

## M.Sc. II Sem. (Zoology)

### Dipnoi - General organization and affinities

- Dipnoi (Gr. di-two, pnee-breathing) is a small order of fresh water bony fishes.
- They respire by gills and lungs.
- Dipnoi evolved during Devonian period.
- They are characterized by short jaws, crushing plate like teeth, internal nares, reduced exo- and endo- skeleton, and diphyccercal tail.
- The air bladder i.e., so called 'lungs' are one or two. They are functional with related changes in the circulatory system and in the heart.

#### Distribution of Dipnoi:

- Modern lung fishes show discontinuous distribution.
- The three surviving genera of lung fishes are *Neoceratodus* (=Epiceratodus) *Protopterus* and *Lepidosiren*. All are inhabitants of river.
- *Neoceratodus* is the only living genus of the family Ceratodontidae, the other being extinct *Ceratodus*. It is found only in the Burnett and Mary rivers of Queens-land in Australia, so commonly called as 'Burnett Salmon' or Australian lungfish.
- *Protopterus* lives in large lakes and rivers of tropical Africa. It is commonly called as 'Nile lungfish' or African lung fish.
- *Lepidosiren* is found in river Amazon and Paraguay basin in South America. It is commonly called as 'Amazon lungfish' or South American lungfish.

#### Primitive characters of Dipnoi

1. Unconstricted notochord.
2. Presence of cloaca.
3. Spiral valves in intestine.
4. Valves in the conus.

5. Diphyrcercal tail.
6. Ventral inferior nostril.
7. Persistent notochord without any constriction.
8. Cartilaginous autostylic skull.

### **Specialised characters of dipnoi:**

- Internal nares, possibly help in breathing through the nose.
- Respiration by lungs (modified air bladder) in addition to gill-respiration.
- Auricle is partly divided into two and nearly three-chambered heart.
- One of the paired auricles receives oxygenated blood through a special pulmonary arch from the lungs.
- Conus arteriosus spirally twisted and contractile in nature.
- Separation of pulmonary and systemic circulation.
- Large paired cerebral hemispheres.
- Well-developed Mullerian duct.
- Presence of characteristic tooth plates, used for crushing of shelled invertebrates.
- Bones absent in the jaw.

### **General Organization of Dipnoi**

#### **External Structures of Dipnoi:**

- The three extant dipnoans have elongated piscean body covered by overlapping cycloid scales.
- The dorsal, anal and tail fins are continuous
- The pectoral and pelvic fins are usually designated as the 'limbs'.
- These are extremely elongated, filamentous structures and are devoid of fin-rays.
- The tail is diphyrcercal (Protocercal or isocercal) in the living genera
- The operculum and a slit-like branchial opening are present on either side.

- The external nostrils are enclosed within the upper lip and two internal nostrils open into the mouth cavity.
- The lateral line sensory system is well-developed.
- The cloacal aperture lies at the root of the tail.
- Two abdominal pores usually open into the cloaca.

### **Digestive System of Dipnoi**

- The teeth form characteristic tooth-plates for crushing the molluscan shells.
- The tooth-plates are formed by the fusion of many small denticles.
- The alimentary canal is a simple tube. The pharynx leads into an oesophagus.
- The lung-fishes lack distinct stomach.
- The intestine is ciliated and contains a spiral valve running along the entire length of the intestine and makes about six and a half turns .
- The liver is a single massive gland which is slightly divided into two unequal lobes.
- The gall-bladder is large and situated on the left margin of the liver.
- The pancreas remains embedded within the walls of the gut. The islets of Langerhans are not seen in the pancreas of the dipnoans.
- The spleen is composed of vascular tissue and is attached to the right dorsolateral wall of the stomach.
- The alimentary canal exhibits little histological difference and the whole of the gut is lined by columnar, ciliated and goblet cells

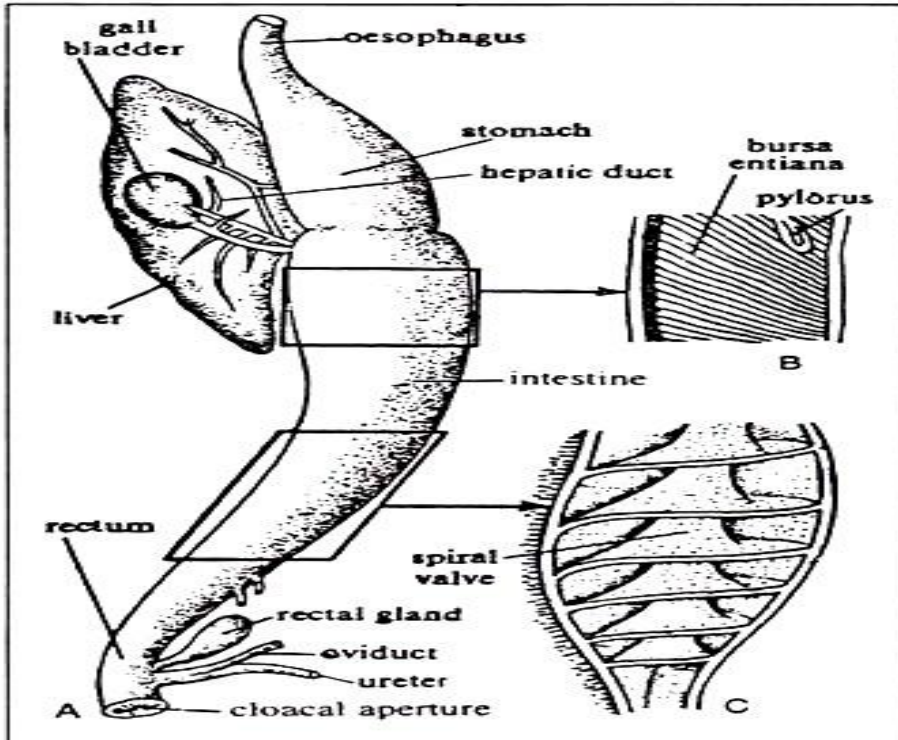


Fig. 6.39 : Digestive system of *Protopterus*. A. Showing the alimentary canal and its relation to the liver. B. A portion of the anterior part of the intestine is cut open to show bursa entiana. C. A part of the intestine is dissected to show the spiral valve.

### Respiratory System of Dipnoi:

- Both gill and pulmonary respiration take place in the lung-fishes. Although the dipnoans possess the gills as well as lungs, they use mostly the lungs.
- The nostrils help in aerial respiration.
- The swim-bladder is modified into the 'lung' which is similar to that of other tetrapods in structure and function.
- The walls of the lungs contain muscle fibres and the internal cavity produces numerous alveoli which lead into minute alveolar sacs. In *Protopterus* and *Lepidosiren* the supply of blood to the lungs is elaborate.
- Aquatic respiration takes place through the gills.
- *Neoceratodus*, the most aquatic of the dipnoans, *Protopterus* and *Lepidosiren* obtain 98% of their oxygen from the air.

### Circulatory System of Dipnoi:

- The circulatory system is well developed.
- The heart is enclosed in a stiff pericardium.
- The heart of the lung-fishes consists of three parts, the auricle, ventricle and conus arteriosus.
- The auricle becomes dilated on either side of a thin and perforated interauricular septum, i.e., the cavity of the auricle is almost divided.
- The ventricle appears to be divided into two parts by the presence of septum, the ventricular cavity is single and lies anterior to the so-called interauricular septum.
- The conus arteriosus becomes spirally twisted and the cavity becomes complicated by the presence of valves.

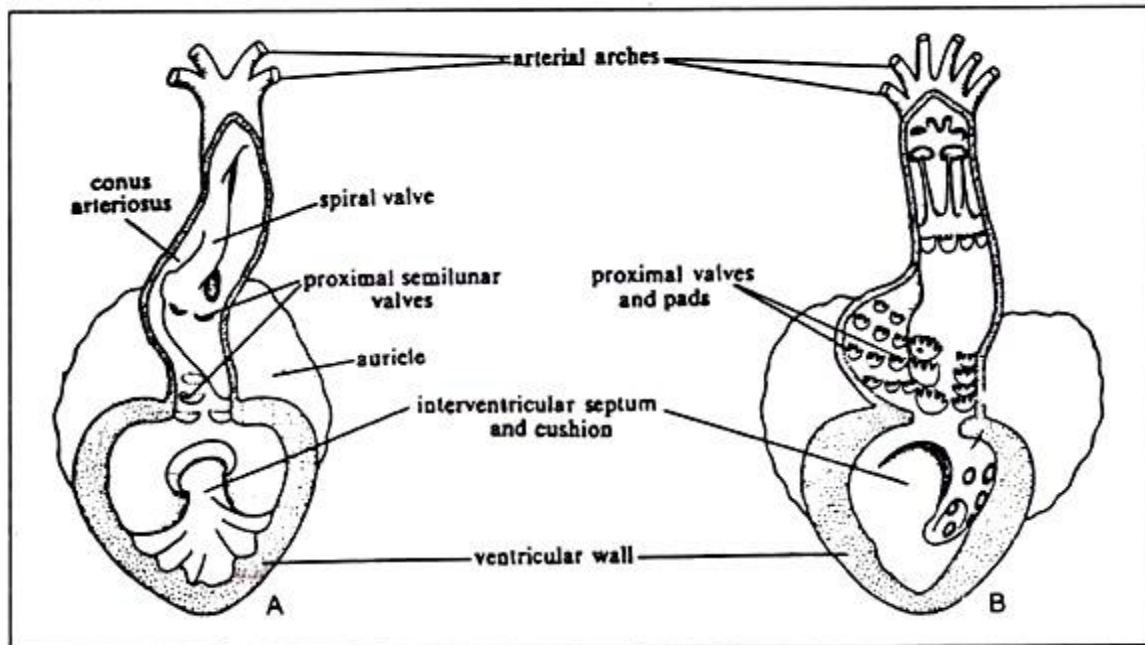


Fig. 6.40 : Diagrammatic sectional (longitudinal) view of the heart – A. *Protopterus* and B. *Neoceratodus* (after Jollie, 1962).

### Nervous System of Dipnoi:

- The telencephalon becomes evaginated into a pair of well-marked cerebral hemispheres.

- The olfactory lobes are sessile and lie dorsal to the anterior ends of the cerebral hemispheres.
- The diencephalon is relatively small and its roof is formed of a large mass of choroid tissue, the saccus dorsalis.
- A pineal body is present on the saccus dorsalis and its stem extends back towards the posterior commissure.
- The hypothalamus bears small inferior lobes.
- The optic lobes are slightly developed and become fused to form single oval mass in front of the cerebellum.
- A peculiarly lobes saccus endolymphaticus or endo-lymphatic sacs lies above the medulla oblongata. The cerebellum is small and forms a narrow transverse ridge.
- A sympathetic nervous system is associated with the vagus nerve.

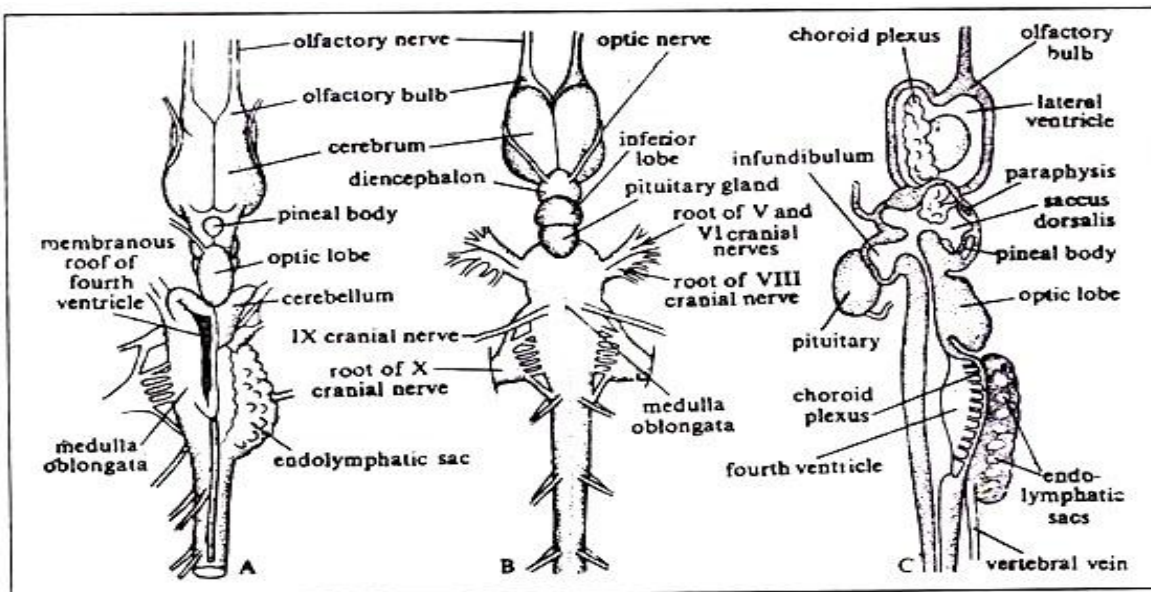


Fig. 6.43 : Brain of *Protopterus*. A. Dorsal view. B. Ventral view. C. Diagrammatic longitudinal sectional view (after Jollie, 1962).

### Excretory System of Dipnoi:

- The excretory system comprises of a pair of elongated kidneys which are separate anteriorly but are usually fused at their posterior ends.

- The kidneys are of mesonephric type and remain in intimate contact with the gonads.
- The kidneys extend throughout the greater part of the visceral cavity.
- Two thick-walled ducts, one from each kidney, may unite in *Neoceratodus* or may remain separate in *Protopterus* and *Lepidosiren* before opening into the cloaca.
- The lung-fishes normally excrete 30-70% of nitrogenous waste products through the gills in the form of ammonia.

### **Reproductive System of Dipnoi:**

- The sexes are separate. The sexual dimorphism is absent excepting *Lepidosiren* where the males develop vascular papillae on the pelvic fins during breeding season.

### **Female Reproductive Organ**

- The ovaries are paired and elongated.
- The ovaries are typically like that of other fishes and are kept in position in *Protopterus* by mesovarium but in *Neoceratodus* these are attached with the dorsal body wall.
- The oviducts are located on the lateral side of the ovaries. Each oviduct (Mullerian duct) opens anteriorly into the body cavity by a fringed slit-like opening.
- The eggs are shed free into the body cavity and carried out by the oviducts.

### **Male Reproductive Organs**

- There are two elongated testes in lung-fishes .
- In *Lepidosiren* and *Protopterus*, the testes are narrow bodies and appear round in cross- section. But in *Neoceratodus* the testes are thick and triangular in cross-section.
- The testes are enclosed by fatty tissues and lie on the ventrolateral sides of the kidneys.

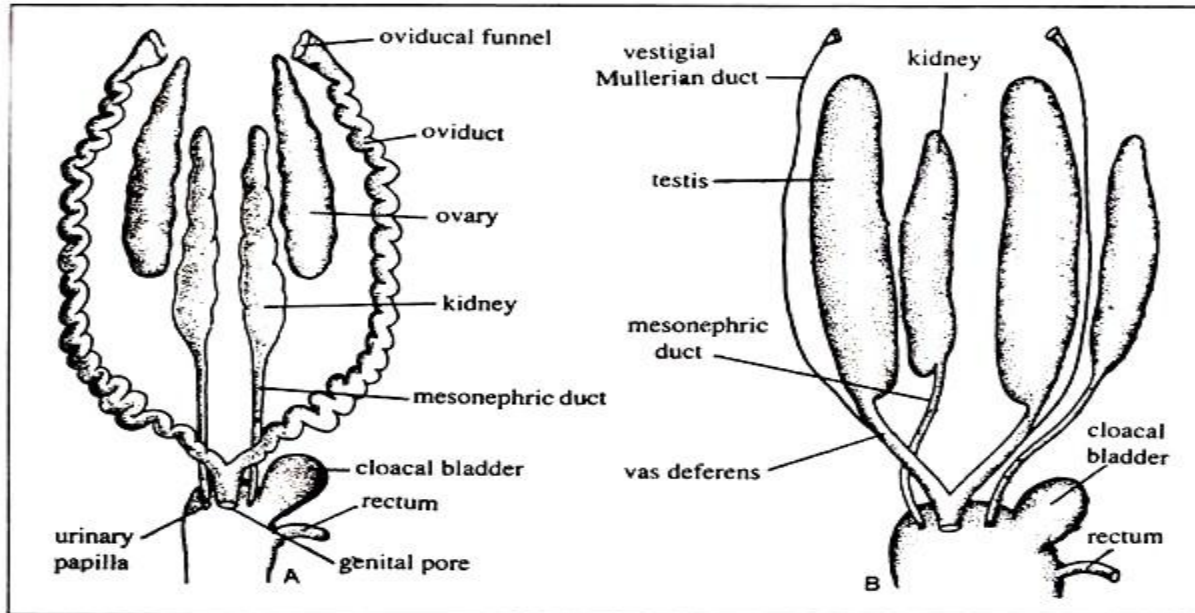


Fig. 6.44 : Urinogenital system of *Protopterus*. A. Female. B. Male. The kidneys are set apart.

### Affinities of dipnoi

- Dipnoi form an interesting group of fishes. Presence of the lungs lead to the view that they are the ancestors of amphibia. Other-words, they were considered as the connecting link between Pisces and Amphibia. This view is no more supported. Present view is to treat them as a specialized or degenerate descendants of the more primitive lobe-finned fishes to which they closely resemble.

**The affinities of Dipnoi can be studied under following heads:**

#### **1. Affinities with fishes:**

- (a) In general
- (b) with elasmobranchi
- (c) with Holocephali
- (d) with Actinopterygii, and
- (e) with Crossopterygii.

#### **2. Affinities and dissimilarities with Amphibia**

##### Affinities with fishes in general:



- 1. Spindle-shaped, eel-like body.
- 2. Body covered with scales (Cycloid).
- 3. Presence of paired fins.
- 4. Diphyccercal caudal fins.
- 5. Persistent notochord.
- 6. Skull with little ossification.
- 7. Paired gill-slits.
- 8. Branchial respiration.
- 9. Lateral line sense organs.

**Affinities with Elasmobranchi:**

- 1. Endoskeleton mostly cartilaginous.
- 2. Intestine with spiral valves.
- 3. Conus arteriosus with valves.
- 4. Each gill with two efferent arteries.
- 5. Absence of nephrostome in uriniferous tubules.
- 6. Small diencephalon with vascular roots.
- 7. Similar female reproductive organs.

**Affinities with Holocephali:**

- 1. Excurrent nostrils opening into mouth cavity.
- 2. Autostylic jaw suspensorium.
- 3. Gills covered with operculum.
- 4. No distinct stomach.
- 5. Intestine with a spiral valve.
- 6. Teeth fused to form dental plates.
- 7. Identical kidneys, gonads and gonoducts.

- 8. Two efferent arteries in each gill.

#### **Affinities with Actinopterygii:**

- 1. Blunt snout with ventral nostril.
- 2. Presence of cycloid scales.
- 3. Strong palate and splenial teeth.
- 4. Presence of operculum covering gills.
- 5. Presence of swim bladder.

#### **Affinities with Crossopterygii:**

- 1. Diphyccercal caudal fin.
- 2. Powerful leg-like lobate fins.
- 3. Identical skull bones.
- 4. Vertebral column upto the tip of caudal fin.
- 5. Air bladder for pulmonary respiration.
- 6. Internal nostrils.
- 7. Presence of contractile conus arteriosus.

#### **Affinities with Amphibia:**

- 1. Semiaquatic habitat.
- 2. Internal nostrils
- 3. Vomerine teeth.
- 4. Autostylic jaw suspensorium.
- 5. Multicellular cutaneous glands.
- 6. Pulmonary respiration.
- 7. Dermal scales as in Apoda.
- 8. Ventral aorta short or absent
- 9. Presence of anterior abdominal vein, posterior vena cava, pulmonary artery and veins.

- 10. Thin walled pericardium.
- 11. Long and narrow cerebral hemispheres.
- 12. Similar structure of egg and development

**Dissimilarities with Amphibia:**

- 1. Paired lobate-fins
- 2. Maxillae and premaxillae are absent.
- 3. Peculiar crushing tooth plates.
- 4. Few anterior vertebrae fused with skull.
- 5. Cartilagenous skull.
- 6. Lungs lie dorsal to gut.
- 7. Urinary bladder from dorsal wall of cloaca.

The above affinities indicate that dipnoans are not most advanced Pisces from which amphibians could evolve. They are degenerate descendants of Crossopterygii. According to Jarvik (1968) dipnoans are more specialized than crossopterygian. According to latest view, both dipnoans and amphibians have originated from some crossopterygian like ancestor.

There must have been a common ancestor for Dipnoi, Crossopterygii and Labyrinthodont amphibia. So most probably, dipnoans are not the “fathers of the amphibia”, but “uncles of the amphibian”. However, Jarvik (1980) considers that the Dipnoi may be related to elasmobranchs than any other animals.