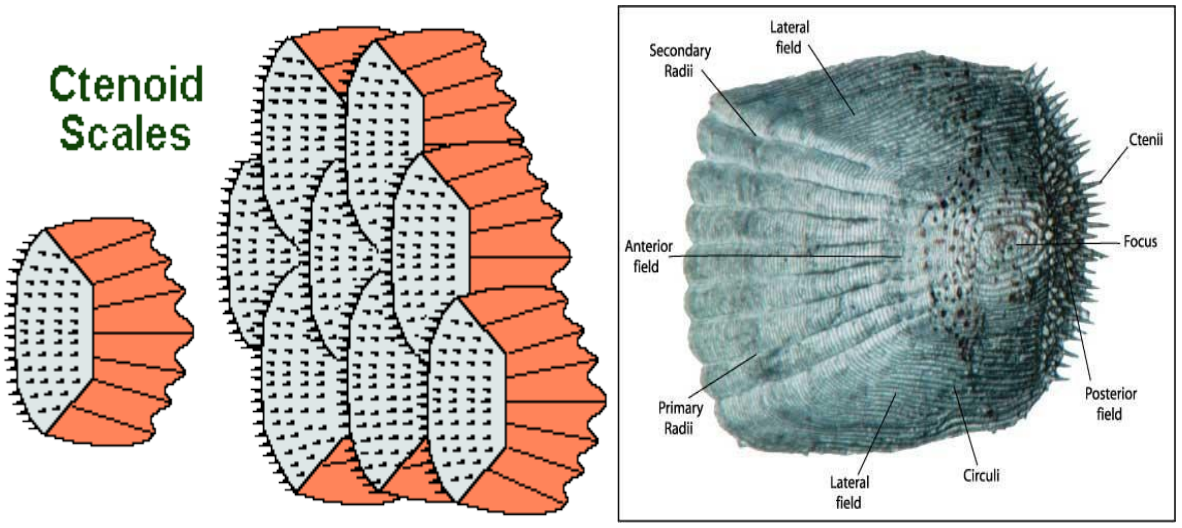
These are thin, flexible, translucent plates, rather circular in outline, thicker in the centre and marked with several concentric lines of growth which can be used for determining the age of fish. They are composed of a thin upper layer of bone and a lower layer of fibrous connective tissue. They overlap each other and each scale is embedded in a small pocket of dermis.

Example: ***Dipnoi, Amia, Carps, Cods***



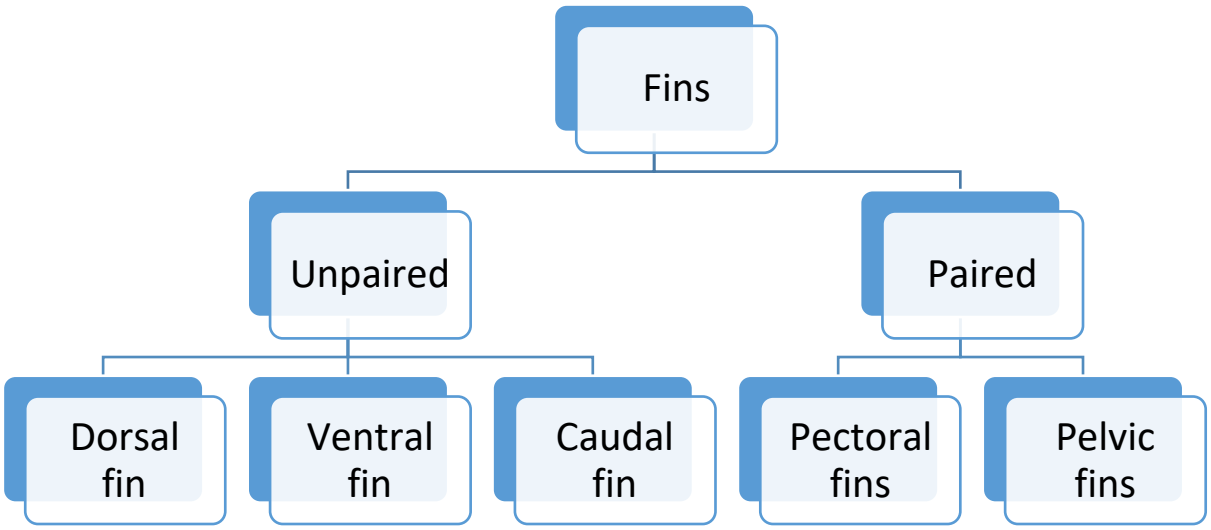
5) Ctenoid Scales:

Structure and arrangement of these scales is similar to the cycloid scales. They are more firmly attached and their exposed free hind part is not overlapped, but bears numerous small combs like teeth or spines. Ctenoid scales are generally present at dorsal side of skin of fish.
Example: ***Flounders***



TYPES OF FINS IN FISHES

- **Thin, broad, flat portion of integument**
- **Supported by bony or cartilaginous fin rays**
- **Fin rays are fibrous or horney**
- **Organ of locomotion**
- **Organ of body balance**
- **Organ of suspension**



1) Unpaired or Median Fins:

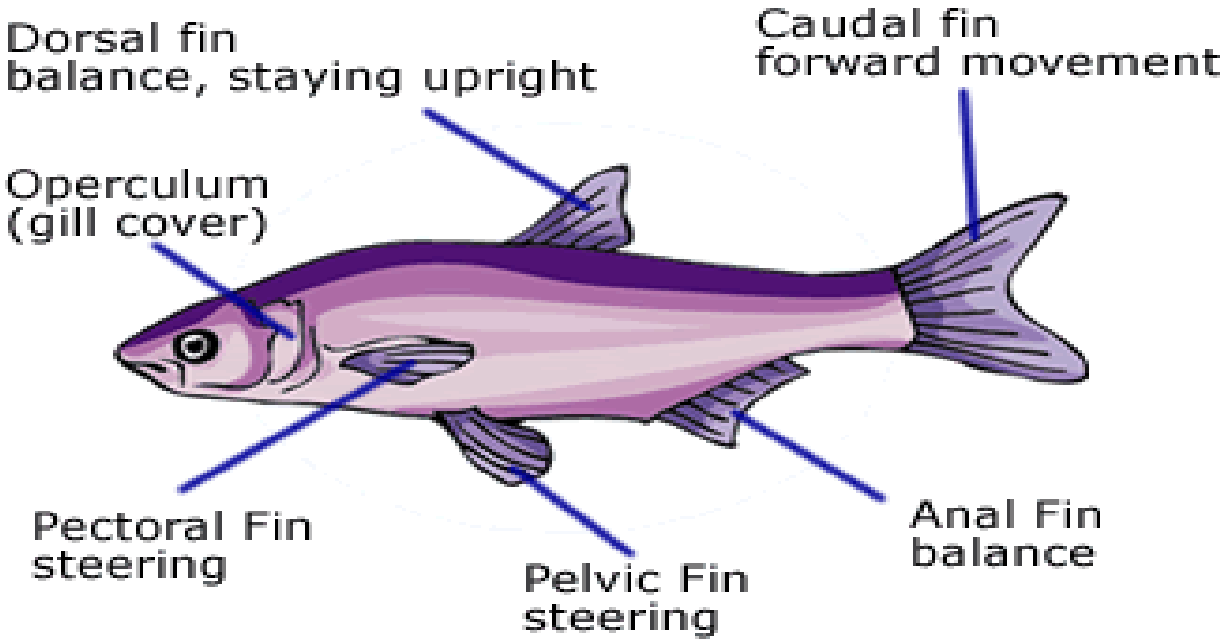
These include one or two dorsal fins along mid-dorsal line, a ventral anal fin behind anus and a tail or caudal fin around the tip of tail. Dorsal fin may be in a series or reduced or absent. Anal fin may be absent in bottom dwellers. The dorsal and the anal fins are provided with a fleshy lobe the base consisting of fin muscles. In all the higher bony fishes, the fleshy lobe at the base of the fin has disappeared.

Dorsal fins

- **Present in mid dorsal line**
- **One or two dorsal fins**
- **In series or reduced or absent**
- **Fleshy lobes made of muscles at base**

Ventral fins

- **Near anus**
- **Absent in bottom dwellers**
- **Fleshy lobe made of muscles at base**
- **In all bony fishes fleshy lobe disappeared**



2) Paired or Lateral Fins:

There are two different types of paired fins. The pectoral fins are present at the anterior side; whereas pelvic fins are present at the posterior side. The pelvic fin also called as thoracic fins when placed below the pectoral fins and abdominal when situated just in front of anus. The supporting endoskeleton of the paired fins varies greatly in different groups of fishes.

- Paired fins were absent in ancestral fishes
- Paired fins developed during evolution

Anterior Pectoral fins

- Present in thoracic region

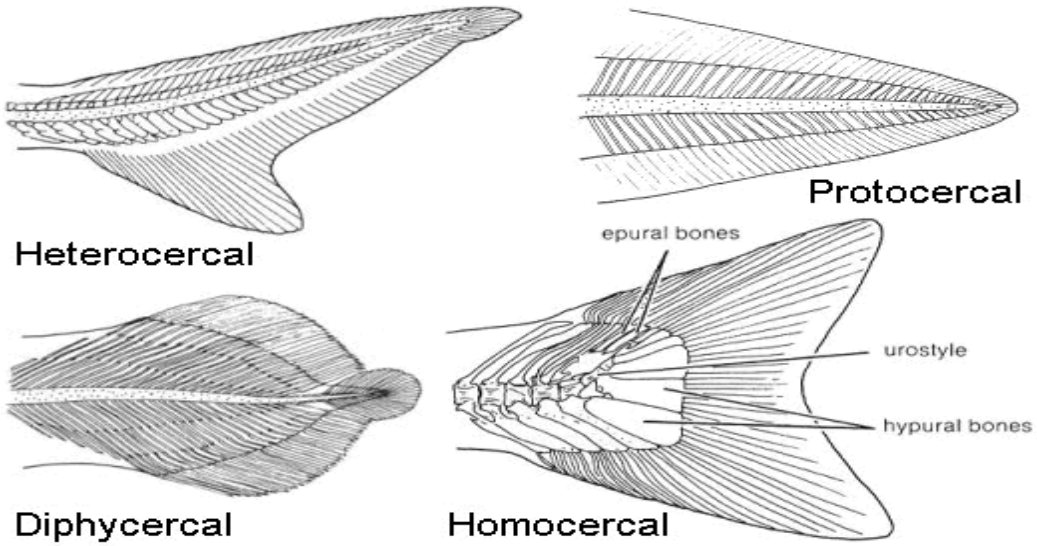
Posterior Pelvic fins

- Also called as Thoracic fins when placed below pectoral fins
- Also called as Abdominal fins when placed before anus

3) Caudal Fins:

The caudal fin differs from the dorsal and anal fins in the nature of its supporting skeleton. The caudal fin is well developed in most fishes because it is important in direction and forward propulsion during swimming.

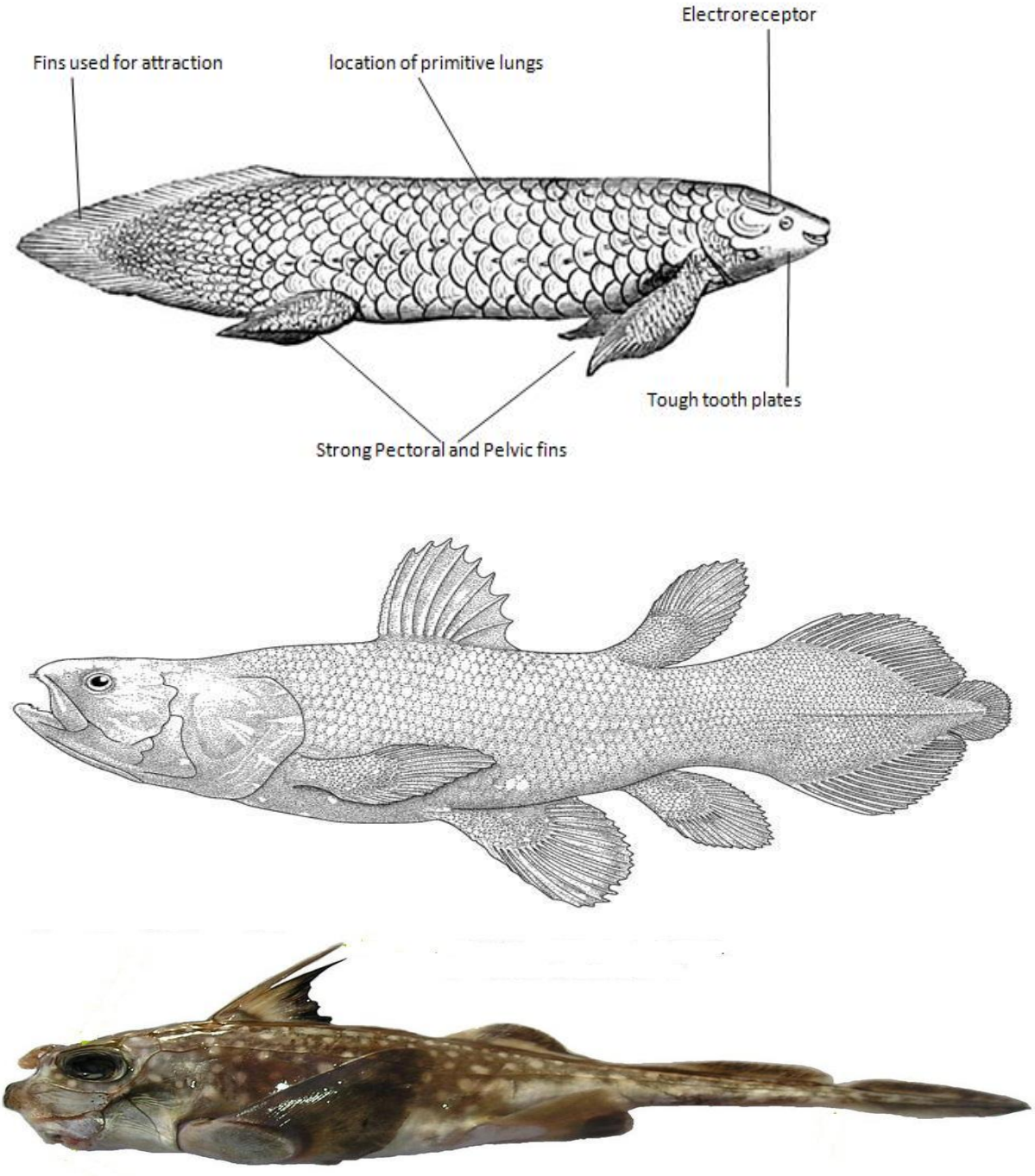
There are three different types of caudal fins found in fishes:



a) Protocercal Fin (First Tail Fin): The protocercal or Diphycercal fin is probably the most primitive type. The hind end of the notochord or vertebral column is straight and divides the caudal fin into two equal lobes, the dorsal epichordal and the ventral hypochordal lobe. The diphycercal fins are also used for secondarily symmetrical tails as in Dipnoi. Diphycercal caudal fin occurs in modern cyclostomes, primitive sharks. In Chimaera and some deep sea fishes, the fin is called isocercal which is very much elongated and symmetrical.

- Also known as diphycercal fin
- Most primitive tail
- Notochord or vertebral column extend in fin
- Notochord or vertebral column support fin
- Dorsal epichordal lobe
- Ventral hypochordal lobe

Example: *Dipnoi, Latimeria, Chimaera*

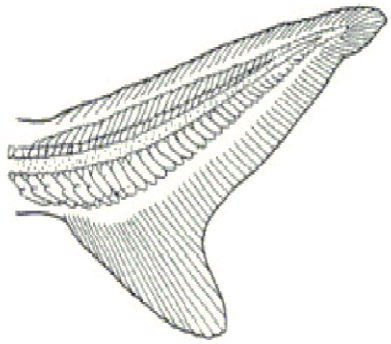


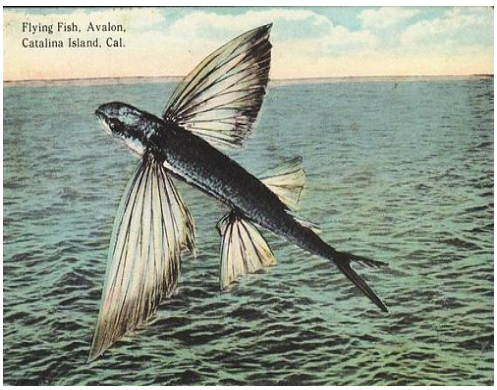
b) Heterocercal Fin: The heterocercal or unequal fin is characteristic of the chondrichthyes and some primitive bony fishes. The hind end of the notochord is bent upwards and continues almost upto the tip of the caudal fin. The ventral hypochordal lobe is much larger than the dorsal epichordal, so that the caudal fin is asymmetrical both externally and internally. Heterocercal caudal fin is the characteristic of bottom feeders, with ventral mouth and without swim bladder. The strokes of larger dorsal lobe in swimming serve to direct fish towards bottom.

Example: *Scoliodon, Cypselurus*

- Found in chondrichthyes and primitive sharks

- Notochord bend and extend in epichordal lobe
- Externally asymmetrical
- Internally asymmetrical
- Heterocercal larger epichordal lobe
- Found in bottom feeders
- Notochord or vertebral column extend to tip of epichordal lobe
- Mouth is ventral

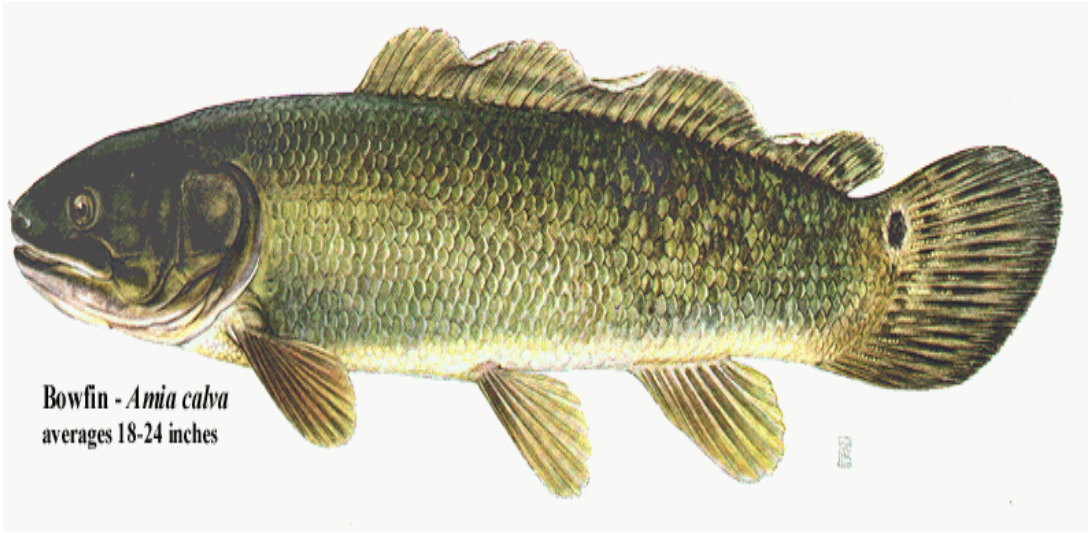


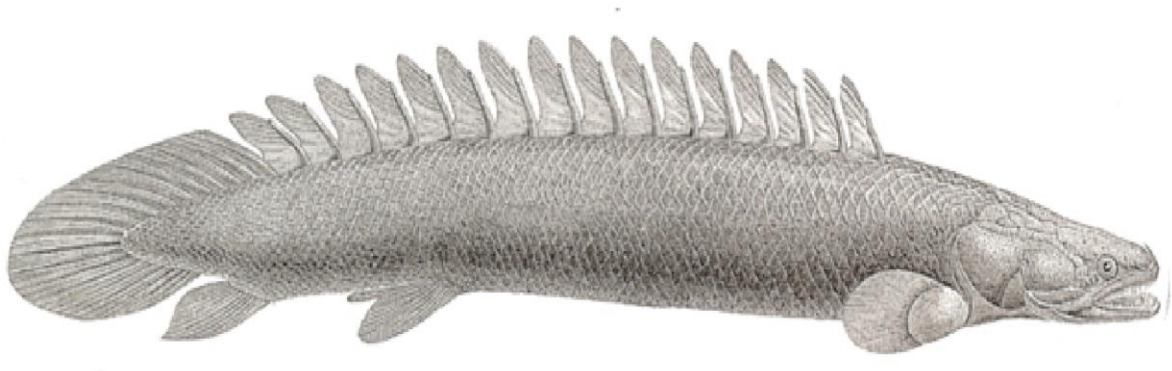


c) Homocercal Fin: The homocercal or equal fin is characteristic of higher bony fishes. It is symmetrical externally consisting of equal sized epichordal and hypochordal lobes. But internally the tail is asymmetrical and the hinder end of the vertebral column is turned upward and greatly shortened. The end of the vertebral column does not reach the posterior limit of the fin. Actually, the epichordal lobe is much smaller than in the heterocercal tail; the homocercal tail is derived from the heterocercal type and intermediate types are found in many bony fishes.

- Symmetrical externally
- Asymmetrical internally
- Vertebral column turned in to epichordal lobe or greatly shortened
- Vertebral column not reach tip
- Evolved from heterocercal
- Mouth is terminal

Example: *Amia, Cod, Tuna, Polypterus*


Bowfin - *Amia calva*
averages 18-24 inches



Uses of Fins:

- Fishes swim mainly by the lateral movements of caudal fin and other fins are used as steering devices and rudders.
- When the body is at resting position, the paired lateral fins serve to maintain equilibrium.
- Fins are also modified to serve other purposes i.e. lung fishes use it as legs in walking.
- The flying fish use their large and extended hypocercal fin for gliding.
- Pelvic fins in some chondrichthyes became modified as claspers and in some teleosts the anal fin forms an intermittent organ or ovipositor.

CHAPTER NO.5 - INTRODUCTION TO CLASS AMPHIBIA

SALIENT FEATURES OF CLASS AMPHIBIA

- They are aquatic, only freshwater as well as terrestrial.
- Body is divisible into head, neck and trunk.
- Skin is smooth, moist and rich in mucous glands.
- Respiration on land by lungs and in water by skin and gills. As they show two modes of life on land and in water, therefore called as Amphibian.
- Endoskeleton is large bony. Vertebral column, pelvic and pectoral girdles are present.
- Heart is three chambered with two auricles and one ventricle.
- Brain is well developed. Ten pairs of cranial nerves are present.
- Sexes are separate, oviparous, metamorphosis and development occurs in water only.
- Most forms under hibernation in winter; some shows aestivation in dry summer.

Example: ***Ichthyophis, Salamandra, Frog, Bufo, Hyla***

SALIENT FEATURES OF ORDER APODA

- The limbs and tail are absent in these animals.
- Pelvic and pectoral girdles are absent.
- Body elongated with ring like grooves, giving an appearance like worm.
- Body consists of only head and trunk.
- The skin contains minute dermal scales.
- Eyes are small and they are non-functional.
- Skull is compact with complete bony roof.
- Males have copulatory organs so fertilization is internal.
- They are strictly burrowing forms and widely distributed in the tropical region.

Example: ***Ichthyophis, Siphonops***

Image 1. *Ichthyophis kodaguensis* in life from Basarekattae, Western Ghats

SALIENT FEATURES OF ORDER URODELA

- Body is long, narrow, consisting of head, trunk and tail.
- Tail is present, useful for locomotion both on land and in water.
- Adults and larvae are similar in appearance because adults have retained many larval characters. This condition is called as Neoteny.
- The larvae and aquatic adults have lateral line receptors.
- Gills and gill slits may persist in adult but internal gills are absent.
- The limbs are of equal size but weakly developed.

- Fertilization is usually internal.
- Eyes have outer covering called as eyelids.
- The Urodela is found in Asia, Europe, North Africa and North America.

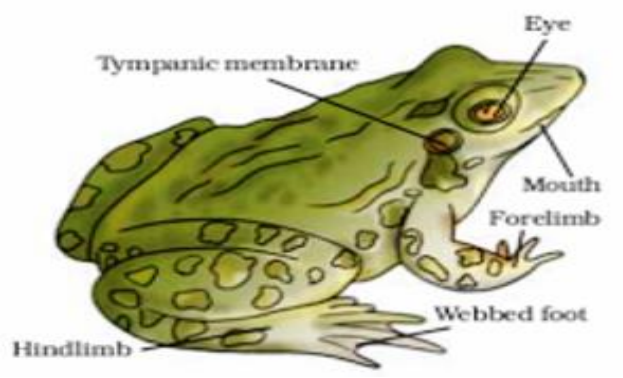
Example: ***Salamandra,*** ***Siren,*** ***Triton***



SALIENT FEATURES OF ORDER ANURA

- They have a short, broad body comprising of head and trunk. Tail is absent in adults.
- Skin does not show presence of scales.
- Forelimbs are short with 4 digits and hind limbs, long and stout with 5 digits.
- The hind limbs are adapted for leaping and swimming.
- They are first vocal vertebrates.
- They are aquatic, terrestrial and arboreal.
- Fertilization is external.
- Larva is very different from the adults so that its metamorphosis into an adult is marked.
- They have a tongue and tympanum.

Example: ***Rana tigrina, Hyla, Alytes Frog Bufo (Toad)***



PARENTAL CARE IN AMPHIBIA

Amphibians show extraordinary parental care to save as many as possible. The frogs and toads lay large number of eggs. In some cases about 10,000 eggs are laid per year just to save at least a few hundreds of them. Frog eggs are relished by fish, turtle, and snakes and even by other frogs. It is really hard for an egg to transform into an adult from after overcoming all these hurdles. Hence, parents try to protect their eggs from enemies. All the groups of amphibians show instances of parental care.

PARENTAL CARE IN APODANS

Certain Apodans, like Ichthyophis and Hypogeophis, lay eggs in burrows, where the mother carefully guards them by coiling her body around them till they hatch. In Geotrypetes, large yolky eggs are retained in the posterior parts of the oviducts, where development occurs. When yolk is consumed the embryos hatch. These spread throughout the length of the oviducts and develop further, deriving nourishment by the oral absorption of uterine milk. The oviducal wall and foetal epithelium are highly vascular, which allow gaseous exchange. Parental care in Ichthyophis

PARENTAL CARE IN URODELES

These are tailed amphibians. Amphiuma and Salamanders exhibit great level of parental care. In Amphiuma the Congo eel, the mother carefully guards the eggs by coiling her body around them. In *Desmognathus fuscus*, the dusky Salamander, the female carries the eggs attached round her neck. The female of Salamandra, retains her few eggs within her body for 10-12 months and gives birth to the larvae. These larvae complete their development in water.

In the European Alpine Salamander, the mother retains her one or two eggs that develop fully before birth. Parental care in Salamander

Parental care in salamander

Parental care in *Pipa*

PARENTAL CARE IN ANURANS

Frogs and toads show the highest degree of parental care. Most of the frogs step into water for laying eggs. They deposit their eggs on plants overhanging ponds and in moist places near ponds. A South African tree frog *Phylomedusa* glues its eggs to the leaves hanging over a pond and on hatching, the tadpoles roll down straight into the water below where they undergo further development. A Brazilian tree frog *Hyla fabre* lays eggs in mud craters called the nurseries which the male builds in shallow water by moving in a ring and pushing up mud. A nursery is about 30 cm in diameter and its rim is a little higher than the level of water. Male of the European midwife toad *Alytes obstericians* takes the eggs along with it to protect them. The male of this toad winds the string of eggs around his hind feet and burrows into moist soil. It periodically comes out to feed and moisten the eggs. When the larvae are ready to hatch, it shifts to a nearby pond to release the larvae. The Pipa species have a more interesting way of protecting their eggs. Female *Pipa dorsigera* undergoes certain changes during the breeding season. The egg carrying tube, oviduct, elongates and protrudes out to reach the skin on its back. After laying eggs on its own back the female allows the male to fertilize and spread the eggs evenly on its back. The dorsal skin then develops many pouches to enclose the eggs. For about ten weeks the female carries the embryos on her back. After the tadpoles emerges breaking open the pouches, her skin returns to its normal size. Parental care in Toad Parental care in Pipa

CHAPTER No.6 STUDY OF *SCOLIODON*

Fishes can be divided into two groups: (1) Cartilaginous fish or Chondrichthyes (2) Bony fish or Osteichthyes. The genus *Scoliodon* is a cartilaginous fish.

Systematic Position:

Phylum	Chordata
Sub-phylum	Vertebrata or Craniata
Section	Gnathostomata
Class	Chondrichthyes
Order	Pleurotremata
Family	Carcharinidae
Genus	*Scoliodon*
Species	*sorrakowah*

Habits and Habitat:

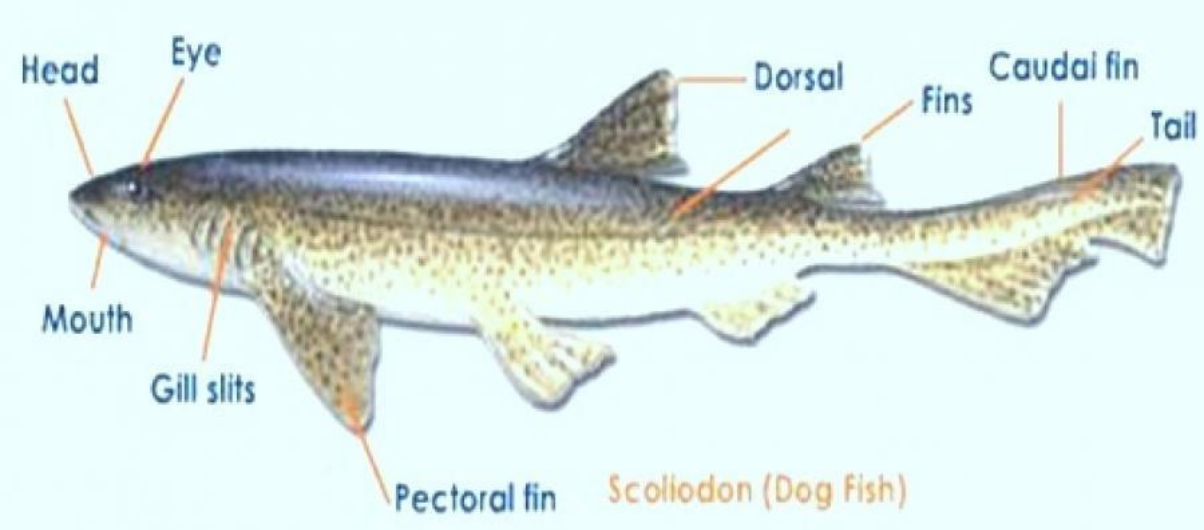
It is **carnivorous** fish and **voracious** feeder. The *Scoliodon* is active swimmer and aquatic breather like other fishes. *Scoliodon* exhibits sexual dimorphism i.e. sexes are separate and distinguishable externally. Fertilization is internal. The *Scoliodon* is **viviparous** i.e. gives birth to the young ones. It has a wide distribution in the Indian Ocean, Bay of Bengal, and Eastern Pacific Ocean and in the Atlantic Ocean along the coast of South America.

Economic Importance:

1. *Scoliodon* has great educational and experimental value because of its availability and size.
2. Sharks are used as human food in many countries, but *Scoliodon* is consumed by African poor people.
3. The dried skin of shark is called **shagreen** is used for covering carcasses, jewel boxes, sword handles and ornamental works.
4. Scoliodon fins are dried and then boiled to yield a gelatinous substance favored for soups.
5. The dried skin of shark also used for smoothing and polishing furniture.
6. *Scoliodon* can be used as fertilizer; cod liver oil is good medicine.

External Characters:

The body of *Scoliodon* is 60 cm long, laterally compressed, spindle-shaped, tapering at the both ends. The dorsal and lateral sides are dark grey while the ventral side is white. The body surface is very rough due to presence of **placoid scales**. The body is divisible into head, trunk and tail.

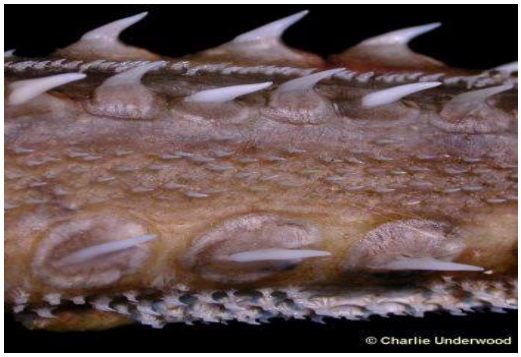


1) Head: The head is flattened and dorso-ventrally compressed, prolonged into blunt, wedge-shaped snout. The mouth is wide crescentic in shape, located ventrally and is guarded by the upper and lower jaws. The large circular eyes are at the sides of the head and provided with a movable nictitating membrane. The nostrils are obliquely placed on the ventral surface of snout they are olfactory in function instead of respiration. There are five vertical slits on each side are' present called the branchial or gill clefts.

2) Trunk: The middle region of body extends from just behind the last gill cleft up to the cloacal aperture. Trunk is thickest part of the body and is laterally compressed. Trunk contains median unpaired fins and paired lateral fins. A median unpaired fin includes first dorsal fin, second dorsal fin and ventral fin. The first dorsal fin found anterior to middle part of the body. The second dorsal fin is found a little behind the first dorsal fin. The ventral fin is found on ventral side, little distance to the position of second dorsal fin. There are 2 pairs of lateral or paired fins on trunk as pectoral fins and the pelvic fins. The pectoral fins are larger than pelvic fins. In male, each pelvic fin bears along its inner edge a stiff, rod-like copulatory organ called the **clasper**. The cloacal aperture opens at the base of the tail on the ventral side between the two pelvic fins.

3) **Tail:** The tail is portion behind cloaca, and is laterally compressed, bent up-wards. The caudal fin is bifurcates into dorsal epichordal and ventral well developed hypocaudal lobes. It has structure different than circular so such tail is known as **heterocercal** tail.

Placoid scales



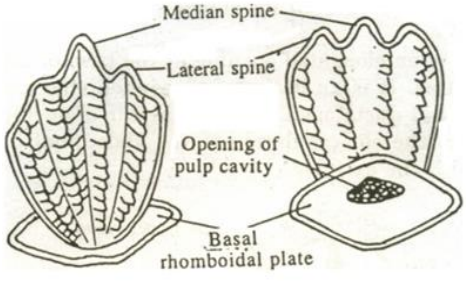


Fig. 3.5: Placoid Scale

The placoid scales are characteristics of elasmobranch or chondrichthyes fishes. They are derived from both epidermis and dermis of skin. Placoid scales are embedded in the skin and are minute dentine embedded in the dermis. A typical placoid scale is distinguished into the basal plate and spine.

Basal plate: It is a diamond-shaped or rhomboidal plate formed of cement like material. It lies embedded in the dermis and is firmly attached to it by strong fibers of connective tissue. The basal plate is perforated by a small opening which leads into the pulp cavity of the spine. The pulp cavity is filled with numerous odontoblast cells, connective tissue, fibers, nerve cells and blood vessels which collectively form the pulp.

The Spine: It is a flat, backwardly directed trident structure projecting out of the skin and giving it roughness. The spine composed of a hard calcareous substance, the dentine which is external coated with a hard dense enamel like substance, the vitrodentine. The vitrodentine is secreted by the epidermal cells.

Importance of Scales in Fishes:

I. They protect the body and for that purpose are differently modified into spines, knobs or bony plates.
2. The structure and arrangement of scales has a taxonomic value.
3. Scales are also useful in identification of fishes.
4. Scales form an important tool in the paleontological study of fishes, as they are well preserved and get embossed clearly on the surrounding clay.

Digestive system of *Scoliodon*:

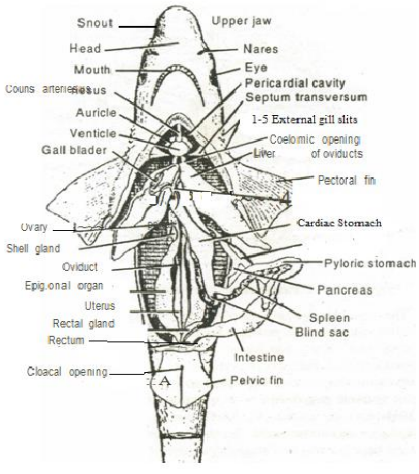


Fig. 3.7: General Viscera of *Scoliodon*

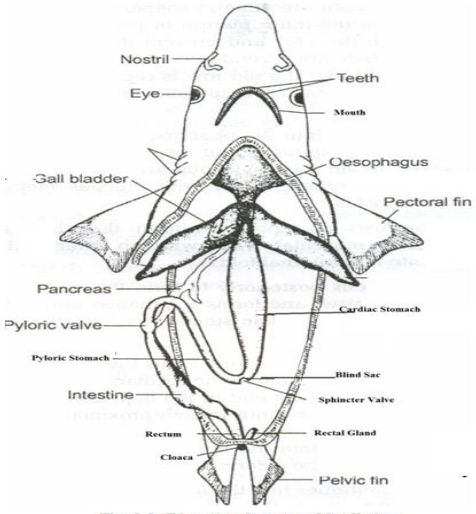


Fig. 3.8: Digestive System of Scoliodon

a) Alimentary canal: The alimentary canal of *Scoliodon* comprises the mouth, buccal cavity, pharynx, oesophagus, stomach, intestine and rectum and cloaca.

1 Mouth: It is a wide ventral crescentic opening which leads into a spacious dorso-ventrally compressed buccal cavity. The mucous membrane of buccal cavity is raised into a thick fold to form **tongue.** The tongue is non muscular and non-glandular. There are no glands in the buccal cavity comparable to the salivary glands of higher vertebrates.

The teeth are of same size called **homodont**, and the old row is replaced by the new one called **polyphyodont.** They are in several parallel rows on the inner margin of the upper and lower jaws. The teeth are used to catch the prey and prevent its escape but not to crush or masticate it.

2 Buccal Cavity: It is a large, dorsoventrally compressed cavity opens into the pharynx, on either side of which lie the internal openings of the spiracle and five gill pouches. The spiracle is vestigial represented by an inconspicuous oval pit and the gill-pouches are large. The cavity of pharynx is lined with mucous membrane containing numerous dermal denticles.

3 Pharynx: The pharynx narrows posteriorly to form the short oesophagus. The oesophagus has thick muscular walls with an internal lining of mucous membrane raised into longitudinal folds.

4 Oesophagus: The pharynx becomes narrow posteriorly and merges into the oesophagus. It is short, dorso-ventrally compressed and lined with mucous which is highly folded. The mucous is composed of ciliated cells and mucous glands. The oesophagus posteriorly widens to form a large muscular stomach.

5 Stomach: It consists of two chambers, cardiac and pyloric stomach. The stomach is bent on itself and forms a **J -shaped** organ, the long proximal limb of which is called the cardiac stomach, while the short distal limb is called the pyloric stomach. At the junction of cardiac and pyloric limbs there is a blind outgrowth, the **blind sac.** The inner mucous lining of the cardiac stomach is also thrown into prominent longitudinal folds that end in the depression of the blind sac. The lining of the pyloric stomach is quite smooth proximally but is slightly folded distally. At the end of pyloric stomach there is a muscular **bursa entiana**.

6 Intestine: It is a wide tube running straight backwards into the abdominal cavity and opening positively into the rectum. The internal surface of the intestine is increased by a characteristics fold of the mucous membrane, the **scroll valve**, having one edge attached to the inner wall of the intestine and the other rolled up longitudinally on itself into a scroll, making an anti-clockwise spiral of about two and half turns. In a transverse section the scroll valve looks like

a watch spring. The scroll valve serves not only to increase the extent of the absorptive surface of the intestine but also prevents the rapid flow of food through the intestine.

7 Rectum: It is the last part of the alimentary canal. The rectal (caecal) gland opens dorsally into the rectum. It secretes a fluid which poured into the intestine but its action is unknown.

Digestive Glands:

1. Liver: It is a large, massive, elongated, bilobed, yellowish gland, occupies greater part of the abdominal cavity. The right and left lobes are leaf shaped and attached to the septum transversum by a median suspensory ligament. The right lobe of the liver possesses a thin walled, V shaped sac called the gall bladder. It stores the bile. The bile from the gall bladder is carried by long bile duct which' on its way receives branches from the right and left lobes of liver and forms the common bile duct. The common bile duct opens in the duodenum.

Liver produces **bile**, stores glycogen and fat and destroys the worn out erythrocytes.

2. Pancreas: It is a compact, whitish, ribbon like bilobed gland situated between the cardiac and pyloric stomach and secrete the pancreatic juice. The pancreatic duct runs across the complete length of the gland and opens into the intestine opposite to the opening of bile duct.

3. Rectal gland: It is short thick diverticum arising from the dorsal wall of the rectum. It secretes a fluid which poured into the intestine but its action is unknown.

4. Gastric glands: These glands occur in the wall of the stomach which secret gastric juice as well as hydrochloric acid.

5. Intestinal glands: These glands occur in the wall of the intestine which secretes intestinal juice for digestion of food.

Physiology of digestion:

Food: The new born babies and young ones are bottom feeders and they feed exclusively on prawns. As growth proceeds they change their diet to crabs, small soles etc. The full grown *Scoliodon* mainly feeds on fishes such as mackerel, oil sardine, silver bellies etc. and also crabs, lobsters and worms. Sharks feed at one or two days intervals.

Ingestion: The prey is held with the help of teeth and jaws and engulfed entirely without mastication.

Digestion: By the process of digestion, the complex and no absorbable food is transformed to simple absorbable form. The digestion mainly occurs in the cardiac stomach. As compared to the intestinal digestion it is quite fast. The cells of the mucous membrane of the cardiac stomach secrete gastric juice which contains hydrochloric acid and pepsin. The gastric juice digests

proteins but not chitin.

Action of gastric juice:

(1) Pepsinogen HCl HCl Pepsin
(Inactive) → (Active)

(2) Proteins + Pepsin → Syntonin, peptones, proteases.

Digestion in Intestine: The semi-digested food from the stomach enters the intestine and mixes with bile and pancreatic juice. The intestinal digestion and absorption needs a period of three to five days which depends on the temperature of the surrounding water. Warm water accelerates the process.

Action of Bile:

(1) It makes the acidic food alkaline which is necessary for the action of pancreatic juice.

(2) Trypsinogen —**Bile**→ Trypsin
(Inactive) **Enterokinase** (Active)

(3) Fats —Bile→ Emulsification

Action of pancreatic juice:

Pancreatic juice contains trypsin in the form of inactive trypsinogen, amylopsin and lipase. It acts as follows

(1) Chymotrypsinogen —**Enterokinase**→ Chymotrypsin
(Inactive) (Active)

(2) Proteins —**Trypsin / Chymotrypsin**→ Polypeptides, peptones, proteoses.

(3) Polypeptides, peptones, proteases —**Erepsin**→ Amino-acids

(4) Polysaccharides —**Amylases**→ Disaccharides (Maltose)

(5) Maltose —**Maltase**→ Glucose (Monosaccharide)

(6) Emulsified fats —**Lipase**→ fatty acids, glycerol.

Absorption: The digested food is absorbed into the blood over the surface of intestine and scroll valve.

The Respiratory system:

Scoliodon is adapted to aquatic respiration and breathes by means of *gills* on either side of the pharynx. There are five pairs of gill pouches in *Scoliodon.* Water enters the buccal cavity and pharynx through the mouth and passes out through the gill-slits, bathing the gills on its way through the branchial pouches. Each pouch is compressed antero-posteriorly and communicates, on, the one hand with the cavity of the pharynx by a large internal branchial aperture, and on the other, with the exterior by a narrow external branchial aperture. The mucous membrane lining the gill-pouches is raised into a series of horizontal folds, the branchial lamellae which are richly supplied with blood capillaries. Each gill-pouch has two sets of gill-lamellae one on its anterior wall and another on its posterior wall. The posterior set of lamellae being longer than the anterior set. Successive gill pouches are separated from one another by stout fibro-muscular partitions called the interbranchial septa, in the inner or pharyngeal border of which are imbedded the visceral arches, with their branchial rays.

These two sets of lamellae attached to a visceral arch constitute a **complete *gill*** or **holobranch**, while a single set makes **hemibranch** or a **half-gill.** A gill-pouch thus contains the posterior hemibranch of one gill and the anterior hemibranch of the succeeding gill. The hyoid arch bears gill-lamellae on its posterior surface only and, therefore, has only a half-gill or hemibranch; the first four branchial arches bear gill-lamellae on both surfaces called as holobranch; while the fifth branchial arch is, entirely gill-less called as hemibranch.

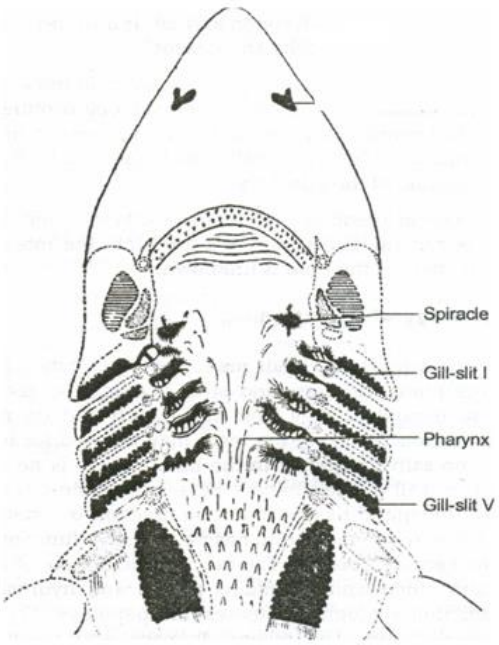


Fig. 3.10: *Scoliodon* - Pharynx exposed to show gill pouches

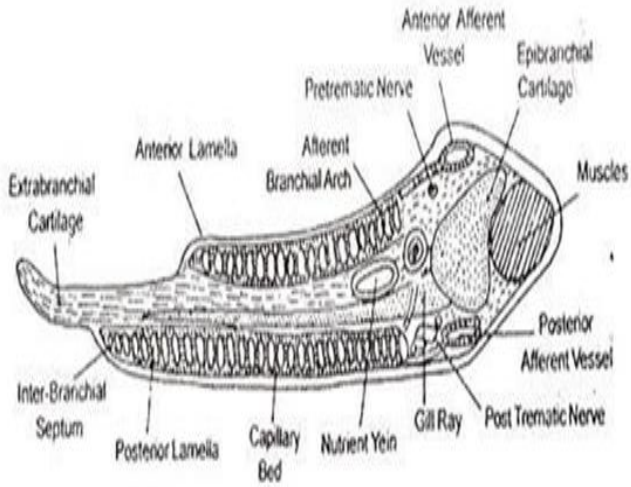


Fig. 3.11: Scoliodon- Horizontal section of holobranch

Mechanism of Respiration:

The fish depresses the floor of the buccal cavity by the contraction of the hypobranchial muscles, and consequently, the buccal cavity is enlarged, mouth is opened and the water rushes in to fill the enlarged buccal cavity. The cavity of the pharynx is next enlarged by the raising of the branchial arches, while the mouth is closed by the action of the adductor muscles. Following the line of least resistance, the water enters the branchial pouches, and is forced out through the external gill-slits. In the gill pouches, the water comes in contact with the capillaries of the gill-lamellae, where the non-oxygenated blood is separated from the oxygen dissolved in water only by the very thin capillary-wall, so that the oxygen passes into the blood, while the carbon dioxide in the blood diffuses out into the water. Thus an efficient exchange of oxygen (O_2) and carbon dioxide (CO_2) take place between the blood and sea water by a process of endosmosis and exosmosis.

The Blood Vascular System:

The blood vascular system includes the heart, arterial system and venous system.

Heart:

The heart of Scoliodon is a bent muscular tube; it lies in the pericardial cavity below pharynx. . It is reddish brown and conical organ. The heart consisting of the following chambers:

1. The sinus venosus
2. The auricle
3. The ventricle and
4. The conus arteriosus.

1. The sinus venosus: It is a thin-walled triangular chamber placed transversely along the base of the pericardial cavity. Two large veins, the ducti Cuvieri, enter the sinus laterally, while the two hepatic sinuses open into it in the postero-median line. Anteriorly, the sinus venosus opens into the auricle through the sinu-auricular aperture, guarded by a pair of membranous valves which prevent the backward flow of the blood.

2. The auricle: The auricle is a large triangular sac with walls thicker than those of the sinus venosus. It is situated in front of the sinus venosus and dorsal to the ventricle. The sides of the auricle projecting on either side of the ventricle give it the characteristic ear-like or auricular appearance. It communicates with the ventricle by the auriculo-ventricular aperture guarded by a bilabiate valve.

3. The ventricle: It is the most prominent part of the heart and is supported ventrally by the coracoids cartilage. It has very thick muscular walls, the inner lining of which is traversed numerous muscular strands that give ventricle and spongy texture. The ventricle opens in the

conus arteriosus and opening is guarded by cuspid valves. The valves are provided by **chordae tendinae** (elastic threads)

4. The conus arteriosus: The conus arteriosus is a stout; muscular tube which extends anteriorly from the ventricle to the front of the pericardial cavity. The interior of the conus arteriosus is provided with two transverse rows of semi-lunar valves, each row containing three valves a dorsal and two ventro-laterals. In addition to these, there is always a small accessory valve on either side of the dorsal. Fine tendinous threads from the free ends of the valves are attached anteriorly and posteriorly to the muscular processes of the wan to hold the valves in place. The conus arteriosus is continued forwards through the wall of the pericardium as the ventral or cardiac aorta.

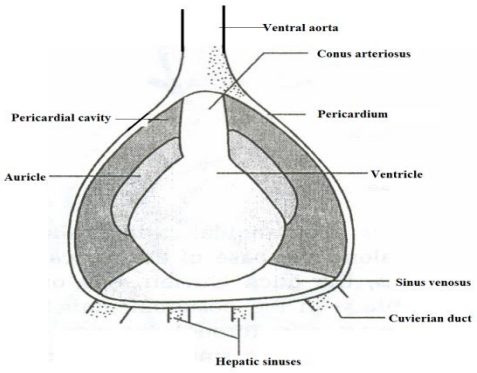


Fig. 3.12: *Scoliodon* - heart ventral view

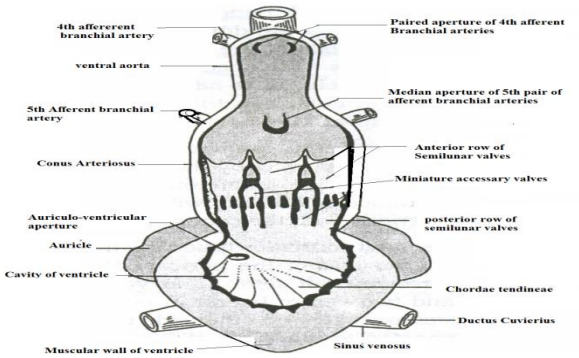


Fig. 3.13: Scoliodon: Heart dissected from ventral side

Working of Heart: The function of the heart is to pump the blood to the different parts of the body. Since the blood passes through heart only once in it's the circuit, it is obvious that there should be sufficient pressure in the heart to force the blood through the different organs of the body. This is effected by the rhythmic contraction of the different parts of the heart in a definite Succession and at regular intervals. The heart-beat or contraction starts in the sinus venosus, and the blood brought to it from the different parts of the body by the veins is forced into the atrium or auricle through the sinu-auricular aperture. The membranous valves guarding this aperture prevent the blood from flowing back into the sinus venosus. The muscular contraction next spreads over the auricle and drives the blood into the ventricle. Here again, the return of blood into the auricle is prevented by the bilabiate valves guarding the auriculo-ventricular aperture. Then wave of contraction passes to ventricle and the contraction of the ventricle forcing the blood into the conus arteriosus. As the wave of contraction passes from the ventricle to the conus and thence into the ventral aorta, any return of the blood into the ventricle is prevented by the two rows of semi-lunar valves present in the conus arteriosus. Then the blood passes into the afferent arteries which break up into the capillaries of the gills where the blood is oxygenated. Thus, only the venous blood (Deoxygenated) passes through the heart in

Scoliodon. This is known as the single type of circulation and the heart is called venous or branchial heart. A cardiac branch of the vagus nerve forms a nerve plexus in a patch of muscles in the sinus venosus to form a sinuauricular node where the heart-beat starts.

Nervous system:

The nervous system of Scoliodon consists of three parts:

(1) Central nervous system: It includes **brain** and spinal cord.

(2) Peripheral nervous system: It includes cranial and spinal nerves.

(3) Automatic nervous system:

(1) Central nervous system:

(A) Brain: The brain is divided into three parts: fore-brain, mid-brain and hind-brain.

a).Fore-brain: The fore-brain includes olfactory lobes, cerebrum and the diencephalon.

The **olfactory lobe** consists of pair of stout stalks, the olfactory peduncles extending forwards and outwards from the antero lateral angle of the cerebrum. Olfactory peduncles end in a bilobed mass called olfactory bulb or lobe, closely applied to the olfactory sac of its own side. The olfactory tract and bulbs enclose narrow cavities, the olfactory ventricles or **rhinocoels.**

The **cerebrum** is undivided massive structure with no median groove to separate it into right and left cerebral hemispheres. It contains pair of cavities called lateral ventricles or **paracoels** separated by median partition and they are continued with foramen of Monro. The dorsal surface of cerebrum is quite smooth but on mid ventral surface, there is small opening, called neuropore through which emerge a pair of delicate nerves, the terminal or pre-olfactory nerves. Each of these nerves bears a ganglion along its course and runs alongside the olfactory tract of its own side to innervate the mucous membrane of the olfactory sac.

The cerebrum is continued behind into the narrow diencephalon which is very short and is completely hidden by the forward prolongation of the cerebellum. The roof of the diencephalon is extremely thin and membranous; being non-nervous in character, but contains numerous blood vessels forming the anterior choroid plexus. Ventrally its anterior margin bears optic chiasma of two optic nerves. Just behind the chiasma a hollow projection called infundibulum is situated on the floor. Attached posteriorly to infundibulum is a sac like hypophysis and both make up the pituitary body. Close to the lateral sides of infundibulum lie two thick walled oval sacs called the lobi inferiors, the distal end which is continued into a pair of glandular sacs, the sacci vasculosi with thin walls.

(b) Mid brain:

It is not a prominent part and remains closely concealed dorsally by cerebellum and ventrally by the infundibullar outgrowths. It consists mainly of a pair of large, rounded dorsal swellings

the optic lobes or carpora bigemina, which are the centres of sight and hearing. Each optic lobe has a cavity called **optocoel.** Ill and IV cranial nerves arise from midbrain.

(c) Hind brain: It consists of two parts cerebellum and medulla oblongata.

Cerebellum is large, elongated and rhomboidal structure overhanging the optic lobes in front and part of medulla behind. Its dorsal surface is irregularly folded and divided into three lobes by two transverse furrows. It has a cavity called metacoel. Anterior end of hind brain arises, a pair of hollow outgrowths, the carpora restiformia or auricular lobes.

Medulla oblongata, the last part of the brain is a triangular structure and continues posteriorly into the spinal cord. Medulla is roofed over by a thin, non-glandular and vascular membrane, the posterior choroid plexus. It has a wide cavity called fourth ventricle or **myelocoel.**

Functions of Brain:

1. Olfactory lobes and cerebrum are useful for sense of smell
2. The cerebellum is the seat of regulation of balance and muscular control.
3. The lobi inferiors and sacci vasculosi are centres for smell and taste.
4. Optic lobe has optic, olfactory, gustatory and acoustic-lateral sensory centres
5. The medulla oblongata contains the respiratory centres.

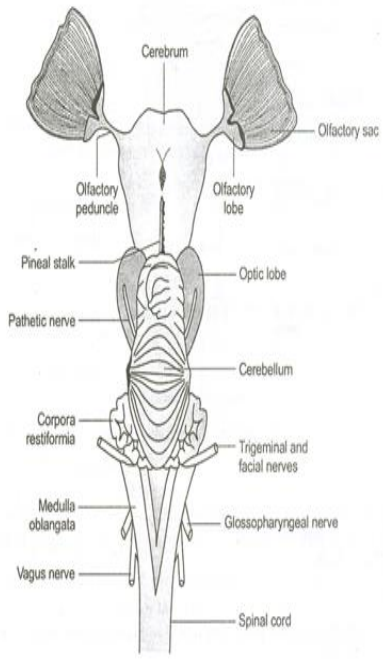


Fig. 3.16: *Scoliodon*- Dorsal view of brain

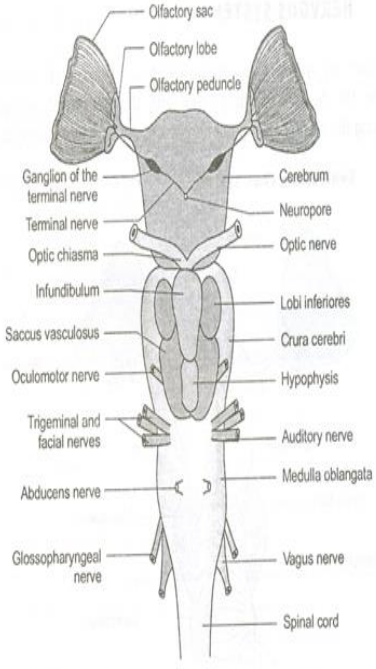


Fig. 3.17: Scoliodon - Ventral view of Brain

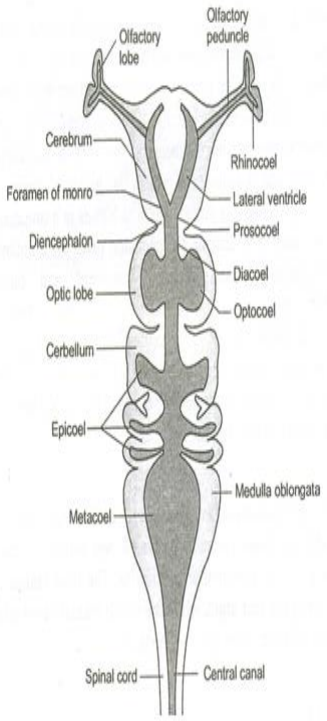


Fig. 3.18: *Scoliodon* - L. S. of the Brain

Urinogenital System:

The excretory and reproductive organs are closely related to each other and are deals with together hence it called as urinogenital System. In *Scoliodon* Sexes are separate and the urinogenital system includes different organs in the male and female fishes.

Male Urinogenital System:

The kidneys are a pair of long ribbon-like glandular structures, lying dorsal to the peritoneum and extending anteriorly to the base of the liver and posteriorly to the side of the cloaca. The posterior portion of the kidney is greatly thickened and laterally compressed and forms the chief organ of excretion. In this portion uriniferous tubules are present. The anterior part is comparatively narrow and non-renal part, which results from the fact that this portion cones into the service of the genital system. In this portion uriniferous tubules are absent. The posterior broader part of each kidney is excretory and contains masses of coiled uriniferous tubules with peritoneal funnels, Malphighian bodies and collecting tubules. The collecting tubules of the anterior region are very small and open into Wolffian duct, while the collecting tubules of the posterior region open into a common duct, the ureter. The ureters finally open into a wide chamber called urinogenital sinus and it opens into the cloaca. The urine is hypotonic to blood. The genital part of the system includes a pair of testes, vasa efferentia, a pair of Wolffian ducts, a pair of sperm, sacs, a pair of siphons and a pair of claspers.

Testes: There are two elongated testes, each running from the liver to the rectal gland. They are attached to the abdominal wall by a double fold of peritoneum called ***mesorchium.*** Each testis is composed of numerous seminiferous tubules lined with germinal epithelium. Each testis is made up to numerous lobules with median central canal

Vasa efferentia: From each testis arise several thin tubular vasa efferentia which open into the anterior and of that vas deferens. These ducts are convoluted called as epididymis. The vas deferens which passes back to form a broad seminal vesicle. The seminal vesicle of both sides open behind into a large triangular chamber called urinogenital sinus.

Sperm sac: On either side of the urinogenital sinus lies a club shaped sperm sac. The function sperm sac is unknown.

Siphons: A pair of elongated siphons lies on the ventral side of the body between the skin and muscles.

Claspers (Myxopterygium): These are paired stiff, rod like copulatory organs which are modified pelvic fin. Each claspers is a tube partially open on the dorsal side forming a triangular groove which open into cloaca.

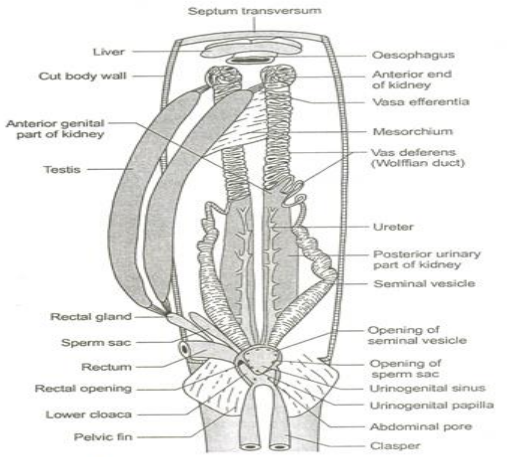


Fig. 3.26: *Scoliodon* male urinogenital system

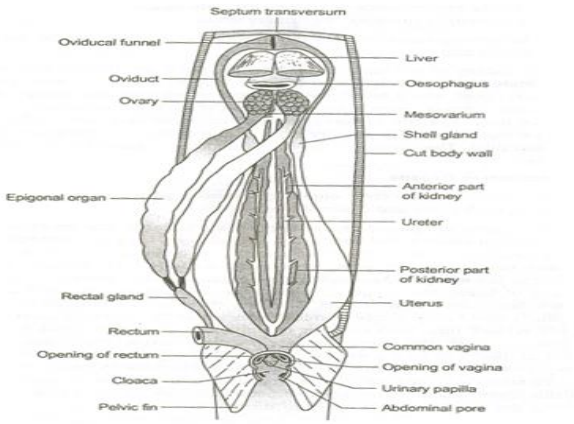


Fig. 3.27: *Scoliodon* female urinogenital system

Female Urinogenital System:

There is no direct connection between kidneys and genital organs in the female. Therefore, anterior part of kidneys is extremely reduced. The posterior part of kidney is thick and massive and which is functional renal part. It also extends to the posterior limit of the cloaca. From each kidney arises a ureter and two ureters unite to form a common ureter which opens into a urinary sinus. The female genital part of the system includes paired ovaries, oviducts, shell glands and uteri.

Ovary: These are large, yellowish, lobulated, saccular bodies and vary in form and size as per the age of shark. They are located in the abdominal cavity-and attached to the anterior abdominal wall middorsally by a fold of peritoneum called **mesovarium.** The surface shows a number of rounded projections which contain the developing ova. They extend back from the base of liver and merge into the epigonal organ.

Oviducts: They are large tubes extending along the complete length of the body and are also known as mullerian ducts**.** Anteriorly they are narrow and unite mid ventrally below the oesophagus. They open into the coelom by zigzag slit like aperture, the ostium or oviducal funnel lying ventral to the oesophagus and posterior' to transverse septum

Shell gland: The gland is also known as oviducal or nidamental gland which is heart shaped and shows narrow middle mucus secreting zone and posterior large shell secreting zone

Uterus: Towards the posterior region, the oviduct dilates to form a uterus. The two uteri unite to form a short vagina, which opens into cloaca.

Yolk sac placenta.

In Scoliodon fertilization is internal, during copulation the claspers are introduced into the cloacal aperture of the female for the transmission of spermatozoa. Scoliodon is viviparous and gives birth to young ones. The egg of is strongly telolecithal and cleavages are meroblastic. The first cleavage plane is simply a furrow in the surface of the germinal disc. The second cleavage occurs at right angle to the first one. After this stage, the cleavage plane is irregular. By this way of cleavage, a blastodisc is separated from a layer of periblast cells. The posterior region of the blastodisc grows faster than the other regions and is raised from the yolk mass to become a double-layered germ ring. This germ ring is raised posteriorly to form a blastopore.

The developing embryo is provided with a tubular yolk stalk. This yolk stalk connects the intestine of the embryo with the yolk sac. The yolk sac contains yolk material which provides nutrition for the developing embryo. When the yolk is fully exhausted the yolk sac becomes folded and becomes anchored with the uterine wall of the mother as the yolk-sac placenta. With the formation of placenta, the yolk stalk is lost and the blood vessels of the yolk stalk form the placental cord. The placental cord connects the embryo with the yolk-sac placenta. The placental cord develops many finger-like processes called appendicula. The appendicula help in the absorption of nutrients secreted from the uterine wall of the mother.

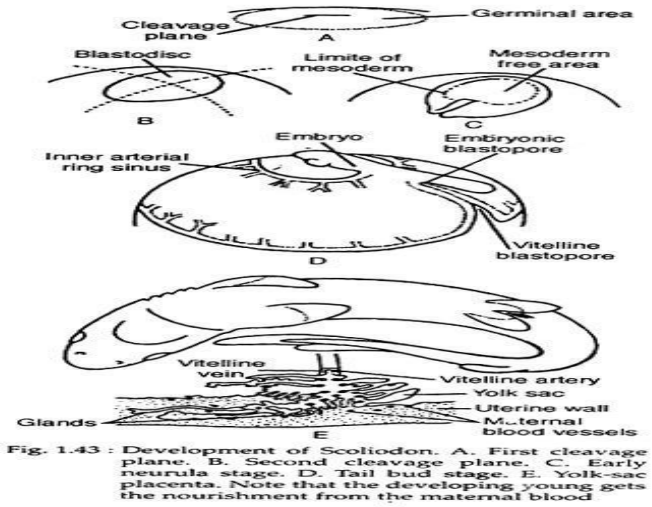


Fig. 1.43 : Development of Scoliodon. A. First cleavage plane. B. Second cleavage plane. C. Early neurula stage. D. Tail bud stage. E. Yolk-sac placenta. Note that the developing young gets the nourishment from the maternal blood

MCQs

1. Liver of Scoliodon is ----------
   a) Single lobed. b) Bilobed.
   c) Trilobed. d) Four lobed.

2. The pericardial and abdominal cavity in Scoliodon is separated by ----------.
   a) Septum transversum. b) Septum longitudinum.
   c) Diagonal septum. d) Muscle sheath.

3. Sinus venosus receives blood from----------.
   a) Ductus cuvieri. b) Ductus cuvieri & hepatic sinuses.
   c) Ventral aorta. d) Hepatic Sinuses.
4. *Scoliodon sorrakowah* belongs from class----------. a) Osteichthyes. b) Chondrichthyes. c) Amphibia. d) None of these.
5. Vagina of Scoliodon is formed by the union of---------- a) Uteri. b) Ureters. c) Vas deferens. d) Vasa efferentia.
6. A complete gill is called ----------.
   a) Epibranch. b) Holobranch. c) Abranch. d) Hemibranch

7. Tail of Scoliodon is ----------.
   a) Homocercal. b) Heterocercal. c) Hypocercal. d) Hypercercal.
8. Cavities of Medulla oblongata is ----------.
   a)Paracoel. b) Epicoel. c) Optocoel. d) Metacoel.
9. Internal ear of Scoliodon is also called as ----------.
   a)Eye. b) Pinna. c) Stato-acoustic organ d) Ear.
10. The teeth of Scoliodon shows……..dentation
    a)Heterodont & diphyodont. b) Heterodont & polyphyodont. c) Homodont & diphyodont. d) Homodont & polyphyodont.
11. The teeth in Scoliodon are adapted for ----------.
    a)Chewing. b) Biting,tearing & chewing. c) Holding and tearing. d) Biting.
12. Scoliodon is commonly called as ----------.
    a)Dog fish. b) Freshwater fish. c) Marine fish. d) Flying fish.

13. Cavities of optic lobe is ----------.

a)Paracoel b) Epicoel c) Optocoel d) Metacoel

14. Each testis of Scoliodon is attached to dorsal body wall by …….

a)Mesorchium. b) Mesoovarium. c) Mesoderm d) Mesocardium

15. Each ovary of Scoliodon is attached to dorsal body wall by …….

a)Mesorchium. b) Mesoovarium. c) Mesoderm d) Mesocardium

16. The skin of Scoliodon is covered with ---------- scales

a)Ctenoid b) Ganoid c) Placoid d) Cycloid

17. In Scoliodon ----------pairs of gill-slits are present.

a)3 b) 5 c) 6 d)7

18. The heart of Scoliodon is ----------.

a)Single chambered . b) Two chambered.

c)Three chambered. d) Four chambered.

19. ----------semicircular canals are found in membranous labyrinth of Scoliodon.

a)One. b) Two. c) Three. d) Four.

20. The retina of Scoliodon contains photosensitive cells called----------.

a)Cones. b) Rods. c) Rods & cones. d) None of these.

21. Olfactory sacs are ----------.

a)Rheoreceptors. b) Thermoreceptors. c) Chemoreceptors. d) Photoreceptors.

22. Which of the following is not an eye ball muscle of Scoliodon

a)Superior rectus b) inferior rectus c) superior oblique d) superior diagonal.

23. . …… are unpaired fins in Scoliodon

a)Pectoral b) pelvic. c) pectoral and pelvic d) caudal.

24. What is the habitat and habit of Scoliodon?

a)Marine, herbivorous. b) Fresh water, carnivorous. c) Marine, carnivorous & predator. d) Fresh water, omnivorous.

25. Scoliodon is commonly called as ----------.
    a)Dog fish b) Catfish c) Flying fish d) lungfish
26. Indian shark is ----------.animal.
    a) Viviparous. b) Oviparous. c) Ovoviviparous. d) None of these.
27. The heart of Scoliodon receives----------.
    a)Venous blood. b) Both venous and
    arterial blood. c) arterial blood. d) Blood only from gills.
28. Scroll valve present in the intestine of Scoliodon takes----------turns.
    a)one & half. b) two & half. c) Three & half. d) Five & half.
29. Ampullae of Lorenzini are ----------. a) Photoreceptors. b) Thermoreceptors. c) Rheoreceptors. d) Tangoreceptors.
30. Clasper bears a dorsal groove with anterior opening known as-------. a) Apopyle. b) Sperm sac. c) Hypopyle. d) Siphon.
31. The body of Scoliodon is divided into ----------. a) Head and Trunk. b) Head, trunk & tail. c) Head, neck, trunk & tail. d) Head, neck & tail.

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Course Title: Animal Diversity - IV Course Code: ZO – 241

Semester - IV (2 credits – 30 Hours)

Contents

CHAPTER 1

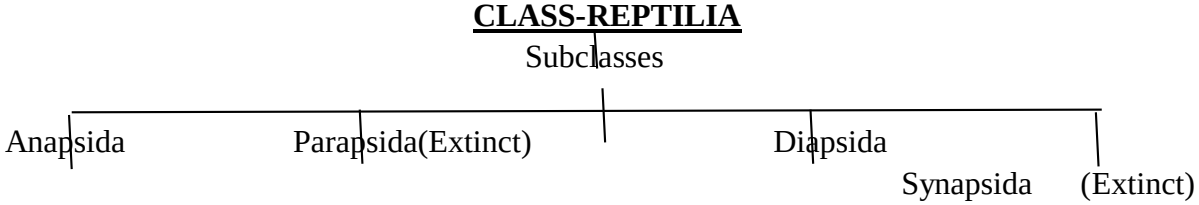
Introduction to class –Reptilia (04L)

1.1 Salient features of class Reptilia with one example (name only) – Chelone, Calotes.

General Characters

1. Reptiles are cold blooded, terrestrial or aquatic animals.
2. Body is covered with horny scales or scutes.
3. Skin is dry and skin glands are absent.
4. Limbs tetrapodus pentadactyle type.
5. Skull with single median occipital condyle.
6. Mandible consists of many pieces and articulates with the cranium through the quadrate bone.
7. Vertebrae are gastrocentrous.
8. Ribs form a true sternum.
9. Respiration by lungs.
10. Heart is divided into two auricles and incompletely divided ventricle.
11. Right and left aortic arches are complete and functional.
12. Red blood corpuscles (R.B.C.) are nucleated.
13. Kikneys without nephrostomes. Each kidney is provided with separate ureter.
14. Twelve pairs of cranial nerves.
15. Lateral sense organs are absent.
16. Embryonic membranes (amnion and allantois) are present.
17. Fertilization is internal. Eggs are laid on land.
18. Typical cloaca is present.

Class reptilia is divided into four subclasses



Subclass I- ANAPSIDA

1 Terrestrial or aquatic Body is enclosed in the carapace and plastron.

2 Tetrapodus pentadactyle with walking limbs or paddles. No temporal vacuities or fossae in the skull.

3 Trunk is enclosed in a bony shell composed of dorsal carapace and ventral plastron, which may or may not be covered with horny shields.

4 Limbs are generally strong.

5 Tail is always present.

6 Jaws without teeth but with horny sheaths.

7 Copulatory organ is unpaired.

8 Cloacal opening is longitudinal. 8 Oviparous.

Examples: *1. Chelone, 2. Chrysemis 3. Kachuga 4. Trionyx 5. Testudo.*

Subclass II – PARAPSIDA Single temporal vacuity present behind the eye and bounded below by post-frontal and supra-temporal bones **(Extinct Forms).**

Subclass III – DIAPSIDA

Terrestrial, arboreal or burrowing forms. Eyelids are movable. Body is covered by horny epidermal scales. Two temporal vacuities on each side. Two temporal vacuities are present. Post-orbital and squamosal usually meet between the temporal vacuities. Anterior orbital vacuities are absent. Post-temporal fenestrae are usually present. Humerus with two foramina. Teeth are acrodont. .Parietal foramen is present. Vertebrae are amphicoelus. Vertebrae are procoelous. Sternum is present. Cervical vertebrae with two headed ribs. Thoracic ribs possess uncinate process. Abdominal ribs are present. Prepubis present. Pubis does not share in the formation of acetabulum. Heart is four chambered and ventricle is completely divided into two by a septum. Lungs are spongy. Cloacal opening is longitudinal. Males possess a median unpaired penis.

Examples: *. Hemidactylus . Calotes Typhlops . Python.Chaemeleon . Draco Phrynosoma . Varanus . Crotaphytus Mabuiya Gecko Ophisaurus Rhineura .Iguana . Heloderma . Molloch. Eryx johni . Lycodon. Bungarus Naja naja. Enhydrina. Hydrophis. Viper* **Sphenodon. *Crocodilus,*** *Alligator,Gavialis.*

Subclass IV – SYNAPSIDA

1. One temporal vacuity is present on each side bounded above by the post-orbital and below by the quadrato-jugal.

(Extinct Forms).

……

1.2 Venomous and Non-venomous snakes – Cobra, Russell's viper, Rat snake, Grass snake.

Most of the Indian snakes are non-poisonous and harmless creatures. Of 330 Indian species only 69 are poisonous comprising 29 species of sea snakes and 40 species of land snakes. The poisonous snakes have a poison apparatus in head and a pair of larger teeth or gangs in upper jaw. When they bite, there may be two large circular punctures made by the fangs on the skin of the victim. But non-poisonous snakes have neither poison apparatus nor gangs. When they bite, they leave many small pricks only. Some of the most common Indian poisonous snakes are Cobras, Kraits, Pitvipers, Vipers and Sea snakes. The snakes are elongated and limbless reptiles with body covered by scales. A majority of the snakes are non-poisonous and they are beneficial to man since they destroy harmful insects and destructive rodents. There are very few snakes which are deadly poisonous and cause death from snake bite. It is easy to distinguish them from non-poisonous ones on the basis of the shape of their tails and the size and arrangement of scales and shields on their body.

A simple workable key for identification of Indian poisonous and non-poisonous snakes is given in the table below.

Key to identify Poisonous and Non-poisonous snakes of India

Structures	Characters	Nature	Snakes
Tail	Tail laterally compressed	Poisonous	Sea snakes *Hydrophis, Enhydrina*
	Tail cylindrical, tapering	Poisonous or Non-poisonous Examine further	Land snakes
Belly scales or ventrals	Scales small, continuous with dorsals	Non-poisonous	
	Ventrals broad, fully covering belly	Non-poisonous Examine further	Pythons
Head scales, loreal pit, sub-caudals	Head scales small, head triangular, no loreal pit (a) Subcaudals double (b) Subcaudals single	Poisonous Poisonous Poisonous	Pitless vipers *Viperarusselli* *Echiscarinata*
	Head scales small, a loreal pit present between nostril and eye	Poisonous	Pit vipers *Lachesis Ancistrodon*
Vertebrals, 4th infralabial, 3rd supralabial	Vertebrals enlarged, hexagonal, 4th infralabial largest	Poisonous	Kraits *Bungarus*
	Vetebrals not enlarged, 3rd supralabial touches eye &nostrils (a) Neck with a hood and spectacle mark (b) Hood absent	Poisonous Poisonous	Cobra, *Naja* Coral snakes, *Callophis*

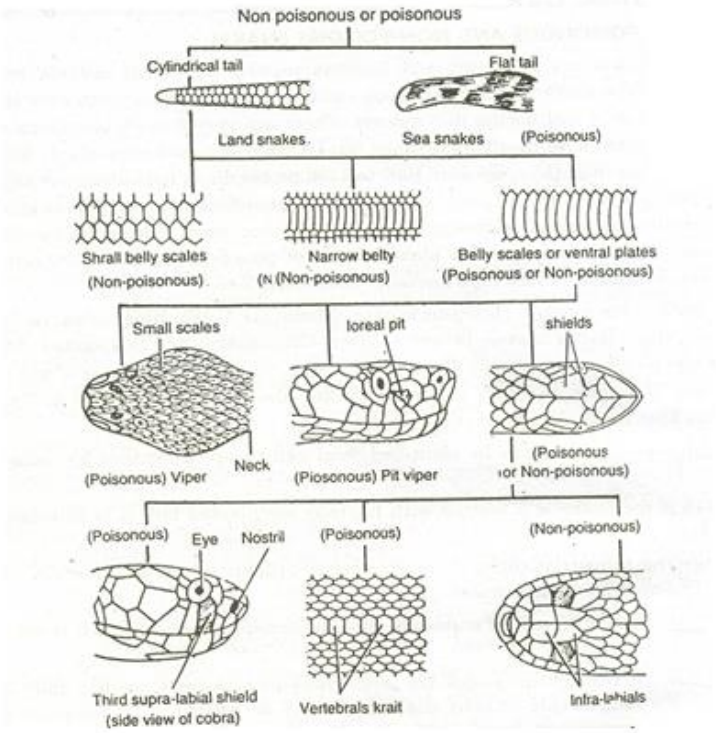


Fig. Key for Identification of Poisonous and Non-poisonous Snakes

POISONOUS SNAKES

1) COBRA

The common Indian cobra is *Najanaja* or *Najatripudians*. It is the most common and deadly poisonous snake of India. Length is about 2 metres and black or brown colour variable. Head is small and indistinct. Pupil is round. Neck can dilatate into a hood supported by ribs and may bear spectacle marks dorsally. The 3rdsupralabial shield of upper lip touches eye and nasal shield. Subcaudal shields are in 2 rows. Fangs are anterior, grooved and permanently erect. It feeds on small birds, rats, frogs, lizards etc. Its chief enemies are the jungle fowls which destroy its young brood, and the mongoose that kills it.

One of the largest and deadliest venomous snakes is the King cobra or *Ophiophagushannah*, also known as *Najahannah* or *Najabungarus*. It lives in deeply forested areas and grows to about 4 metres. It feeds mainly on monitor lizards and other snakes, hence the name King cobra.

2) KRAIT

Kraits occur all over India. The common krait, *Bungaruscaeruleus*, grows to a length of 1.2 metres. Vertebrals are large and hexagonal, 4thinfralabial is the largest. Subcaudals are single. Ventral surface is white. Dorsal surface is bluish or brownish black with narrow white cross streaks. Their fangs are small and wounds inflicted superficial, but poison is three times as virulent as that of cobra. It is a terrestrial and diurnal snake, feeding on small amphibians, lizards, snakes and mammals. The banded krait, *Bungarusfasciatus*, is more restricted to northern India. Its body is marked with alternate broad black and yellowish rings imparting a beautiful but dreadful appearance.

3) PITLESS VIPER

The largest Indian pitless viper is the Russel's viper or *Viperarusselli*. It is about 1.5 metres long. Its head is distinct, triangular, flat and covered with small scales. Nostrils are lateral, oblique and very large. Upper surface of body shows three rows of large black rings appearing like chains, hence the common name *Chain viper*. Head shows a yellow A-mark. Subcaudal shields are in 2 rows. Fangs are large, tubular (solenoglyph) and lie down when not in use. It marks a loud hissing sound when attacked. It is nocturnal, viviparous, and thoroughly terrestrial and feeds chiefly on mice.

Another pitless viper from South India is *Echiscarinata*. It lives in sandy areas with scant vegetation. It is small, about half a meter long, and with a single row of sub-caudals. Colour is green or brown with black and brown spots and a white belly. Back scales are strongly keeled and serrated, hence the common name, saw scaled viper. In other features it resembles the russel's viper. Its bite is not fatal to man.

4) PIT VIPER

Pit vipers differ from pitless vipers in having a loreal pit between the eye and nostril on either side. The loreal pits form heat sensitive organs. But they resemble pitless vipers in the possession of a robust body, triangular head with scales, broad ventrals, vertical pupil, solenoglyph fangs and viviparity. *Ancistrodonhimalayanus*, the brown Himalayan pit viper of India, is very common in eastern hills as well as Kashmir and grows to nearly 70 cm. Its head bear shields, subcaudals are in 2 rows and tail ends in a long spine-like scale.

Lachesis strigatus, also common in South India, grows to about 45 cm. Its snout has shields; rest of the head bears scales. Slightly prehensile tail ends in a conical scale. Colour is

brown with irregular dark spots. Neck bears a white horse-shoe mark. A dark brown band runs behind each eye.

The famous rattle snake (*Crotalus*) of North America is easily distinguished by the presence of a rattle at the end of tail. It consists of 10-12 horny hollow segments loosely held together. During locomotion, the rattle strikes ground producing a rattling sound. Before, striking the rattle vibrates producing a buzzing sound which serves as a warning.

5) SEA SNAKES

Sea snakes inhabit tropical parts of Indian and Pacific Oceans. They pass their whole life in sea water and are highly poisonous. They look eel-like and are easily identified by their elevated and laterally compressed oar-like tails, suited for swimming. Their food consists of small fish. Head is small and shielded above. Eyes are small with rounded pupil. Norstrils are valvular and lie at the tip of snout to permit breathing while in water. Ventral shiels are narrow, rudimentary or absent. All are viviparous. Most common Indian sea snake is *Hydrophis* with 20 or more species. Its lower jaw is not notched in front. In *Enhydrina*, the lower jaw is deeply notched in front.

6) CORAL SNAKES

These are small snakes of cobra family (Elapidae) living in sandy areas near sea beaches. Although poisonous, they are not fatal to man. As in Cobra, the 3rdsupralabial touches eye and nostril, but hood and spectacle mark are absent. Common South Indian coral snake, *Hemibungarusnigrescens*, is 1.2 metres long, coloured black or brown above and red below. A black, mid-dorsal line runs throughout with black oval spots on either lateral side. *Callophis* is about 50 cm long. It is without longitudinal band but with about 40 narrow, equidistant, black white edged rings. *Micrurus*, a poisonous coral snake of U.S.A. and tropical countries, is beautifully coloured with bands of black, red and yellow.

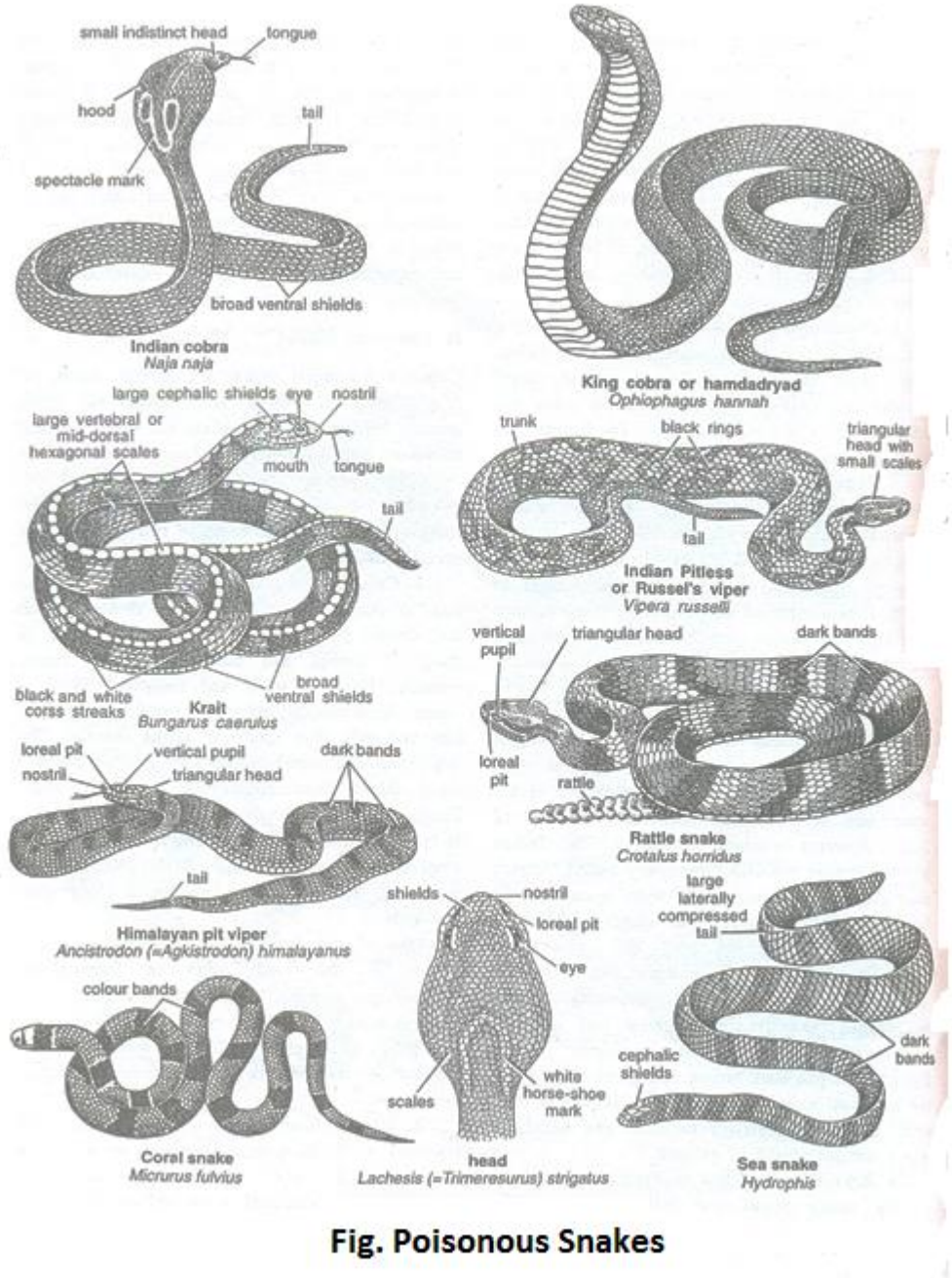


Fig. Poisonous Snakes

NON POISONOUS SNAKES

1) *TYPHLOPS*

It is a small burrowing snake blackish or brownish in colour and 175-180 cm long. It looks like earthworm, hence the name Worm snake. Tail is blunt and is either conical or end in spine. Body scales are small, uniform and semicircular. Blunt snout is covered with large shields. Eyes are vestigial and hidden beneath shining scales, hence the common name Blind snake. Teeth are absent in lower jaw. It is harmless and feeds on insect larvae and termites. *Typhlopsbraminus* and *Typhlopsthurstoni* are common in India.

2) *PTYAS*

Ptyasmucosus is the most common Indian rat snake called 'Dhaman'. Colour is olive or greenish above and whitish below. Head is distinct from neck and head shields are regular. Eyes are large. Tail forms more than one-third of body, which may attain a length of 2.5 meters. It is an active and alert snake, moving about usually during day. It feeds on mammals, birds and frogs and often enters human dwellings in search of rats and mice.

3) *TROPIDONOTUS*

It is the common pond or grass snake. It frequents freshwaters to feed on frogs, toads, fish etc. Body is stout, cylindrical and 1 meter long. Back is rough due to keeled scales. Colour is yellow or brown with black spots. In *Tropidonotusquincunciatus*, two black streaks run behind from each eye. It looks like a cobra but is harmless.

4) *ERYX*

The sand boa or *Eryxjohnii* burrows in dry sandy plains and hills in India. The cylindrical body is about 1 meter long with indistinct head and a blunt snout. Tail is small, non-prehensile, thick and bearing a false resemblance to head, hence the common name double-headed snake or 'Dumuhi'. Colour is brown and head and body covered with small scales. A conical prominence in a groove on either side of cloaca represents a rudimentary hind limb. *Eryxjohnii* is non-poisonous and feeds on rats, mice and squirrels which it kills by constriction and swallows. Another Indian species is *Eryxconicus*.

5) *PYTHON*

The largest non-poisonous snakes belong to the family Boidae. Pythons are oviparous and boas ovoviviparous. The largest species, *Python reticulates* of South East Asia grows to over 10 metres. A close second is the water boa or Anaconda (*Eunectesmurinus*) of South America reaching 8 metres. The Indian python, *Python molurus*, commonly called 'Ajgar', may grow upto 6 metres. It lives upon trees in forests. Body is plump and sluggish. Head is depressed with truncated snout. Tail is short and prehensile. Pupil is vertical. Adult has a claw or spur on either side of cloaca, representing vestigial hind limbs. Dorsally, the anterior half of head bears shields, the posterior half scales. Diamond-shaped dark brown and green spots mark the body. A brown spear-like mark is present over head. It feeds exclusively on birds and mammals which are suffocated in its coils.

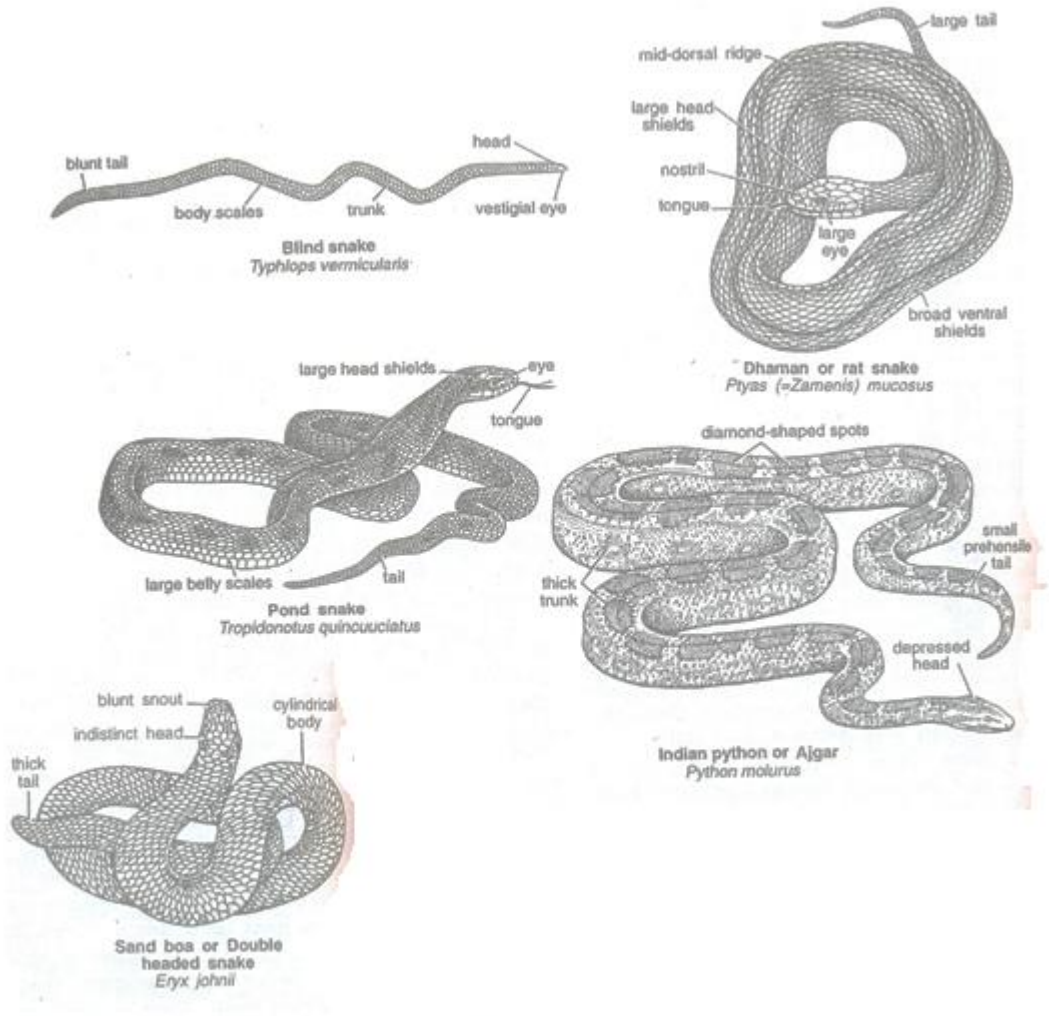


Fig. Non-poisonous Snakes

1.4 DESERT ADAPTATIONS IN REPTILES

Reptiles represent the first terrestrial vertebrates, adapted for life in dry places on land. The dryness of skin to prevent loss of moisture from body, method of reproduction including amniotic eggs, capable of development on land, and the devices for economizing in the use of water, are some of the achievements in their desert adaptations. Desert is habitat in which constant scarcity of water is there. Trees are absent and the large waste land is covered with sand. Temperatures are very high, rainfall is very low and there is always adverse condition for the survival of reptiles.

Following are some desert adaptations observed in reptiles.

1) **Impervious skin:**Evaporation of water takes place from body surface through skin. Therefore, to prevent water loss through skin, it becomes impervious by covering scales, scutes, shields or spines. The common desert lizard (*Moloch*) shows the covering of spines on body.
2) **Dwelling during night:** Due to hot climatic conditions during day time, there is extra loss of body water by the process of evaporation. To prevent evaporation of body water, the desert reptiles are active during night, called as nocturnal in habit. During night, there is fall in environmental temperature and water loss is prevented.
3) **Burrowing habitat:** The desert reptiles like *Uromastix* lives in burrows. The temperature in the burrows is lower than that of earth surface, so many reptiles live during day time in the burrows to avoid hot environmental conditions.
4) **Water cells:** The desert lizard *Uromastix* shows presence of water cells in the intestine. These cells have the capacity to store extra amount of water than normal intestinal cells. The stored water is used during scarcity of water in the desert area.
5) **Reduced metabolic rate:** The reptiles living in desert area show low metabolic rate. The metabolic activities becomes slow, so that the body requires less water to complete the metabolism.
6) **Excretion:** Desert reptiles produce uric acid, as their nitrogenous waste product. There is no need of water for removal of uric acid. The animals reabsorb water from faeces and urine for conservation of water.
7) **Hygroscopic skin:** The animals like spiny lizard, *Moloch* shows presence of hygroscopic skin. This type of skin has the ability to absorb environmental moisture from air and conserve in the cells of skin.
8) **Protection:** Many desert reptiles exhibit self protection. The body is covered by spines or scales. The animals like rattle snake and lizards are provided with poison apparatus. The nostrils, eyes and ears are protected from sand and dust storms.

MCQs

1 The respiratory organ in reptiles is……

a) lungs b) epidermis

c) skin d) gills

2 ……. is not the subclass of class reptilia

a) Cestoda b) Parapsida

c) Diapsida d) Synapsida

3 In …… skin is dry and skin glands are absent.

a) Reptiles b) Birds

c) Mammals d) Amphibians

4 In reptiles there are presence of …….. pairs of cranial nerves.

a) Ten b) Eleven

c) Twelve d) Thirteen

5 No temporal vacuities or fossae in the skull is a characteristic of subclass……

a) Synapsida b) Parapsida

c) Diapsida d) Anapsida

6 In subclass ……..tail is always present.

a) Parapsida b) Diapsida

c) Anapsida d) Synapsida

7 *Chelone* is an example of subclass……

a) Diapsida b) Anapsida

c) Synapsida d) Parapsida

8 *Testudo* and *Trionyx* are the examples of subclass…….

a) Anapsida b) Parapsida

c) Diapsida d) Synapsida

9 In subclass parapsida …….. temporal vacuity is present

a) Single b) double

c) tripple d) many

10 In subclass diapsida …….. temporal vacuities are present

a) one b) two

c) three d) four

11 *Hemidactylus and. Calotes* are the examples of subclass…….

a) Anapsida b) Parapsida

c) Diapsida d) Synapsida

12 ……. Is commonly called as flying lizard

a) *Typhlops* *b) Draco*

c) *Calotes* *d) Hemidactylus*

.

1 In reptiles the respiration is by……

a) lungs b) epidermis

c) skin d) gills

2 ……. is not the subclass of class reptilia

a) Cestoda b) Parapsida

c) Diapsida d) Synapsida

3 In …… skin is dry and skin glands are absent.

a) Aves b) Reptiles

c) Fishes d) Amphibians

4 In reptiles there are presence of …….. pairs of cranial nerves.

a) Twelve b) Thirteen

c) Fourteen d) Fifteen

5 Some of the most common Indian…….. snakes are Cobra, Krait and Vipers

a) venomous b) non poisonous

c) non venomous d) sea

6 A majority of the snakes are …….. snakes

a) venomous b) poisonous snakes

c) non venomous d) deadly poisonous

7 The *Naja naja* is a scientific name of ……

a) Cobra b) Krait

c)Viper d) Dhaman

8 The *Vipera russelli* is a ……snake

a) sea b) non poisonous

c) non venomous d) venomous

9 The Indian python, *Python molurus* is commonly called as …….

a) Dhaman b) Ajgar

c)Viper d) Cobra

10 Which of the following is poisonous snake?

a) Dhaman b) Ajgar

c)Viper d) Anaconda

11 Which of the following is non venomous snake?

a) Viper b) Dhaman

c) Cobra d) Krait

12 Which of the following is not a desert adaptation in reptiles?

a) Impervious skin b) Burrowing habitat

c) Hygroscopic skin d) master of flight

13 In desert reptiles -------- gland is absent to avoid water loss.

a) Sweat b)Salivary

c) Mammary d) Gastric

14 The ……. animals are mostly active only at night.

a) aquatic b) arborial

c) desert d) grazing

15 In desert there is constant scarcity of --------

a) water b) sunlight

c) heat d) temperature

16 To avoid water loss some desert reptile undergoes summer sleep called.....

a) Aestivation b) Hibernation

c) Nutrition d) Reproduction

17 Which of the following is a desert adaptation in reptiles?

a) Compact body b) Short tail

c) master of flight d) Hygroscopic skin

18 ……..is a country to have the highest snakebite mortality in the world.

a) Pakistan b) Srilanka

c) India d) Nepal

19 *Naja naja, Bungarus* and *Viper* are the most common …….snakes

a) venomous b) non poisonous

c) non venomous d) sea

20 In reptiles skin is ……. due to absence of glands.

a) coloured b)dry

c) moist d) oily

21 Generally most of the snakes are …….. snakes

a) non venomous b) poisonous

c) venomous d) deadly poisonous

22 In reptiles there are presence of …….. pairs of cranial nerves.

a) Twelve b) Eleven

c) Ten d) Nine

23 The desert animals are mostly ……...

a) nocturnal b) diurnal

c) active during day d) active in sunlight

24 To avoid water loss some desert reptile undergoes aestivation which is called.....

a) Summer sleep b) Hibernation

c) Winter sleep d) sleeping sickness

25 Which of the following is not a desert adaptation in reptiles?

a) Reduced metabolic rate b) Short tail

c) Burrowing habitat d) Hygroscopic skin

26 What is the symptom of a snake bite?

a) Decreased saliva production b) Decreased sweat production c) increased pulse rate d) anxiety

27 What is not the symptom of a snake bite?

a) Increased saliva production b) Increased sweat production c) increased pulse rate d) anxiety

Chapter 2 Introduction to class –Aves

(05L)

2.1 Salient features of class Aves with two examples (names only) – Sparrow, Parrot.

General Characters

1. Birds are warm blooded vertebrates with an exoskeleton of feathers.
2. The fore-limbs are modified into wings, each bearing three clawless digits and provided with feathers for flight.
3. The hind-limbs are adapted for walking, perching or swimming and bearing four toes.
4. No skin gland except the oil glands on the tail.
5. The bones, forming the skeleton, are spongy, light in weight containing air cavities.
6. Skull is monocondylic, having single rounded occipital condyle.
7. The lower jaw is composed originally for five or six bones.
8. Modern birds have no teeth. A horny beak is present.
9. The cervical and free thoracic *vertebrae* are usually heterocoelous but may be procoelous or amphicoelous.
10. The sacral vertebrae are fused with the lumbar and with fewer of more of the posterior thoracic and anterior caudal to form a synsacrum.
11. The posterior caudal vertebrae are usually fused to from a pygostyle.
12. Vertebral ribs are double-headed, provided with uncinate process.
13. The sternum is broad, usually with a longitudinal ventral keel for the attachment of flight muscles.
14. The coracoid is usually more or less pillar-like; the scapula is sabre-shaped.
15. The clavicles and interclavicle unite to form a V-shaped furcula.
16. Distal carpals and metacarpals are united to form a carpo-metacarpus.
17. Proximal tarsals are fused with the tibia to form a tibio-tarsus and metatarsals with the distals to form the tarso-metatarsus.
18. In the leg, the ankle joint is inter-tarsal.
19. The gullet is dilated into a crop. Stomach is divided into a glandular proventriculus and a muscular gizzard. Cloaca is three chambered.
20. Lungs are spongy and non-distensible. Air-sacs ar present and some of them communicate with air-cavities in the bones.

21. The voice is produced by the syrinx situated near the junction of the trachea with the bronchii.
22. Lyrinx is without vocal cords.
23. The heart is four chambered. Only right aortic arch is present in the adult.
24. R.B.C. are oval, nucleated and biconvex.
25. Renal portal system is vestigial
26. Kidneys are metanephric, three-lobed and ureters open into the cloaca.
27. The cerebral hemispheres and cerebellum are large and the optic lobes are displaced laterally.
28. Sexes are separate and sexual dimorphism is well-marked.
29. The left ovary alone is present.
30. Fertilization is internal.
31. Oviparous. Large ovum containing much yolk invested with albumen.
32. The embryo has an amnion, an allantois and a large yolk-sac.
33. Parental care is highly developed.

CLASS-AVES

Subclasses

I — Archaeornithes — Ex. *Archaeopteryx* (Extinct)

II — Neornithes

Subclass – ARCHAEORNITHES

1. Extinct Jurassic birds of Mesozoic age.
2. Tail long with more than 13 caudal vertebrae bearing rectrices arranged in two lateral rows.
3. Pygostyle was absent.
4. Vertebrae were amphicoelous.
5. Three fingers and metacarpals were free, each with a claw.
6. Teeth embedded in sockets were present in both jaws.
7. Examples : 1. *Archaeopteryx*, 2. *Archaeornis.* — Extinct

Subclass II – NEORNITHES

1. Living as well as extinct birds.
2. Tail is usually short, ends in a pygostyle.
3. The rectrices are arranged in a semicircle around the pygostyle.
4. Teeth are absent except in few forms.
5. The metacarpals are fused with the distal carpals to form a carpo-metacarpus.
6. Except in one case, not more than two digits of the hand bear claws.
7. Claws are absent in the fore-limbs.
8. The sternum is well-developed and usually provided with a keel or carina.
9. Vertebrae are heterocoelous in living forms.
10. Caudal vertebrae are 13 or less.

– PALAEOGNATHAE

1. Mostly flightless walking or running birds.
2. Wings are reduced or absent.
3. Teeth are absent.
4. Tail vertebrae are free.
5. Coracoid and scapula are small and fused at an obtuse angle.
6. Sternum devoid of keel or carina.

Examples: ***Struthiocamelus*** (Ostrich).. *Dromaeus* (Emus).. *Casuarius* (Cassowaries). *Apteryx* (Kiwi).

NEOGNATHAE

1. Modern, usually small flying birds.
2. Skull is neognathus, i.e, with short vomer and palatines extending posteriorly.
3. Teeth arc entirely absent.
4. Feathers having interlocking mechanism.
5. Wings are well-developed.
6. Sternum with a well-developed keel.
7. Tail vertebrae are 5 or 6.
8. Pygostyle is present.
9. Fore-limbs with metacarpals joined and fingers included in the wings.

Example: ***Aptenodytes*** (Penguin). ***Gavia immer*** (Common loon). *Podiceps, Podilymbus. Puffinus* (Petrels).***Pelecanus*** (Pelecan).. *Ardea* (Great blue heron),. *Phoenicopterus* (Flamingo).Ducks, Geese, Swans. Vultures, Kites, Hawks and Falcone,

Gypus.. *Gallus* (Jungle fowl),. *Pavo cristatus* (Peacock), *Coturnix* (Quail). *Erancolinus* (Grey patridge),. *Phasianus* (Phesants).. *Grus* (Crane), . *Fulica atrica* (Common Coot), *Antegona antegona* (Sarus crane).**:** *Diatryma* (Extinct).. *Lobivanellus indicus* (Red-wattled lapwing), 2. *Hydrophasianus chirugus* (Pheasant-tailed jacana), 3. *Tringa glariola* (Sand-piper), 4.*Capella* (Snipe), 5. *Larus* (Gull), etc. *Columba livia* (Blue-rock pigeon), 2. *Goura cristata* (Crowned-pigeon), 3.*Streptopelia risoria* (Ring-dove) 4.*Streptopelia chinensis* (Spotted dove), etc. *Cuculus canorus* (Cuckoo), 2. *Eudynamys scolopaceous* (Koel).. *Pisittacula eupetra* (Large Indian Parrakeet), 2. *Psittacula krameri* (Green parrot) *Bubo bubo* (Great-horned-owl), *Ketupa zeylonensis* (Brown-fish owl).. Swifts, 2. Humming birds. King-fisher.1. *Dryobates* (Yellow-front-pied woodpecker), *Brachypternus bengalensis* (Golden-beak woodpecker).. *Passer domesticus* (Common house-sparrow), 2. *Corvus splendens* (Common House crow), 2. *Acridotherus tristis* (Common myna), 4.*Saxicoloides fulicata* (Indian robin), 5.*Oriolus oriolus* (Golden oriole), 6.Bulbul, 7.Swallos.

2.2 Flight adaptations in birds.

Young (1958) is not wrong when he calls the birds as ‘masters of the air’. There is practically no system or no organ that has not been modified in relation to flight. The following account precisely indicates how much birds are adapted to their aerial mode of life through their anatomy, embryology, physiology and ecology.

1) Shape

The shape of the body represents the sum of all its several adaptations. The perfectly streamlined spindle-shaped body of a bird is designed to offer minimum resistance to the wind, and hence easily propelled through the air in the same manner as the fish swim through water quite easily without any waste of effort.

2) Compact body

The compact body, light but strong dorsally and heavier ventrally, helps in maintaining balance in the air. The attachment of the wings high up on the thorax, the high position of such light organs as lungs and air-sacs, the low and central position of the heavy muscles, sternum and digestive organs beneath the midline of the attachment of two wings and consequently low centre of gravity, are also structural facts of importance.

3) Body covering of feathers

Feathers are diagnostic of birds, since no other group of animals has developed them. The smooth, closely fitting and backwardly directed contour feathers make the body streamlined and further help its passage through the air by reducing friction to minimum. The light feathers hold a considerable blanket of enveloping air around the body and add much to its buoyancy. The non conducting covering of feathers insulates the body perfectly and prevents loss of heat which enables the bird to endure intense cold at high altitudes and also to maintain a constant temperature.

4) Forelimbs modified into wings

The forelimbs have been converted into the unique and powerful organs, the wings. These marvelously designed structures equipped with special flight muscles have been developed as instruments of propulsion through air. The elongated flight feathers of wings are called the remiges. The expanded membranous part or vanes of each remix forms a flexible and continuous surface for striking the air in flight. The flight feathers of a wing form a broad surface for supporting the bird in air. The particular shape of the wing, with a thick strong leading edge, convex upper surface and concave lower surface, causes reduction in air pressure above and increase below, with minimum turbulence behind. This helps in driving the bird forwards and upwards during flight.

5) Short tail

The short muscular tail bears a series of long, strong but light caudal feathers or rectrices arranged in a fan-like manner and serves as a rudder for steering during flight, to suddenly check flight, and as a counterbalance in perching.

6) Beak

The conversion of forelimbs into wings is duly compensated by the presence of a bill or beak. The mouth is drawn out into the horny beak, which is used as forceps in picking up things. Besides procurement of food, the beak is also used for nest-building, which in other animals is done by the forelimbs.

7) Mobile neck and head

The neck of birds is very long and flexible. Since the birds' bill is used for feeding, preening, nest-building, offence and defense and the like, mobility of neck and freedom of movement of the head are very important.

8) Bipedal locomotion

The forelimbs being no longer available, the hind limbs or legs spring somewhat anteriorly from the trunk to balance and to support the entire weight of the body and for locomotion on the ground or in water. Bipedality is as characteristic of birds as flight, since flightless birds have all retained the habit of walking on two legs. The legs are also relatively stronger.

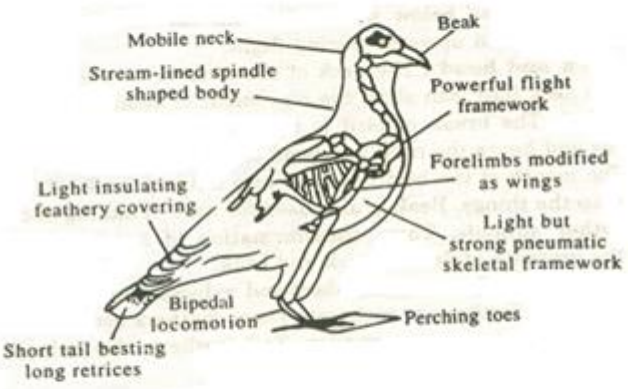


Fig. Diagram showing Aerial adaptations in Bird

9) Large muscles of flight

While muscles of the back are greatly reduced, the flight muscles on the breast are greatly developed, weighing nearly one-sixth of the whole bird. The wing is depressed or lowered by an enormous pectoralis major. It is elevated or raised by pectoralis minor the tendon of which passes through the foramen triosseum to be inserted dorsally on the head of humerus. There are other muscles of minor importance.

10) Endoskeleton

The fusion of bones built with the smallest amount of material after the 'hollow girder principle', combines strength with lightness, one of the first essentials in successful flight. Most of the bones are pneumatic and filled with air-sacs instead of bone marrow. Skull bones are light and most of them firmly fused together. Uncinate processes of thoracic ribs help in producing compactness, necessary for flight, by concentrating the mass. The rigidity of the dorsal part of vertebral column, due to fusion of vertebrae, provides a firm fulcrum for the action of wings.

11) Air-sacs and respiration

The inelastic lungs of birds are supplemented by a remarkable system of air-sacs, which grow out from lungs and occupy all the available space between internal organs, even extending to the cavities of hollow bones. The air-sacs secure more perfect aeration of lungs and help in internal perspiration, thus helping in the regulation of the body temperature. The avian lungs are completely emptied with each breath, there being no residual air remaining, so that respiration is more effectively accomplished.

12) Warm bloodedness

Birds are warm blooded animals. The perfect aeration of blood is responsible for the high temperature of body (40^0-46^0 C), which is a necessity for flight requiring a great output of energy over a longer period.

2.3 BEAK AND FEET MODIFICATIONS IN BIRDS

2.3.1 Beak Modifications in Birds

The entire modern avian world if characterized by the absence of teeth. The upper and lower jaw bones become elongated to form a peculiar beak or bill covered by a horny sheath called rhamphotheca. The modifications of type of beaks are mainly related to the type of food eaten and to the manner of feeding. Birds exhibit almost indefinite variations in shape, size and structure of beaks, of which only some of the most important and common types are described here.

1) **Seed eating beak:** Short, stout, peg-like and conical beaks are characteristic of small granivorous or seed eating birds, such as sparrows, finches and cardinals. The weaker beaks are used for piercing up small seeds, while more powerful beaks are meant for crushing large and hard shelled seeds and fruit stones.

2) **Fruit eating beak:** In parrots, the beak is sharp, massive, deeply hooked and extremely strong. It is well adapted for gnawing or braking open hard seeds and nuts, which form their staple diet. The enormous beak of hornbills, looking so heavy and cumbersome, is really quite light as its interior is of a cellular structure. It is suggested that these cells act as resonators, thus enabling the bird to produce its exceptionally loud cry.

3) **Insectivorous beak:** In swallows and swifts, the beak is small, wide and delicate to scoop up their living insect prey while on wing. In fly catchers, the beak is short but strong, with mandibles notched at the tip and beset with numerous rectal bristles at the base. In hoopoe and robin, the beak is long, slender and slightly curved and meant for turning the leaves or probing into the soil for insect grubs and pupae.
4) **Cutting beak:** Birds such as crow possess long, sharp and slender beaks with cutting edges, which can be used in various ways.
5) **Wood chiseling beak:**Woodpeckers have elongated, straight and stout chisel-like beaks for drilling into the barks or wood for insect larvae or for nest construction. They have thickened, shock absorbent skull bones and strong neck muscles to make such pounding feasible.
6) **Tearing and piercing beak:** The carnivorous birds which feed on carrion and flesh such as vultures, hawks, eagles, owls, kites, etc. have short, pointed , sharp edged and powerful, hooked beaks for tearing the flesh and operated by well-developed mandibular muscles.

7) **Mud probing beak:** Familiar examples of mud probing beaks are found in snipe, stilt, sand piper, Jacana, lapwing, etc. Their beaks are extremely long and slender and are used as a probe for thrusting far down into water and mud in search of worms and larvae. Some of these birds are remarkable for the slenderness and extreme length of their beaks.

8) **Water and mud straining beak:** In ducks, teals and geese, the beak is broad and flat. The edges of the jaws are furnished with horny serrations or transverse lamellae, which act as a sieve or strainer, letting the water and mud pass out while retaining the food in the mouth. Such a beak enables the bird to avail itself of the rich store of food in the shape of insects and other organism. In flemingo, the beak is distally curved downwards and likewise furnished with shifting lamellae. The two halves of lower jaw are considerably enlarged so that the comparatively narrow upper jaw closes upon a wide cavity.
9) **Fish catching beak:**Herons, Kingfishers and Storks have long, powerful and sharply pointed, spearing beaks to capture fish, frogs, tadpoles and similar aquatic animals. Cormorants have long and narrow beaks, the edges of which are armed with sharp

backwardly directed, teeth like processes meant for capture of fish. In darters, these serrations take the form of fine needle like points.

10) **Spatulate beak:** The spoon-bill possesses a very specialized form of beak. It is flattened throughout its length but terminates in a broad, spatulate or spoon-like expansion meant for dabbling in water and mud in search of insects, worms, fish, mollusks and other small animals upon which the bird feeds.

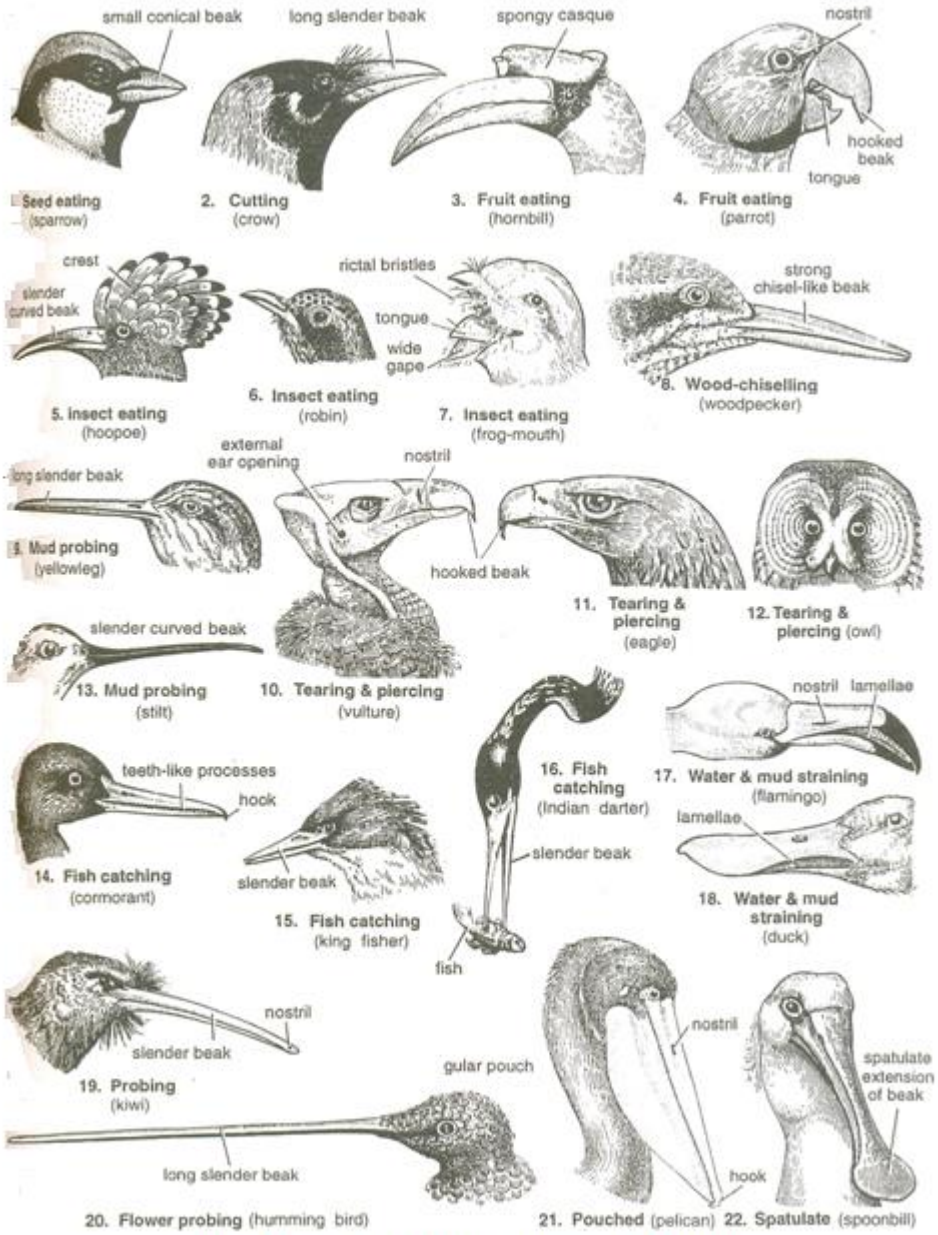


Fig. Beaks Modification In Birds

2.3.1 Feet Modifications in Birds

The feet of birds are also modified variously in accordance with the character of the environment and the manner of locomotion.

1) **Cursorial or running feet:** In running birds, the legs are powerful and the number of toes is reduced. The hind toe may be elevated, reduced or absent. In bustards, emu, rhea and cassowary, only three toes, directed in forward direction are present. Ostrich has only two toes, of which the outer one is smaller and without a nail.
2) **Perching feet:** The majority of birds belong to the category of perching birds or passers, such as sparrows, crows, bulbuls, robins, mynahs, etc. Three toes are anterior and slender, while one toe or hallux is posterior, strongly built and opposable, so that they can securely fasten the foot to a branch or a perch.
3) **Scratching feet:** The feet of fowls, quails, pheasants, etc. are stout, with strongly developed claws and well adapted for running as well as scratching the earth. The foot of male bird is usually provided with a pointed bony spur for offence and defence.
4) **Raptorial feet:** Predatory or carnivorous birds, such as eagles, kites, vultures, owls, etc. have strongly taloned feet for striking and grasping their prey. The toes have strongly developed sharp and curved claws. There are four toes present. Large and fleshy bulbs, called tylari, are found on the undersurface of the toes, especially developed in the sparrow-hawk.
5) **Wading feet:** the legs and toes of exceptionally long and slender in wading or marshy birds such as herons, snipes, jacana, lapwing, etc. These serve to walk over aquatic vegetation or marshes. The web is absent or feebly developed.
6) **Swimming feet:** In swimming birds, the toes are webbed, partially or completely. In diving birds, like coots and grebes, the web is lobate and the toes are free. In swimming and paddling birds, such as ducks and teals, only the anterior three toes are united in a web. In pelican and cormorant, all the four toes are enclosed in the web.
7) **Climbing feet:** In parrots and woodpeckers the feet are used as grasping organs and especially adapted for climbing vertical surfaces. The second and third toes are in forward direction while the first and fourth toes are in backward direction.
8) **Clinging feet:** In swifts, martinets and humming birds, all the four toes are in forward direction and serve to cling to steep faces of cliffs or under caves of houses, etc.

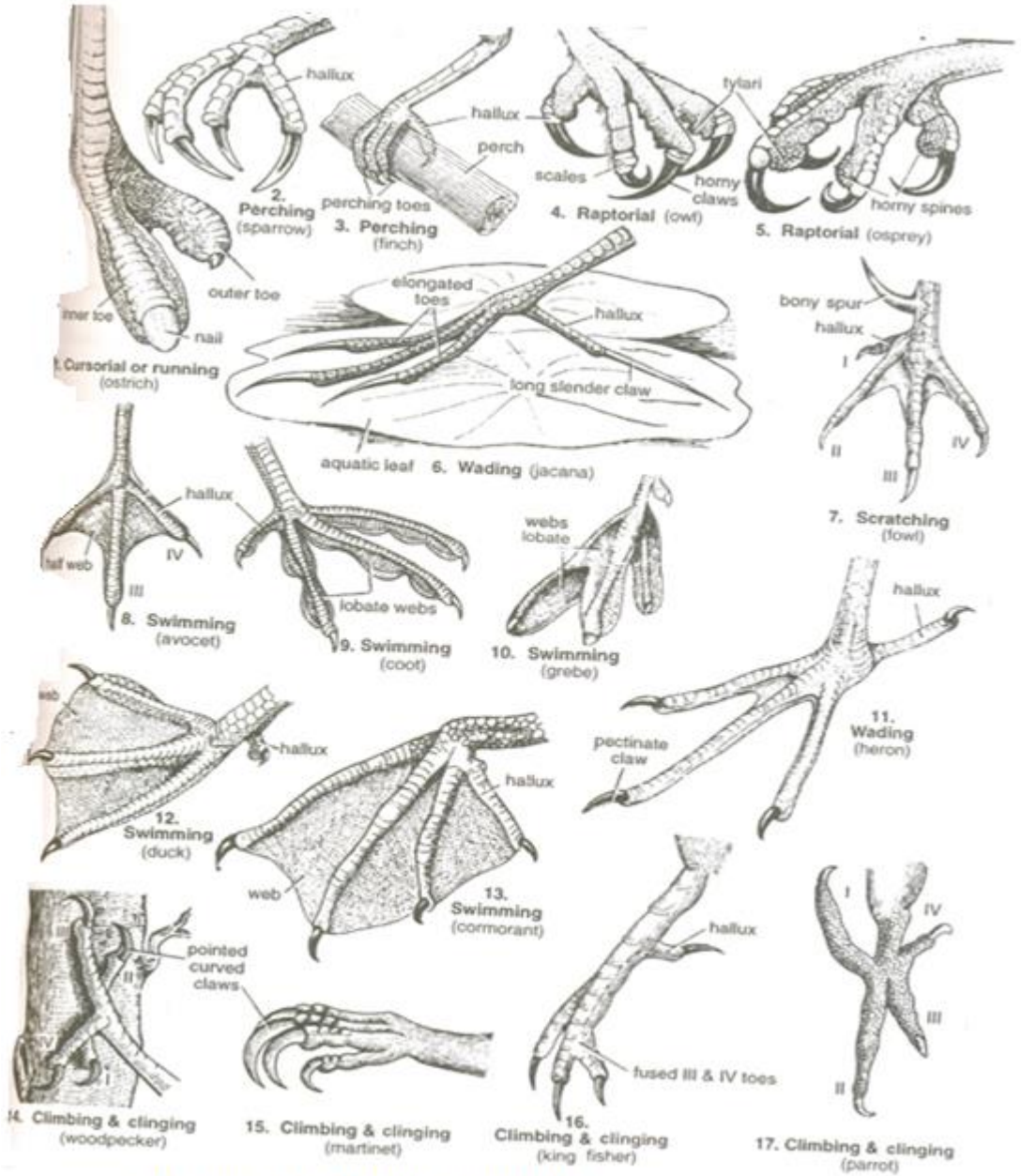


Fig. Feet Modifiction in Birds

2.4 MIGRATION IN BIRDS

One of the most spectacular events concerned with the bird life is the seasonal migration of many species, and their ability to navigate. In broad sense, 'migration', as defined by Cahn, "is a periodic passing of animals from one place to another, (L. migrare – to travel)". When applied to other animals, it means their dispersal or immigration, implying no return journey. On the other hand, bird migration is a two way journey. It means a regular, periodic, to-and-

fro movement of a population of some birds between their summer and winter homes, or from a breeding and nesting place to a feeding and resting place.

Types of migration in birds

1) Latitudinal migration

Because of the gift of wings, birds conveniently exploit two different parts of the earth. The most familiar migrations are latitudinal migration, in which birds migrate, north to south and vice versa. These are pronounced in the Northern hemisphere, having larger land masses. Birds move during summer over the temperate and sub-arctic regions of Northern hemisphere, where there are facilities for feeding and nesting. The birds return to the south for shelter during winter, when north is covered with ice and snow. Several North American and Eurasian birds cross the equator to spend winter in deeper and warmer parts of South America and Africa.

The American golden plover (*Pluvialisdominica*) passes the nine months of winter 8,000 miles south in the pampas of Argentina, thus enjoying two summers each year and knows not a hint of winter. Some birds of Siberia visit the plains of Himalayas in India. An opposite but lesser movement occurs in the Southern hemisphere, where the seasons are reversed.

2) Longitudinal migration

Some birds make migration that are longitudinal rather than latitudinal, that is, east to west and vice versa. These birds migrate from East part of world to West, or in opposite direction, to cross different longitudinal distance, so called as longitudinal migration. The bird, Starling moves from a breeding area in East Europe or Asia towards the Atlantic coast, to avoid the continental winter.

3) Altitudinal migration

Wherever large mountains are found in temperate regions, the birds migrate regularly up and down their slopes, as the weather changes. The birds pass the summer in the mountainous regions, but return to the lowlands in winter. It is merely a dispersal or short journey from the bleaker slopes to the more protected valleys and has been called altitudinal or vertical migration. It occurs in the Grebes and Coots of Andes in Argentina, Violet green swallows of Great Britain and the Willow ptarmigan of Siberia.

4) Partial migration

Many species of temperate regions are only partial migrants. An addition is made in constant residents, which do not migrate at all, by an influx of new individuals of the same species for a short period. Thus barn owls (*Tytoalba*), blue birds and many blue jays of Canada and Northern United States travel southwards to mingle with the sedentary populations of the southern states. Songthrush, redbreast, titmouse, finch, etc., seen throughout the year, actually represent partial migrants, as the birds seen in winter are not the same as seen in summer.

5) Seasonal migration

Field observers in temperate countries have grouped migrating birds according to seasons. Thus, in Britain, swifts, swallows, nightingales and cuckoos are summer visitors, for they arrive in spring from the south, remain to breed and leave for the south in autumn, chiefly from the north, stay throughout the winter and fly northwards again in spring. While, some like snipes and sandpipers are the birds of passage, seen for a short time twice a year on their way to colder or warmer countries in spring and autumn.

6) Irregular or vagrant migration

In some birds, such as herons, after breeding, the adults and the young may stray from their home to disperse in all directions over many or a few hundred miles in search of food and safety from enemies. Sometimes sea birds are taken by hurricanes to as far as 2,000 miles away from home seas to drop exhausted or to die on unfamiliar shores.

Advantages of migration

1) Birds get suitable place for breeding and nesting.
2) The birds get plenty of food supply in the place of migration.
3) They get more time for food search.
4) The birds escape from excess cold or heat and storms.
5) It provides strong survival value for the species through evolution.
6) It also provides opportunity for genetic exchange with individuals of other parts of the world.

Disadvantages of migration

1) Migration is expensive in terms of food and energy requirements.
2) Thousands of birds are killed during migration due to sudden change in the weather, such as heavy rainfall, snow fall or stormy winds.
3) Many birds die due to hitting with high towers, big buildings, lamp posts, ceilometers beams at the airports etc.
4) Small birds are killed by their predators.
5) Non-stop, long journey is exhaustive to the birds and some drown in the seas while crossing them.

MCQs

13……. are warm blooded vertebrates with an exoskeleton of feathers.

a) Reptiles b) Birds

c) Mammals d) Amphibians

14 In …… skin gland is absent except the oil glands on the tail.

a) Fishes b) Reptiles

c) Birds d) Amphibians

15 In birds…….. are adapted for walking, perching or swimming

a) Fore-limbs b) Fins

c) Feathers d) hind-limbs

16 In ……the bones, forming the skeleton are spongy.

a) Fishes b) Mammals

c) Birds d) Amphibians

17 In birds the …….. are modified into wings

a) Feathers b) hind-limbs

c) Fore-limbs d) Fins

18 In birds …….. is divided into a glandular proventriculus and a muscular gizzard.

a) Pharynx b) Stomach

c) Intestine d) Rectum

19 The only left ovary is present in class……...

a) Amphibians b) Mammals

c) Fishes d) Aves

20 Archaeornithes and Neornithes are the two subclasses of class…….

a) Reptiles b) Mammals

c) Aves d) Fishes

21 ……. are the extinct Jurassic birds of Mesozoic age.

a) Neornithes b) Living birds

c) Modern birds d) Archaeornithes

22 *Archaeopteryx* and *Archaeornis* are the examples of ……

a) Neornithes b) Archaeornithes

c) Modern birds d) Living birds

23 …… is an example of flightless or running birds.

a) Flamingo b) Vulture

c) Ostrich d) Hawks

24 …… is an example of flightless or running birds.

a) Crow b) Emu

c) Vulture d) Hawks

25 In bird …….wings are well-developed

a) Kiwi b) Vulture

c) Ostrich d) Emu

26 In bird …….. teeth were embedded in sockets and present in both jaws.

a) Crow b) *Archaeopteryx*

c) Vulture d) Hawks

Chapter 3) Introduction to class - Mammalia.

(04L)

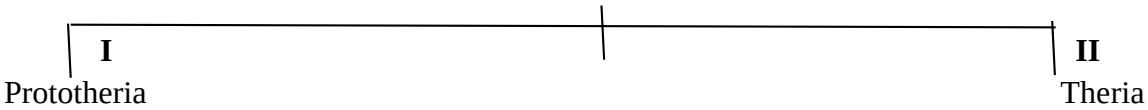
3.1 Salient features of class Mammalia with two examples (names only) – Rat, Rabbit.

General Characters

1. Mammals are warm blooded animals.
2. The skin is more or less covered with hairs (except Cetacea).
3. Sudoriporous (sweat**)** glands and sebaceous (oil) glands are present in the skin.
4. Mammary glands in females, whose function is that of nourishing the young, are also present.
5. External ears (pinnae) are present.
6. Teeth are heterodont (differentiation into incisors, canines and molars), thecodont (embedded in the alveolar pockets of jaw) and diphyodont (only two sets of teeth, a milk set replaced by permanent set).
7. Skull with tow occipital condyles which are formed entirely by the exoccipitalscv.
8. Skull is without prefrontals, postfrontals, quadrato-jugal, supraorbitals and basipterygoids.
9. The lower jaw is composed of a single bone, on each side, the dentary which articulates with squamosal of its side.
10. Vertebrae are gastrocentrous composed of three pieces, the centrum, and tow epiphyses.
11. With few exceptions mammals possess seven cervical vertebrae.
12. The ribs articulate with the vertebrae by two heads, capitulum and tuberculum.
13. The digits in the fore-and hind-limbs are never more than five, but often reduced.
14. Limbs are either plantigrade or dirgitigrade or unguligrade.
15. Presence of a muscular diaphragm between thoracic and abdominal cavities.
16. Heart is four chambered with only a left aortic arch.
17. R.B.C. are non nucleated.
18. Brain with four optic lobes.
19. The kidney is metanephros.
20. Penis is always present.
21. Viviparous. The young, except in monotremes, develops in the uterus for some time and born alive.

CLASS-MAMMALIA

Subclasses



Subclass I-PROTOTHERIA

1. No external pinna on the ear.
2. Teeth are present only in young, adults with horny beak.
3. A cloaca is present into which ureters and urinogenital sinus open.
4. Mammary glands are without nipples.
5. The pectoral girdle possesses large coracoid bones and interclavicle.
6. The pelvic girdle possesses epipubic bones extending from the pelvis.
7. Vertebrae are without epiphyses.
8. The ribs have only a single head, the tuberculum being absent.
9. The cervical ribs are present.
10. In the skull, tympanic bulla and lacrimals are absent; the jugal is reduced or absent.
11. There is no corpus callosum in the brain.
12. The cochlea is a simple process of the sacculus and not coiled.
13. Testes are abdominal.
14. Females are oviparous.
15. Found in Australia, Tasmania and New Guinea.

Examples : 1. *Echidna,*

2Ornithorhynchus.

Subclass II-THERIA

1. Includes marsupial and placental mammals.
2. Ear usually with external pinna.
3. Teeth are usually present both in youngs and adults.
4. Cloaca is usually absent.
5. Mammary glands with nipples.
6. Testes usually in the scrotal sac.
7. Vasa deferentia and bladder opening through a common urethra in penis.
8. Ureters open into the base of bladder.

9. Oviducts open into a vagina.
10. Females are viviparous

Infraclass I – METATHERIA

1. Marsupium or brood pouch is present in the females.
2. Mammary glands are sebaceous and bearing nipples.
3. Epipubic (marsupial) bones are usually present and attached with the pubis.
4. Separate coracoid and interclavicle are absent.
5. Ribs bear two heads, tuberculum and capitulum.
6. Vertebrae with epiphyses.
7. Corpus callosum is feebly developed or absent.
8. Vagina and uterus are double (didelphic condition.)
9. Viviparous.
10. Placenta is usually absent.

Order 1.Marsupialia

Examples : 1. *Didelphis* (Opossum). 2. *Dasyurus* (Tiger-cat).3. *Caenolestes,* 4. *Notoryctes* (Marsupial mole),5. *Parameles* (Bandicoot). 6. *Macropus* (Kangaroo).

Infraclass II- EUTHERIA

1. Marsupium (marsupial pouch) is entirely absent.
2. Mammary glands are well developed with nipples.
3. Epipubic bones are absent.
4. Ribs bear two heads, tuberculum and capitulum.
5. Clooca is absent.
6. Corpus callosum is absent.
7. Urinogenital organs open independently of the rectum.
8. Testes are usually contained in scrotal sacs.
9. Vagina is single.
10. Viviparous.
11. The young always nourished for a considerable time in the uterus by means of allantoic placenta and born in a relatively advanced state.

Examples: 1. *Erinaceus, . Paraechinus* (Hedgehog),. *Scapanus,* . Talpa (Mole), *Sorex,. Echinosorex* (Shrews). *Galeopithecus*. *Pteropus,. Xantharpyia,. Cynopterus. Magaderma, Rhinolophus, Desmodus, Eptesicus* (Brown bat).. *Lemur,* . *Indris,* . *Chirogale,* . *Chiromys (Aye-aye).* . *Loris.*. Monkeys, .Apes, . Man.Rabbits and Hares.. *Funambulus* (Squirrel), . *Rattus rattus* (house rat), . *Hystrix*

(Porcupine). . Guinea pig, etc. Whales, Dolphins.*Panther leo* (Lion), . *Panther tigris* (Tiger),*Prionalurus bengalensis* 4. *Acinonyx* (Hunting leopard),(Leopard cat).. Civet cat,. *Herpestes* (Mangoose), 7. *Hyaena*. *Canis* (Wolf), . *Vulpes* (Fox), *Lutra* (otter), etc. *Otario jubata* (Sea-lion), *Odobenus* (Walrus), . *Phoca* (Seal).*Equus* (Horse), Zebra, *Tapirus* (Tapir),. *Rhinoceros*.. *Hippopotmus* (Horese of river), . *Sus* (Pig), *Dicotyles* (Peccaries), Camelus (Camel),. deer, . Giraffe,. Antelope, Cow, Buffalo, . Sheep, . Goat, etc.

3.2 Egg laying mammals.

Most primitive living mammals are egg laying mammals, also called as monotremes, belonging to subclass Prototheria. They are represented by two types, spiny anteaters (*Tachglossus* and *Zaglossus*) and duckbills (*Ornithorhynchus*), confined to the Australian region.

1. *Tachyglossus* (Spiny anteater)

The Australian spiny anteater or echidna is *Tachyglossusaculeatus*. It is found throughout Australia and Tasmania. It is terrestrial and burrowing about 45 cm long. Body is covered with coarse hair and small spines, except on the belly. The short limbs have broad feet bearing strong claws for fast digging. The long tubular snout forms a slender beak with terminal rounded mouth. Tongue is long, protrusible and sticky, and used to sweep insects. Teeth are absent. Upper surface of tongue has horny serrations which grind against ridges on palate. Eyes are small, without nictitating membrane, external ears are inconspicuous, and tail is absent.
During breeding season, the female develops a temporary abdominal pouch into which she puts her single egg (sometimes 2 or 3) for incubation. Egg shell is leathery. The young one hatches in an immature condition. It is carried for some time in pouch and nourished on milk from mammary glands without teats. Male anteater also possesses mammary glands secreting milk to feed the young. This condition is known as gynaecomastism. Male anteater also has a hollow tarsal spur on each hindleg connected to a poison gland in the thigh. Second claw of each hindleg forms a long and curved toilet claw to clean spines. Sweat glands are absent. Cervical vertebrae bear separate ribs.

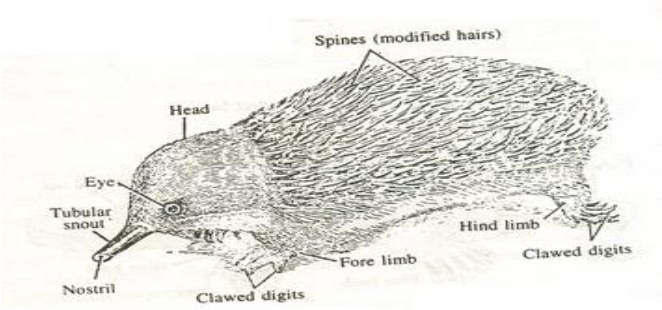


Fig. Spiny Ant Eater

2) *Ornithorhynchus* (Duckbill)

Duck-billed platypus, *Ornithorhynchusanatinus*, is found in the rivers of Eastern Australia and Tasmania. It is a beaver-like monotreme about 50-60 cm long and well adapted to life in water. It has a thick covering of soft, waterproof fur and a flattened tail. Eyes are small, bead-like, with nictitating membrane, and there are no external ears. Toes are clawed as well as webbed, the webs extending beyond the tips of claws. Upper jaw forms a broad sensitive bill, like that of a duck, covered with soft hairless rubbery skin. With its bill, the animal probes in the bottom mud of streams for worms, crustaceans, insect larvae, molluscs, etc. Teeth are replaced in the adult by horny epidermal plates meant for crushing hard food. Each hindleg of male carries a sharp, stout, movable, hollow tarsal spur on its heel, connected with a poison gland higher in the leg. These spur mark sexual dimorphism, serve to hold the female in sexual embrace and are used in combat.

The female burrows in the bank of a river and constructs a nest of grass at the end of a subterranean tunnel. Usually 2 eggs are laid at a time. The female curls around them for incubation and remains inactive for about 2 weeks. Newly hatched young are exceedingly immature, naked, blind and each 2.5 cm long. Female holds the young to the abdomen with the help of her tail. As the mammary glands are modified sudorific glands have no teats, the young feed by lapping milk from the two milk grooves on the abdomen of the female.

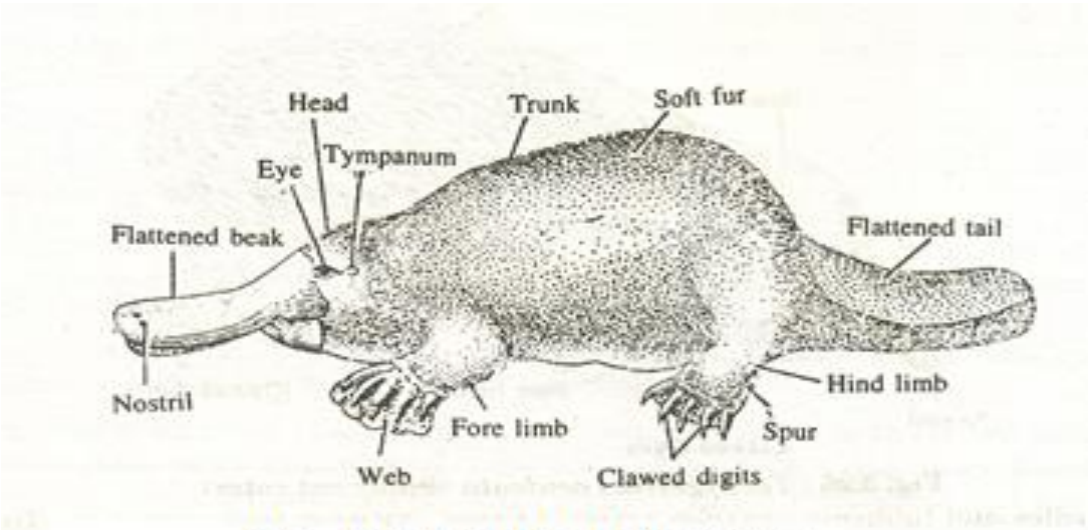


Fig. Duck Billed Platypus

3.3 Aquatic adaptations in mammals.

Whales, dolphins and porpoises of the order Cetacea are large marine animals, well adapted for aquatic life. Their cylindrical streamlined body tapers towards long fish like tail, ending in two fleshy horizontal lobes or flukes. Forelimbs are modified into broad paddle-like flippers whiles posterior limbs are absent. A thick layer of fat or blubber under skin compensates for lack of hairs and insulates body.

1. Physeter (Sperm Whale)

Physetercatodon, commonly called as sperm whale is common in warmer seas. It is the largest toothed whale with male upto 25 metres long while female only half in size. There is no dorsal fin. The enormous, barrel shaped head or rostrum measures a third of toal body length and filled with about one ton of spermaceti oil. It is non edible but used in industry as a lubricant, in making candles and as a base of cosmetics. A peculiar stone like substance, ambergris is formed in its stomach and is used in perfumes. Upper jaw has vestigial teeth. Lower jaw is much shorter than the upper and bears numerous functional homodont conical teeth. It feeds mostly on squids. When it comes to surface, it expires forcibly through the single nostril. The moist warm exhaled air condenses in cold atmosphere forming a spout of water. This act is called blowing.

2. Balaenoptera (Blue Whale)

The blue whale, Balaenopteramusculus, is a whalebone whale. It may grow upto 35 metres and weigh 150 tons. It is the longest whale and the largest animal that has ever lived. It feeds in Arctic and Antarctic waters but migrates to temperate waters to breed. Body is blue above and yellow below. It is distinguished from sperm whale in having a small dorsal fin, smaller head, narrow ridges on throat and slightly curved jaws. Instead of teeth moth cavity is provided with a series of numerous parallel horny plates of whalebone or baleen hanging down from the palate. These act as sieves or strainers for microscopic animals or plankton on which they live. Thus the largest animal in the world, live upon the smallest.

3. Platanista (Ganges Dolphin)

All freshwater dolphins have long, almost bird like, beaks containing upto 200 teeth in both the jaws. ‘Susu’ or Ganges dolphin, *Platanistagangetica*, lives in the Ganges, Brahmaputra and perhaps in the Indus rivers and their tributaries. Body is 2 to 3 metres long, dark grey in colour, with a small head with a well developed maxillary crest, long beak and sharp teeth in both the jaws. It probes in the mud for shellfish.

1) Delphinus (Common Dolphin)

It is the common marine dolphin having a large number of teeth. It differs from *Platanista* in having a neck, well developed eyes and a dorsal fin in the centre of back.

2) Monodon (Narwhal)

Monodonmonoceros lives in Arctic waters and grows to 5 metres in length. In male, one of the two upper incisors grows into a spirally twisted tusk or horn, upto 2.5 metres long, and of unknown function. The female retains undeveloped incisors, buried in premaxillae.

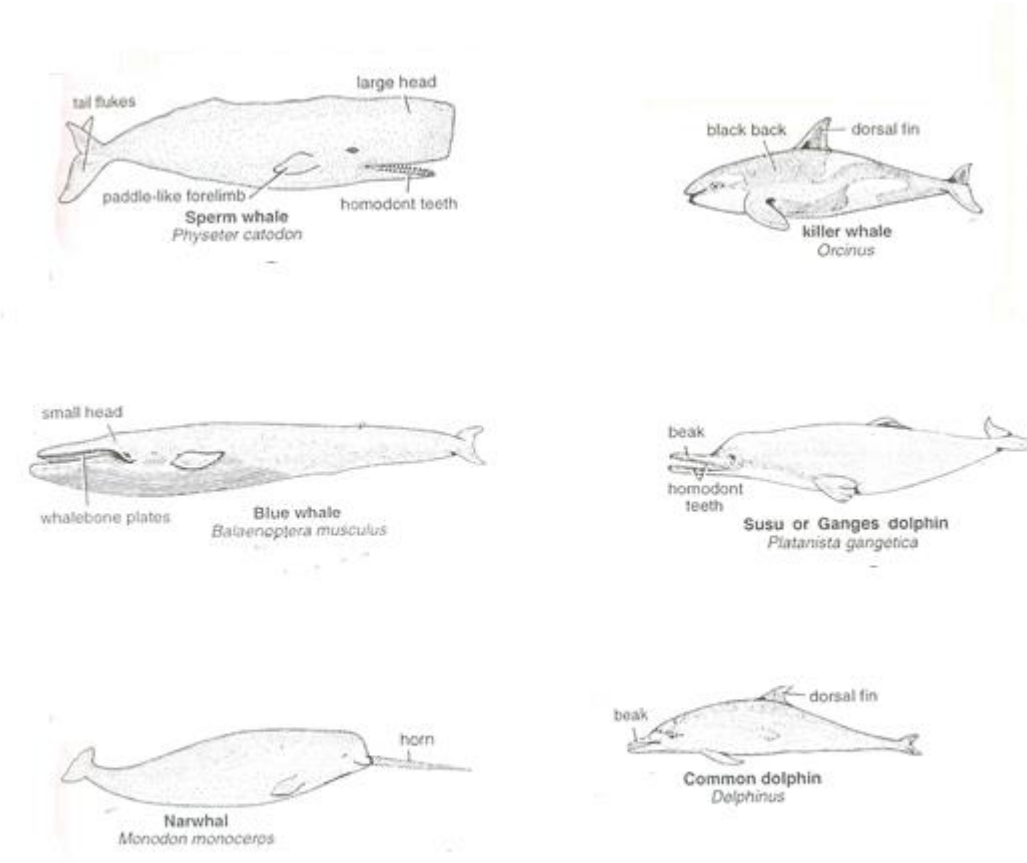


Fig. Aquatic Mammals

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3.4 Flying adaptations in mammals.

3.5 Cursorial and fossorial adaptation in mammals

MCQs

27 …….. are warm blooded animals.

a) Reptiles b) Mammals

c) Snakes d) Fishes

28 In ……. sweat glands and sebaceous glands are present in the skin

a) Crocodiles b) Fishes

c) Lizzards d) Mammals

29 For nourishing the young ones presence of mammary glands in females is a characteristic of …….

a) Reptiles b) Fishes

c) Aves d) Mammals

30 External pinna of ears are present in class……

a) Amphibians b) Mammals

c) Fishes d) Aves

31 Mostly mammals are……..

a) Oviparous b) Viviparous

c) Egg laying d) Ovo-viviparous

32 ……..is the subclass of class mammalia

a) Neornithes b) Archaeornithes

c) Pisces d) Theria

33 No external pinna on the ear is a character of subclass……

a) Metatheria b) Prototheria

c) Eutheria d) Theria

34 In subclass …….mammary glands are without nipples.

a) Eutheria b) Metatheria

c) Prototheria d) Theria

35 In subclass …….females are oviparous.

a) Theria b) Metatheria

c) Eutheria d) Prototheria

36 *Echidna* and *Ornithorhynchus* are the examples of subclass…….

a) Prototheria b) Theria

c) Eutheria d) Metatheria

37 Subclass …….. includes marsupial and placental mammals.

a) Prototheria b) Neornithes

c) Archaeornithes d) Theria

38 In subclass Theria teeth are usually present in …….

a) young b) young and adults.

c) adults d) juveniles

39 …… is marsupial animal

a) Rabbit b) Kangaroo

c) Cow d) Buffalo

40 To which subclass Egg laying Platypus belongs?

a) Prototheria b) Theria

c) Eutheria d) Metatheria

41 Whales and dolphins belong to class.....

a) Amphibians b) Mammals

c) Fishes d) Aves

46 The Spiny anteater is an example of class…….

a) Amphibians b) Aves

c) Mammals d) Reptilia

48 Ant eater and Platypus are the examples of subclass…….

a) Prototheria b) Metatheria

c) Eutheria d) Theria

Chapter 4 Rat

4.1 Systematic position, habit and habitat:

Systematic position

- Phylum - Chordata
- Subphylum - Vertebrata or Craniata
- Class - Mammalia
- Order - Rodentia
- Family - Muridal
- Genus - Rattus
- Species - *rattus (*Black Rat)

Habits and Habitat

- The common house rats are **cosmopolitan** in distribution and found all over the world and have average age of about 3 years.
- They are herbivorous, fossorial and nocturnal animals and undergo hibernation.
- Their body is covered with hairs.
- They show sexual dimorphism.
- They are prolific breeders.
- Fertilization is internal and time interval between fertilization and birth (gestation) is about 22 to 23 days.
- They are completely grown at six to eight months of age.
- The rat breeds more than four times in a year producing 6-8 young ones in each litter.
- Newly born young ones are blind, deaf and without hairs.
- The mother feeds the young ones on milk.

4.2 External characters:

The body is divisible into head, neck, trunk and tail.

Head:

- The head is broader posteriorly and tapers anteriorly as a naked terminal snout.
- A pair of nostrils, like inverted commas, is present above the mouth.
- Below the nostrils is the cleft upper lip, which exposes the two upper incisors.
- The pair of bulging eyes are placed on the lateral sides of the head.

- The nictitating membrane is reduced and eyelids have very fine and short eyelashes.
- The head on its posterolateral position bears a pair of external ear or pinna.
- The mouth is located beneath the nostrils and remains guarded by upper and lower lips.
- Long bristle-like hair helps the animal to measure width of area through which the animal is to pass even in perfect darkness.

Neck:

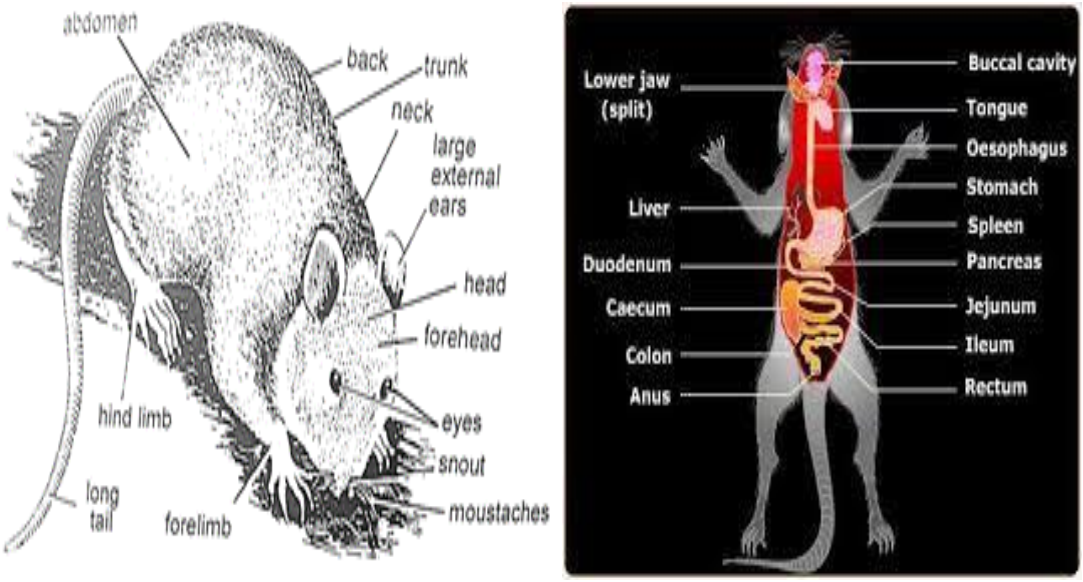
- It is a short connective between head and trunk.
- With the help of neck, the animal can bend its head in different directions.

Trunk:

- It is depressed major part of the body divided into thorax and abdomen.
- The ventral surface of female bears 6 pairs of teats or nipples, three pectoral (thoracic) and three inguinal (abdominal).
- The trunk bears two pairs of limbs, two smaller forelimbs and two hindlimbs.
- Each limb is made up of proximal segment (stylopodium), middle segment (Zeugopodium) and distal segment (autopodium).
- Five digits are present in autopodium of each limb.
- The first digit is thumb or pollex, which is much reduced with a peculiarly flattened nail and two phalanges.
- Typical walking pads, the tori are present on the tips of digits, palm and at the base of palm. Anus lies posteriorly at the base of tail.

Tail:

- Tail is long cylindrical and tapering structure lies above the anusand is used as a balancing organ.
- It bears overlapping scales and sparse hair in between.



4.3 Digestive system

Alimentary canal : Alimentary canal is coiled tube comprises mouth, buccopharyngeal cavity, oesophagus, stomach, small intestine (duodenum, jejunum and ileum), large intestine (caecum, colon and rectum) and anus.

(1) Mouth: The mouth opens in the buccal cavity that is surrounded by the vestibule, which is a space between the lips, cheeks and teeth.

(2) Buccopharyngeal cavity: It is space enclosed by two jaws. Buccopharyngeal cavity consists of broader buccal cavity in the anterior region and narrow pharynx in the posterior region. Jaws bear teeth. The teeth are heterodont, thecodont and monophyodont. Each jaw carries two incisors and six molars the incisors grow throughout life and act as growing teeth. A sharp cutting edge is maintained due to the absence of enamel on the surface. The canines and premolars are absent. The middle of buccal cavity contains a muscular tongue having taste buds. Pharynx is a common chamber for the passage of food and air.

(3) Oesophagus: It is a short tube situated dorsal to the trachea and leads into pear-shaped stomach.

(4) Stomach: It is wide curved part lies on the left side behind the diaphragm. It has a greater curvature on left side, a lesser curvature on right side. Stomach contains goblet cells for mucus, oxyntic cells for HCl and peptic cells for secretion of pepsinogen.

(5) Small intestine: Stomach leads into small intestine, which can be differentiated into three parts duodenum (U-shaped), jejunum (straight) and ileum (coiled). Digestive glands of small intestine secrete intestinal juice which contain enzymes lipase, nuclease, peptidase, lactase, sucrase and maltase.

(6) Large intestine: It has three part-caecum, colon and rectum. Caecum is slightly constricted about its middle. The apical portion contains a distinct mass of lymphoid tissue forming the vermiform appendix. Caecum opens into the first part of large intestine, the colon which is divisible into an ascending, a transverse and a descending colon leads into rectum, which opens outside through the anus.

Digestive glands

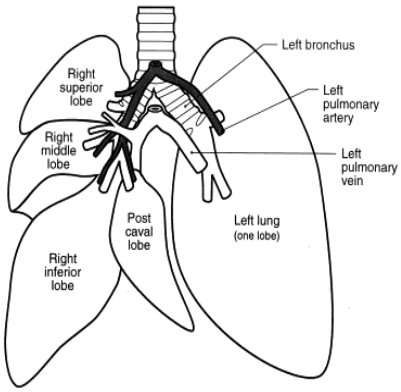
(1) Salivary glands (2) Liver (3) Pancreas (4) Gastric Glands (5) Intestinal Glands

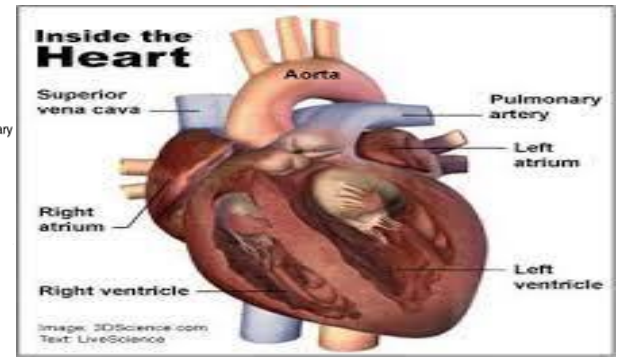
Food and feeding:

- Black rats are omnivores and eat a wide range of foods, including seeds, fruit, stems, leaves, fungi, and a variety of invertebrates and vertebrates.
- They are harmful to farmers, since they feed on a variety of agricultural-based crops, such as cereals, sugar cane, coconuts.

4.4 Respiratory system

- Two lungs are respiratory organ doing inspiration and expiration.
- The lungs are placed one on an either side of the heart lie in the thoracic cavity and are covered by visceral pleura.
- Each lung possesses a large number of alveoli where gaseous exchange occurs between air and blood. Trachea divides into two primary bronchi that pass into lungs. There are three lobes of the right lung and only one in the left.
- The respiratory tract consists of nostrils, nasal chambers, internal nares, glottis, larynx, trachea, bronchi, bronchioles and alveoli.
- The nostrils lead into the olfactory or nasal chambers.
- The two nasal chambers lead into pharynx through internal nares.
- Pharynx contains a slit like glottis, which leads into voice box called larynx.
- Larynx passes into trachea and wind pipe which runs ventral to oesophagus.





4.5 Blood vascular system:

Blood vascular system is of closed type and comprises blood, heart and blood vessels.

Structure of Heart:

- The heart lies on the midline and placed obliquely in the thoracic cavity, surrounded by pericardial cavity.
- The heart has four chambers; the right atrium and right ventricle and the left atrium and left ventricle.
- Blood flows from the right atrium into the right ventricle via the tricuspid valve (right atrio-ventricular valve) with three cusps of fibrous tissue.
- Blood flows from the left atrium into the left ventricle via the bicuspid or mitral valve (left atrio-ventricular valve).
- Aortic and pulmonary valves each have three leaflets and called semilunar valve.
- The right cardiac arteries supply right and left atria, whereas the left cardiac arteries only supply to small portion of the left atrium.

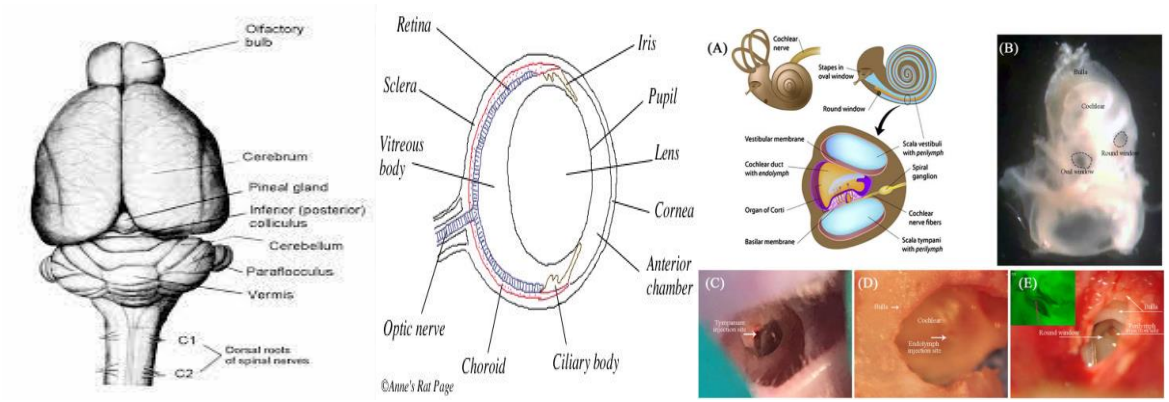
4.6 Nervous system

The nervous system is divisible into **Central Nervous System, Peripheral Nervous system and Autonomic Nervous System.**

(1) **Central Nervous System (CNS):** It is a hollow, dorsally placed structure lying along the middorsal axis of the body. It comprises the brain and spinal cord.

Brain :

- The brain is lodged in the cranium of the skull.
- It is covered by three membranes inner most membrane piamater, the next is the arachnoid mater and outer most duramater.
- The sub dural space is present below the dura mater and sub arachnoid space lies below the arachnoid mater.
- These spaces are filled with a fluid.
- The cerebral hemispheres form the largest part of the brains.
- The posterior portion of the brain is composed of medulla oblongata which tapers in the spinal cord.
- The spinal cord is a long tube-like thick-walled structure emerges out through the foramen magnum of the skull and passes through neural canal of vertebral column.



4.7 Sense Organs

Structure and functions of Eye & Ear.

4.8 Reproductive system.

A) Male Reproductive system: The male reproductive organs of a rat are a pair of testes, epididymis, vasa deferens, urethra, penis and spermatic cord.

(1) **Testes:** A pair of testes is found in the scrotal sacs. Each testis is an elongated and ovoid body attached posteriorly to scrotal sac by gubernaculum. Testis of male rat descends in the scrotal sacs between the 30^{th} to 40^{th} day of life through inguinal canal. The inguinal canal remains open throughout life, but during sexually inactive period, the tests may be withdrawn into abdominal cavity.

(2) **Epididymis:** These are paired structure. Each epididymis is a mass of long narrow coiled tubule lying along the testis which consists of anterior caput epididymis, middle corpus epididymis and posterior cauda epididymis. Epididymis stores the sperms.

(3) **Vasa deferentia:** There is a pair of vasa deferentia. A vas deferens arises from the cauda epididymis. Vasa deferentia carry sperms.

(4) **Seminal vesicles:** There is a pair of seminal vesicles which are large and lobulated except for the smooth tip which is doubled back upon itself. They are not store houses for sperms. Their secretion is alkaline and forms the bulk of seminal fluid (semen).

(5) **Urethra:** It is divided into three parts –

(i) Prostatic urethra is surrounded by the prostate gland.

(ii) Membranous urethra is the shortest portion and runs from the prostate to the bulb (base) of the penis.

(iii) Penile urethra passes through the penis and opens at the tip of the penis as urinogenital aperture.

(6) **Penis:** It is a copulatory organ which is covered by a loose sheath, the prepuce. The penis of the rat has a bony process called the os penis. Penis bone is also present in bat, dog, walrus and whale.

Accessory Glands: Male accessory sex glands –

(1) **Ampullary glands:** The outer end of the vas deference near the entrance into the urethra is enlarged into ampulla, which contain ampullary glands to secrete mucus.

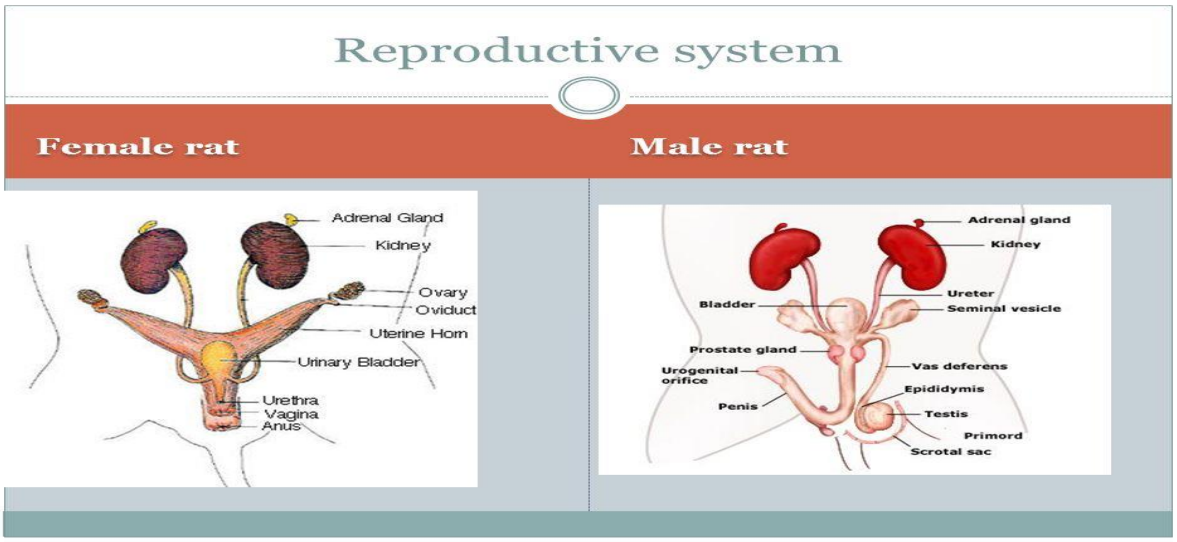
(2) **Vesicular glands:** These are branched glands which originate from the vas deferens behind the ampulla.

(3) **Coagulating glands:** Closely applied along the minor curvature of the seminal vesicles and within the same sheath are the coagulating glands. The secretion of these glands serve to coagulate the seminal fluid (Semen).

(4) **Prostate glands:** There are two prostate glands whose secretion is rich in citric acid, lipid and acid phosphatase.

(5) **Cowper's glands:** (Bulbo-urethral glands): These are one pair which originate from the urethra at the base penis. They produce a secretion during sexual excitement which protects the sperms from traces of acids found in the urethra (as the urine also passes through the penile urethra).

(6) **Preputial glands (Glands of Tyson)**: They develop from the skin forming prepuce. They are modified sebaceous (oil) glands which secrete peculiar odorous secretion.



B) Female reproduction system: The female reproductive organs consists of a pair of ovaries, fallopian tubes, uteri, a single common vagina and a clitoris.

(1) **Ovaries:** Ovaries are paired small yellowish compact structure suspended in the body cavity by mesovarium.

(2) **Fallopian Tubes (Oviducts or uterine tubes):** There is one pair of convoluted Fallopian tubes. Each Fallopian tube begins with fimbriated funnel which receives ova from the ovary.

As the fertilization is internal, it takes place in the dilated upper most portion of the Fallopian tubes.

(3) **Uterus (Womb)**: The uterus is a hollow muscular structure. The uterine horns are fused near vagina. The wall of the uterus consists of outer covering of peritoneum, the perimetrium, middle layer of smooth muscle fibres, the myometrium and inner layer of simple columnar epithelium, the endometrium. The embryo gets attached to the uterine wall through placenta. Embryonic development takes place in the uterus. Placenta provides the physiological connection between developing foetus and uterine wall (endometrium) of the mother.

(4) **Vagina:** It is a tubular structure which extends from the uterus and opens outside as vaginal opening (= vulva). Penis of the male rat is inserted into the vagina during copulation. The vagina also helps to deliver the young ones at the time of birth.

(5) **Clitoris:** It corresponds to the penis of the male but it is reduced in size and does not have any passage (it is solid structure). The clitoris is found anterior to the vulva.

Accessory Glands

(1) **Vestibular glands:** These are small mucous glands which open on the surface of the vestibule of the vagina.

(2) **Bulbo-urethral glands:** These are small glands which are present in relation with the urethra.

(3) **Preputial glands:** There is one pair of large preputial glands which are near the tip of the clitoris.

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