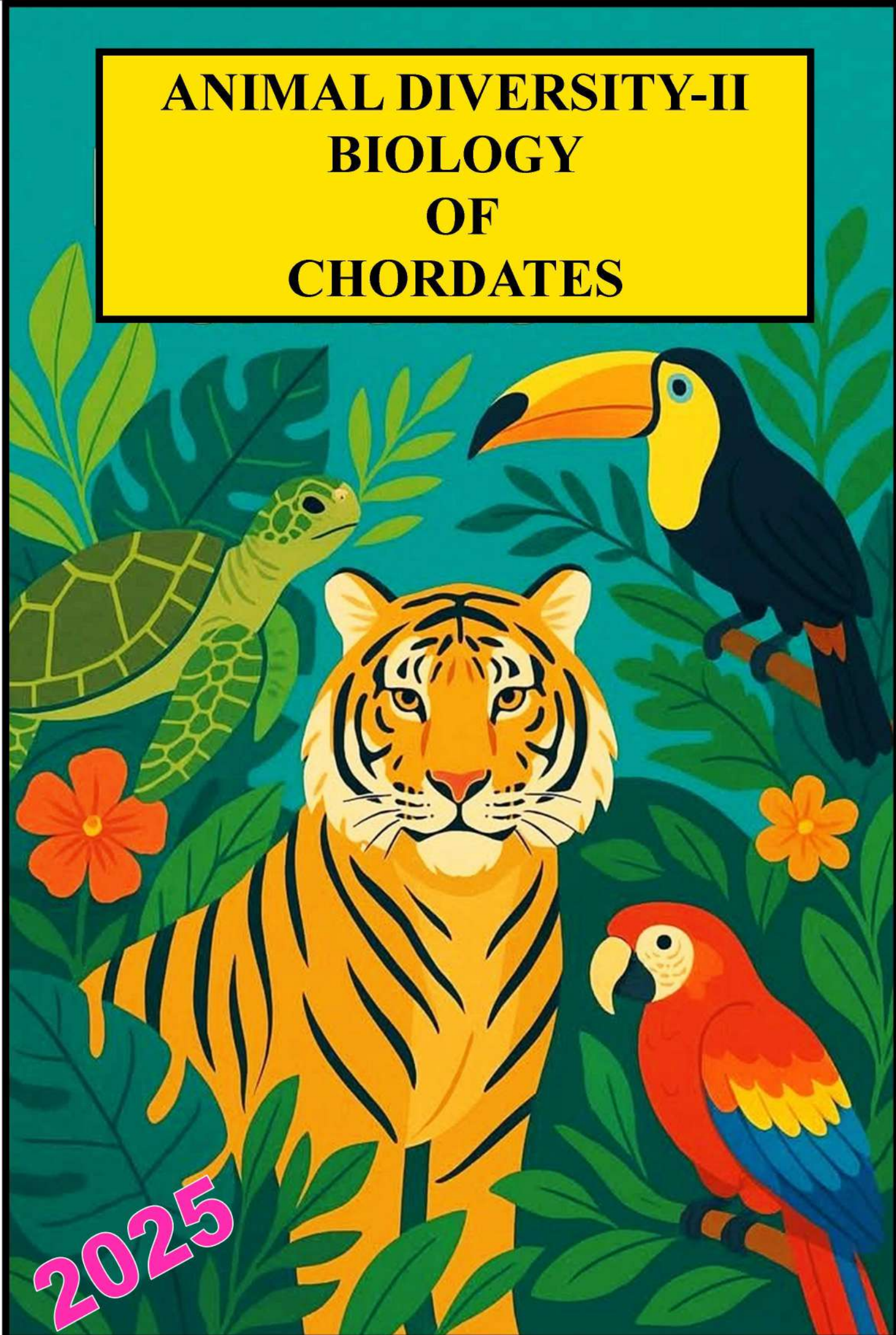
ANIMAL DIVERSITY-II
BIOLOGY
OF
CHORDATES



2025

ANIMAL DIVERSITY BIOLOGY OF CHORDATES - PAPER – II

Study Material

Edited By

Dr. V. Uday Kiran,

Assistant Professor of Zoology

DEPARTMENT OF ZOOLOGY

LOYOLA DEGREE COLLEGE (YSRR), PULIVENDULA – 516 390.

SEMESTER-I

COURSE 2: ANIMAL DIVERISTY-II BIOLOGY OF CHORDATES

Theory **Credits: 3** **3 hrs/week**

COURSE OBJECTIVES:

- To understand the animal kingdom.
- To understand the taxonomic position of Protochordata to Mammalia.
- To understand the general characteristics of animals belonging to Fishes to Reptilians.
- To understand the body organization of Chordata.
- To understand the taxonomic position of Protherian mammals.

LEARNING OUTCOMES:

By the completion of the course student will able to –

- Describe general taxonomic rules on animal classification of chordates
- Classify Protochordata to Mammalia with taxonomic keys
- Understand Mammals with specific structural adaptations
- Understand the significance of dentition and evolutionary significance
- Understand the origin and evolutionary relationship of different phyla from Prochordata to Mammalia.

SYLLABUS:

UNIT - I

1.1 General characters and classification of Chordata up to classes
1.2 Salient features of Cephalochordata, Salient features of Urochordata
1.3 Structure and life history of *Herdmania*, Retrogressive metamorphosis –Process and Significance
1.4 Cyclostomata, General characters, Comparison of Petromyzon and Myxine

Activity: Model preparation /Assignment /Students Seminar/Quiz/Project/Peer teaching/Report writing after watching any video on the above

Evaluation: Instructor supposed to prepare a detailed Rubrics for the evaluation of the above activity

UNIT - II

2.1 General characters of Fishes, Salient features Dipnoi
2.2 *Scoliodon*: External features, Digestive system, Respiratory system
2.3 *Scoliodon* Structure and function of Heart, Structure and functions of the Brain.
2.4 Migration in Fishes, Types of Scales

Activity: Model preparation /Assignment /Students Seminar/Quiz/Project/Peer teaching/Report writing after watching any video on the above

Evaluation: Instructor supposed to prepare a detailed Rubrics for the evaluation of the above activity

UNIT - III

3.1 General characters of Amphibia, General characters of Reptilia
3.2 *Rana hexadactyla*: External features, Respiratory system, Structure and function of Heart
3.3 *Rana hexadactyla* structure and functions of the Brain
3.4 *Calotes*: External features, Digestive system, structure and function of Brain
3.5 Identification of Poisonous snakes

Activity: Model preparation /Assignment /Students Seminar/Quiz/Project/Peer teaching/Report writing after watching any video on the above
Evaluation: Instructor supposed to prepare a detailed Rubrics for the evaluation of the above activity

UNIT - IV

4.1 General characters of Aves
4.2 *Columba livia*: External features, Digestive system, Respiratory system
4.3 *Columba livia*: Structure and function of Heart, structure and function of Brain
4.4 Migration in Birds, Flight adaptation in birds

Activity: Model preparation/Assignment /Students Seminar/Quiz/Project/Peer teaching/Report writing after watching any video on the above
Evaluation: Instructor supposed to prepare a detailed Rubrics for the evaluation of the above activity

UNIT - V

5.1 General characters of Mammalia
5.2 Classification of Mammalia up to sub - classes with examples
5.3 Comparison of Prototherians, Metatherians and Eutherians
5.4 Dentition in mammals, Aquatic mammals Adaptations

Activity: Model preparation/Assignment /Students Seminar/Quiz/Project/Peer teaching/Report writing after watching any video on the above
Evaluation: Instructor supposed to prepare a detailed Rubrics for the evaluation of the above activity

CO-CURRICULAR ACTIVITIES

- Preparation of charts on Chordate classification (with representative animal photos) and retrogressive metamorphosis
- Clay models of Herdmania and Amphioxus
- Visit to local fish market and identification of local cartilaginous and bony fishes
- Maintaining of aquarium by students
- Model of fish heart and brain
- Preparation of slides of scales of fishes
- Visit to local/nearby river to identify migratory fishes and prepare study notes
- Preparation of Charts on above topics by students (Eg: comparative account of vertebrate heart/brain/lungs, identification of snakes etc.)
- Collecting and preparation of Museum specimens with dead frogs/snakes/lizards etc., and/or their skeletons
- Additional input on types of snake poisons and their antidotes (student activity).
- Collection of bird feathers and submission of report on Plumology
- Taxidermic preparation of dead birds for Zoology Museum
- Map pointing of prototherian and metatherian mammals
- Chart preparation for dentition in mammals

Unit – I

1.1. Write general characters' and classification of Chordata up to classes.

PHYLUM CHORDATA — GENERAL CHARACTERS

1. **Notochord**
    - A flexible, rod-like supporting structure.
    - Present at least in the embryonic stage.
    - In vertebrates, it is replaced by the vertebral column.
2. **Dorsal Hollow Nerve Cord**
    - Lies dorsal to the notochord.
    - Develops into the brain and spinal cord.
3. **Pharyngeal Gill Slits**
    - Paired openings in the pharyngeal region.
    - Used for filter feeding (in lower chordates) and respiration (in fishes).
    - Present in embryos of all chordates.
4. **Post-Anal Tail**
    - Extends beyond the anus.
    - Helps in locomotion; may be reduced in adults of some species.
5. **Endostyle or Thyroid Gland**
    - Endostyle in lower chordates aids in filter-feeding.
    - In vertebrates, it is replaced by the thyroid gland.
6. **Bilateral Symmetry**
7. **Triploblastic, Coelomate Body**
8. **Organ-System Level of Organization**
9. **Closed Circulatory System**
10. **Complete Digestive System**
11. **Respiration by gills, lungs, or skin**
12. **Excretion by nephridia or kidneys**

CLASSIFICATION OF CHORDATA (Up to Classes)

Chordata is divided into **three subphyla**:

1. Subphylum Urochordata (Tunicata)

General Features

- Marine, sessile or free-swimming.

- Notochord present only in **larval tail**.
- Body covered by *tunic* (cellulose-like tunicin).
- Larva is tadpole-like and motile; adult is sessile.
- Respiration by pharyngeal gill slits.
- Hermaphroditic.

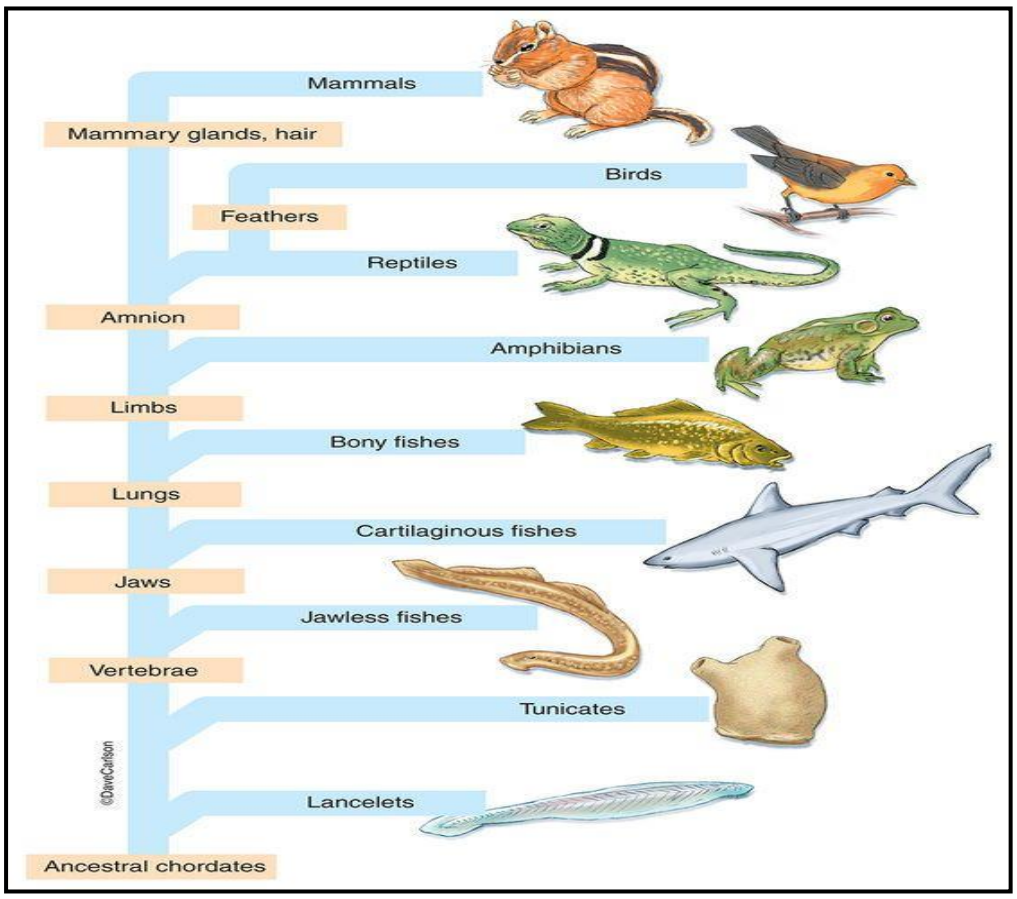
Classes

1. **Ascidiacea** – Sea squirts (e.g., *Herdmania*)
2. **Thaliacea** – Salps
3. **Appendicularia (Larvacea)** – *Oikopleura*

2. Subphylum Cephalochordata

General Features

- Small, fish-like marine chordates.
- Notochord persists throughout life.
- Segmented muscles (myotomes) present.



- Filter-feeders.
- Example: **Amphioxus (Branchiostoma lanceolatum)**.

Classes

- **Cephalochordata** (no further division)

3. Subphylum Vertebrata (Craniata)

General Features

- True vertebral column.
- Distinct head with brain protected by cranium.
- Well-developed endoskeleton.
- Paired appendages (fins or limbs).
- Closed circulatory system with chambered heart.
- Kidneys for excretion and osmoregulation.

DIVISION OF VERTEBRATA

Vertebrates are divided into two divisions:

A. Agnatha (Jawless Vertebrates)

Class: Cyclostomata

- Eel-like, marine or freshwater.
- Circular mouth without jaws.
- No paired fins.
- Cartilaginous skeleton.
- Parasitic or scavengers.
- Examples: **Petromyzon (Lamprey), Myxine (Hagfish)**.

B. Gnathostomata (Jawed Vertebrates)
Superclass: Pisces (Fishes)

Class 1: Chondrichthyes (Cartilaginous Fishes)

- Endoskeleton completely cartilaginous.
- Mouth ventral.
- Placoid scales.
- Gill slits 5–7, without operculum.
- Internal fertilization.
- Examples: **Shark, Scoliodon, Sting ray, Torpedo**.

Class 2: Osteichthyes (Bony Fishes)

- Endoskeleton bony.
- Mouth terminal.

- Operculum covers gills.
- Cycloid, ctenoid, or ganoid scales.
- Swim bladder present.
- External fertilization common.
- Examples: **Rohu, Catla, Tuna, Seahorse**.

Superclass: Tetrapoda
Class 3: Amphibia

- First vertebrates to live on land.
- Moist skin without scales.
- Respiration by gills, lungs, or skin.
- Three-chambered heart.
- External fertilization; larvae aquatic.
- Examples: **Frog, Toad, Salamander**.

Class 4: Reptilia

- Dry, scaly skin (keratinized).
- Lungs well developed.
- Three-chambered heart (except crocodiles—four-chambered).
- Internal fertilization; amniotic egg.
- Examples: **Lizards, Snakes, Turtles, Crocodiles**.

Class 5: Aves (Birds)

- Feathers present.
- Forelimbs modified into wings.
- Pneumatic (hollow) bones.
- Four-chambered heart.
- Warm-blooded (homeothermic).
- Oviparous.
- Examples: **Pigeon, Sparrow, Eagle, Ostrich**.

Class 6: Mammalia

- Body covered with hair.
- Mammary glands present.
- Diaphragm separates thorax and abdomen.
- Four-chambered heart.

- Warm-blooded.
- Mostly viviparous.
- Examples: **Human, Cow, Dog, Bat, Whale**.

1.2 Salient features of Cephalochordata, Salient features of Urochordata

Salient Features of Cephalochordata

1. **Marine, small fish-like animals**, usually found half-buried in sand.
2. **Notochord persists throughout life** and extends from head to tail.
3. **Dorsal hollow nerve cord** present for the entire length of the body.
4. **Segmented muscles (myotomes)** are clearly visible.
5. **Pharynx with numerous gill slits** used for filter feeding.
6. **Head is poorly developed; no distinct cranium** → hence called *Acraniata*.
7. **Tail is well developed** and helps in locomotion.
8. Body is **laterally compressed** and elongated.
9. **Closed circulatory system**, but **heart absent**; blood is pumped by contractile vessels.
10. **Excretion by protonephridia** (flame-cell-like structures).
11. **Dioecious (separate sexes)**; fertilization external.
12. Shows **all three chordate features** (notochord, nerve cord, gill slits) well-developed even in adults.
13. Example: **Branchiostoma (Amphioxus / Lancelet)**.

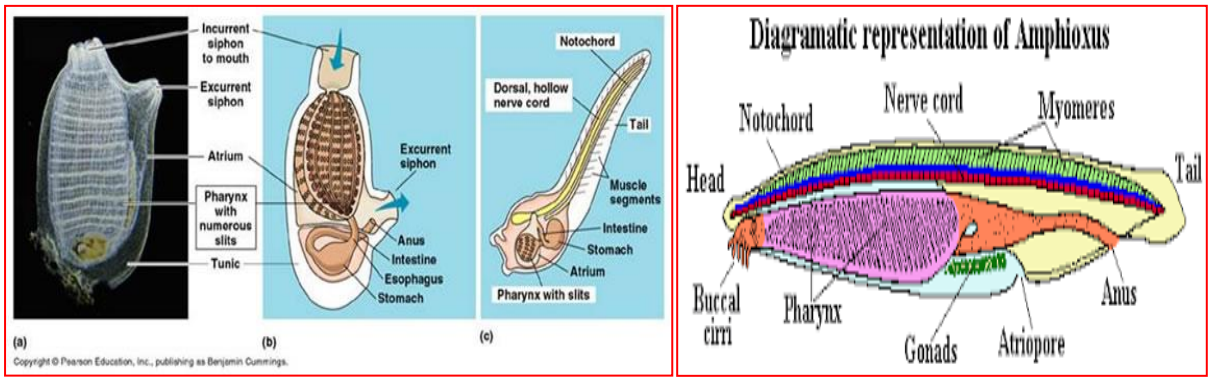
Salient Features of Urochordata (Tunicata)

1. **Marine animals**, either sessile, colonial, or free-swimming.
2. **Larva is tadpole-like** and shows all major chordate characters.
3. **Adults are highly degenerate** and lose notochord and nerve cord → *retrogressive metamorphosis*.
4. **Notochord present only in the tail region of larva** → hence **Urochordata** ("tail chord").
5. Body is covered by a **tunic** made of **tunicin** (cellulose-like substance).
6. Pharynx is **large with many gill slits**, used in filter feeding.
7. **Nervous system reduced in adults**; simple nerve ganglion present.
8. **Circulatory system open** with a heart that can **reverse the direction of blood flow**.
9. **Hermaphroditic**, with external fertilization (in most).
10. Respiration through **pharyngeal gill slits**.
11. Adult body often shows two siphons:

- **Incurrent siphon**
- **Excurrent siphon**

12. Examples:

- **Ascidiacea:** *Herdmania, Ascidia*
- **Thaliacea:** *Salpa*
- **Appendicularia:** *Oikopleura*



1.3. Structure and life history of *Herdmania,* Retrogressive metamorphosis –Process and Significance

Introduction

Herdmania is a simple, marine, sedentary animal that belongs to the subphylum **Urochordata** of phylum **Chordata**. It is commonly known as a **sea squirt** because it expels water when disturbed. The adult shows a very simple, non-chordate-like body lacking a notochord and dorsal nerve cord. However, its **tadpole larva** possesses all key chordate characters such as a **notochord, dorsal nerve cord, and gill slits**. Because the larva is more advanced than the adult, Herdmania demonstrates an important evolutionary process called **retrogressive metamorphosis**. Thus, Herdmania helps in understanding the evolutionary link between simple tunicates and higher chordates.

Structure of Herdmania (Adult)

The adult Herdmania is a soft, sac-like, **non-motile** animal attached to rocks or other hard surfaces in shallow seas.

1. Body Covering (Tunic)

- Herdmania is covered by a tough, leathery outer layer called the **tunic or test**.
- The tunic contains **tunicin**, a cellulose-like substance.
- It protects the animal and gives shape to the body.

2. Body Openings (Siphons)

There are **two siphons** on the body:

- **Branchial (oral) siphon** – water enters through this.
- **Atrial siphon** – water leaves through this.

  Each siphon has **tentacles** that filter incoming water.

3. Body Wall

- Made of muscle layers and connective tissue.
- Helps in contracting the body and expelling water.

4. Pharynx with Gill Slits

- The **pharynx** is a large, basket-like structure with many **gill slits**.
- It is used for **filter feeding and respiration**.

5. Digestive System

- Includes **mouth → pharynx → oesophagus → stomach → intestine**.
- Digestion is extracellular, and food particles are filtered from the water.

6. Circulatory System

- Contains a **simple heart** that pumps blood.
- The heart can **reverse the direction** of blood flow periodically.

7. Nervous System

- Very reduced in adults.
- Only a **nerve ganglion** and few nerves are present.

8. Reproductive System

- Hermaphroditic (both male and female organs).
- Shows **external fertilization**.

Life History of Herdmania

1. Release of Gametes

The adult Herdmania releases **eggs and sperm** into the sea through the atrial siphon.
Fertilization happens **outside the body** in the seawater.

2. Formation of Tadpole Larva

After fertilization, a **tadpole-like larva** develops.
This larva has the three chordate characters:

- A **notochord** in the tail
- A **dorsal nerve cord**
- **Gill slits** in the pharynx

3. Larval Behavior

The larva can **swim freely**, but it does **not feed**.
Its only purpose is to find a safe place to settle.

4. Attachment

The larva attaches to a hard surface like a rock using **sticky adhesive papillae** present on its head.

5. Metamorphosis

After attaching, the larva changes into an adult by **retrogressive metamorphosis**.
During this, the **tail, notochord, and nerve cord disappear**, and the body becomes simple.
The animal becomes **non-moving and filter-feeding**.

Retrogressive Metamorphosis: Process and Significance

Retrogressive metamorphosis means the larva is **more advanced** than the adult.
During metamorphosis, the larva **loses its chordate characters** and becomes a simple adult.

Process of Retrogressive Metamorphosis

When the larva attaches:

1. Degeneration of Notochord

- The notochord in the tail disappears completely.

2. Disappearance of Tail

- The swimming tail is absorbed into the body.

3. Reduction of Dorsal Nerve Cord

- The long dorsal nerve cord reduces to a small **nerve ganglion**.

4. Loss of Sense Organs

- Larval sense organs like ocellus and statocyst disappear.

5. Enlargement of Pharynx

- The pharynx enlarges into a **branchial basket** with more gill slits.

6. Development of Adult Organs

- The tunic, siphons, gonads, and digestive system become fully functional.
- The animal becomes **sessile and filter-feeding**.

Significance of Retrogressive Metamorphosis

1. Shows Evolutionary Position of Urochordates

- Demonstrates that tunicates are **degenerate chordates**.
- The larval form shows true chordate features, proving they belong to phylum Chordata.

2. Adaptation for Sedentary Life

- Adult Herdmania is adapted for **filter feeding** and a **sessile lifestyle**.
- Loss of notochord, tail, and nerve cord helps conserve energy.

3. Demonstrates Evolutionary Trend

- Shows how some organisms evolve towards **simplification** instead of complexity.

4. Important in Embryology

- Teaches that **ontogeny (development)** can reveal ancestral characters.

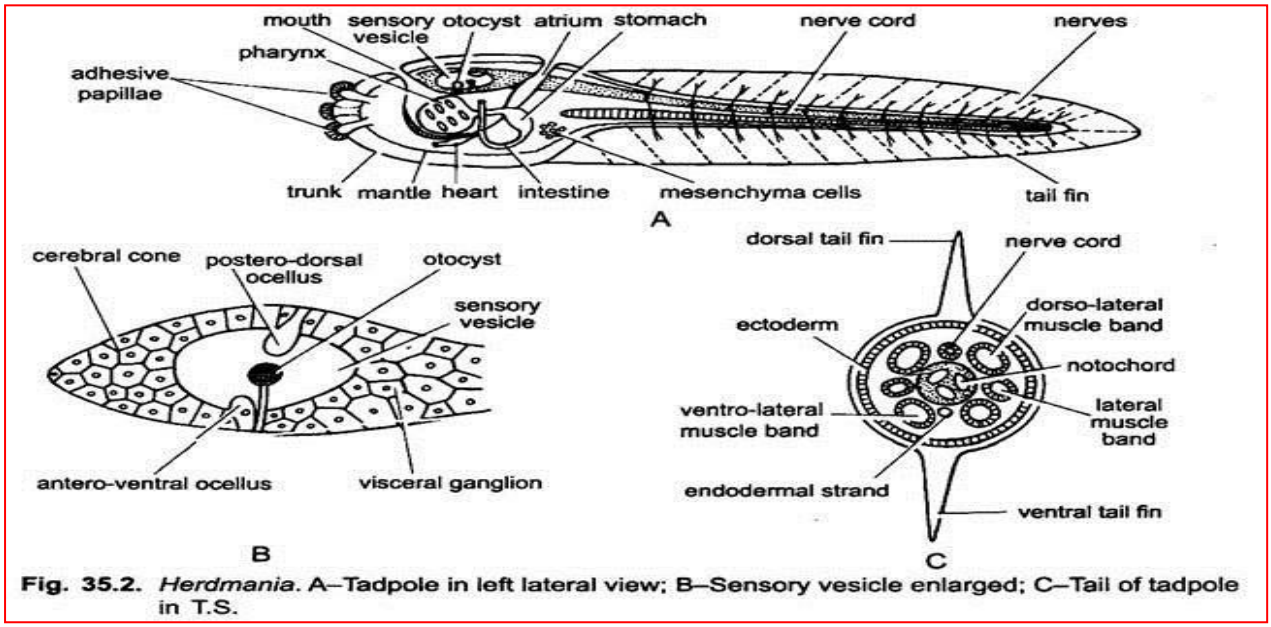


Fig. 35.2. *Herdmania*. A–Tadpole in left lateral view; B–Sensory vesicle enlarged; C–Tail of tadpole in T.S.

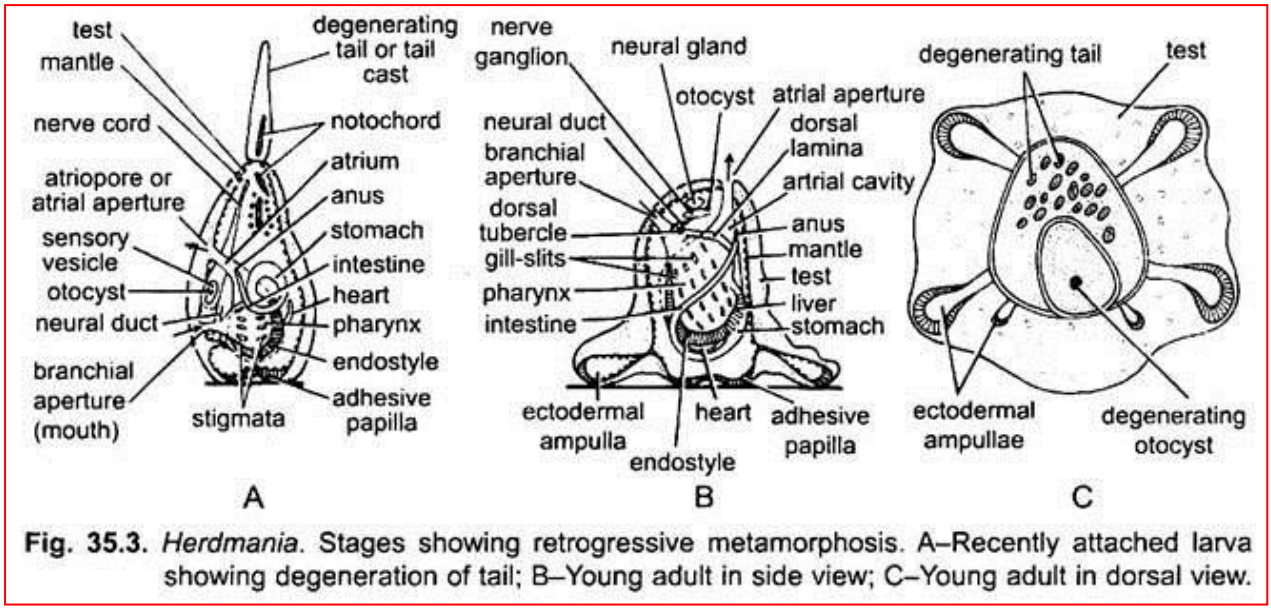


Fig. 35.3. *Herdmania*. Stages showing retrogressive metamorphosis. A–Recently attached larva showing degeneration of tail; B–Young adult in side view; C–Young adult in dorsal view.

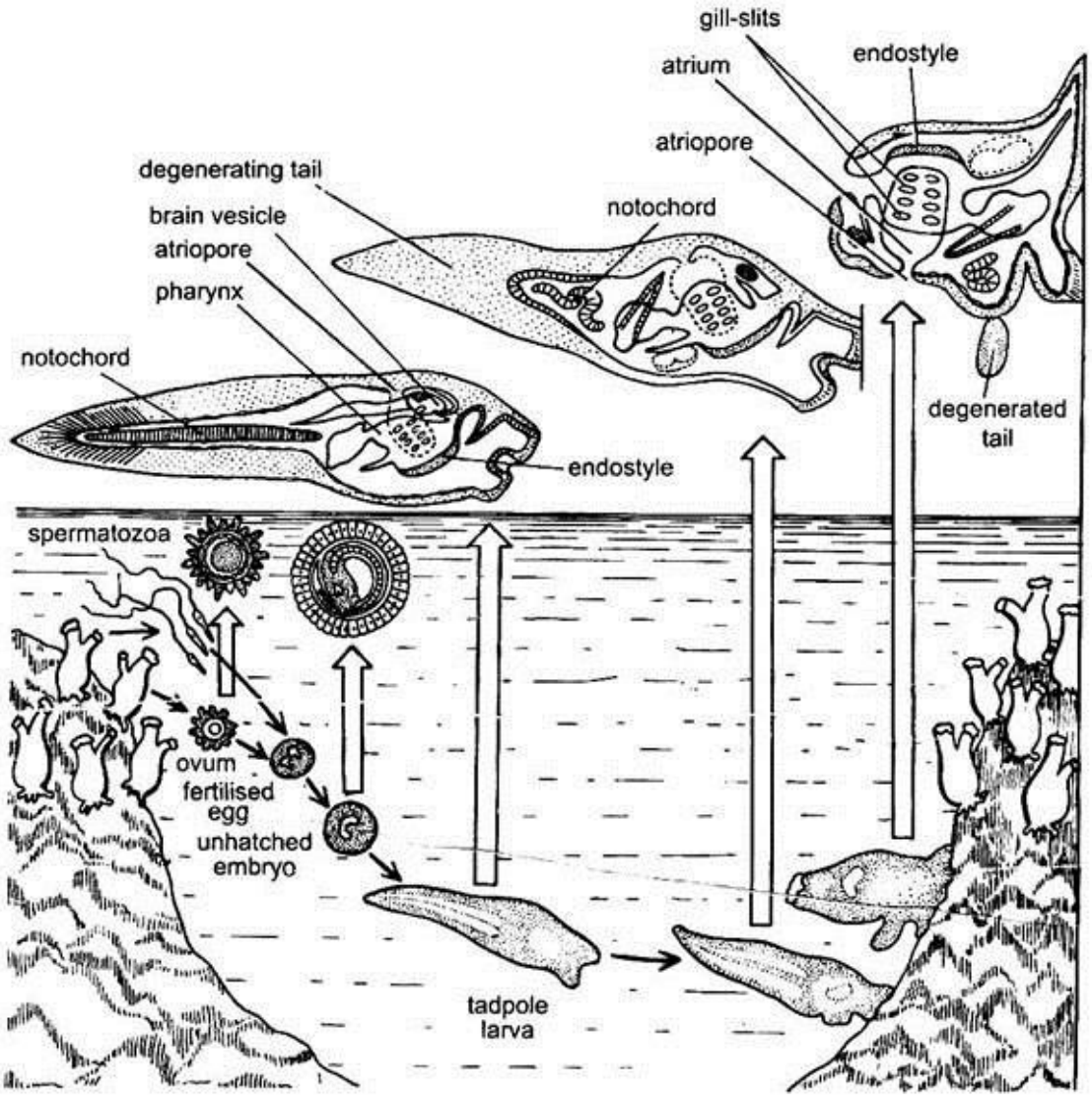


Fig. 35.4. Life cycle of a simple ascidian, showing retrogressive metamorphosis of tadpole larva, later its attachment with the solid substratum.

1.4 Cyclostomata, General characters, Comparison of Petromyzon and Myxine

General Characters of Cyclostomata

Cyclostomes (Agnatha) include **lampreys** and **hagfishes**. They are the **most primitive living vertebrates**.

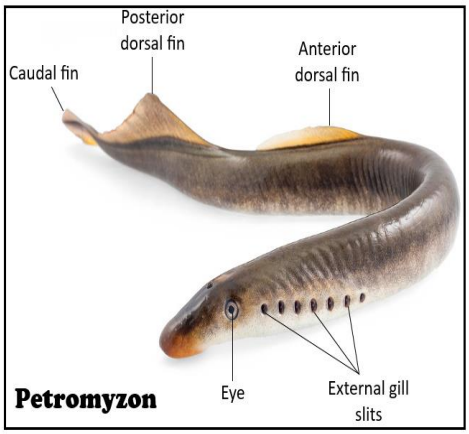
General Features

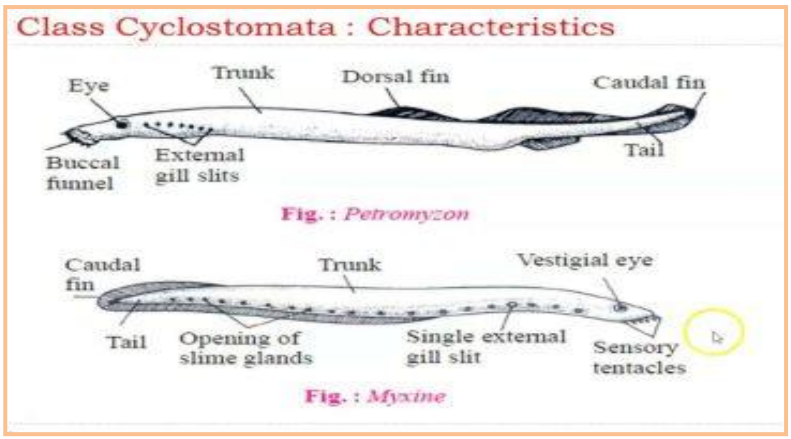
1. **Body shape**: Eel-like, elongated, soft-bodied.
2. **Skeleton**: Cartilaginous; **no true bone**.
3. **Jawless**: Mouth without jaws; circular mouth (hence "Cyclostomata").
4. **Teeth**: Keratinous teeth present on tongue or buccal cavity.
5. **Notochord**: Persistent throughout life.
6. **Fins**: Median (dorsal and caudal) fins; **no paired fins** (no pectoral/pelvic).
7. **Scales**: Absent.

8. **Gills**: 6–15 pairs of gill pouches; respiration via gill sacs.
9. **Circulation**: Two-chambered heart (one atrium, one ventricle).
10. **Digestive system**: Simple; no stomach (food goes directly to intestine).
11. **Reproduction**: Dioecious; external fertilization; **larva is ammocoete** (in lampreys).
12. **Habitat**: Mostly marine; lampreys may migrate to freshwater for breeding.
13. **Nervous system**: Brain poorly developed; 10 pairs of cranial nerves.
14. **Excretory system**: Mesonephric kidneys.

Petromyzon (Lamprey) vs Myxine (Hagfish)

S .no	Petromyzon (Lamprey)	Myxine (Hagfish)
1	Lives in marine & freshwater (many anadromous)	Lives only in marine (deep sea)
2	Ectoparasitic – sucks blood of fishes	Scavenger – feeds on dead/dying fishes
3	Sucker-like mouth with many keratin teeth	Slit-like mouth with few tongue teeth
4	Eyes well-developed	Eyes poorly developed
5	7 pairs of separate gill pouches	6–15 gill pouches; openings often fused
6	No slime glands	Slime glands highly developed
7	Rudimentary vertebral blocks present	No vertebrae, only skull present
8	External fertilization; ammocoete larva	Direct development; no larval stage





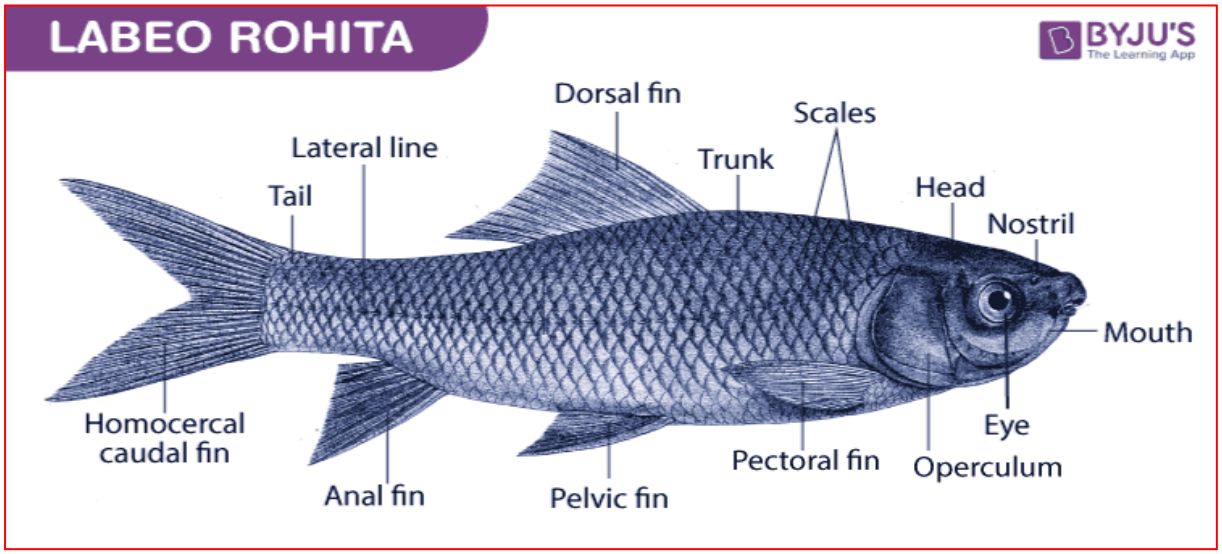
UNIT - II

2.1 General characters of Fishes, Salient features Dipnoi

General Characters of Fishes

1. Fishes are cold-blooded (ectothermic) aquatic vertebrates.
2. They live in freshwater, marine water, and brackish habitats.
3. Body is streamlined for fast and efficient swimming.
4. Body is divided into head, trunk, and tail.
5. Skin is covered with scales (placoid, cycloid, ctenoid, or ganoid).
6. Mucous glands in skin reduce friction and protect from infection.
7. Respiration takes place mainly through gills.
8. Gills are covered by an operculum in bony fishes.

9. Locomotion is performed by paired (pectoral, pelvic) and unpaired fins.
10. Heart is two-chambered with single circulation.
11. They possess a lateral line system to detect water vibrations.
12. Excretion is mainly ammonotelic, done by mesonephric kidneys.
13. Nervous system is well developed with eyes, nostrils, and inner ear.
14. Most fishes reproduce sexually with external fertilization.
15. Swim bladder (air bladder) in bony fishes helps maintain buoyancy.



Salient Features of Dipnoi (Lungfishes)

1. Dipnoi are freshwater lungfishes showing features intermediate between fishes and amphibians.
2. They have both gills and true lungs for dual aquatic and aerial respiration.
3. African lungfishes undergo aestivation in mud during drought using a protective mucus cocoon.
4. Body is elongated with cycloid scales and filamentous or lobe-like paired fins.
5. Notochord persists throughout life and skeleton is mostly cartilaginous.
6. Heart is partially divided, showing an early stage of double circulation.
7. Larvae have external gills resembling amphibian tadpoles.
8. They exhibit ureotelic excretion during aestivation and ammonotelic excretion in water.
9. Found in Australia, Africa, and South America, living in rivers, ponds, and swamps.
10. Considered "living fossils" and an evolutionary link between fishes and amphibians.

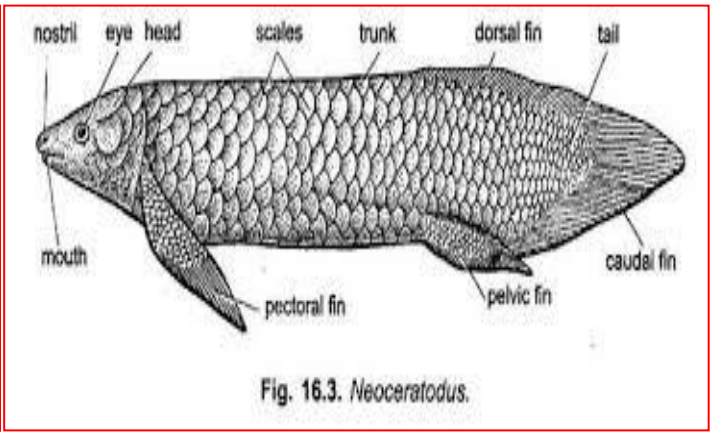
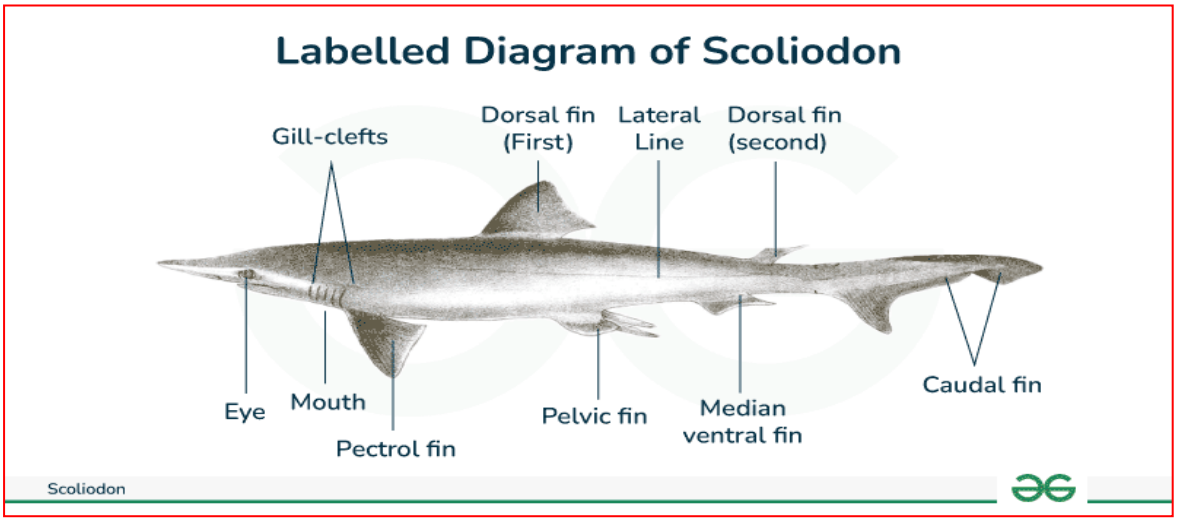


Fig. 16.3. *Neoceratodus.*

2.2. Scoliodon: External features, Digestive system, Respiratory system.

Labelled Diagram of Scoliodon

The well labeled diagram of scoliodon is given below:



- **Head and Snout:** Scoliodon's streamlined appearance and pointed head facilitate its quick swimming motion. Take note of the prominent snout that gives this shark its common name, spadenose shark.
- **Gill Slits/openings:** On each side of its head, the scoliodon has five pairs of gill holes that allow it to get oxygen out of the water.
- **Dorsal Fins:** The two dorsal fins that are present are the first and second. These fins allow for more stable swimming.
- **Pectoral Fins:** The shark uses its pectoral fins on either side of the body to help it navigate and maintain balance.
- **Pelvic Fins:** The shark's stability and control are enhanced by its pelvic fins which are situated on its ventral side.
- **Anal Fin:** Situated near the tail on the ventral side, the anal fin helps in mobility and navigation.

- **Caudal Fin:** The caudal fin, or tail fin, is forked, allowing for powerful and efficient swimming.
- **Teeth:** The scoliodon's powerful, sharp teeth are perfect for snatching and tearing prey.
- **Lateral Line:** The shark uses its lateral line which runs the length of its body to help detect vibrations and movement in the water.

Characteristics of Scoliodon

Scoliodon has some unique characteristics that enable it to survive in the aquatic environment

1. **Streamlined Body:** The shark's streamlined body form reduces drag and allows it to travel swiftly in the water.
2. **Cartilaginous Skeleton:** Unlike bony fish, scoliodon has a cartilaginous skeleton, giving it flexibility and lower overall weight.
3. **Carnivorous Diet:** Scoliodon is a carnivorous predator that feeds on fish and other aquatic creatures. It can easily capture prey with its razor-sharp teeth.
4. **Efficient Respiratory System:** Because of its five pairs of gill slits and spiracles which allow it to efficiently absorb oxygen from the water, scoliodon can survive in a wide range of aquatic environments.
5. **Reproductive Strategy:** The highly evolved form of shark reproduction known as viviparous reproduction in which the embryos develop inside the mother's body is exhibited by the scoliodon.

Digestive System of Scoliodon

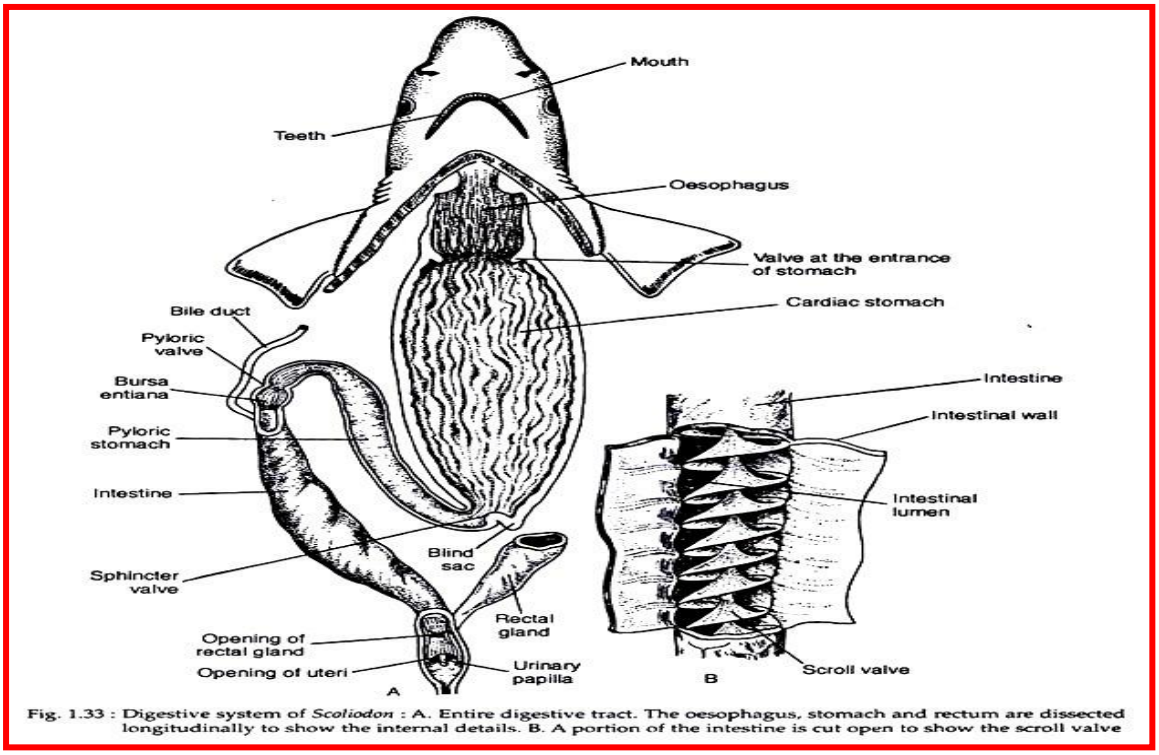


Fig. 1.33 : Digestive system of *Scoliodon* : A. Entire digestive tract. The oesophagus, stomach and rectum are dissected longitudinally to show the internal details. B. A portion of the intestine is cut open to show the scroll valve

The digestive system of *Scoliodon* consists of the **alimentary canal** and **digestive glands**, which together perform ingestion, digestion, absorption, and egestion. As a carnivorous fish, *Scoliodon* feeds mainly on smaller fishes and crustaceans, and its digestive system is well adapted for swallowing and digesting animal food.

Alimentary Canal

Mouth

The mouth of *Scoliodon* is a semi-oval slit situated at the ventral side of the head. It is bounded by upper and lower lips and opens directly into the buccal cavity. Its wide opening helps the fish to grasp and swallow whole prey.

Buccal Cavity

The mouth leads into a dorso-ventrally flattened buccal cavity lined by strong jaws. The jaws bear numerous **sharply pointed homodont teeth**, all similar in shape and directed backwards. They are **polyphyodont**, meaning they are continuously replaced and arranged in several rows. These teeth are not used for chewing but for firmly grasping slippery prey. A thick, flat, non-muscular tongue lies on the floor of the buccal cavity.

Pharynx

Posterior to the buccal cavity lies the pharynx, which is a broad and muscular chamber. On each lateral side of the pharynx, an oval pit of the **spiracle** and **five separate gill slits** are present. The

pharynx plays a dual role: conducting food to the oesophagus and passing water over the gills for respiration.

Oesophagus

The pharynx narrows into a short but wide tube called the oesophagus. Its inner lining bears longitudinal folds that help the quick passage of swallowed food into the stomach. As *Scoliodon* swallows its prey whole, the oesophagus is highly distensible and muscular.

Stomach

The stomach is a large **U-shaped** organ and the main site of digestion. It has two limbs: the anterior **cardiac stomach**, which is longer, wider, and capable of great distension to hold bulky prey, and the posterior **pyloric stomach**, which is shorter and narrower. A small blind sac and a sphincter valve lie at the junction of these two portions. The pyloric stomach ends in a strong muscular **pyloric valve**, which regulates the passage of food into the intestine through a thick-walled chamber called the **bursa entiana**.

Intestine

The intestine begins from the bursa entiana and is a straight, wide tube. Its anterior region receives the openings of the bile duct and the pancreatic duct. A characteristic feature of the *Scoliodon* intestine is the presence of a **scroll valve (spiral valve)**, formed by internal spiral folds of the intestinal lining. This structure increases the surface area for absorption and slows down the movement of food, allowing maximum digestion and nutrient uptake. The posterior part of the gut forms the **rectum**, which opens into the cloaca. A small finger-like **caecal or rectal gland** opens into the rectum from its dorsal side.

Digestive Glands

Liver

The liver is a large, yellowish, bilobed gland that occupies much of the body cavity. A V-shaped gall bladder lies within the right lobe and stores bile. The bile duct, which carries bile from the gall bladder and liver, opens into the anterior part of the intestine. The liver secretes bile, stores glycogen and fat, and destroys old red blood cells.

Pancreas

The pancreas is a whitish bilobed gland, with a major lobe extending along the posterior region of the cardiac stomach and a small ventral lobe attached to the pyloric stomach. The **pancreatic duct** opens into the intestine opposite the bile duct opening. It secretes pancreatic juice containing digestive enzymes—trypsinogen, amylopsin, and lipase—which act on proteins, carbohydrates, and fats.

Caecal (Rectal) Gland

The caecal or rectal gland is a small, finger-like tubular structure attached to the dorsal side of the rectum. It is highly vascular and composed mainly of lymphoid tissue. Although its exact function is not fully understood, it is believed to be involved in ionic and salt balance.

Spleen

The spleen is a dark, compact organ situated close to the cardiac and pyloric portions of the stomach. Although placed near the digestive organs, it has no direct role in digestion. Functionally, it belongs to the circulatory system, taking part in the formation and destruction of blood cells.

Food and Physiology of Digestion

Scoliodon is a predatory carnivore that feeds on fishes, crabs, lobsters, and worms. Food is swallowed whole, and no digestion occurs in the buccal cavity. In the stomach, gastric juice containing **pepsin** and **hydrochloric acid** breaks down proteins. In the intestine, bile emulsifies fats, while pancreatic enzymes digest proteins, carbohydrates, and lipids. The **scroll valve** slows down the movement of food and ensures maximum digestion and absorption. Finally, undigested matter passes into the rectum and leaves the body through the cloaca.

Respiratory System of *Scoliodon*

Scoliodon (the spiny dogfish) is well adapted for aquatic respiration and breathes through gills. These gills are present inside a series of gill pouches located on both sides of the pharynx.

Gill Pouches and Their Structure

Water enters the mouth and passes into the buccal cavity, then into the pharynx. From the pharynx, water flows through the gill slits and over the gills present within the branchial pouches, allowing respiration.

There are **five pairs of gill pouches** in *Scoliodon*.

Each gill pouch:

- Is compressed antero-posteriorly
- Opens internally into the pharynx through a **wide internal branchial aperture**
- Opens externally through a **narrow external branchial aperture**

The inner surface of each pouch is lined with mucous membrane that forms **horizontal folds called branchial lamellae**, which contain numerous blood capillaries for gaseous exchange.

Each gill pouch contains **two sets of gill lamellae**:

- One on the **anterior wall**
- One on the **posterior wall** (usually longer)

Interbranchial Septa and Gill Arrangement

Adjacent gill pouches are separated by **interbranchial septa**. Embedded in the inner edge of each septum is a **visceral arch** supported by branchial rays.

These visceral arches alternate with the gill pouches:

- Each arch supports the **posterior lamellae** of one gill pouch
- And the **anterior lamellae** of the next pouch

Together, the anterior and posterior lamellae attached to one visceral arch form a **complete gill or holobranch**.
If only one side bears lamellae, it is called a **hemibranch**.

Gill distribution in *Scoliodon*:

- **1st–4th branchial arches → holobranchs (complete gills)**
- **Hyoid arch → hemibranch (lamellae only on posterior side)**
- **5th branchial arch → gill-less**

Mechanism of Respiration

Respiration in *Scoliodon* involves a coordinated action of muscles and gill structures to ensure continuous water flow over the gills.

1. Ingress of Water

- The floor of the buccal cavity is lowered by the **hypobranchial muscles**.
- This increases the cavity's volume.
- The mouth opens, allowing water to rush into the expanded buccal cavity.

2. Passage of Water to Gill Pouches

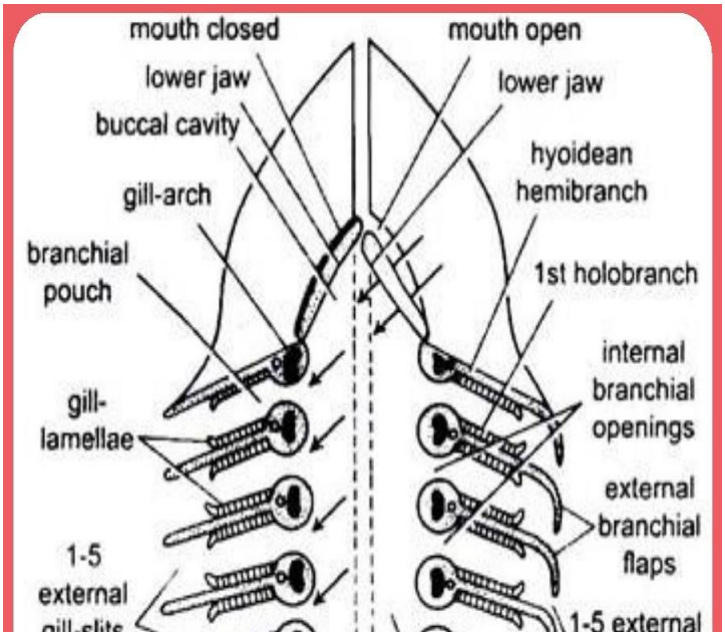
- The branchial arches rise, enlarging the pharyngeal cavity.
- The mouth then closes due to the **adductor muscles**.
- Water is forced to move from the pharynx into the gill pouches and then out through the external gill slits.

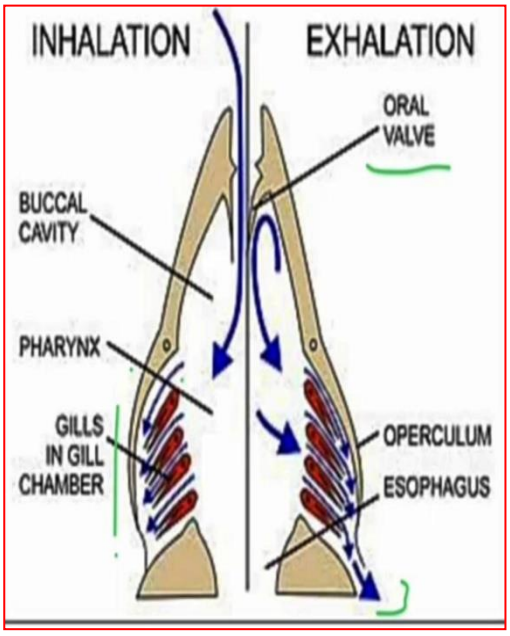
3. Gaseous Exchange

Inside the gill pouches:

- Water flows over the gill lamellae.
- Deoxygenated blood flows through the capillaries of the lamellae.
- The thin capillary walls allow **oxygen (O_2)** from water to diffuse into the blood.
- At the same time, **carbon dioxide (CO_2)** from the blood diffuses out into the water.

This exchange takes place through **endosmosis and exosmosis**, ensuring efficient oxygenation of blood.





***2.3 Scoliodon* Structure and function of Heart, Structure and functions of the Brain.**

Heart of *Scoliodon* (Dogfish Shark): Structure and Function:

The heart of *Scoliodon* is a **muscular, four-chambered organ** located ventrally in the head region, just below the pharynx. It plays a crucial role in maintaining a **single-circuit circulatory system**, typical of fishes, where deoxygenated blood from the body is pumped to the gills for oxygenation.

Structure of the Heart

The heart of *Scoliodon* is **S-shaped**, elongated, and placed mid-ventrally in the pericardial cavity. It consists of **four chambers arranged in a linear sequence**, all carrying **deoxygenated blood**. The four chambers (from posterior to anterior) are:

A. Sinus Venosus

- It is the **posterior-most chamber**, thin-walled and triangular.
- Formed by the union of two **ducts of Cuvier** and a posterior **hepatic vein**.
- Opens anteriorly into the atrium through a **sinu-atrial aperture** guarded by valves.

Structure role: Collects blood from all parts of the body and regulates its flow into the atrium.

B. Atrium (Auricle)

- A **large, thin-walled**, bilobed chamber.
- Lies anterior to the sinus venosus.
- Sends blood to the ventricle through the **atrioventricular aperture** guarded by two flaps of valves.

Structure role: Acts as a reservoir; ensures smooth, continuous supply of blood to the ventricle.

C. Ventricle

- The **largest and most muscular chamber**, conical in shape.
- Thick-walled with strong cardiac muscles.
- Pumps blood under high pressure.

Structure role: Provides the force required to send blood into the conus arteriosus and then to the gills.

D. Conus Arteriosus (Conus Truncus)

- An anterior muscular tube following the ventricle.
- Has **several rows of semilunar valves**, preventing backflow.
- Leads into the **ventral aorta**, which distributes blood to gills via afferent branchial arteries.

Structure role: Regulates blood pressure, prevents backflow, and ensures steady blood flow to the gills.

2. Pericardium

- The heart is enclosed in a **pericardial cavity** lined by a pericardial membrane.
- The cavity contains **pericardial fluid** for lubrication and reducing friction during heartbeats.

3. Blood Flow Pathway

Body → Sinus venosus → Atrium → Ventricle → Conus arteriosus → Ventral aorta → Gills

All chambers of the heart carry **deoxygenated blood**, which becomes oxygenated only after passing through the **gills**.

4. Function of the Heart

A. Pumping Deoxygenated Blood

The heart pumps deoxygenated blood collected from the body towards the gills, where gas exchange occurs.

B. Ensuring Unidirectional Flow

Valves between chambers (sinu-atrial valves, atrioventricular valves, semilunar valves) ensure blood flows in only one direction.

C. Creating Blood Pressure for Branchial Circulation

The strong ventricle generates the required pressure to push blood through:

- Ventricle → Conus arteriosus → Ventral aorta → Afferent branchial vessels → Gills

D. Supporting Single-Circuit Circulation

Scoliodon has a **single-loop circulatory system**:

- Heart → Gills → Body → Heart

The heart ensures continuous delivery of blood to tissues after oxygenation in the gills.

E. Maintaining Rhythmic Contractions

Cardiac muscles in the ventricle maintain rhythmic contractions essential for continuous blood circulation.

5. Special Features of Scoliodon Heart

- All heart chambers carry **only venous blood**.
- Presence of a well-developed **conus arteriosus with multiple semilunar valves**.
- The heart is **myogenic**, meaning it generates its own heartbeat.
- Operates under relatively **low pressure**, except at the ventricle.
- Adapted for the respiratory needs of a marine predator.

Brain of *Scoliodon* (Dogfish Shark): Structure and Function

The brain of *Scoliodon* is a well-developed and elongated organ located inside the cartilaginous cranium. It is adapted to the shark's predatory lifestyle, depending heavily on senses such as smell, vision, and balance. The brain is divided into **three main regions**—the **forebrain**, **midbrain**, and **hindbrain**—each performing specialized functions essential for survival in the aquatic environment.

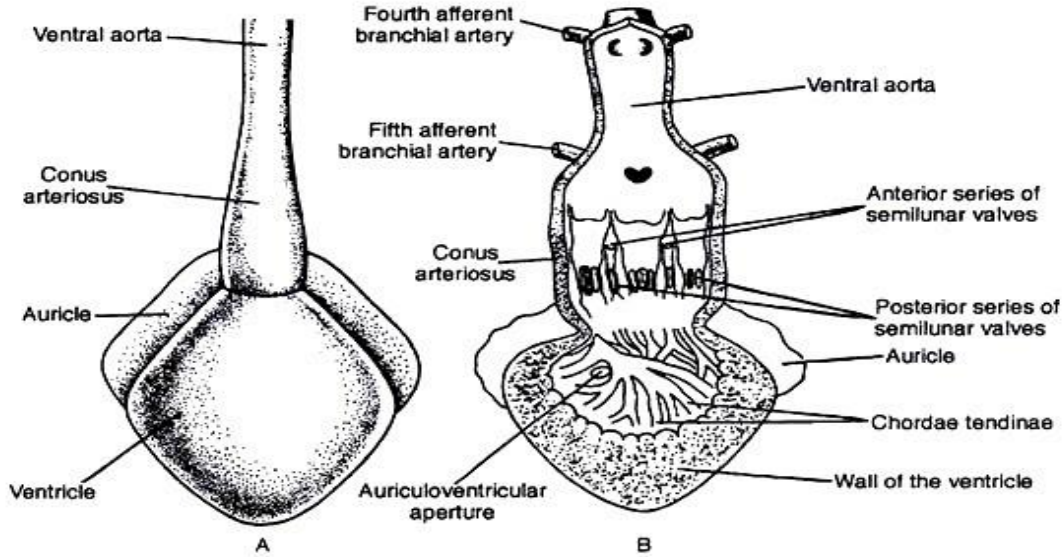


Fig. 1.35 : Heart of *Scoliodon* : A. An intact heart showing the position of different chambers. B. Diagrammatic longitudinal sectional view of the heart

Structure of the Brain

Overall Shape and Position: The brain is long, slightly flattened dorsoventrally, and lies in the cranial cavity. It is continuous posteriorly with the spinal cord. Its surface is smooth except for the cerebellum, which shows distinct ridges.

Protective Coverings

The brain is protected by:

1. **Cranial Cartilage:** Forms a strong, rigid case.
2. **Meninx Primitiva:** A thin, delicate membrane covering the brain (comparable to meninges in higher vertebrates).
3. **Perichondrium:** A fibrous outer sheath lining the cranium.

Between the brain and the meninx, **cerebrospinal fluid (CSF)** is present, acting as a cushion and maintaining constant internal pressure. CSF also fills the ventricles of the brain, ensuring nutrient exchange and protection against mechanical shock.

2. Divisions of the Brain

The brain is clearly divided into **forebrain, midbrain, and hindbrain**, each containing distinctive structures.

A. Forebrain (Prosencephalon)

1. Olfactory Lobes

- Large, paired structures located at the anterior end.
- Connected to the nasal capsules by olfactory nerves.
- Each lobe leads into the brain through a short olfactory tract.

Significance:

These lobes are exceptionally large due to the shark's dependence on smell for detecting prey, blood traces, and navigating the ocean.

2. Cerebral Hemispheres

- Paired, rounded hemispheres located just behind the olfactory lobes.
- Small and smooth-surfaced compared to mammals.
- Connected internally by a narrow commissure.

Significance:

The cerebrum performs basic integration and coordination of sensory information. While not highly developed, it helps in simple decision-making, learning, and controlling instinctive behavior.

3. Diencephalon

Located behind the cerebrum; includes:

- **Thalamus:** Relay center for sensory impulses.
- **Hypothalamus:** Regulates hunger, hormone release, osmoregulation, and internal homeostasis.

- **Infundibulum and Pituitary:** Important for endocrine control.

Significance:

The diencephalon integrates sensory information and maintains internal physiological balance.

B. Midbrain (Mesencephalon)

Optic Lobes

- Two large, rounded swellings on the dorsal surface.
- Dominant part of the midbrain in *Scoliodon*.
- Well supplied with optic nerves from the eyes.

Significance:

The optic lobes are the chief visual centers. They process visual impulses, help detect movement in water, track prey, and maintain orientation.

Midbrain Nerves

- The **oculomotor nerve (III)** arises from this region.
- Controls movements of the eyeball and pupil.

C. Hindbrain (Rhombencephalon)

1. Cerebellum

- A large, arched, and highly developed lobe.
- Shows transverse ridges on the dorsal surface.
- Connected to the medulla by thick nerve tracts.

Significance: The cerebellum is the coordination center. It regulates:

- Swimming movements
- Body balance
- Spatial orientation
- Muscular coordination

This makes it crucial for the active, fast-swimming lifestyle of the shark.

2. Medulla Oblongata

- Posterior-most part of the brain.
- Continuous with the spinal cord.
- Houses vital reflex centers.

Significance: The medulla controls:

- Heartbeat
- Respiration
- Blood pressure

- Swallowing and gill ventilation

  It also integrates lateral line impulses (water pressure and vibration detection).

3. Cranial Nerves

Scoliodon possesses **10 pairs of cranial nerves**, each associated with sensory and motor functions such as smell, vision, jaw movement, gill arch control, and lateral line sensation.

4. Functions of the Major Brain Regions

Forebrain Functions

- **Olfactory lobes:** Detecting smell; essential for hunting.
- **Cerebrum:** Integrating sensory inputs, basic decision-making, simple learning.
- **Diencephalon:** Hormonal regulation, internal homeostasis, sensory relay.

Midbrain Functions

- **Optic lobes:** Processing vision; detecting movement; prey localization.
- **Oculomotor control:** Coordinating eye movements.

Hindbrain Functions

- **Cerebellum:** Maintaining balance, posture, and precise swimming control.
- **Medulla oblongata:** Regulating involuntary vital functions, coordinating breathing and gill movements.

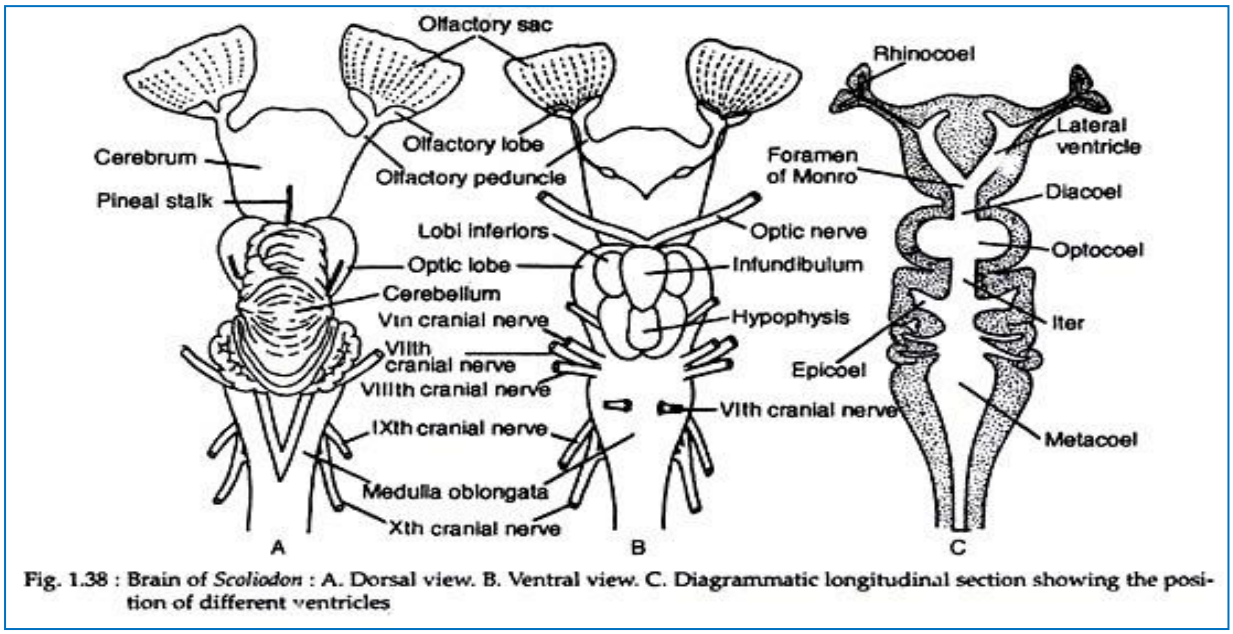


Fig. 1.38 : Brain of *Scoliodon* : A. Dorsal view. B. Ventral view. C. Diagrammatic longitudinal section showing the position of different ventricles

2.4. Migration in Fishes, Types of Scales

Migration in Fishes – Detailed Notes

Introduction: Migration in fishes refers to the regular, periodic, and long-distance movement **of fishes from one habitat to another for specific purposes such as** breeding, feeding, growth, or avoiding unfavourable conditions**. It is a** directional and seasonal movement **and is an important adaptive behaviour in the fish life cycle.**

Causes for Migration

1. **Breeding (Spawning Migration)**
    - Many fishes travel long distances to reach safe spawning grounds with ideal conditions for egg laying and larval survival.
2. **Feeding Migration**
    - Fishes migrate to areas where food availability is high, such as plankton-rich waters.
3. **Climatic Factors**
    - Temperature, salinity, and oxygen levels influence migration.
    - Fishes move to environments with optimal water conditions.
4. **Shelter and Protection**
    - To escape predators, pollution, drought, flood, or other disturbances.
5. **Life Cycle Completion**
    - Different stages of life (larva, juvenile, adult) may require different ecological conditions.
6. **Genetic / Instinctive Behavior**
    - Many migratory behaviours are guided by innate mechanisms such as memory, magnetic fields, olfactory cues, and ocean currents.

Types of Fish Migration

1. Anadromous Migration

- Fishes migrate from **sea to freshwater** for breeding.
- Spend most of their life at sea but return to rivers to spawn.
- Example: **Salmon**, **Hilsa (Tenualosa ilisha)**, **Sturgeon**.

2. Catadromous Migration

- Fishes migrate from **freshwater to sea** for breeding.
- Spend most of their life in rivers/lakes but breed in the sea.
- Example: **Eel (Anguilla)**.

3. Potamodromous Migration

- Migration occurs **entirely within freshwater systems** such as rivers and lakes.
- Example: **Carps**, **Trout**, **Mahseer**.

4. Oceanodromous Migration

- Migration occurs **entirely within the marine (sea) environment**.
- Example: **Tuna**, **Herring**, **Mackerel**.

5. Amphidromous Migration

- Movement between sea and freshwater **not related to breeding**.
- Occurs for feeding or growth.
- Example: Some **gobies** and **smelts**.

6. Latitudinal Migration

- Movement between **north and south** regions within the ocean.
- Usually guided by temperature changes and food availability.
- Example: **Sardines**, **Herrings**.

7. Vertical Migration (Diel Migration)

- Daily movement from deep waters during the day to surface waters at night.
- Helps in feeding and avoiding predators.
- Very common in **deep-sea fishes and plankton-feeders**.

Importance of Migration

- Ensures **reproductive success**
- Helps in obtaining **food**
- Maintains **population size and genetic diversity**
- Allows fishes to avoid harsh conditions
- Supports **marine and freshwater ecosystems**

TYPES OF SCALES IN FISHES

Scales are protective, overlapping structures embedded in the dermis of the fish skin. They protect the body, reduce friction during swimming, and provide flexibility.

1. Placoid Scales (Dermal Denticles)

- Found in **cartilaginous fishes**: Sharks, Rays, Skates.
- Structure resembles a **tooth** with:
  - A **basal plate**
  - A **dentine spine**

- An outer layer of **enamel-like vitrodentine**

- Hard, rough, and pointed backward.
- Advantages:
  - Reduce water friction → **increase swimming speed**
  - Provide protection against predators and parasites.

2. Ganoid Scales

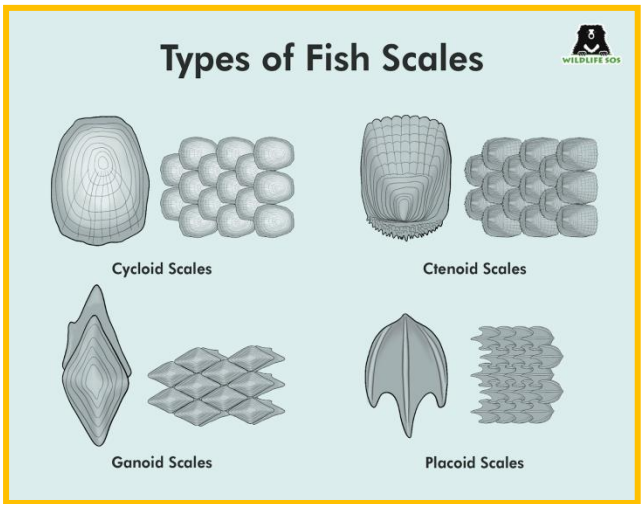
- Present in **primitive bony fishes**.
- Strong, thick, rhomboid-shaped.
- Covered with a shiny enamel-like layer called **ganoine**.
- Found in **Gar (Lepisosteus)**, **Polypterus**.
- Provide heavy protection but reduce flexibility.

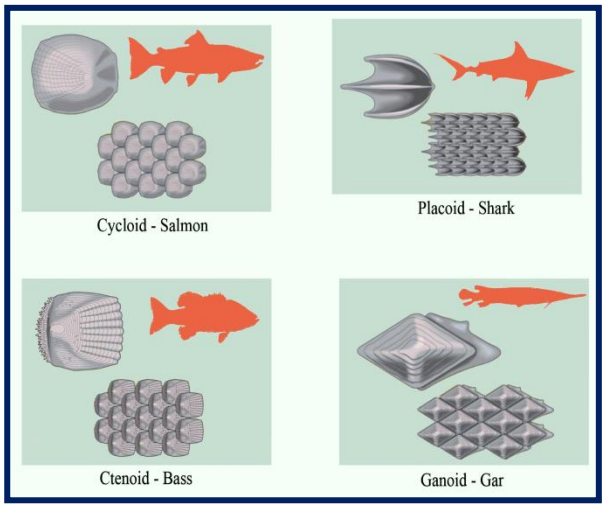
3. Cycloid Scales

- Found in **soft-rayed teleost fishes** (advanced bony fishes).
- Thin, flexible, round scales with **smooth edges**.
- Made of **concentric growth rings** (circuli).
- Examples: **Carp**, **Salmon**.
- Allow smooth, flexible movement of the fish.

4. Ctenoid Scales

- Found in **spiny-rayed teleost fishes**.
- Similar to cycloid scales but with **tiny tooth-like projections** called **ctenii** on the posterior edge.
- Rough textured.
- Examples: **Perch**, **Tilapia**.
- Provide extra protection and reduce slipping.





Unit-III

3.1. General characters of Amphibia, General characters of Reptilia

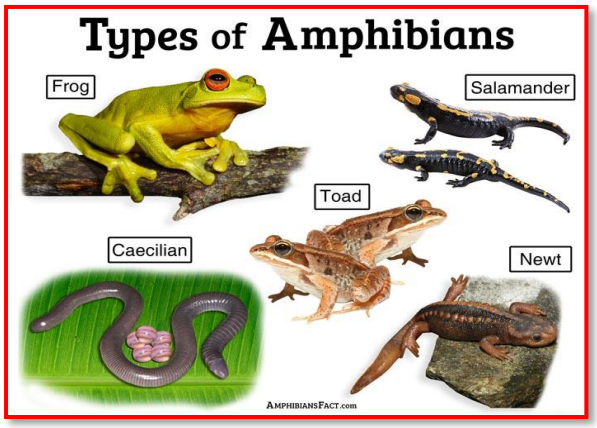
GENERAL CHARACTERS OF AMPHIBIA

1. Amphibians live **both in water and on land** (dual life).
2. Body divided into **head and trunk**; tail may be present or absent.
3. Skin is **moist, smooth, and glandular**, without scales.
4. Mucous glands in skin keep the body **moist**.
5. Some species have **poison glands** (e.g., toads).
6. Usually have **two pairs of limbs**; each limb has **five digits**.
7. Limbs are absent in caecilians (Ichthyophis).
8. Respiration occurs through **gills (larvae), lungs (adults), skin**, and buccal cavity.
9. Heart is **three-chambered** (2 atria + 1 ventricle).
10. Blood circulation is **double**, but some mixing occurs.
11. Kidneys are **mesonephric**.
12. Excretion is usually **ureotelic** (urea).
13. Fertilization is generally **external** (frogs and toads).
14. Eggs are **soft, non-shelled**, and laid in water.
15. Development includes **metamorphosis** (tadpole → adult).
16. Tadpoles resemble fish (gills, tail).
17. They are **ectothermic** (cold-blooded).
18. Examples: **Frog**, **Toad**, **Salamander**, **Caecilian**.

GENERAL CHARACTERS OF REPTILIA

1. Reptiles are mainly **terrestrial** vertebrates.
2. Body divided into **head, neck, trunk, and tail**.
3. Skin is **dry, rough**, and covered with **scales or scutes**.
4. Skin lacks **mucous glands**.
5. Limbs usually **two pairs**, pentadactyl; absent in snakes.
6. Claws present at the end of digits.
7. Respiration **only by lungs** (well-developed).
8. Heart is **three-chambered**, except crocodiles (four chambers).
9. Blood circulation is **double** with little mixing.
10. Kidneys are **metanephric**.
11. Excrete **uric acid** (uricotelic), conserving water.
12. Fertilization is always **internal**.

13. Eggs have **calcareous or leathery shells**.
14. Most are **oviparous**; some are ovoviviparous/viviparous.
15. They are **cold-blooded** (ectothermic).
16. Sense organs well developed; some have Jacobson's organ (snakes, lizards).
17. Limbless forms (snakes) have **movable jaws** for swallowing large prey.
18. Examples: **Lizard, Snake, Turtle, Crocodile**.

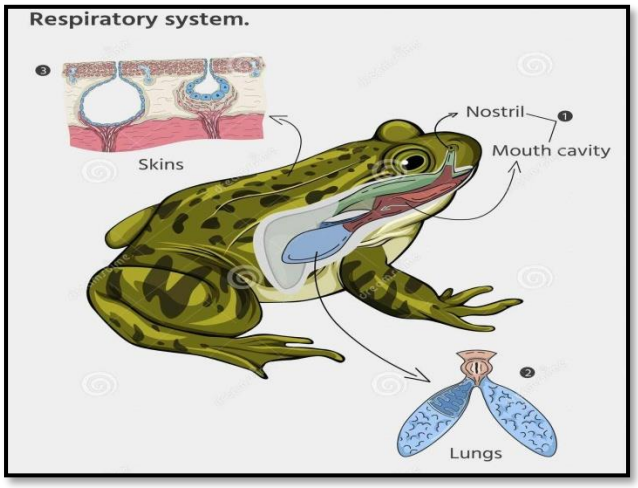


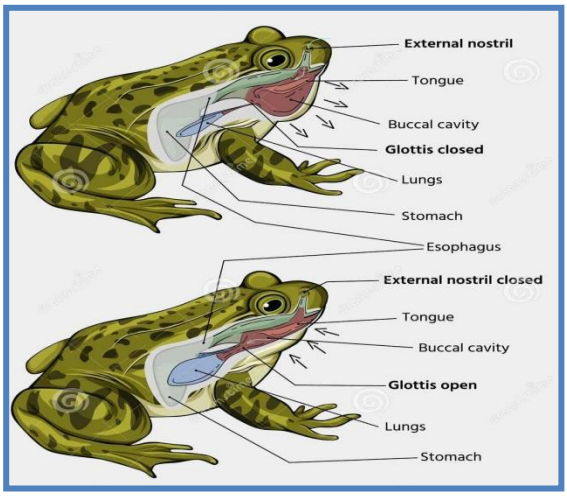
***3.2.Rana hexadactyla*: External features,Respiratory system, Structure and function of Heart**

Rana hexadactyla – External Features

1. Body is **streamlined** and adapted for jumping and swimming.
2. Body divided into **head and trunk** (no neck, no tail).
3. Skin is **smooth, moist, and glandular**, without scales.
4. Skin colour is **green** with darker patches for camouflage.
5. Head is **broad and triangular**.
6. Two small **nostrils** present at the tip of the snout.
7. Eyes are **large and bulging**, located on top of the head.
8. Each eye has **upper eyelid, lower eyelid**, and a **nictitating membrane**.
9. **Tympanum** (external eardrum) is present behind each eye.
10. Mouth is **large and wide** at the front.
11. Forelimbs are **short**, used for support.
12. Each forelimb has **four digits** without webbing.
13. Hindlimbs are **long, strong, and muscular**.
14. Each hindlimb has **five digits** with **webs** between them.
15. A **rudimentary sixth digit (tubercle)** is present → hence name *hexadactyla*.
16. **Cloacal aperture** present at the posterior end of the trunk.
17. Males have **nuptial pads** and **vocal sacs** (females lack them).

Respiratory system





Here are a few organs involved in Respiratory System of Amphibians:

1. Gills

The larvae of aquatic amphibians, such as frogs and salamanders, breathe through external gills. Gills are feather-like projections that extract oxygen from water as it passes over them.

They are located on the sides of the head and neck. Gills allow amphibian larvae to remain underwater and obtain oxygen while they grow.

2. Lungs

As amphibians transition from larvae to terrestrial adults during metamorphosis, their gills are replaced by lungs. Lungs provide a larger surface area for gas exchange. Air is brought into the lungs through the mouth and nostrils.

The walls of the lungs are thin and permeable, allowing oxygen to diffuse into **blood vessels**. Lungs enable adult amphibians to breathe air.

3. Skin

Both larval and adult amphibians use their skin as a respiratory organ. Their skin is moist and contains many blood vessels close to the surface. Oxygen can pass through the skin into the bloodstream.

An amphibian's skin accounts for up to half of their oxygen uptake. Cutaneous respiration allows them to supplement lung and gill breathing.

Respiration in Aquatic Amphibians

Aquatic amphibian larvae like tadpoles rely mostly on gills and their skin to obtain oxygen while submerged. Blood circulates through the fine filaments of the external gills, allowing oxygen to be absorbed.

The thin skin is also well-vascularized and facilitates cutaneous gas exchange. Together, the gills and skin provide sufficient oxygen for larvae to grow underwater.

Respiration in Terrestrial Amphibians

As amphibians mature into air-breathing adults, lungs develop to facilitate respiration on land. Lungs provide a larger surface area and better diffusion of oxygen than gills. The walls of amphibian lungs are thin and permeable. Air flows in and out through the nostrils.

In addition to lungs, the moist skin of terrestrial amphibians allows them to continue cutaneous respiration. This dual respiratory system enables gas exchange in both water and air.

Adaptations for Respiration Aquatic and Terrestrial Environments

Amphibians have made several adaptations to their respiratory system to facilitate gas exchange in both water and air. These adaptations include:

1. Spongy lungs

The lungs of amphibians are spongier than those of mammals. This increases the surface area for gas exchange, which is essential for breathing air.

2. Skin folds

Some amphibians have skin folds that increase the surface area of their skin and facilitate cutaneous respiration.

3. Buccal pumping

Amphibians can use their buccal muscles to pump air into their lungs, even when their mouths are closed. This allows them to breathe while underwater.

How Respiratory System of Amphibians Work?

Here is the pathway of the respiratory system in amphibians in bullet points:

Inhalation

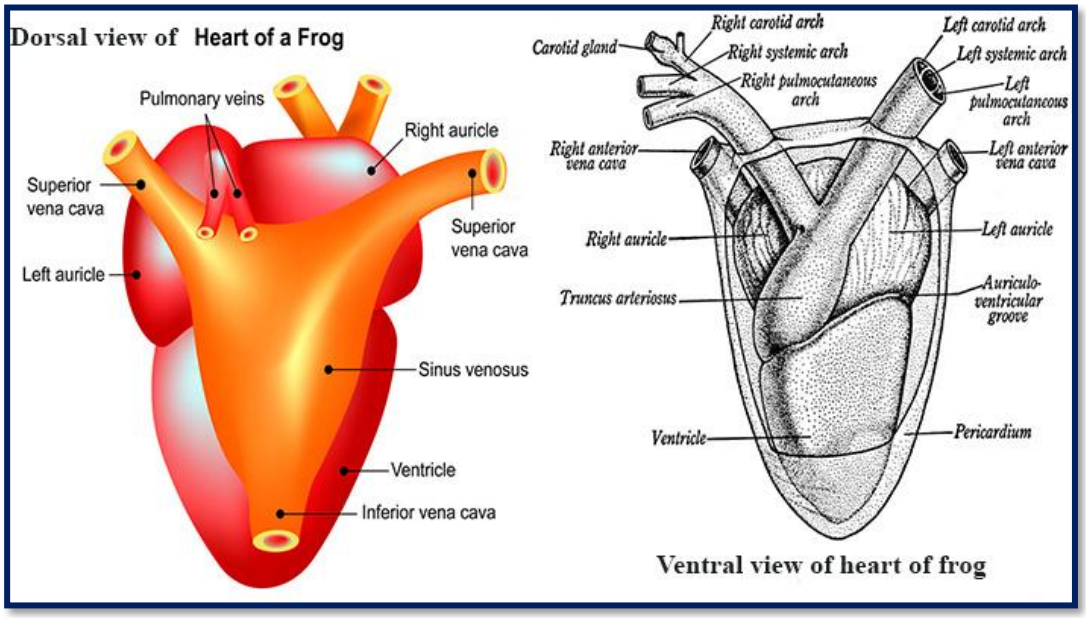
- Air enters the body through the nostrils.
- Air passes through the nasal cavity, where it is warmed and humidified.
- Air travels down the pharynx, which is a tube that leads to both the esophagus and the larynx.
- The larynx, also known as the voice box, contains the vocal cords.
- Air travels down the trachea, which is a tube that leads to the lungs.
- The trachea divides into two bronchi, one for each lung.
- The bronchi branch into smaller and smaller passages called bronchioles.
- The bronchioles terminate in clusters of tiny air sacs called alveoli.
- Gas exchange occurs between the air in the alveoli and the blood in the surrounding capillaries.

Exhalation

- Air flows back through the bronchioles, bronchi, and trachea.
- Air exits the body through the nostrils.

Structure and function of the Frog Heart:

The frog heart is a highly specialized organ that supports the amphibious mode of life of frogs, which live both in water and on land. It is a **three-chambered** muscular pumping organ located in the **pericardial cavity**, and it plays a major role in maintaining circulation and transporting gases, nutrients, and wastes throughout the body. The structure of the frog heart and its functioning are adapted to handle blood coming from both the lungs (oxygenated) and from the body tissues (deoxygenated).



Structure of the Frog Heart

The frog heart is enclosed within a double-layered membrane called the **pericardium**, which protects the heart and reduces friction during its beating. Structurally, the heart consists of **three chambers**—two atria and one ventricle—and is connected to major blood vessels that regulate the flow of blood.

1. Sinus Venosus

At the posterior region of the heart lies a thin, triangular sac called the **sinus venosus**. It receives **deoxygenated blood** from all parts of the body through three major veins called the **precaval and postcaval veins**. The sinus venosus opens into the right atrium through the **sino-atrial aperture**, which contains valves to prevent backflow of blood.

2. Atria

The frog heart contains two atria:

- **Right Atrium:** Receives deoxygenated blood from the sinus venosus.
- **Left Atrium:** Receives oxygenated blood returning from the lungs and skin through the **pulmonary veins**.

The two atria are separated by an **inter-atrial septum**, but externally they appear as a single chamber. Both atria contract simultaneously and push blood into the ventricle.

3. Ventricle

The ventricle is a **single, thick-walled muscular chamber** that forms the main pumping portion of the heart. Unlike mammals, frogs have only one ventricle. The internal wall contains a network of **trabeculae** (muscular ridges) that help reduce complete mixing of oxygenated and deoxygenated blood. Blood from both atria enters the ventricle through an **atrioventricular aperture** guarded by valves.

4. Truncus Arteriosus

From the ventricle arises a large, tube-like structure called the **truncus arteriosus**, which divides into several arterial arches. Inside the truncus is a **spiral valve**, a twisted structure that plays an important role in directing different types of blood into appropriate arteries. The truncus arteriosus divides into three pairs of arches:

- **Carotid arches** – supply blood to the head and brain.
- **Systemic arches** – supply blood to the body organs.
- **Pulmocutaneous arches** – carry blood to the lungs and skin for oxygenation.

The presence of valves prevents backflow of blood into the ventricle.

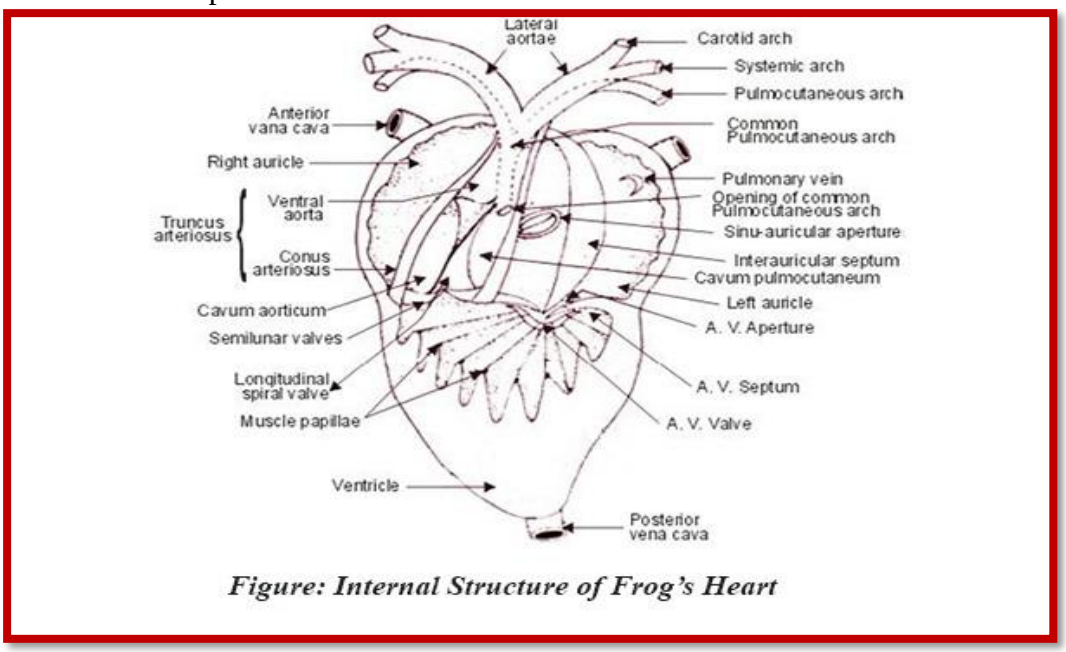


Figure: Internal Structure of Frog's Heart

Function of the Frog Heart

The frog heart carries out a **double circulation**, though it is incomplete because a single ventricle is present. The functioning of the heart includes receiving blood, pumping it, and distributing it efficiently to the body and respiratory organs.

1. Reception of Blood

- **Deoxygenated blood** from the body enters the sinus venosus and then flows into the right atrium.
- **Oxygenated blood** from the lungs and skin returns via the pulmonary vein and enters the left atrium.

2. Atrial Contraction

Both atria contract at the same time. Their contraction pushes:

- oxygen-rich blood from the left atrium, and oxygen-poor blood from the right atrium into the single ventricle.
- Due to trabeculae, these two types of blood undergo **partial mixing** but remain somewhat separated.

3. Ventricular Contraction and Blood Distribution

When the ventricle contracts, blood is pumped into the **truncus arteriosus**, where the **spiral valve** plays an important role.

The spiral valve ensures that:

- Oxygenated or richer blood moves into the **carotid arteries** (to head and brain).
- Mixed blood goes into the **systemic arches** (to body organs).
- More deoxygenated blood flows into the **pulmocutaneous arteries** (to lungs and skin for re-oxygenation).

Thus, even though frogs have a single ventricle, the spiral valve aids in separating blood streams and directing them to appropriate regions.

Double Circulation (Incomplete)

Frogs show both:

1. **Pulmonary circulation:** Heart → lungs → heart
2. **Systemic circulation:** Heart → body → heart

Because there is only one ventricle, the circulation is not completely separated, hence called **incomplete double circulation**.

Structure and Function of the Frog Brain

The frog brain is the main controlling center of the nervous system. It lies inside the cranium and is protected by meninges. Though simpler than the human brain, it is well-developed to regulate the frog's amphibious lifestyle, including movement, respiration, feeding, and sense organs. The frog brain is divided into **three major regions**: the **forebrain**, **midbrain**, and **hindbrain**. Each region controls specific functions necessary for survival.

STRUCTURE OF THE FROG BRAIN

The frog brain is elongated, bilaterally symmetrical, and consists of the following parts:

1. Forebrain (Prosencephalon)

The forebrain is the anterior part of the brain. It includes:

a. Olfactory Lobes

- Paired, rounded structures present at the front.
- Connected to the nasal chambers.
- Well-developed because frogs depend on smell for locating food and recognizing surroundings.

b. Cerebrum (Cerebral Hemispheres)

- Two small oval hemispheres behind the olfactory lobes.
- Comparatively smaller than mammals.
- Responsible for learning, memory, voluntary actions, simple behavior, and sensory integration.

c. Diencephalon

Located behind the cerebrum, includes:

- **Thalamus** → relays sensory information to higher centers.
- **Hypothalamus** → regulates hunger, temperature, water balance, and hormonal control through the pituitary gland.
- **Pineal and Infundibular body** → related to biological rhythms and hormonal regulation.

2. Midbrain (Mesencephalon)

The midbrain is the centre for **vision and coordination**.

a. Optic Lobes (Tectum)

- Two large, rounded lobes on the dorsal surface.
- Highly developed because frogs mainly depend on sight to locate prey and detect movement.
- Control visual reflexes and body orientation.

b. Cerebral Peduncles (Nerve Pathways)

- Connect the forebrain with the hindbrain.
- Carry motor and sensory impulses.

3. Hindbrain (Rhombencephalon)

The hindbrain controls vital involuntary activities like respiration, heartbeat, and balance.

a. Cerebellum

- A narrow, transverse band between the optic lobes and medulla.
- Controls balance, posture, swimming movements, and coordination of voluntary muscles.
- Less developed compared to birds and mammals.

b. Medulla Oblongata

- Posterior-most part, continuous with the spinal cord.
- Controls involuntary functions such as heartbeat, respiration, digestion, and reflex actions (swallowing, vomiting).
- Important centre for maintaining life processes.

FUNCTIONS OF THE FROG BRAIN

The frog brain performs a variety of essential functions:

1. Sensory Functions

- **Olfactory lobes** help in smell and locating food.
- **Optic lobes** process visual signals like movement of prey and predators.
- Receives taste, touch, and temperature sensations through cranial nerves.

2. Motor Coordination

- **Cerebellum** coordinates muscular movements during jumping, swimming, and walking.
- Controls posture and body balance.

3. Regulation of Involuntary Activities

- **Medulla oblongata** controls heartbeat, blood pressure, breathing rate, swallowing, and digestion.

4. Higher Functions

- The **cerebrum** performs basic learning, memory, and simple decision-making.
- Helps in behavioral patterns like feeding, mating, and territorial responses.

5. Homeostasis

- **Hypothalamus** regulates hunger, water balance, body temperature, and hormone secretion via the pituitary gland.

- Maintains internal stability of the body.

6. Coordination Between Systems

- Brain integrates sensory information and sends suitable responses through motor nerves.
- Controls all body organs through cranial and spinal nerves.

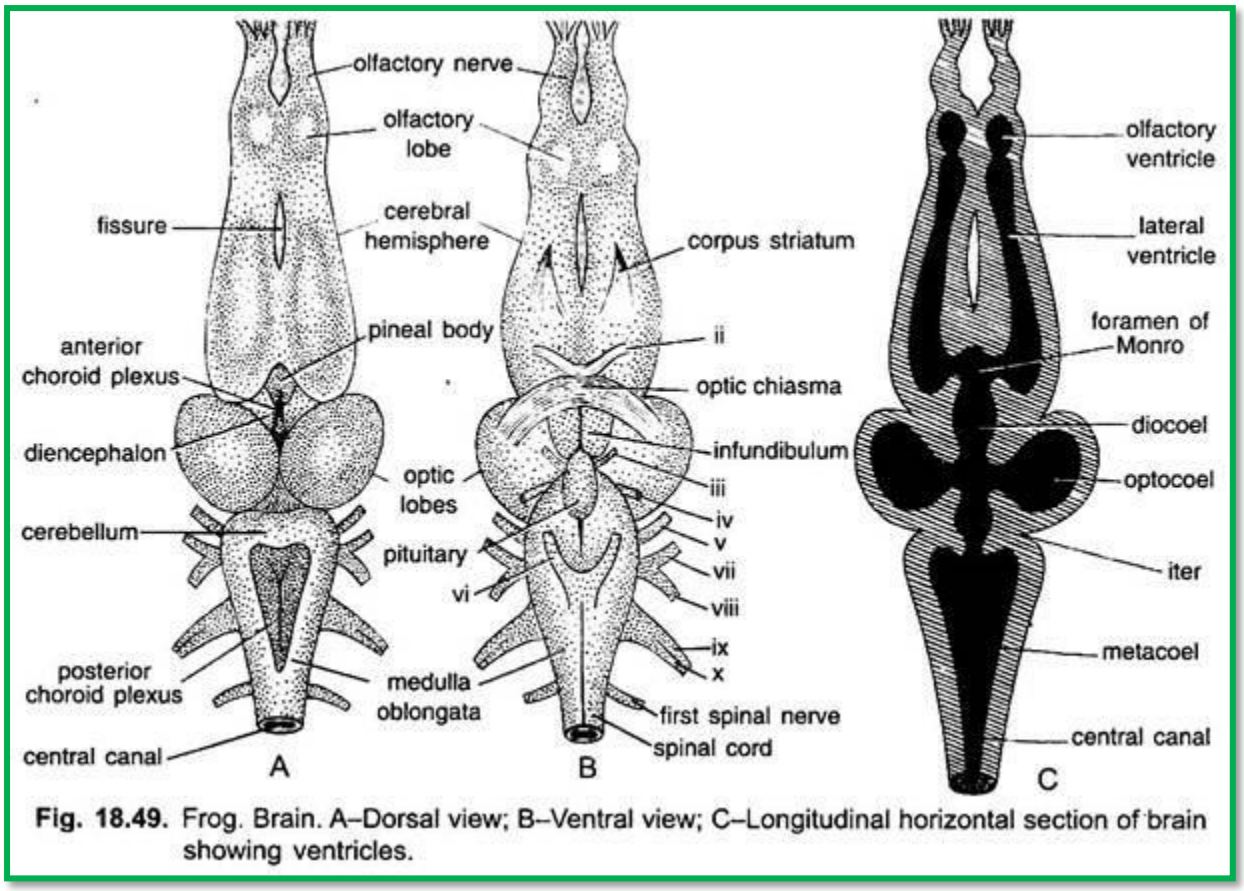


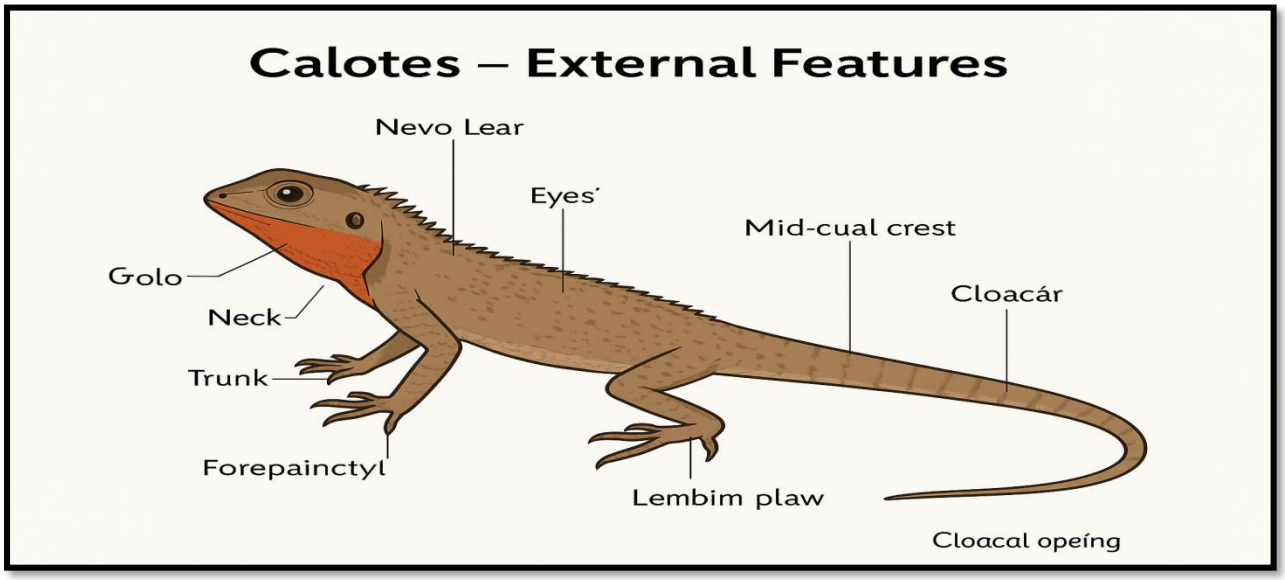
Fig. 18.49. Frog. Brain. A–Dorsal view; B–Ventral view; C–Longitudinal horizontal section of brain showing ventricles.

3.4 *Calotes*: External features, Digestive system, structure and function of Brain

Calotes – External Features

1. Body elongated, slender, and laterally compressed.
2. Skin dry, rough, and covered with keratinized overlapping scales.
3. Body divided into head, neck, trunk, and tail.
4. Head triangular with a pointed snout.
5. Eyes large with movable eyelids and a nictitating membrane.
6. External ear present as a circular tympanum behind the eyes.
7. Nostrils small, located at the tip of the snout.
8. Mouth wide with pleurodont teeth and a sticky tongue for catching insects.
9. Neck short but flexible, allowing free movement of the head.
10. Trunk long and laterally compressed.
11. A mid-dorsal crest of pointed scales present on the trunk region.

12. Two pairs of pentadactyl limbs present.
13. Digits long, ending in sharp claws adapted for climbing.
14. Tail long, tapering, and flexible, used for balance and defense.
15. Tail shows autotomy (can break off when caught).
16. Body color usually brown or grey with dark bands for camouflage.
17. Males turn bright red on head and throat during breeding season.
18. Cloacal opening present at the posterior end of the trunk.
19. Sexual dimorphism present—males have larger crest and brighter coloration.
20. Adapted for climbing bushes, walls, and tree trunks.



Digestive system of Calotes

The digestive system of *Calotes* is well-developed and adapted for its **carnivorous** diet. It includes the **alimentary canal** and **digestive glands**.

1. Alimentary Canal

a. Mouth

- The mouth is wide and bounded by strong jaws.
- **Teeth** are small, sharp, and homodont (all similar).
- Teeth are acrodont — directly attached to the upper edge of the jawbone.
- The tongue is long, sticky, and used for capturing insects.

b. Buccal Cavity

- Contains teeth, tongue, and internal nostrils.
- Helps in holding and swallowing prey.

c. Pharynx

- Opens into the oesophagus and also contains the opening of the glottis (respiratory opening).
- No proper separation between buccal cavity and pharynx.

d. Oesophagus

- A short, muscular tube.
- Passes the swallowed food into the stomach by peristalsis.

e. Stomach

- A thick, muscular, sac-like organ.
- It secretes **gastric juice** containing HCl and enzymes.
- Proteins are digested here.

f. Small Intestine

Small intestine has 2 regions:

i. Duodenum

- U-shaped and receives bile from the liver and enzymes from the pancreas.

ii. Ileum

- Long and coiled.
- Complete digestion and absorption of nutrients occur here.

g. Large Intestine (Colon + Rectum)

- Short and wide.
- Absorbs water and stores undigested food.

h. Cloaca

- A common chamber for digestive, urinary, and reproductive systems.
- Opens outside through the cloacal aperture.

2. Digestive Glands

a. Liver

- Large, bilobed (two-lobed).
- Produces **bile**, which helps in digestion of fats.
- Bile is stored in the **gall bladder**.

b. Pancreas

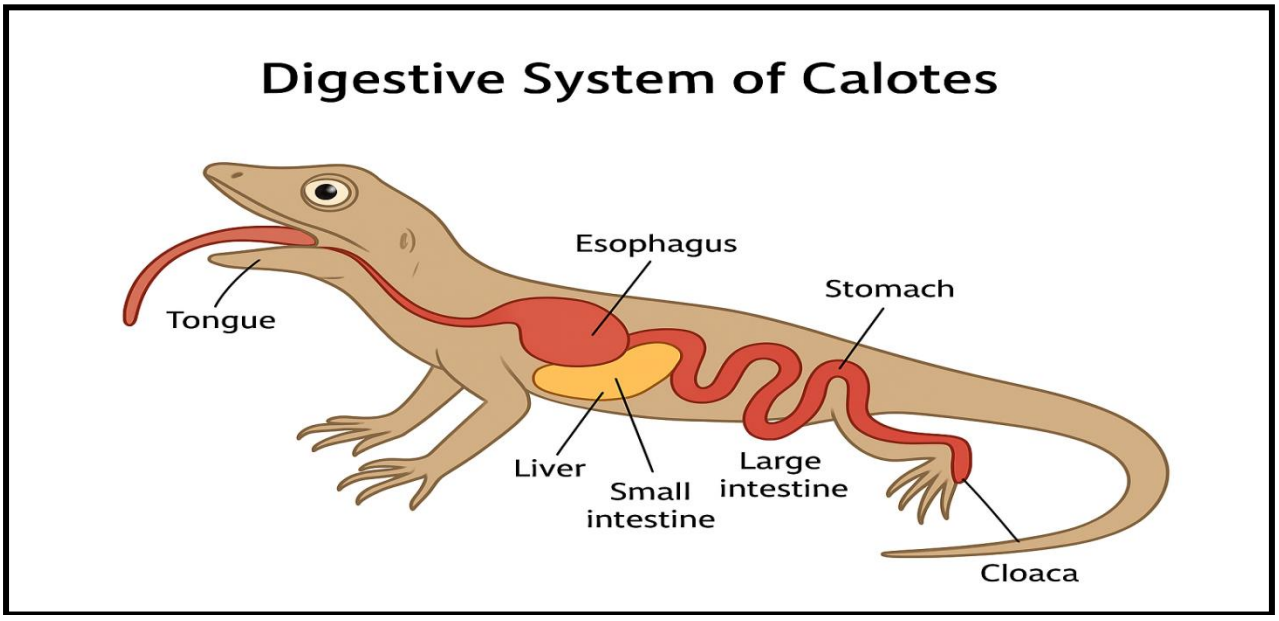
- Located between stomach and duodenum.
- Produces **pancreatic enzymes** for digestion of proteins, fats, and carbohydrates.

c. Gastric Glands

- Present in stomach walls, secrete HCl and pepsin.

3. Mechanism of Digestion

In *Calotes*, digestion begins when it catches prey with its long, sticky tongue and swallows it whole because it cannot chew. Food passes through the oesophagus into the stomach, where acids and enzymes like pepsin start breaking down proteins. The partly digested food then enters the duodenum, where pancreatic juices and bile complete the digestion of proteins, fats, and carbohydrates. In the ileum, nutrients are absorbed into the bloodstream. The remaining undigested waste moves to the large intestine, where water is absorbed, and the waste is finally expelled through the cloaca.



Calotes Brain structure and Functions

Brain of Calotes – Structure and Functions:

The brain of *Calotes* is relatively simple and follows the basic reptilian pattern. It is enclosed in the skull and connected posteriorly to the spinal cord. The brain is divided into **three main regions**:

Forebrain (Prosencephalon)

Structure

The forebrain consists of:

- **Olfactory lobes** (anterior, small but distinct)
- **Cerebrum** or **cerebral hemispheres** (moderately developed)
- **Diencephalon** (contains thalamus and hypothalamus)
- **Pineal body** on the dorsal side

Functions

- Controls **smell perception** through olfactory lobes
- Cerebrum is involved in:
    - **Behavioral responses**
    - **Learning and memory (limited)**
    - **Voluntary activities**
- Diencephalon regulates:
    - **Sensory relay**
    - **Temperature regulation**
    - **Hunger, thirst**
    - **Hormonal control through pituitary**

2. Midbrain (Mesencephalon)

Structure

- Contains **optic lobes** (large, rounded bulges)
- Optic lobes are better developed than in amphibians

Functions

- Major center for **vision**
- Processes **visual impulses**
- Helps coordinate:
    - **Eye movements**
    - **Body orientation**
    - **Reflexes to light and movement**

Vision is the primary sense in Calotes, so this part is very important.

3. Hindbrain (Rhombencephalon)

Structure

The hindbrain includes:

- **Cerebellum** (small, narrow)
- **Medulla oblongata** (posterior, large and elongated)

Functions

Cerebellum:

- Controls **balance and coordination**
- Helps in **movement of limbs** and **climbing**

Medulla oblongata:

- Controls **vital involuntary functions**:
    - Breathing
    - Heartbeat
    - Blood pressure
    - Digestion

The medulla continues as the spinal cord.

Brain Functions in Calotes

- **Forebrain:** Smell, behavior, hormonal regulation
- **Midbrain:** Vision (dominant sense), reflex actions
- **Hindbrain:** Balance, coordination, vital body functions

3.4. Identification of Poisonous and Non-Poisonous Snakes

Snakes are broadly categorized into **poisonous (venomous)** and **non-poisonous (non-venomous)** based on their anatomical and external features. The following points help to identify them easily.

1. Identification of Poisonous Snakes

A. Head Characteristics

1. **Head is broad and triangular** (wider than the neck).
2. **Large, distinct shields/scales** on the head (in some species).
3. **Eyes often have vertical pupils** (cat-like slit pupils) in vipers.

B. Fangs

1. Presence of **hollow, movable or fixed fangs** connected to venom glands.
2. Fangs are **long and curved** in vipers; **short and fixed** in cobras and kraits.

C. Belly Scales

1. **Large, single ventral scales** present across the belly.
2. These scales help in fast movement.

D. Tail Scales

1. **Subcaudal scales** (below the tail) are **single row** in poisonous snakes.

E. Behaviour and Other Features

1. Some show characteristic **hood formation** (e.g., Cobra).
2. Some have **heat-sensing pits** (pit vipers).
3. Head may have **two small venom glands** connected to fangs.

Examples of Poisonous Snakes

- Cobra (*Naja naja*)
- Krait (*Bungarus* species)
- Viper (Russell's viper, Saw-scaled viper)
- Pit viper

2. Identification of Non-Poisonous Snakes

A. Head Characteristics

1. **Head not broader than neck**; usually narrow and smooth.
2. Head covered with **symmetrical scales**; no special glands.

B. Fangs

1. **No venom fangs**; only small teeth for holding prey.

C. Belly Scales

1. **Belly scales may be small** or **moderate**, but not very broad.
2. Do not completely cover the width of the belly.

D. Tail Scales

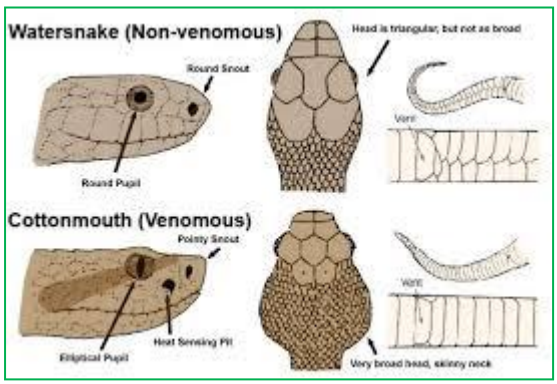
1. **Subcaudal scales** are usually in **double rows**.

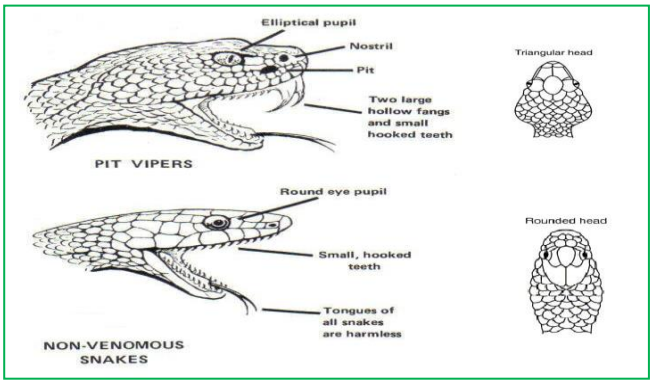
E. Behaviour and Other Features

1. No hood formation.
2. No heat-sensing pits.
3. Usually harmless to humans.

Examples of Non-Poisonous Snakes

- Rat snake
- Water snake
- Sand boa
- Python
- Wolf snake





Unit - IV

4.1. External features of Pigeon - *Columba livia*

Birds belong to the Class Aves (L. *avis* - birds). The most distinguishing feature of birds is the possession of feathers. The study of birds is **Ornithology**. A bird is a **feathered, bipedal, flying vertebrate** possessing **wings.** Their external and internal organization correlates with its aerial habit. More than 500 species of pigeon exist throughout the world. In India, about 10 species of pigeons are found. ***Columba livia*** is found throughout India.

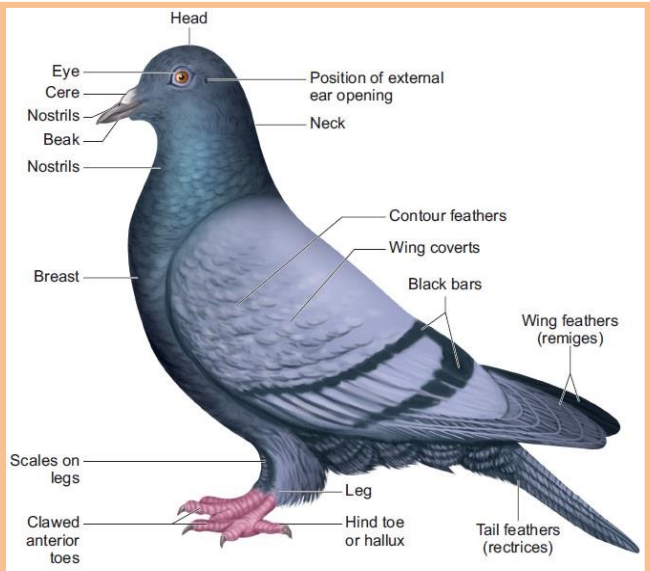


Figure 4.26 Columba livia – Common Rock Pigeon-External Features

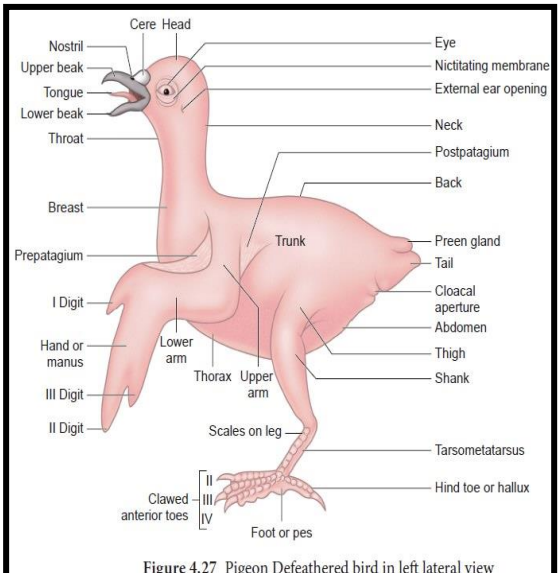


Figure 4.27 Pigeon Defeathered bird in left lateral view

External features

The compact, boat shaped streamlined body of pigeon is well adapted for their aerial mode of life. The body of pigeon is divisible into head, neck, trunk and tail.

External Characters of Pigeon – Point-wise

- **Head** – Small and round, present at the front of the body.

- **Beak** – Made from upper and lower jaws; no teeth.
- **Cere** – Soft, swollen skin at the base of the beak, around the nostrils.
- **Nostrils** – Openings at the base of the beak for breathing.
- **Eyes** – Big and round, on the sides of the head; protected by lids and a nictitating membrane.
- **Ear Openings** – Small openings behind the eyes; connected to the ear by a short tube.
- **Neck** – Long and flexible; helps move the head freely.
- **Trunk** – Spindle-shaped body with wings in front and legs below.
- **Cloaca** – A single opening at the back of the trunk for digestive, excretory, and reproductive systems.
- **Preen (Uropygial) Gland** – Present at the base of the tail; produces oil for cleaning feathers.
- **Tail** – Helps the bird in balancing and turning during flight.
- **Wings (Forelimbs)** – Modified for flying; folded in "Z" shape when resting.
- **Hind Limbs** – Support the bird's weight while standing or walking.
- **Feathers** – Cover the whole body; help in flight and keep the bird warm.
- **Body Temperature** – Birds are warm-blooded and keep their body temperature constant.

Exoskeleton:

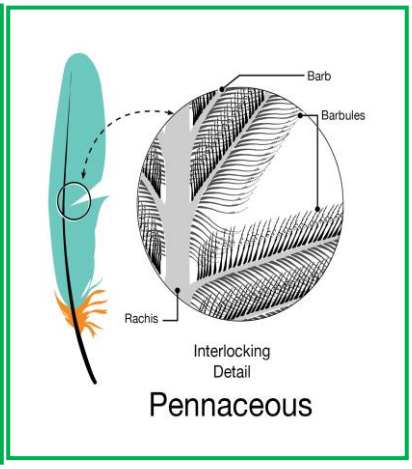
The exoskeleton of pigeon is derived from the **epidermis** and occurs in the form of **horny claws, scales** and **feathers**. Beaks are used for ingestion, fighting and preening of feathers. Claws are used for walking and perching. Epidermal scales are present on the foot and the entire body is covered by feathers. Arrangement of feathers on the body of bird is called **pterylosis** . Feathers are of three kinds: large **quill feathers** on wings and tail which are used for flight; **contour feathers**, form a covering for the body and **filoplumes,** lie between the contour feathers. The **nestlings** are covered with **down feathers** which resemble the filoplumes.

Structure of a Quill feather

The quill feather has a **stem** or **scapus** and is divided into a lower hollow part called **calamus** or **quill** and an upper solid portion called **rachis**. Lower end of the stem has an opening called **inferior umbilicus** which receives a dermal papilla, supplying nutrients and pigments for the growing feathers.

A second opening the **superior umbi-licus** occurs at the junction of the quill and the rachis, on the inner face of the feather; close to this opening is a small tuft of soft feathers called **after**

shaft . Attached to the rachis are small **filament** or **barbs** ; the ra-chis with the barbs constitute the **vane** or the **vexillum**. Each barb is fringed with an oblique set of processes called **barbules**, which have minute **hooklets** or **barbi-cels** by which adjacent barbs are hooked together to form a continuous blade for striking the air during flight.



Anatomy

Endoskeleton

The skeletal system is strong but lightly built. The bones are light and spongy. Many of the long bones contain air instead of marrow (Pneumatic bones). This reduces the weight of the body. The **breast bone** or **sternum** has a broad plate of bone produced ventrally into a prominent vertical **crest** or **keel** to which the powerful muscles of flight are attached.

Flight muscles: Wings are modified forelimbs used for flying, and their movement is controlled by special **flight muscles**. The main flight muscles are the **pectoral muscles**, which include:

- **Pectoralis major** – the largest and strongest muscle attached to the sternum; its contraction **pulls the wings downward** during flight.
- **Pectoralis minor (subclavius)** – a smaller, elongated muscle; its contraction **lifts the wings upward**.
- **Coracobrachialis** – a small muscle that assists in **lowering and rotating the wings**.

4.2 Columba livia: External features, Digestive system, Respiratory system

Digestive System

The alimentary canal of the pigeon consists of the mouth, buccal cavity, pharynx, oesophagus, crop, stomach, small intestine, and large intestine. The mouth has toothless horny beaks and a narrow, muscular tongue containing mucus glands. The oesophagus leads into a bilobed crop that

stores and softens food. The stomach is differentiated into a glandular proventriculus, which secretes gastric juice, and a muscular gizzard that grinds food with the help of swallowed grit or stones. The small intestine, made up of the duodenum and ileum, contains numerous villi for absorption, and receives secretions from the liver and pancreas. The large intestine is short and ends in the cloaca, which has three chambers for digestive, urinary, and reproductive openings. Digestive glands such as buccal, salivary, gastric, hepatic, pancreatic, and intestinal glands aid in digestion, although pigeons lack a gall bladder. Both male and female pigeons also produce crop milk to nourish their young.

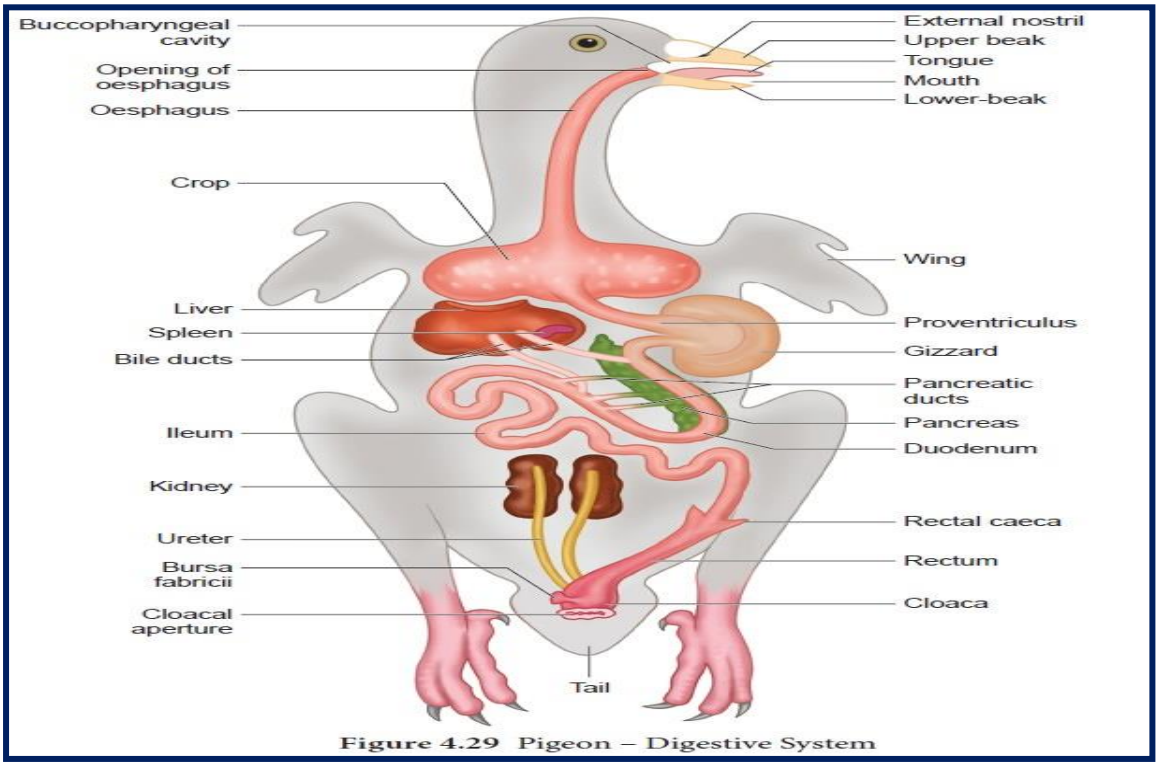


Figure 4.29 Pigeon – Digestive System

Respiratory system:

Birds breathe with the help of a well-developed respiratory system that includes the respiratory tract, lungs, and a special set of air sacs. Unlike mammals, birds do not have a true muscular diaphragm. Air enters through the nostrils and passes into the nasal chambers, larynx, trachea, and finally into the syrinx, which helps produce sounds. The trachea is supported by many small rings and divides into two bronchi, which further branch into fine air capillaries. These tiny capillaries lie close to blood vessels, allowing efficient oxygen exchange.

The lungs of birds are compact, spongy, and firmly attached to the ribs. Along with the lungs, birds possess nine air sacs—two cervical, one interclavicular, two anterior thoracic, two posterior thoracic, and two abdominal. These air sacs not only help in breathing but also make the body lighter and maintain the high body temperature needed for flight. This unique arrangement

ensures that birds get a continuous supply of fresh air, which is essential for their active lifestyle and flying ability.

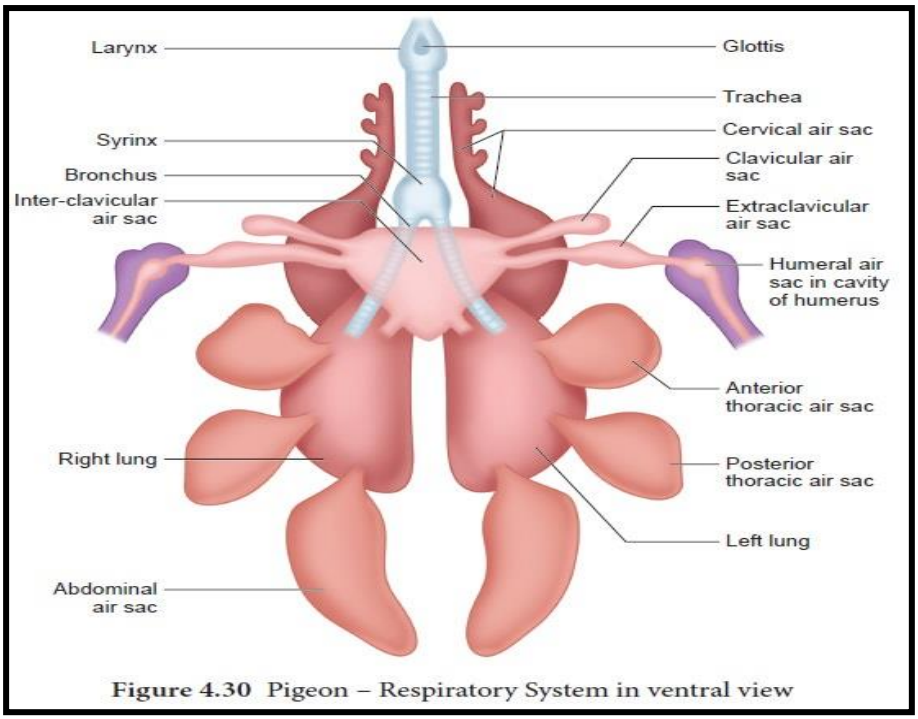


Figure 4.30 Pigeon – Respiratory System in ventral view

Respiratory Mechanism

In birds, the lungs cannot expand or contract like in mammals because they are held tightly in place by a rigid bony framework. Instead, breathing happens with the help of movements of the sternum and ribs. During **expiration (breathing out)**, the body-wall muscles contract, pulling the sternum upward toward the vertebral column. This bends the ribs inward, reduces the size of the body cavity, and forces air out of the lungs. During **inspiration (breathing in)**, the muscles relax, the body cavity expands back to its original size, and fresh air is drawn into the lungs. This mechanism, along with air sacs, ensures continuous airflow and efficient respiration during flight.

Syrinx (Voice Box of Birds)

In birds, the larynx does **not** produce sound. Instead, sound is produced by a special structure called the **syrinx**, located at the point where the trachea splits into the two bronchi. The syrinx is made of a chamber supported by 3–4 tracheal rings and the first bronchial rings. Inside the syrinx, the lining forms thin folds or membranes. When air passes over these vibrating folds, different sounds are produced. This is why birds can create a wide range of calls, songs, and communication signals.

4.3. *Columba livia*: Structure and function of Heart, structure and function of Brain

Structure and Function of the Heart in Pigeon

Structure of the Heart

The heart of the pigeon is a **four-chambered, muscular organ** specially adapted to meet the high energy needs of flight. It consists of **two auricles (atria)** and **two ventricles**, with a complete **interventricular septum** separating the right and left sides. A **sinus venosus is absent**.

The **right auricle** receives deoxygenated blood from all parts of the body through **two precaval veins** and **one postcaval vein**, while the **left auricle** receives oxygenated blood from the lungs through the **pulmonary veins**. Each auricle opens into its corresponding ventricle through auriculo-ventricular apertures guarded by **one-way AV valves**.The **right AV valve** is a single flap without chordae tendineae, whereas the **left AV valve** has **two flaps**, supported by **chordae tendineae** and **papillary muscles**. The **pulmonary aorta** arises from the **right ventricle**, carrying deoxygenated blood to the lungs, while the **systemic aorta (right aortic arch only)** arises from the **left ventricle**, supplying oxygenated blood to the body. Both opening points have **semilunar valves** to prevent backflow.

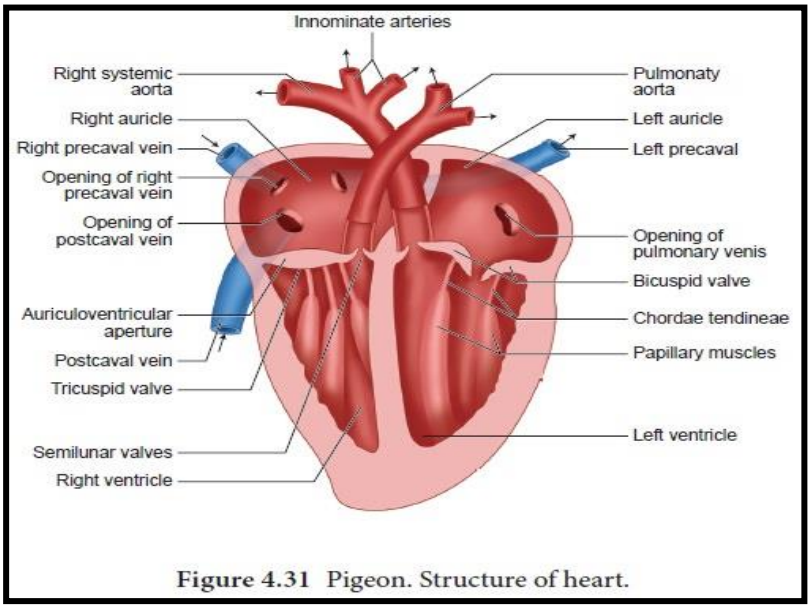


Figure 4.31 Pigeon. Structure of heart.

Function of the Heart

The pigeon heart maintains a **complete double circulation**, meaning that oxygenated and deoxygenated blood are kept completely separate.

- The **right side** of the heart handles **venous (deoxygenated) blood**, pumping it to the lungs through the pulmonary aorta for oxygenation.

- The **left side** handles **arterial (oxygenated) blood**, pumping it through the systemic aorta to supply all tissues of the body.

This separation ensures an **efficient, high-pressure systemic circulation** which is essential for the high metabolic demands of flight. The rapid heartbeat helps birds maintain a **constant high body temperature (homeothermy)** and provides continuous oxygen supply for active muscles.

Structure of the Pigeon Brain

The pigeon brain is well developed and adapted for flight, rapid coordination, and sharp vision. It lies inside the cranial cavity and is protected by two meninges: the outer **dura mater** and the inner **pia-arachnoid membrane**, with **cerebrospinal fluid** between them. Structurally, the brain is divided into **forebrain, midbrain, and hindbrain**.

The **forebrain** includes large, smooth **cerebral hemispheres** that extend backward to meet the cerebellum. These hemispheres are the largest part of the brain. The **diencephalon**, mostly hidden beneath the cerebrum and cerebellum, contains the **optic chiasma**, **infundibulum**, and **pituitary gland**.

The **midbrain** has a pair of large, rounded **optic lobes** situated laterally. These are prominent because vision is the most important sense in birds. The **hindbrain** consists of a highly developed, folded **cerebellum**, which is large compared to other vertebrates. Behind the cerebellum lies the **medulla oblongata**, which continues into the spinal cord. At the anterior tip of the brain, the **olfactory lobes** are very small and poorly developed, indicating a weak sense of smell.

Function of the Pigeon Brain

1. The pigeon brain functions as the main control center for all sensory and motor activities necessary for survival and flight.
2. The **cerebral hemispheres** control voluntary movements, learning, memory, intelligence, and behavioral responses.
3. The **diencephalon** integrates sensory impulses, regulates autonomic functions, and maintains body homeostasis through centers for hunger, temperature, pain and endocrine control.
4. The **optic lobes** of the midbrain are the centers of sight. They process visual information needed for flying, navigation, avoiding predators, and locating food.

5. The **cerebellum** maintains balance, body posture, and precise coordination of wing and body muscles during flight. The **medulla oblongata** controls vital involuntary activities such as breathing, heartbeat, and swallowing.
6. The **olfactory lobes**, though present, play a minor role due to the bird's limited sense of smell.

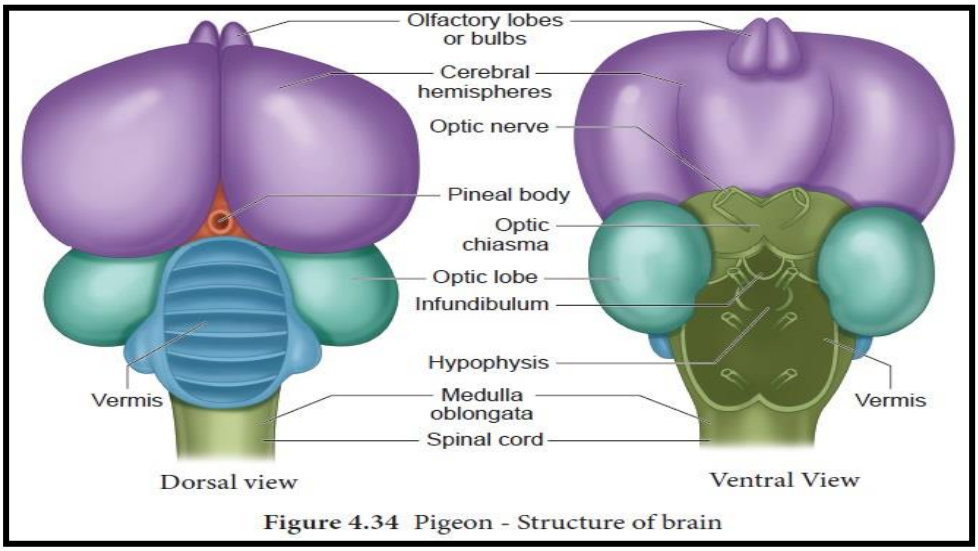


Figure 4.34 Pigeon - Structure of brain

4.4. Migration in Birds, Flight adaptation in birds

Migration in Birds: Migration **is the** seasonal, regular, and long-distance movement **of birds from one habitat to another for feeding, breeding, and survival. It is a highly coordinated biological phenomenon.**

Causes of Migration

1. **Food shortage:** Birds move to places with abundant food during unfavorable seasons.
2. **Breeding:** Many birds migrate to suitable nesting sites for successful reproduction.
3. **Climate:** Birds avoid extreme cold or heat by shifting to favorable climates.
4. **Day length (photoperiod):** Change in daylight triggers hormonal changes that induce migration.
5. **Avoiding predators and competition:** Birds move to safer areas with less competition.

Types of Migration

1. **Latitudinal Migration:** Movement from north to south or vice versa (e.g., Arctic Tern).
2. **Longitudinal Migration:** Movement from east to west.
3. **Altitudinal Migration:** Birds move up or down mountains depending on seasons.
4. **Partial Migration:** Some individuals migrate while others stay.
5. **Local Migration:** Short-distance movement within a small area.

Adaptations for Migration

1. **Strong flight muscles** for continuous flying.
2. **Streamlined body** reduces air resistance.
3. **Well-developed lungs and air sacs** supply extra oxygen.
4. **Efficient circulatory system** with a four-chambered heart.
5. **Fat storage** provides high energy for long flights.
6. **Excellent navigation** using stars, sun, magnetic fields, and landmarks.

Significance of Migration

- Ensures survival during harsh seasons
- Promotes successful breeding
- Helps in utilization of global resources
- Reduces competition for food and nesting sites

Flight Adaptations in Birds

Birds show many structural, physiological, and behavioral adaptations that enable them to fly efficiently.

1. Structural Adaptations

a) Body Shape

- **Streamlined body** to reduce air resistance.

b) Feathers

- **Contour feathers** for smooth body surface.
- **Flight feathers** for lift and propulsion.

c) Modifications of Forelimbs

- Forelimbs modified into **wings**, the main organs of flight.

d) Light Weight Skeleton

- **Hollow, pneumatic bones** filled with air sacs.
- **Reduced bones** (no teeth, light skull) reduce body weight.

e) Strong Muscles

- **Pectoralis major** for downward stroke.
- **Pectoralis minor (supracoracoideus)** for upward stroke.

2. Respiratory Adaptations

- **Air sacs** make the body lighter and provide continuous oxygen supply.
- **Efficient lungs** allow double respiration (inhalation + exhalation).

3. Circulatory Adaptations

- **Four-chambered heart** with rapid heartbeat.
- Efficient transport of oxygen to flight muscles.

4. Physiological Adaptations

- **High metabolic rate** for continuous energy production.
- **Warm-blooded nature (homeothermy)** maintains stable body temperature.
- Ability to store **large amounts of fat** as energy.

5. Nervous System Adaptations

- Large **cerebellum** for balance and coordination.
- Large **optic lobes** for excellent vision during flight.



UNIT - V

5.1 General characters of Mammalia

General Characters of Mammalia

Mammalia is a highly advanced and diverse class of vertebrates known for the presence of **mammary glands** and **hair**. They inhabit almost every type of environment—land, water, and air.

1. Body Covering

- Body is covered with **hair** (fur or wool).
- Hair helps in temperature regulation and protection.

2. Skin and Glands

- Skin is thick with **sweat glands**, **sebaceous glands**, and **mammary glands**.
- **Mammary glands** produce milk to nourish the young.
- Sweat glands help in temperature regulation.

3. Warm-blooded Animals (Endothermic)

- Maintain a constant body temperature.
- Body temperature does not change with the environment.

4. Presence of Mammary Glands

- Females possess well-developed **mammary glands**.

- Young ones are fed with milk.

5. Endoskeleton

- Bony endoskeleton.
- Skull with **single occipital condyle**.
- Vertebrae well-developed.

6. Teeth (Heterodont Dentition)

- Teeth are **heterodont** (different types: incisors, canines, premolars, molars).
- Teeth are **thecodont** (fixed in sockets).
- Usually **diphyodont** (two sets: milk teeth and permanent teeth).

7. Circulatory System

- Four-chambered heart.
- Only **left aortic arch** present.
- Red blood cells (RBCs) are **non-nucleated** (without nucleus).

8. Respiratory System

- Lungs are the respiratory organs.
- Breathing occurs through lungs only (even in aquatic mammals like whales and dolphins).

9. Nervous System

- Highly developed brain.
- Large cerebral hemispheres.
- Advanced sense organs.

10. Reproduction

- Sexes are separate.
- Internal fertilization.
- Most mammals are **viviparous** (give birth to young ones), except **monotremes** (Platypus and Echidna), which lay eggs.

11. Presence of Diaphragm

- A muscular **diaphragm** separates thoracic and abdominal cavities.
- Helps in respiration.

12. Locomotion

- Locomotion occurs through limbs.
- Limbs may be modified:

- Forelimbs → wings (bats)
- Limbs → flippers (whales, seals)

13. Excretion

- Excretory system with **metanephric kidneys**.
- Urine is excreted via **ureters → urinary bladder → urethra**.

14. Distribution

- Mammals are **cosmopolitan**.
- Found in deserts, forests, polar regions, mountains, oceans, and freshwater.

5.2. Classification of Mammalia up to sub - classes with examples.

The class **Mammalia** is broadly divided into **three Sub-classes** based on their reproductive strategy, developmental characteristics, and anatomical features.

1. Sub-class: Prototheria (Monotremes)

These are the **most primitive mammals**, often called **egg-laying mammals**.

Characteristics

1. **Reproduction**
   - Lay eggs (oviparous).
   - Eggs are leathery-shelled like reptiles.
   - Young hatch in an immature condition.
2. **Mammary Glands**
   - Mammary glands present **without nipples**.
   - Milk is secreted onto the skin and lapped up by the young.
3. **Cloaca**
   - A **single opening** for digestive, excretory, and reproductive systems.
4. **Body Covering**
   - Body covered with hair.
   - Beak-like snout in platypus.
5. **Distribution**
   - Restricted to **Australia, Tasmania, and New Guinea**.
6. **Limbs**
   - Forelimbs modified for digging (echidna).
   - Webbed feet for swimming (platypus).

Examples

- **Ornithorhynchus (Platypus)**

- **Tachyglossus / Echidna (Spiny Anteater)**

2. Sub-class: Metatheria (Marsupialia)

These mammals are commonly known as **marsupials**. They give birth to **immature young**.

Characteristics

1. **Reproduction**
    - Viviparous but young are **born in extremely immature condition**.
    - Young crawl into a **marsupium (pouch)** on the mother's abdomen.
    - Development continues inside the pouch.
2. **Placenta**
    - **Placenta is poorly developed** or absent.
3. **Mammary Glands**
    - Mammary glands are inside the pouch.
    - Young attach to nipples for long periods.
4. **Dentition**
    - Large number of teeth compared to other mammals.
5. **Distribution**
    - Mostly in **Australia and nearby islands**.
    - A few species in **South and North America**.
6. **Locomotion**
    - Many are adapted for hopping, climbing, or burrowing.

Examples

- **Macropus (Kangaroo)**
- **Didelphis (Opossum)**
- **Phascolarctos (Koala)**
- **Dasyurus (Native Cat)**

3. Sub-class: Eutheria (Placental Mammals)

These are the **most advanced and diverse mammals**.

Detailed Characteristics

Reproduction

- Viviparous; give birth to well-developed young ones.
- Presence of a **well-developed placenta** for nourishment.

Development

- Long gestation period.
- Parental care is well developed.

Circulation

- Four-chambered heart.
- RBCs are **non-nucleated**.

Brain

- Large and complex brain with developed cerebral hemispheres.

Body Systems

1. **Excretory system** – Metanephric kidney.
2. **Respiratory system** – Lungs with diaphragm.
3. **Dentition** – Heterodont, diphyodont.

Distribution

- Widely distributed across all continents and habitats.

Diversity

Eutheria contains most mammalian orders, such as:

- **Primates** – Humans, monkeys
- **Carnivora** – Dogs, cats, lions
- **Cetacea** – Whales, dolphins
- **Rodentia** – Rats, mice
- **Proboscidea** – Elephants
- **Chiroptera** – Bats

Examples

- **Homo sapiens (Human)**
- **Canis (Dog)**
- **Felis (Cat)**
- **Elephas (Elephant)**
- **Delphinus (Dolphin)**

5.3 Comparison of Prototherians, Metatherians and Eutherians

Feature	Prototherians (Monotremes)	Metatherians (Marsupials)	Eutherians (Placental Mammals)
1. Common Name	Egg-laying mammals	Pouched mammals	Placental mammals
2. Reproduction	Oviparous (lay eggs)	Viviparous; young born immature	Viviparous; young well-developed
3. Development	Development occurs outside body in eggs	Young develop in **marsupium (pouch)**	Development occurs inside uterus with placenta
4. Placenta	Absent	Poorly developed or absent	Well-developed placenta
5. Mammary Glands	Without nipples; milk secreted through skin pores	Nipples present inside pouch	Nipples well-developed; usually outside body
6. Teeth	Adults may lack teeth (e.g., Echidna)	Usually more teeth than placentals	Heterodont dentition; well-developed
7. Cloaca	Present (single opening)	Absent; separate openings	Absent; separate openings
8. Body Temperature	Lower and variable	Moderate	Constant and well-regulated (endothermic)
9. Brain Development	Primitive; small cerebrum	Moderate development	Highly developed brain
10. Distribution	Australia, Tasmania, New Guinea	Australia, South America	Worldwide (cosmopolitan)
11. Examples	Platypus, Echidna	Kangaroo, Opossum, Koala	Humans, Dogs, Cats, Elephants

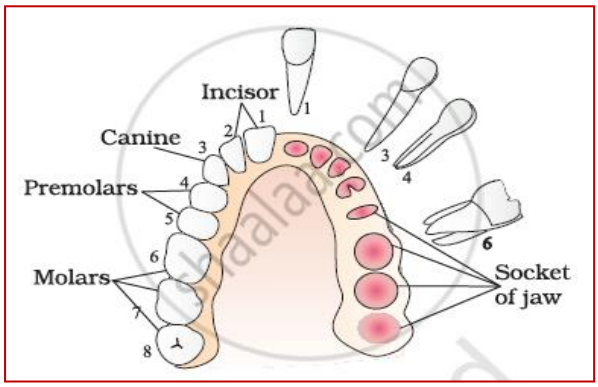
5.4 Dentition in mammals, Aquatic mammals Adaptations

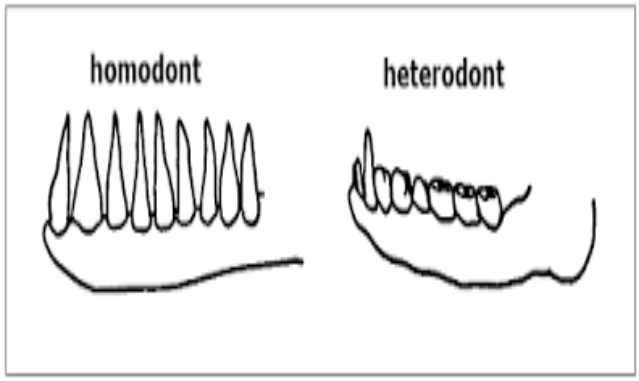
Dentition in mammals is one of the most advanced and specialized among vertebrates. Mammalian teeth show remarkable diversity in shape, function, and arrangement depending on diet and ecological niche.

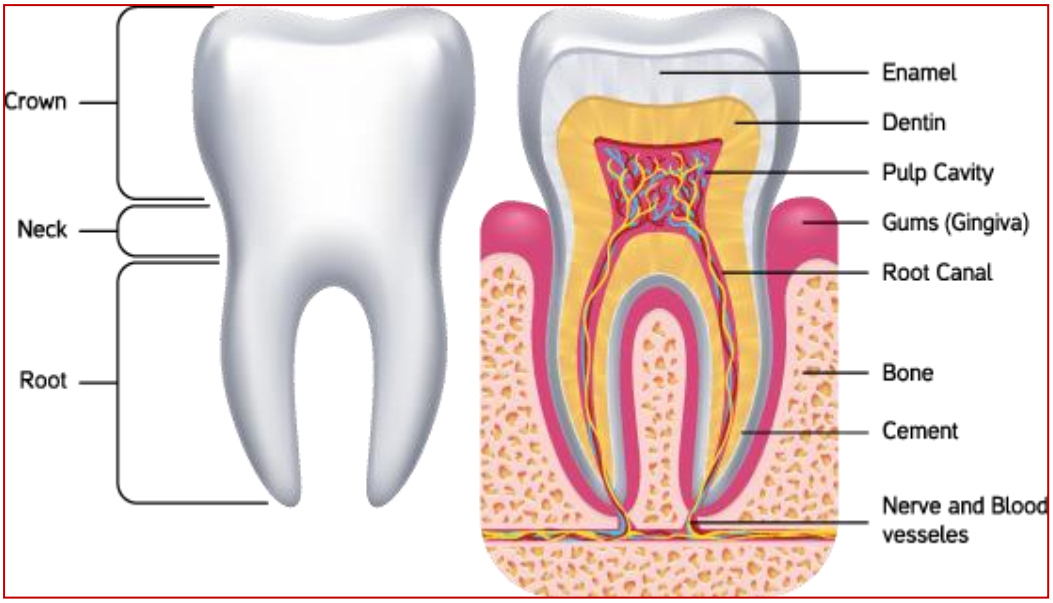
1. General Features of Mammalian Dentition

Mammalian dentition is characterized by **heterodonty**, **thecodonty**, and **diphyodonty**.

- **Heterodont** means that different types of teeth are present, such as incisors, canines, premolars, and molars, each having a specific function.
- **Thecodont** means the teeth are set in **bony sockets** in the jaws, providing strong anchorage for chewing.
- **Diphyodont** refers to two sets of teeth during the lifetime: the **milk (deciduous) teeth** and the **permanent teeth**. This allows young mammals to feed efficiently and adults to adapt to tougher diets.







2. Types of Teeth in Mammals

a. Incisors

These are located at the front of the jaw. They have sharp, chisel-shaped edges used for **cutting, nibbling**, and **gnawing**. Herbivores like rabbits and rodents have well-developed incisors, while they may be absent in some animals like sloths.

b. Canines

Canines are long, pointed teeth used for **piercing and tearing** flesh. In carnivores, they are highly developed (e.g., tigers, lions). In herbivores such as cows, canines are either reduced or absent.

c. Premolars

Premolars are located behind the canines. They typically have one or more cusps and function in **crushing and grinding** food. Their structure varies depending on diet.

d. Molars

Molars are located at the back of the mouth, have broader surfaces, and are used for **thorough grinding** of food. They are highly developed in herbivores due to the need to break down cellulose-rich plant materials.

3. Dental Formula

Mammals express their dentition through a **dental formula**, which shows the number of each type of tooth in one half of the upper and lower jaws. For example, the typical primitive eutherian mammal formula is:

I 3/3, C 1/1, PM 4/4, M 3/3

Humans have a different formula:

I 2/2, C 1/1, PM 2/2, M 3/3

Dental formulas help understand feeding habits and evolutionary relationships.

4. Dentition Adaptations Based on Diet

- **Herbivore dentition**: Flat molars for grinding, reduced or absent canines, and large incisors.
- **Carnivore dentition**: Sharp canines, carnassial teeth for slicing meat, reduced grinding surfaces.
- **Omnivore dentition**: Combination of cutting and grinding surfaces (e.g., humans).
- **Rodent dentition**: Ever-growing incisors for gnawing.

These adaptations help mammals exploit a wide variety of food sources.

Aquatic Mammals – Adaptations

Aquatic mammals include **whales, dolphins, seals, sea lions, manatees**, and others. Although they are mammals, they have evolved several special adaptations to live in water while retaining essential mammalian features like breathing air, giving birth to live young, and feeding their infants with milk.

1. Body Shape and Streamlining

Aquatic mammals possess a **fusiform (streamlined) body shape** that reduces resistance while swimming. This shape resembles that of fish, allowing smooth and efficient movement through water. Their limbs are modified into fins or flippers for propulsion and maneuvering.

2. Limb Modifications

Forelimbs in whales, dolphins, and seals are transformed into **flippers**, providing excellent control and steering. The hind limbs are either reduced or absent, especially in cetaceans (whales and dolphins). In seals and sea lions, hind limbs are modified into **webbed, paddle-like structures**, helping in swimming and diving.

3. Tail Adaptations

Cetaceans possess a **horizontal tail fluke**, which moves up and down to generate thrust. This is a distinct mammalian adaptation, differing from fish which move their tails sideways.

4. Breathing Adaptations

Aquatic mammals have **large lungs** and **enhanced oxygen storage capacity**. They exhibit:

- High concentration of **myoglobin** in muscles
- Slower heart rate during dives (**bradycardia**)
- Ability to collapse lungs during deep dives to avoid nitrogen absorption

Blowholes on the top of the head (in whales and dolphins) help in easy breathing at the water surface.

5. Thermoregulation

Aquatic mammals maintain their body temperature using features like:

- **Thick layer of blubber** (fat) below the skin to retain heat
- Reduced body hair
- Countercurrent heat exchange in flippers

These adaptations allow them to survive in cold oceanic waters.

6. Sensory Adaptations

Many aquatic mammals have excellent hearing and use **echolocation** (e.g., dolphins) to navigate and hunt in murky waters. Eyes are adapted to see both underwater and above water, with modified corneas and lenses. Their sense of smell may be reduced depending on habitat.

7. Feeding Adaptations

Whales show two major feeding adaptations:

- **Baleen whales** possess baleen plates for filter feeding, trapping plankton and small fish.
- **Toothed whales** have simple, conical teeth for catching slippery prey like fish and squid.

Seals and sea lions have strong canine teeth and robust jaws adapted for holding fish.

8. Reproductive Adaptations

Aquatic mammals give birth in water but must bring the young to the surface to breathe. They produce **high-fat milk**, enabling rapid growth and insulation. Mothers often have streamlined mammary glands located in protected regions for easy nursing in water.

9. Locomotion

Their movement is powered mainly by the tail (in cetaceans) or limbs (in pinnipeds). Muscles are arranged to maximize force production during swimming, making them extremely efficient underwater swimmers.

Dr. V. Uday Kiran
Assistant Professor in Zoology
Department of Zoology
Loyola Degree College (YSRR)
E-mail : vempati.uday6@gmail.com