ies and rivers and reached freshwater ponds where they became fishes. Some of the neotenous forms returned to the sea and became *Branchiostoma*.

Thus *Ascidian* tadpole larva is believed to be the direct ancestor of vertebrates. This conclusion is based on the ***ascidian theory of chordate origin*** proposed by *Garstang (1928)*.

2. Branchiostoma (Amphioxus)

Phylum : *Chordata*

Subphylum : *Cephalochordata*

Amphioxus is a ***protochordate***. This animal is peculiar in that the anterior end of the notochord extends into the head. Hence it is included in the subphylum ***Cephalochordata*** (cephalon=head). *Amphioxus* is commonly called ***lancet*** because of its shape. Its scientific name is *Branchiostoma lanceolatum*.

It is a ***marine, burrowing*** animal. It lives in shallow waters. In the day time, it remains in a sandy burrow with the anterior end protruding out. During night it leaves the burrow and leads a free swimming life.

It is ***spindle-shaped*** and laterally compressed. Both ends are pointed and *Amphioxus* looks like a ***lancet*** and hence the name ***lancet***. It is about 4.5 cms long.

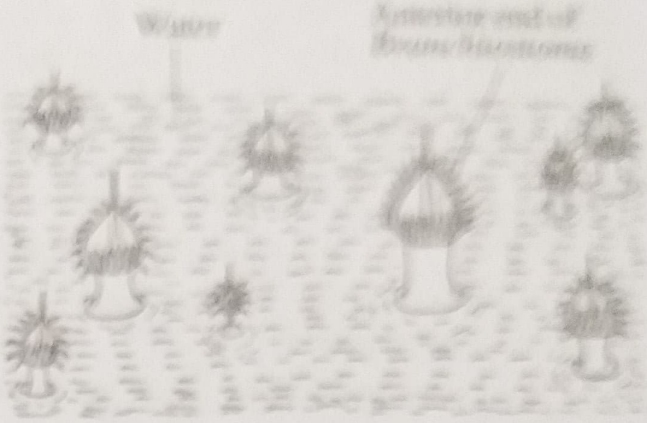

Fig.2.31: Amphioxus in its burrow.

The body is divisible into an anterior ***trunk*** and a posterior ***tail***. It has no head. The anterior end has a pointed process called ***rostrum***. A frill-like membranous enclosure is present beneath the ***rostrum***. It is called ***oral hood***. It is formed by the forward growth of the skin.

The oral hood opens to the outside at the anterior end by a large opening called ***mouth***. The cavity enclosed by the oral hood is called ***vestibule*** or ***buccal cavity***. The margin of the oral hood bears 20 or more tentacles called ***oral cirri.***

Amphioxus has three fins on the body. They are the ***dorsal fin***, the ***caudal fin*** and the ***ventral fin***.

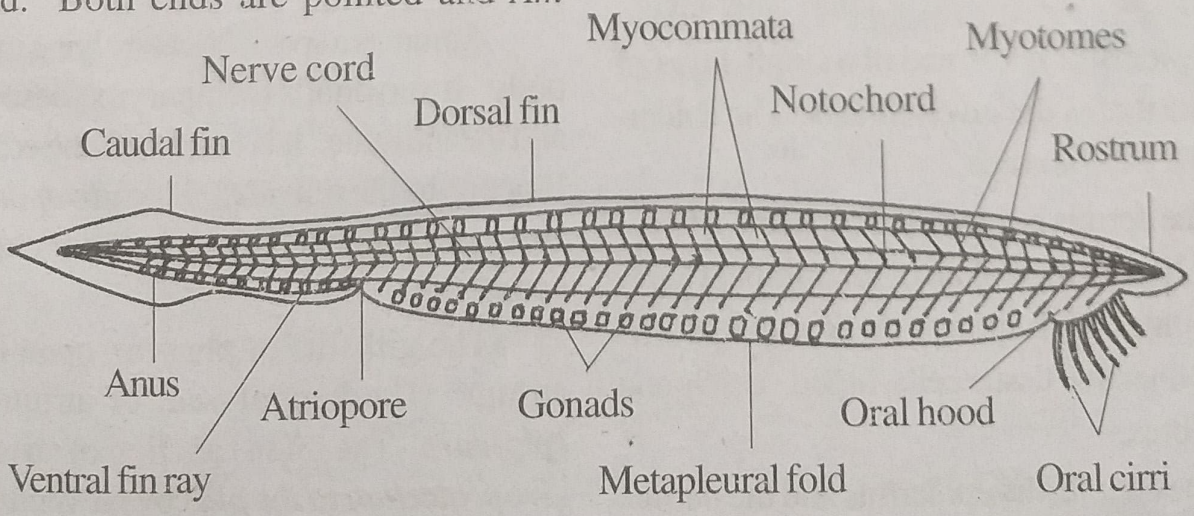

Fig.2.32: Amphioxus.

The dorsal fin is present along the mid-dorsal line throughout the entire length of the body. Posteriorly it surrounds the tail as the ***caudal fin***. Ventrally the caudal fin extends forwards about one third of the length of the body. It is called ***ventral fin***.

The dorsal and ventral fins are supported by a skeletal frame work called ***fin ray boxes***. The caudal fin is without fin ray boxes. Fins are used for ***locomotion***.

The ventral surface of the anterior two-third of the body is flat and is called ***epipleure***. The lateral margins of the epipleure are produced into two thin folds called ***metapleural folds***. The metapleural folds are continuous infront with the oral hood. Posteriorly they are joined with the anterior end of the ventral fin.

Amphioxus has three external openings. They are the ***mouth***, the ***atriopore*** and the ***anus***. The mouth is the wide opening of the ***oral hood***. The anus is located at the anterior end of caudal fin. The atriopore is located at the anterior end of the ventral fin slightly to the left of the middle line.

Body Wall

The body wall is formed of many layers. They are ***cuticle***, the ***epidermis***, the ***basement membrane***, the ***dermis***, the ***muscles*** and the ***peritoneum***. The cuticle is a thin outer layer.

Epidermis is formed of a single layer of cells like that of the invertebrates. The epidermal cells are columnar.

The dermis is formed of connective tissue fibres. It is formed of an outer compact layer and an inner thick spongy layer with a few fibres, connective tissue cells, blood vessels and nerve fibres.

The cuticle, the epidermis and the dermis together constitute the ***skin***.

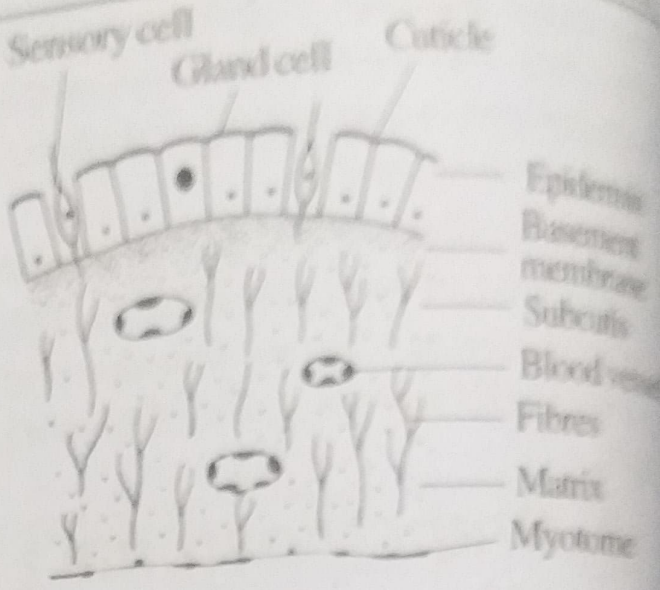

Fig.2.33: Body wall of Branchiostoma

The ***muscles*** are located beneath the skin. They are metamerically segmented and are arranged in a linear series. The muscles are in the form of ***V***- shaped blocks called ***myotomes***. There are about 62 myotomes on each side. The apex of the myotomes is directed forwards. The myotomes of the two sides do not lie opposite to each other; but they alternate with each other. Each myotome is enclosed in a fibrous connective tissue sheath called ***myocomma*** (***pl: myocommata)***. The muscles are internally lined with peritoneum.

The body wall has the following functions ***protection, sensation, locomotion*** and ***support.***

Atrium

Atrium is a spacious cavity lying inside the body. It surrounds the pharynx, oesophagus and the intestine. It is lined with the ***ectoderm***. It opens to the outside by the ***atriopore***. The atriopore is located at the anterior end of the ventral fin.

The gill slits of pharynx open into the atrium. The ventral wall of atrium is the ***epipleure***. The main function of atrium is to ***give protection to the gills*** by preventing them from being closed up with sand.

Coelom

Coelom is the body cavity lying between the body wall and the alimentary canal. It is lined with the ***coelomic epithelium***. Around the pharynx, the coelom is replaced by the atrium. In the pharyngeal region, it is reduced to three types of coelomic spaces.

1. A ***mid-ventral subendostylar coelom*** running below the endostyle.
2. Two ***dorsal longitudinal canals*** lying above the pharynx.
3. The ***vertical coelomic canals*** in the primary gill bars.

Notochord of *Amphioxus*

Notochord is the ***backchord***. It is a gelatinous cylindrical skeletal rod containing vacuolated notochordal cells, located on the back.

The animals containing a notochord are included in the phylum ***Chordata***.

In *Amphioxus*, the notochord extends from anterior tip to posterior end. In other chordates, the notochord extends anteriorly upto the brain only. But in *Amphioxus*, it extends beyond the brain.

As the notochord extends into the head region, *Amphioxus* is called ***cephalochordate***. The anterior extension of notochord helps *Amphioxus* in ***burrowing***.

The notochord is situated above the alimentary canal and below the nerve cord.

It is covered by a ***notochordal sheath***. It is made up of ***fibrous connective tissue***. Inner to the notochordal sheath, there is a thin elastic membrane called ***elastica interna***.

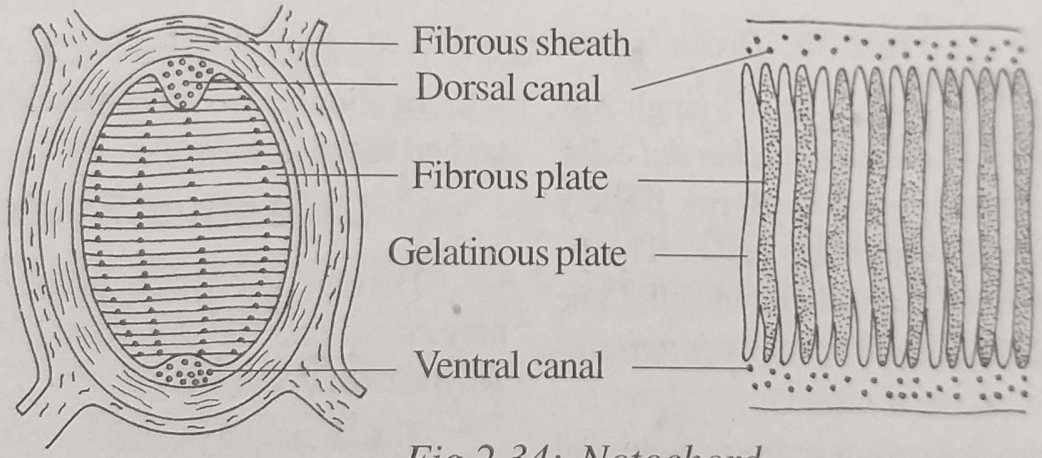

Fig.2.34: Notochord.

It is the ***axial skeleton.*** In vertebrates, vertebral column develops around the notochord.

Below the elastica interna, there are two canals called ***dorsal canal*** and ***ventral canal***. These canals are filled with chordal corpuscles.

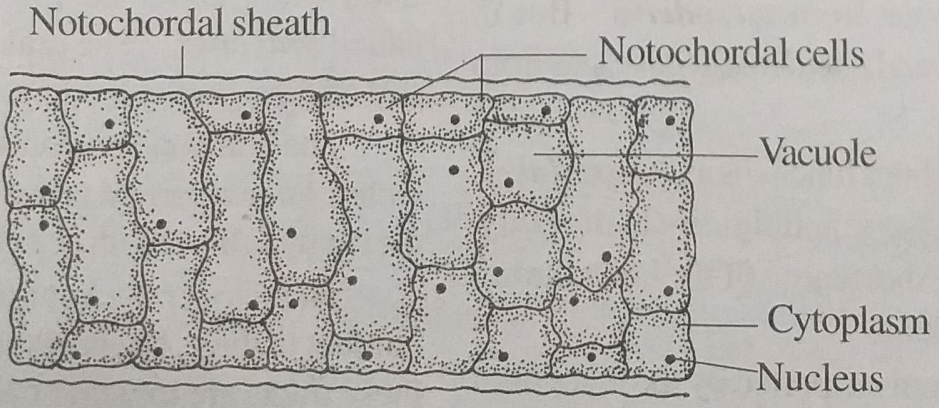

Fig.2.35: L.S through the notochord of developing chordate.

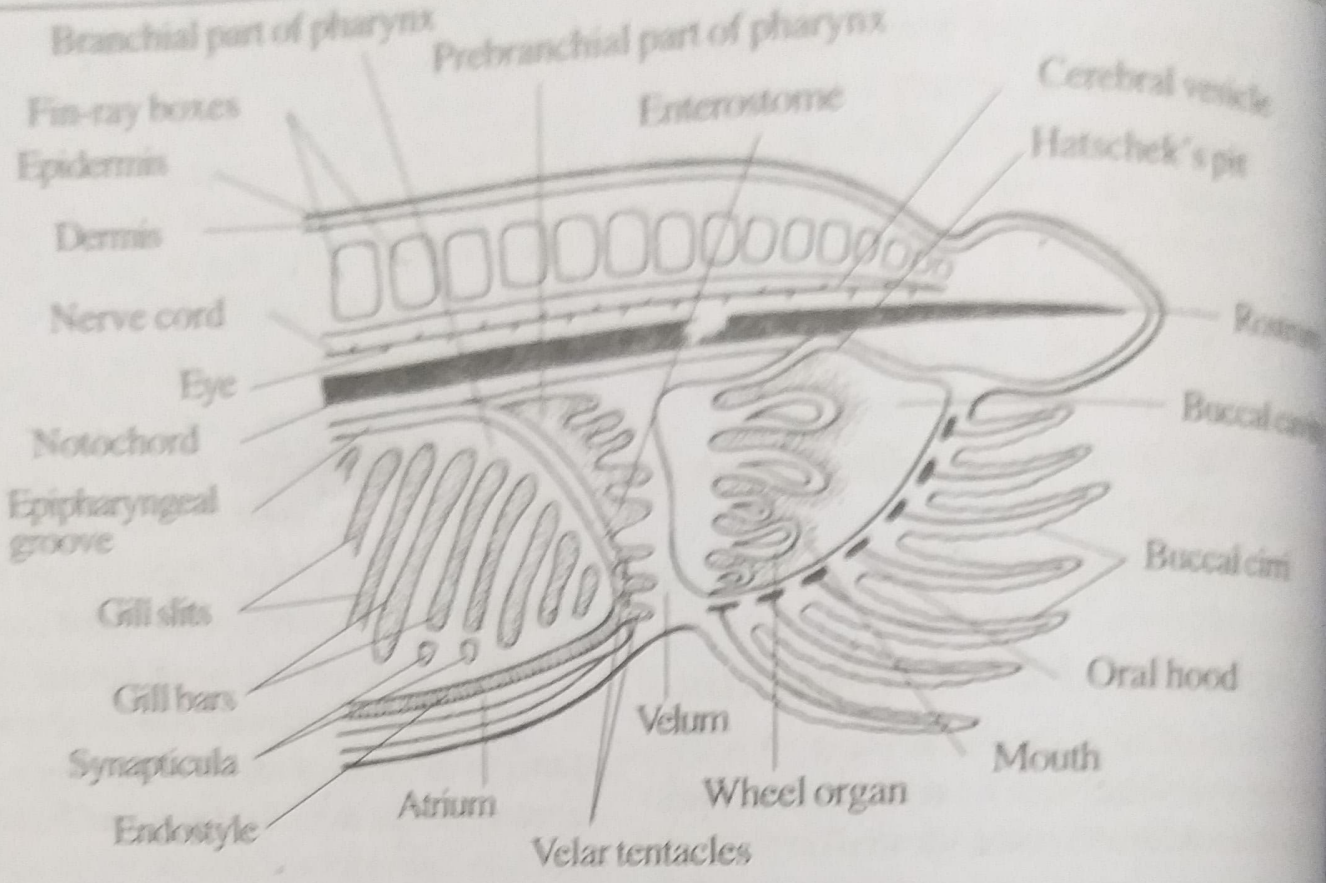

Fig.2.36: Branchiostoma - V.S of anterior region.

The notochord is made up of a single row of disc-shaped cells called ***notochordal*** cells. The notochordal cells are of two types, namely ***fibrous cells*** and ***gelatinous cells***. The fibrous cells alternate with gelatinous cells. The notochordal cells are arranged in a ***longitudinal row***.

In the developing stage, the notochordal cells contain a vacuole. Hence they are ***vacuolated cells***. The nucleus and cytoplasm are pushed towards the periphery.

In *Amphioxus* and vertebrates, the notochord develops from ***mesoderm***. But in *Balanoglossus* and *Ascidians*, it develops from ***endoderm***.

The notochord functions as the ***axial skeleton***. It gives shape and rigidity to the body. It prevents the shortening of the body during muscle contraction.

The rostrum supported by the notochord helps in burrowing.

In *Amphioxus*, the muscles are not attached to the notochord.

Digestive System

The digestive system includes the ***alimentary canal*** and the ***digestive glands***.

Alimentary Canal

The alimentary canal starts from the ***oral hood*** and ends in the ***anus***.

The ***mouth*** is a wide opening located below the rostrum. It is surrounded by a frill-like membrane called ***oral hood***. The oral hood bears about 20 finger-like processes called ***oral cirri***. The oral cirri function as a sort of sieve during feeding.

The oral hood encloses a spacious cavity called ***buccal cavity*** or ***vestibule***. The buccal cavity is lined with ectoderm.

The ectodermal lining is folded to form a number of thick, finger-like ciliated tracts. All these tracts are together called ***wheel organ*** because they create whirling water currents.

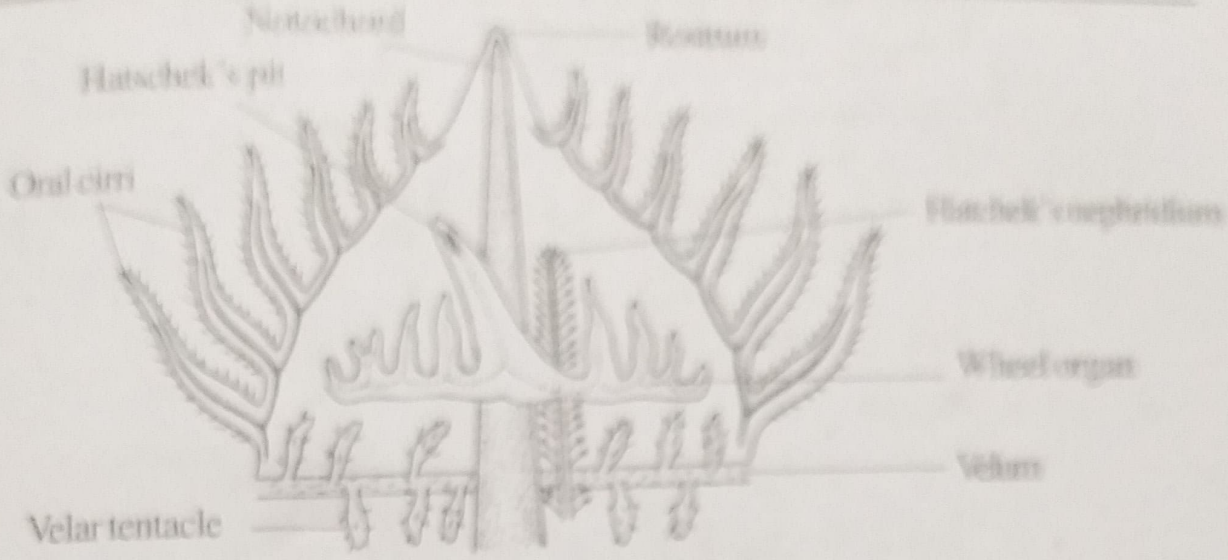

Fig.2.37: Amphioxus - Anterior end viewed from ventral side.

The mid-dorsal tract of the wheel organ is larger. Its groove is called ***Hatschek's groove*** which ends in a glandular depression called ***Hatschek's pit***.

The posterior end of the buccal cavity has a vertical partition called ***velum***. The velum is perforated by an opening called ***enterostome***. The velum bears many ***velar tentacles***.

The enterostome leads into a sac-like structure called ***pharynx***. The pharynx is also called ***branchial basket*** be cause it bears gill slits. It is a laterally compressed sac. The wall of the pharynx on each side is perforated by a row of about 180 vertical slit-like openings called ***gill slits*** or ***branchial apertures***.

The wall of the pharynx lying between the gill slits is called ***gill bars***.

The gill bars are of two types, namely ***primary gill bars*** and ***secondary gill bars***. These two bars regularly alternate with each other.

The gill bars are supported internally by a skeletal rod. The skeletal rod present in the primary gill bar is called ***primary rod***. It encloses a ***coelom*** and it is ***forked*** ventrally. The skeletal rod present in the secondary gill bar is called ***secondary rod***. It has ***no coelom*** inside and it is ***not forked*** ventrally. The primary and secondary gill

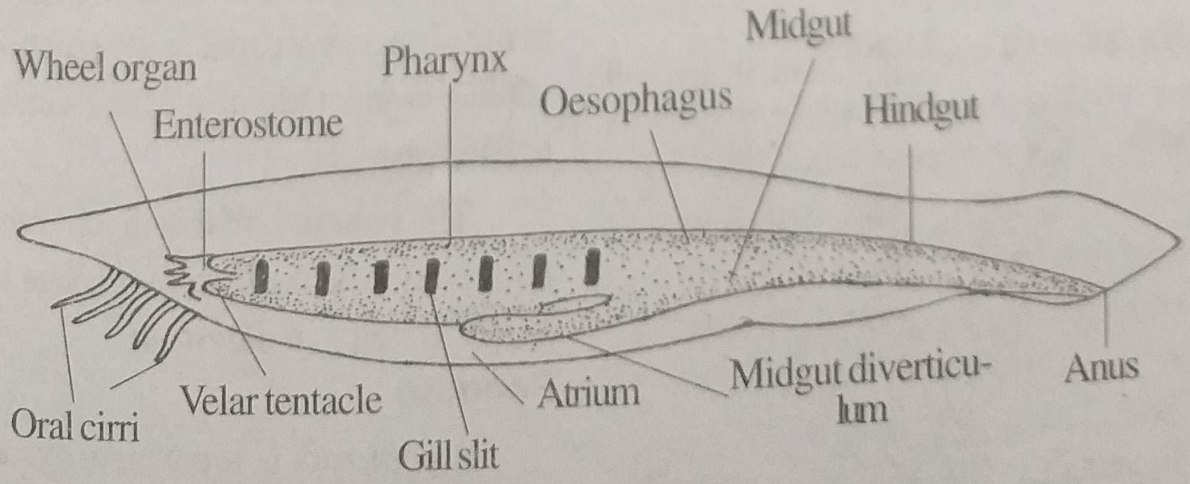

Fig.2.38: Branchiostoma - Digestive system.

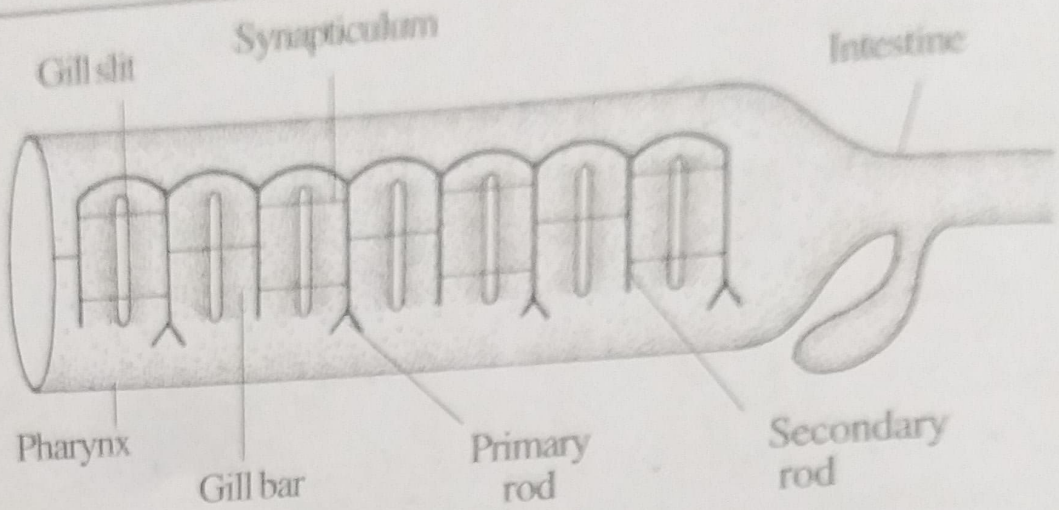

Fig.2.39: Amphioxus-A branchial apparatus.

bars are interconnected by numerous horizontal partitions called ***synapticula***.

The floor of the pharynx has a shallow longitudinal groove called ***endostyle***. It is lined by 5 longitudinal tracts of ***ciliated cells*** alternating with 4 tracts of ***mucous gland cells.*** The cilia of the median tract are much longer than the lateral tracts.

The endostyle is supported by a pair of skeletal plates. The endostyle has two functions: 1. It secretes ***mucous***. 2. It creates ***water current.***

In the roof of the pharynx, there is another ciliated groove called ***epipharyngeal groove***. At the anterior end of the pharynx, there are two transverse ciliated tracts on the inner wall of the pharynx called ***peripharyngeal glands***.

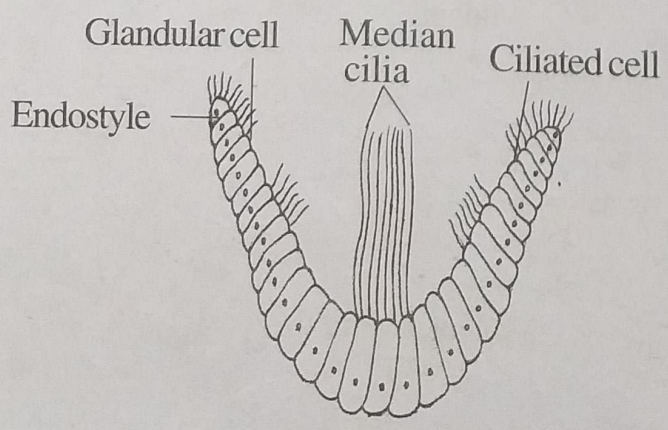

Fig.2.40: Amphioxus-Endostyle.

The peripharyngeal glands are connected to the endostyle ventrally and to the epipharyngeal groove dorsally. The small region of the pharynx lying infront of the peripharyngeal bands lacks gill slits and it is called ***prebranchial region***.

The pharynx leads into a short tubular ***oesophagus***.

The oesophagus leads into the ***intestine***. The intestine is divisible into an anterior wide ***midgut*** and a posterior narrow ***hindgut***. The hindgut opens to the outside by the anus at the base of the caudal fin.

Digestive Gland

Amphioxus has a single digestive gland called ***midgut diverticulum*** or ***hepatic diverticulum***. It is in the form of a sac attached to the alimentary canal in the junction of oesophagus and midgut. It extends forward below the pharynx.

The secretion of this diverticulum contains enzymes like ***lipase, amylase*** and ***protease***. It helps in ***digestion***.

Feeding

Amphioxus is a ***carnivorous animal***. It feeds on microscopic organisms like plank-

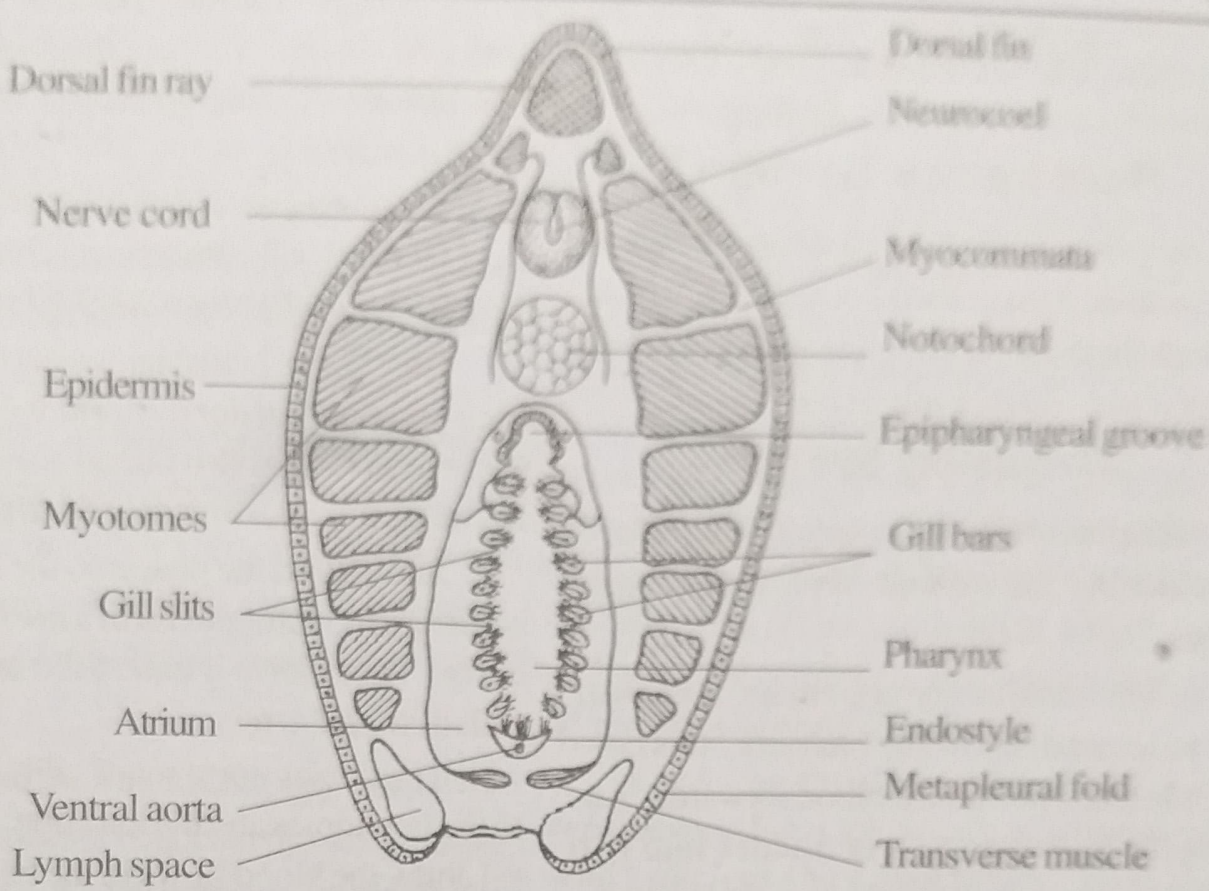

Fig.2.41: Amphioxus - T.S. through pharynx.

ton, protozoans, etc. *Amphioxus* feeds itself in three ways. They are ***ciliary*** feeding, ***filter*** feeding and ***mucous*** feeding.

The beating of the cilia of the gill bars creates a water current. This water current carries food materials.

The water current enters the pharynx via mouth, buccal cavity and enterostome. From the pharynx, water passes into the atrium through the gill slits.

From the atrium the water passes out through the atriopore. The oral cirri and the velar tentacles function as a sieve and they prevent the entry of large particles into the pharynx.

The mucous gland cells of endostyle secrete mucous. The mucous stream moves upwards along the lateral walls of the pharynx.

Food particles carried by the water current are entangled in the mucous. The food laden mucous stream enters the epipharyngeal groove.

In the epiphary-ngeal groove, the mucous stream is converted into a twisted ***mucous cord*** by the beating of the cilia. The mucous cord is then passed into the oesophagus.

From the oesophagus, the mucous cord passes into the midgut. From the midgut it enters the midgut diverticulum for a short distance.

From the midgut diverticulum, it returns to the midgut. Then it enters the hindgut.

Digestive enzymes are secreted by the midgut diverticulum and are poured into the midgut. Digestion occurs inside the midgut and the hepatic diverticulum.

Digested food is absorbed in the hindgut. The undigested materials along with the mucous cord are eliminated through the anus.

In *Amphioxus*, digestion is both ***extracellular*** and ***intracellular***. Extracellular digestion occurs in the midgut.

Detailed Study

1. Shark

Scoliodon sorrakowah

Phylum	:	*Chordata*
Subphylum	:	*Vertebrata*
Superclass	:	*Gnathostomata*
Class	:	*Chondrichthyes*
Subclass	:	*Elasmobranchii*

Scoliodon is a cartilaginous fish. Hence it is included in the class ***Chondrichthyes***. *Scoliodon* is commonly called ***Indian dog fish*** or ***shark***. In tamil, it is called '***Chura Meen***'.

The common species are:

Scoliodon sorrakowah = *S.laticaudas*
Scoliodon dumerilli
Scoliodon palasorrah
Scoliodon walbeehmi

Scoliodon is a ***marine fish***. It is a fast swimmer. It is carnivorous in habit. The sexes are separate. Fertilization is ***internal*** and development is ***direct.*** It is viviparous and giving birth to youngones.

Scoliodon is elongated, spindle-shaped and laterally compressed. Both ends are pointed. It reaches a length of about 60 cm.

Shark ***exhibits counter shading***, an adaptation. The dorsal and lateral sides are dark grey in colour. The ventral side is white in colour. This helps the shark to escape from the enemies.

When an enemy looks shark from above, the dark grey merges with the dark background of the bottom. When an enemy looks from below, the white underside of the shark merges with the lighted background of the atmosphere.

On either side of the body, a faint line extends from the head to the tail. This line is called ***lateral line***. It marks the presence of ***lateral line sense organ*** inside the body.

The skin is rough and the roughness is due to the presence of innumerable backwardly directed ***spine***-like structures called ***placoid scales***.

The body is divisible into three regions, namely ***head, trunk*** and ***tail***.

The head is present at the anterior end. It is dorso-ventrally flattened. Anteriorly, it is produced into a pointed ***snout***.

The head contains a ***mouth*** on the ventral side. It is a ***crescentic*** opening. It is bounded by two jaws, namely an ***upper jaw*** and a ***lower jaw***. Each jaw has one or two rows of teeth.

Infront of the mouth, two ***slit***-like openings are situated on the ventral side. They are called ***nares*** or ***nostrils***. They are used exclusively as an olfactory organ and not as a respiratory organ.

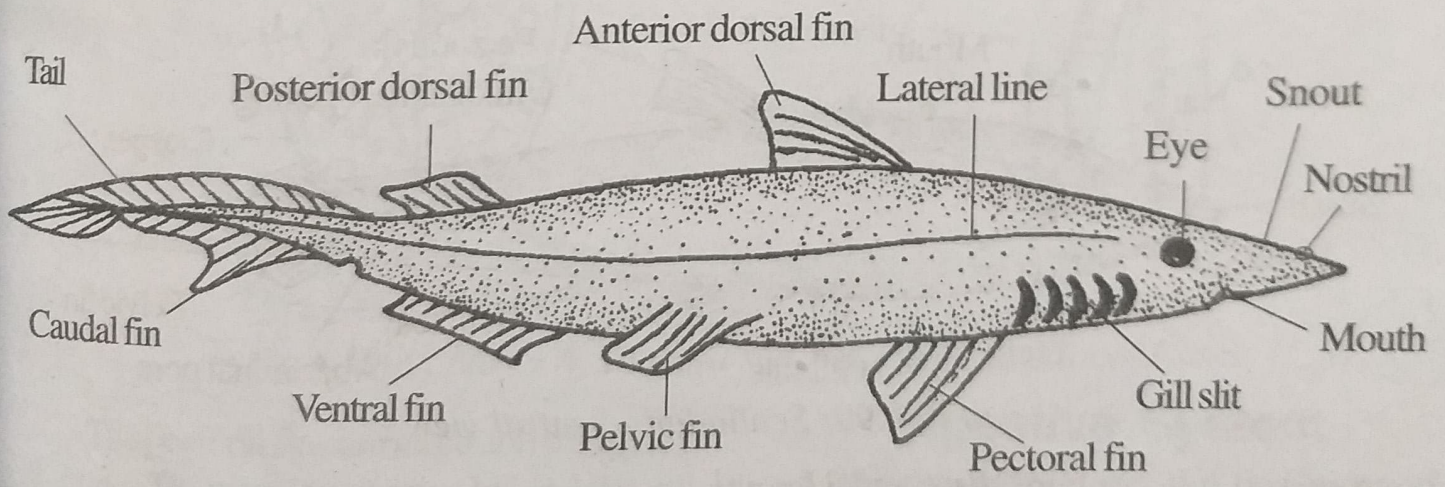

Fig.4.98: Scoliodon (shark) - lateral view.

Two prominent ***eyes*** are present on the sides of the head at a place between the mouth and nares.

Each eye is protected by three eyelids, namely an ***upper eyelid***, a ***lower eyelid*** and a ***nictitating membrane*** or ***third eyelid***. The upper and lower eyelids are immovable.

The nictitating membrane is thin, transparent and ***movable***. It lies along the lower side and can be drawn over the eye to cover it, when required.

The head and snout, on the dorsal side, contain numerous groups of pores called ***ampullary pores***. They are the external openings of ***ampulla of Lorenzini***.

Five pairs of vertical ***slit***-like openings are present on the sides of the head behind the eyes. These openings are called ***external gill slits*** or ***external branchial apertures***. They open into the pharynx.

The ***trunk*** extends from the last gill slit to the cloacal aperture. The trunk is laterally compressed. It contains ***fins*** and ***cloacal aperture***.

The trunk has an anterior ***median dorsal fin***, a pair of ***pectoral fins*** behind the head and a pair of ***pelvic fins*** infront of the tail.

The cloacal aperture lies between the pelvic fins.

The tail is the posterior region and it extends behind the cloacal aperture. It constitutes about half of the length of the trunk. It is also laterally compressed like the trunk. It is slightly bent upwards. Such an upturned tail is called ***heterocercal tail***.

The tail bears three fins, namely a ***posterior median dorsal fin***, a ***caudal fin*** and a ***ventral fin***.

Fins

Fins are specialized locomotory organs of fishes. ***Fins are flap-like outgrowths of the body wall directed backwards and supported by rods and fin rays.***

Shark has two types of fins. They are ***median fins*** or ***unpaired fins*** and ***paired fins*** or ***lateral fins***.

1. Median Fins or **Unpaired Fins :** Median fins are located along the median line of the body. They are unpaired and are arranged individually.

Shark has three types of median fins, namely two ***dorsal fins***, a ***caudal fin*** and a ***ventral fin***.

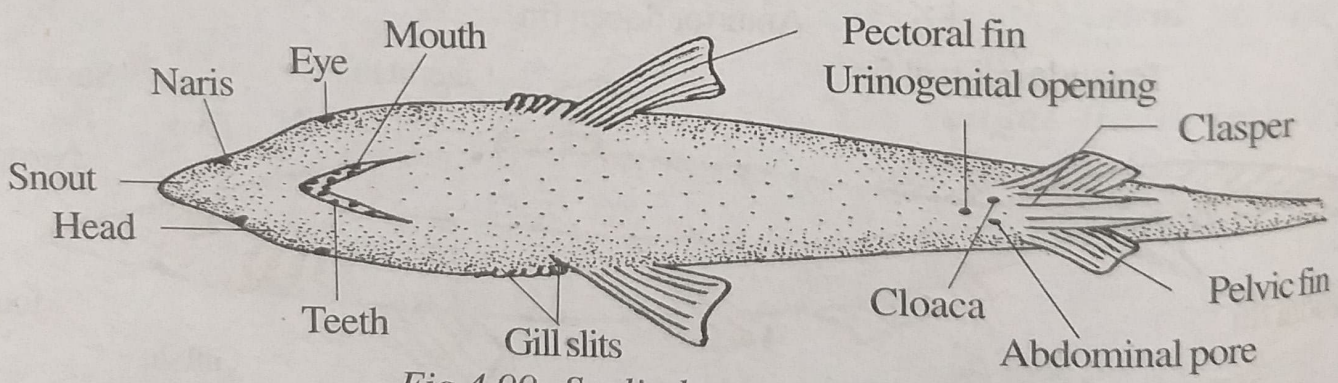

Fig.4.99: Scoliodon - ventral view.

One dorsal fin lies along the median line about the middle of the body. It is called ***anterior dorsal fin*** or ***first dorsal fin***. It is ***triangular*** in shape.

The ***second dorsal fin*** lies just infront of the tail. It is called ***posterior dorsal fin***. It is ***rectangular*** in shape.

The heterocercal tail is surrounded by a ***caudal fin***. The caudal fin is formed of two

lobes, namely a dorsal ***epichordal lobe*** and a ventral ***hypochordal lobe***.

The hypochordal lobe has a notch dividing it into a large anterior part and a small posterior part. In the root of the caudal fin, there is a ***caudal pit*** on both the dorsal and ventral sides.

The ventral side has a ***ventral fin*** infront of the caudal fin.

2. Paired Fins or **Lateral Fins:** Paired fins occur in pairs on the lateral sides of the body, especially in the trunk region. As they are present on the lateral sides, they are also called ***lateral fins***.

Shark has two types of lateral fins, namely ***pectoral fins*** and ***pelvic fins***. These fins correspond to the fore limbs and hind limbs of higher vertebrates.

Placoid Scales

The skin of shark contains thousands of ***spine-like*** structures called ***placoid scales***. They form the ***exoskeleton***. They are ***dermal*** in origin.

Each placoid scale has a ***basal plate*** and a ***spine***. The spine is a ***trident***. It is formed of ***dentine***.

The dentine is externally coated with ***enamel***. It encloses a cavity called ***pulp cavity***.

It is filled with ***pulp*** containing numerous ***odontoblasts, blood vessels, nerves***, etc.

The basal plate is ***diamond-shaped***. It has an opening in the centre to open into the pulp cavity.

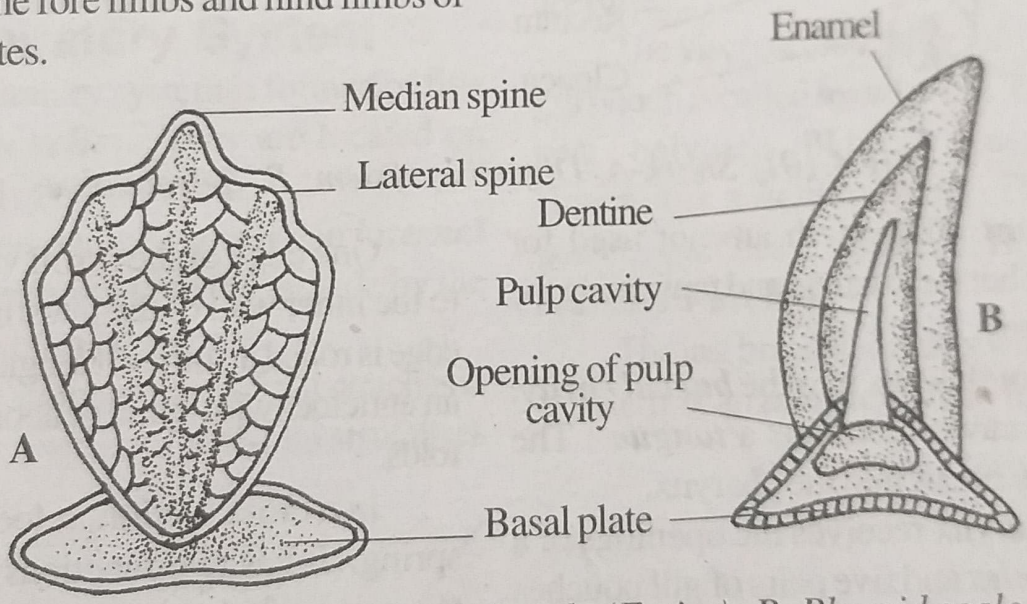

Fig.4.100: Shark - A. Placoid scale (Entire); B. Placoid scale (L.S).

The pectoral fins are large and triangular in shape. They are located just behind the gill slits.

The pelvic fins are smaller and are subtriangular. They are located on the ventral side at the junction of the trunk and tail on either side of the cloacal aperture.

In the male, each pelvic fin bears on its inner edge, a rod-like structure called ***clasper***. Each clasper has a groove on its dorsal surface leading into a cavity at its base.

Digestive System

The digestive system includes the ***alimentary canal*** and the ***digestive glands***.

Alimentary Canal

The alimentary canal starts with the mouth. The mouth is ***crescent***-shaped and it is located on the ventral side of the head. It is bounded by upper and lower jaws.

The jaws are provided with one or two rows of teeth. The teeth are ***homodont*** and

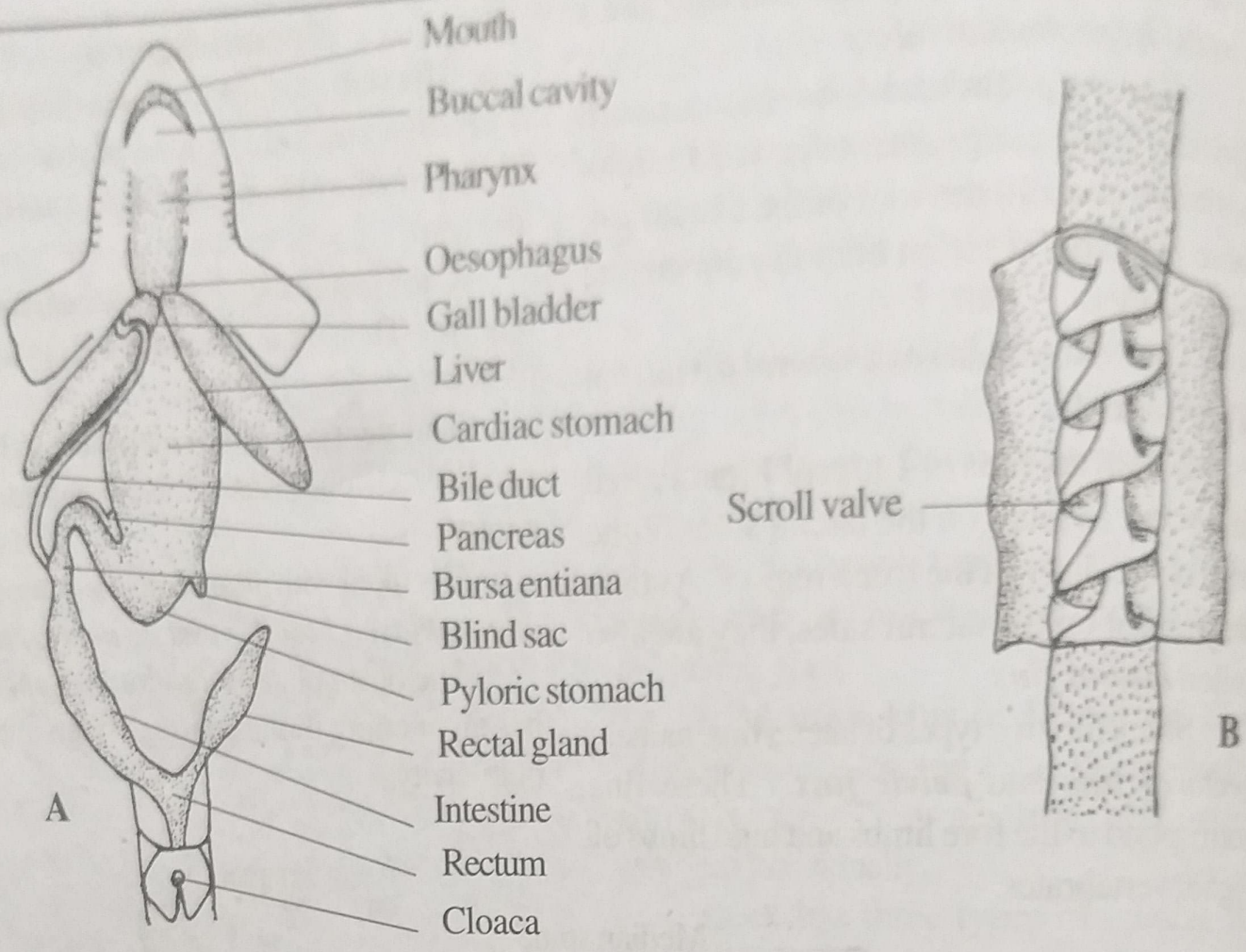

Fig.4.101: Shark-A. Digestive system; B. Spiral valve.

polyphyodont. The teeth are not used for mastication; but for catching and preventing the escape of prey.

The mouth leads into the ***buccal cavity***. The buccal cavity contains a ***tongue***. The buccal cavity opens into the pharynx.

The pharynx receives the openings of a pair of ***spiracles*** and five pairs of gill pouches on the sides. The pharynx is followed by a narrow ***oesophagus***.

The oesophagus opens into the ***stomach***. It is **J**-shaped. The stomach has two regions, namely an anterior, wide ***cardiac*** stomach and a posterior, narrow ***pyloric*** stomach. These two are separated by a short ***blind sac***.

The distal end of pyloric stomach is slightly dilated to form a sac called ***bursa entiana.***

The stomach leads into the ***intestine***. The intestine is lined with mucous membrane. The mucous membrane is folded to form a ***scroll valve***.

One edge of the scroll valve is attached to the inner wall of the intestine and the other edge is rolled up on itself longitudinally making an anticlockwise spiral of about two and a half folds.

In a cross section, it looks like a watch spring. It has two functions: a. ***It increases the area of absorption***. b. ***It prevents the rapid flow of food through the intestine***.

The intestine leads into the ***rectum*** which opens into the ***cloaca***. The rectum contains a ***rectal gland.***

Digestive Glands

Shark has two digestive glands, namely the ***liver*** and the ***pancreas***.

Liver: Liver is located at the junction of oesophagus and cardiac stomach. The liver is formed of two lobes. The two lobes are united anteriorly and free posteriorly.

The right lobe contains the ***gall bladder***. A bile duct arises from the gall bladder and it opens into the intestine.

The liver has three functions: 1. ***It secretes bile***, 2. ***It stores glycogen and fat***, 3. ***It destroys worn out RBC***.

Pancreas: The pancreas is located in the loop of the stomach. It is ***bilobed***. The ***pancreatic duct*** arising from the pancreas opens into the intestine opposite to the bile duct.

Physiology of Digestion

Shark is ***carnivorous***, feeding on fishes, crustaceans, molluscs, etc. The teeth prevent the escape of prey. Digestion starts in the stomach and is completed in the intestine. Absorption occurs in the intestine. The scroll valve helps absorption.

1. Frog
Rana hexadactyla
Rana tigerina
Rana cyanophlyctis

Phylum	:	*Chordata*
Subphylum	:	*Vertebrata*
Superclass	:	*Gnathostomata*
Class	:	*Amphibia*
Subclass	:	*Lissamphibia*
Order	:	*Anura*
Genera	:	*Rana*

Frogs are ***amphibians.*** They live sometimes in water and at other times on land. Hence they are included in the class ***Amphibia*** (***Amphi*** - two; ***bios*** - life). They are ***bilaterally symmetrical***, ***cold blooded***, ***anamniotic tetrapods***.

The genus *Rana* includes three main species. They are:

Rana tigerina

Rana hexadactyla

Rana cyanophlyctis

Rana tigerina is commonly called ***Indian bull frog.*** It is the largest of the Indian frogs.

The female frog reaches 16 cm long. It is olive green in colour with ***leopard-like spots.*** It has a median vertebral stripe from snout to cloaca. It has ***longitudinal glandular folds*** on the back.

The vocal sacs are ***bright blue.*** It is ***carnivorous*** feeding on insects, crabs, other frogs, toads, lizards, small snakes, small birds,

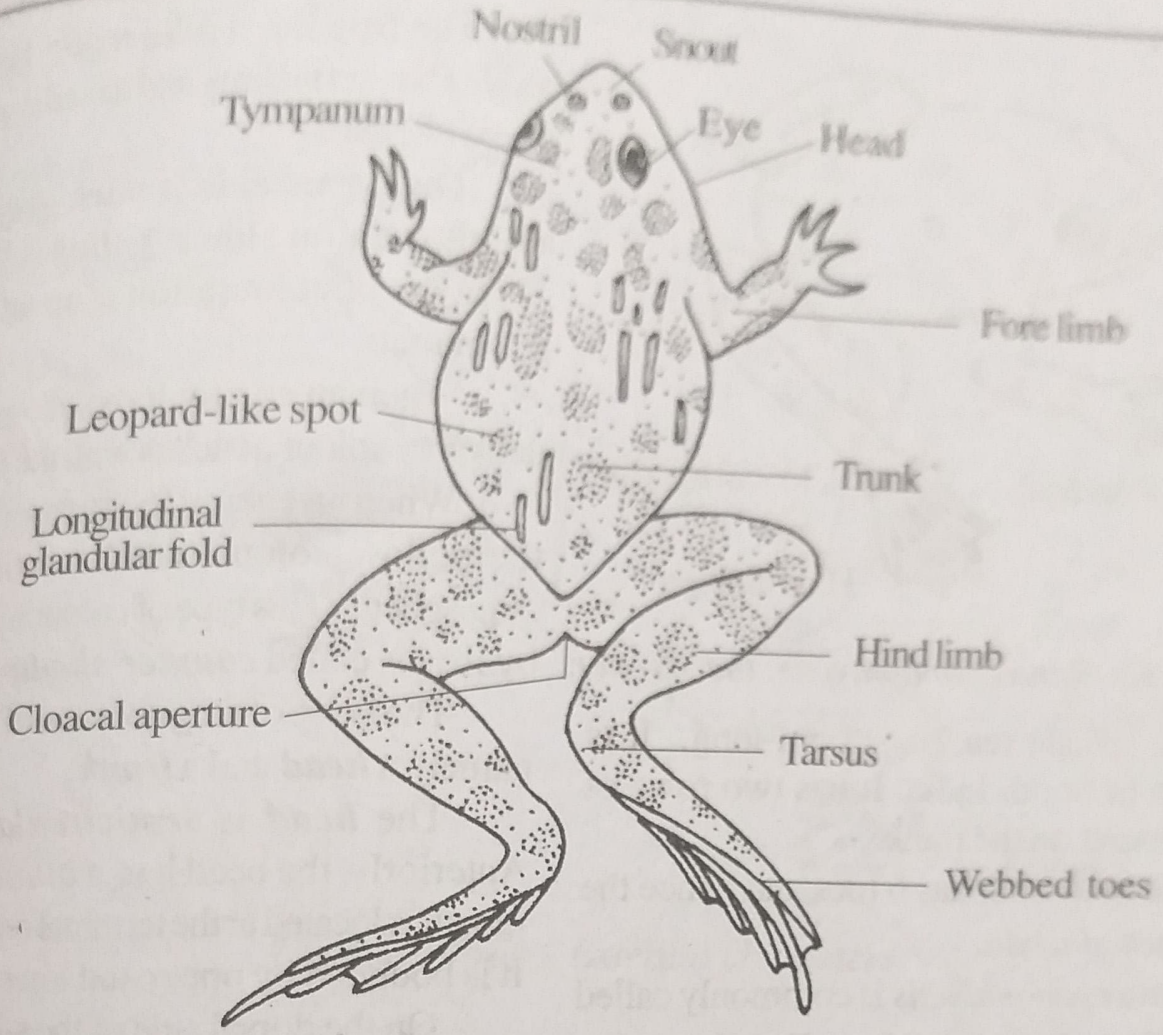

Fig.5.40: Rana tigerina, the Indian bull frog dorsal view.

nice and shrews (***Daniel***, 1975). It is an dible frog. The legs are being exported. It is ommon in North India.

Rana hexadactyla is commonly called ***green frog.*** It is green in colour with black patches on the dorsal side.

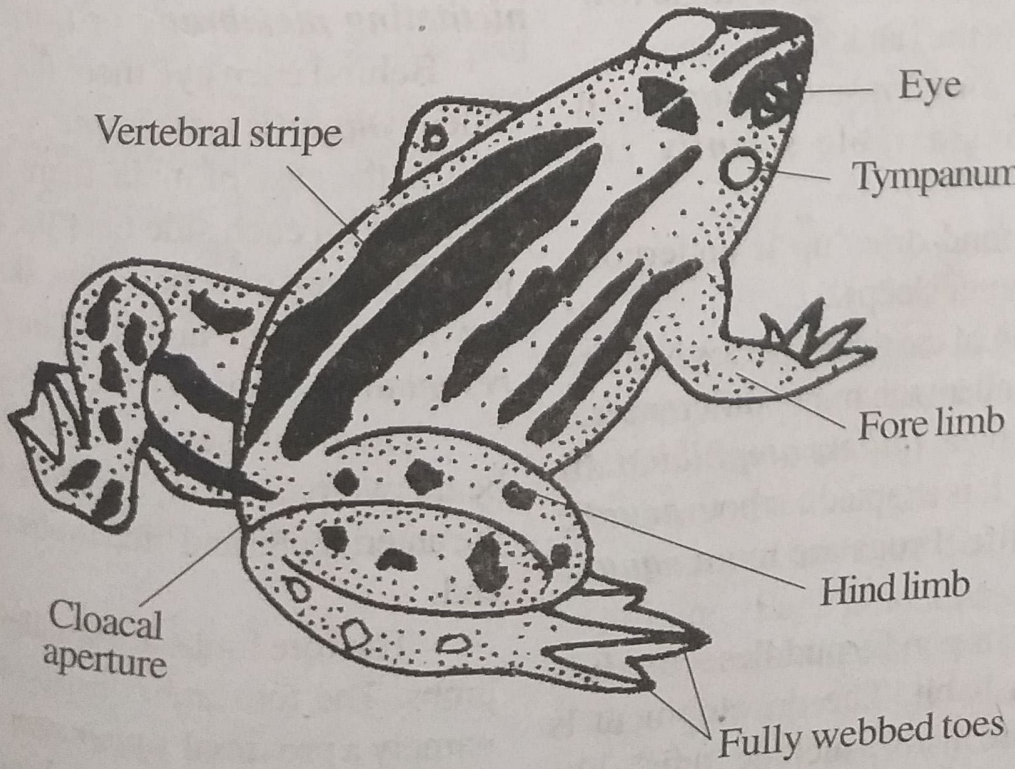

Fig.5.41: Rana hexadactyla

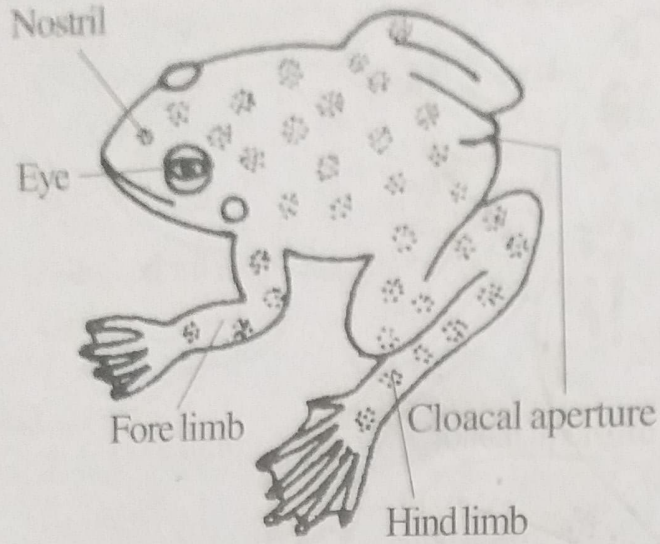

Fig.5.42: Rana cyanophlyctis, the skipper.

The female reaches 13 cm long. It is common in South India. It has two rows of ***porous warts*** on the flank.

The hind limb has 6 toes and hence the name *hexadactyla.*

Rana cyanophlyctis is commonly called ***skipper frog.*** It is a small frog. Female reaches only 6cm in length. Grey or olive with dark spots.

The vocal sacs are ***bluish white*** hence; the name ***cyanophlyctis***. It has a single row of ***porous warts*** on the flanks.

Toe tips are ***swollen*** and ***rounded.*** It can tolerate considerable ***salinity*** and ***pollution.***

When the pond dries up it undergoes ***aestivation*** (summer sleep).

The anatomy of the three species of frogs is more or less similar with minor differences.

Frog is a typical ***tailless amphibian.*** It leads a ***dual life.*** It is adapted for both ***aquatic*** and ***terrestrial*** life. Frogs are more ***aquatic*** than ***terrestrial.***

Frog lives in ponds, puddles, etc. It is ***carnivorous*** in habit. The development is ***indirect***. The life history includes a fish-like ***tadpole larva***.

The frog has a ***bilaterally symmetrical*** body. The skin is slimy and naked and it contains no exoskeleton.

The dorsal side is ***dark grey*** in colour and the ventral side is ***yellowish*** in colour. This type of colouration is an adaptation to the animal.

When an enemy looks from above, the dark grey colour matches with the dark bottom.

When an enemy looks from the bottom, the yellow colour matches with the light atmosphere. This type of colouration exhibited by frog is called ***counter-shading***.

The body of frog consists of two regions, namely a ***head*** and a ***trunk***.

The ***head*** is ***semicircular*** in shape. Anteriorly, the head has a ***blunt snout***. The mouth is located at the terminal end of the head. It is bounded by upper and lower ***jaws***.

On the dorsal side of the snout there is a pair of openings called ***external nostrils***.

Behind the nostrils two ***eyes*** are situated. The eyes are provided with three eyelids, namely an ***upper eyelid,*** a ***lower eyelid*** and a ***nictitating membrane*** or ***third eyelid***.

Behind each eye there is a circular area called ***tympanic membrane***.

In the case of male, there are two ***vocal sacs*** one on each side near the angles of the jaw. They are pouches of the skin opening on the floor of the mouth. They function as ***resonators*** amplifying the croaking.

The trunk has a characteristic bulge, it bears two pair of appendages; fore -limbs at the anterior end and hind limbs at the posterior end.

The fore limbs are smaller than the hind limbs. The fore limb consists of three regions, namely a proximal ***upper arm*** (***brachium***), a middle ***fore arm*** (***antebrachium***) and a distal ***hand*** (***manus***).

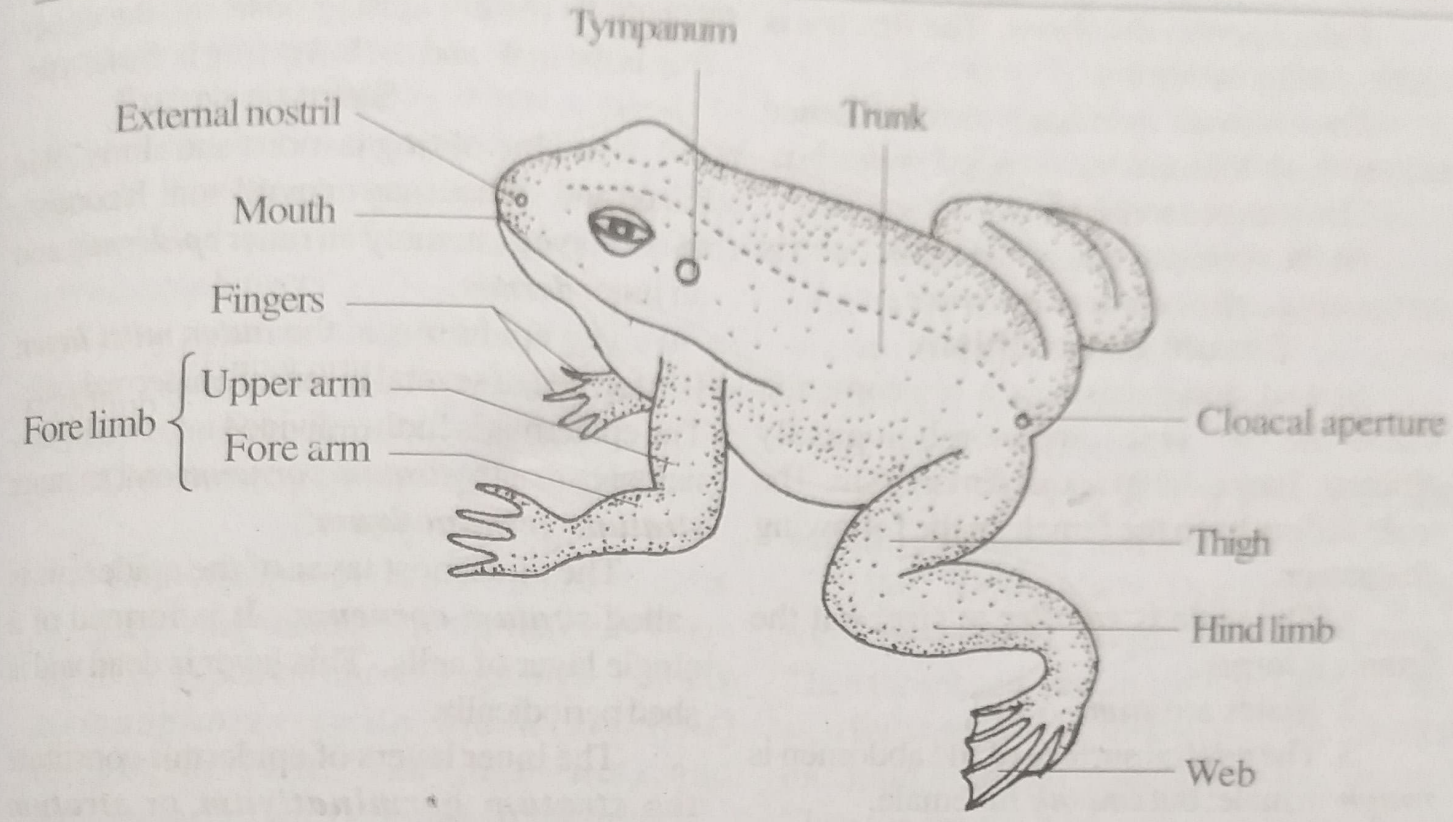

Fig.5.43: Frog - External characters.

The hand in turn is divisible into three regions, namely a ***wrist*** (***carpus***), a ***palm*** (***metacarpus***) and the ***fingers***. Frog has 4 fingers. The first finger, corresponding to our thumb (pollex) is absent.

In the case of male, a ***cushion***-like pad develops on the index finger during the breeding season. It is called ***nuptial pad***. The nuptial pads help to grip the female during amplexus.

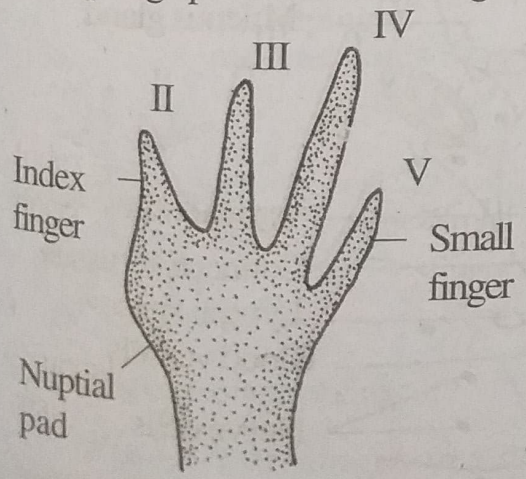

Fig.5.44: Frog - Hand showing nuptial pad.

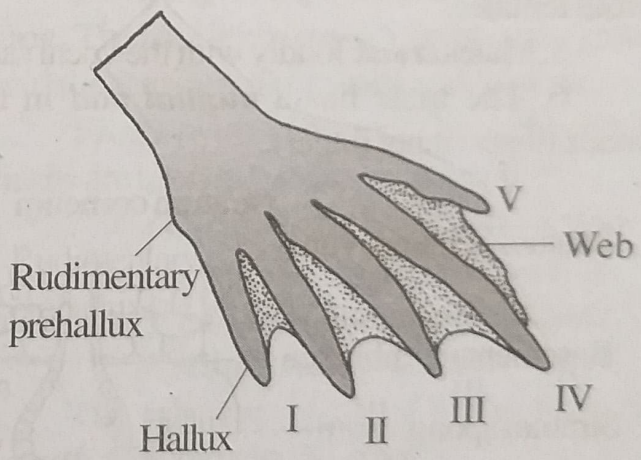

Fig.5.45:Rana tigerina - Foot.

The frog has a pair of ***hind limbs***. They are located at the posterior end of the trunk. The hind limbs are strongly built and are much longer than the fore limbs.

The hind limbs are used for jumping and swimming. Each hind limb consists of three regions, namely a ***proximal thigh*** (***femur***), a ***middle shank*** (***crus***) and a ***distal foot*** (***pes***).

The foot in turn is divisible into three regions, namely an ***ankle*** (***tarsus***), an ***instep*** (***metatarsus***) and the ***toes***.

Rana tigerina has 5 toes. The first toe is called *hallux* or ***big toe.***

Rana hexadactyla has 6 toes and hence the name. Additional toe is called *prehallux.*

The toes are ***webbed.***

At the posterior end of the trunk there is an opening called ***cloacal aperture***.

Sexual Dimorphism

Sexual dimorphism is a phenomenon where the two sexes are morphologically different. Frog exhibits sexual dimorphism. The male differs from the female in the following characters:

1. The male is ***smaller*** in size; but the female is ***larger***.
2. Males are ***slim.***
3. The ventral surface of the abdomen is ***rough*** in male; but ***smooth*** in female.
4. The male has two ***vocal sacs*** located near the ankles of the jaw. They are absent from females.
5. Males ***croak*** loudly with the vocal sacs.
6. The male has a ***nuptial pad*** in the index finger (inner finger).
7. In the copulating position, the upper frog is the male and the lower frog is the female.

Skin

The skin of frog is moist and slimy. It is naked and without any exoskeleton. It consists of two layers, namely an outer ***epidermis*** and an inner ***dermis***.

The epidermis is the ***outer most layer.*** It is formed of several layers of epidermal cells. The epidermis is further divided into two layers, namely an outer ***stratum corneum*** and an inner ***stratum germinativum***.

The outermost layer of the epidermis is called ***stratum corneum.*** It is formed of a single layer of cells. This layer is dead and is shed periodically.

The inner layers of epidermis constitute the ***stratum germinativum*** or ***stratum Malpighii***. This layer is formed of columnar cells. New cells are formed from this layer.

A ***basement membrane*** separates the epidermis from the ***dermis.***

Dermis is the ***inner layer of the skin.*** It is differentiated into two layers, namely an

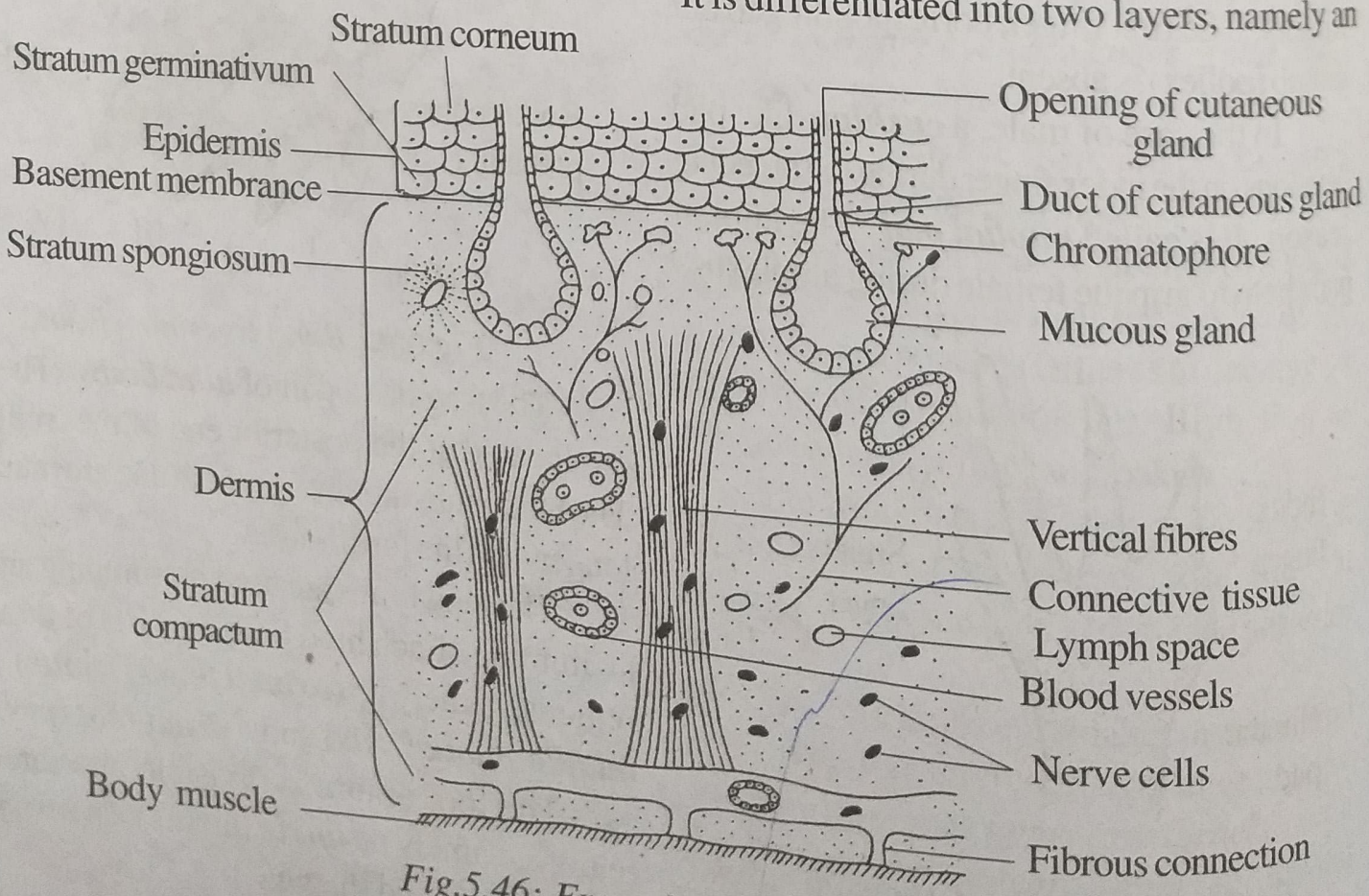

Fig.5.46: Frog - V.S. of the skin.

outer ***stratum spongiosum*** and an inner ***stratum compactum***.

The ***stratum spongiosum*** consists of loose network of ***connective tissue*** with ***blood vessels.*** It contains many ***mucous glands.*** The superficial part of this layer contains ***chromatophores***.

The ***stratum compactum*** is made up of ***dense connective tissue, smooth muscle fibres, nerves*** and ***blood vessels.***

Chromatophores and Colour Changes

Chromatophores are the pigment cells. They are lying scattered in the dermis. There are three types of chromatophores, namely ***melanophores*** (with ***black pigment***) ***lipophores*** (with ***red pigments***) and ***guanophores*** (with ***crystals of guanine***).

The colour of the skin is produced by the combination of pigments and the reflection of light from the guanine crystals.

Frog can change its colour. Change in the colour of the skin is brought about by the movement of pigments in the chromatophores. When the pigment is dispersed, the skin is dark. When the pigment concentrates, the skin becomes light. This phenomenon helps the frog to change its colour according to the colour of the environment.

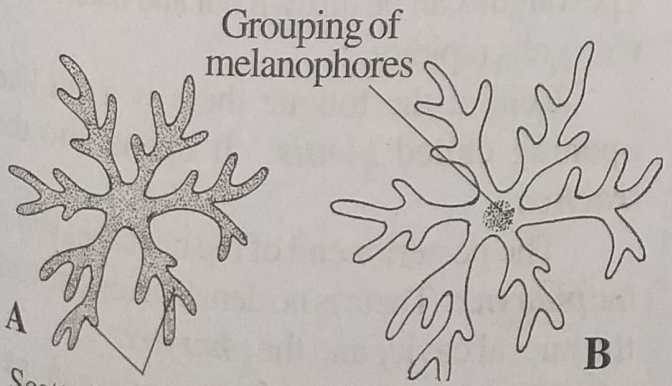

Fig.5.47: Melanophores and colour changes.

A. The skin is darker in colour
B. The skin is light in colour.

Coelom

The cavity lying between the body wall and the alimentary canal is called ***coelom***. The ***pericardial*** cavity is also a part of the coelom. The coelom is lined by a layer of coelomic epithelium called ***peritoneum***. The visceral organs are located inside the coelom. They are suspended in the body wall by transparent membranes called ***mesenteries***.

Locomotion

Frog moves by three methods, namely ***walking, jumping*** and ***swimming.***

Frog ***walks*** slowly. During walking one fore limb is lifted and placed a step forward. Then the second fore limb is lifted and placed a step forward. This is followed by the lifting of one hind limb and placing it a step forward. Then the second hind limb is lifted and placed a step forward. Then the process is repeated.

Jumping is the common movement of frog. The hind limbs make a thrust on the ground and the frog jumps upward and forward.

Frogs swim in water. The webbed hind limbs are used as oars in swimming.

Digestive System

The digestive system consists of ***alimentary canal*** and ***digestive glands.***

Alimentary Canal

The alimentary canal starts from the ***mouth*** and ends in the ***cloaca***.

The ***mouth*** is a wide opening located at the terminal end of the head. It is bounded by the ***upper*** and ***lower jaws.*** A single row of ***teeth*** is present in the upper jaw.

The mouth leads into the ***buccal cavity.*** The buccal cavity contains the following structures:

Maxillary teeth
Vomerine teeth
Internal nostrils
Eye balls
Eustachian apertures

tissues, blood vessels and *nerves*.

Respiratory System

Frog exhibits ***aerial respiration.*** There are three types of respiration. They are the following:

1. Cutaneous respiration
2. Buccopharyngeal respiration
3. Pulmonary respiration.

1. Cutaneous Respiration

It is the ***skin respiration***. The skin is used as the respiratory organ. The skin is kept moist by the ***mucous*** secreted by the ***mucous glands.***

The skin is permeable to gases. The skin has abundant ***blood supply***. The oxygen from outside diffuses into ***blood*** and the ***carbon dioxide*** from the blood diffuses out through the skin.

Cutaneous respiration takes place both in the water and on land.

2. Buccopharyngeal Respiration

Respiration occurring inside the buccal cavity and the pharynx is called ***buccopharyngeal respiration***. It is a ***terrestrial respiration*** where air is used.

The buccal cavity and the pharynx are lined with thin mucous membrane which is moist with mucous, permeable to gases and richly supplied with blood vessels.

The buccopharyngeal cavity communicates to the exterior through a pair of ***respiratory tracts***. Each respiratory tract consists of an ***internal nostril,*** a ***nasal chamber*** and ***external nostril***.

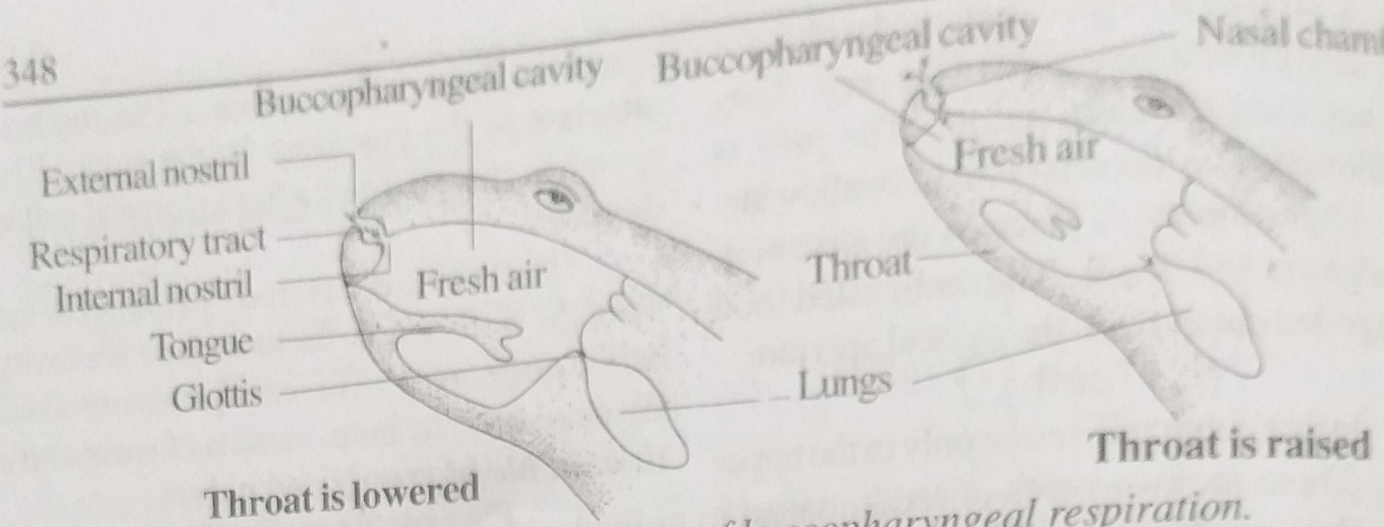

Fig.5.53: Frog - Mechanism of buccopharyngeal respiration.

The buccopharyngeal respiration is brought about by the raising and lowering of the throat alternately.

When the throat is lowered the buccopharyngeal cavity becomes enlarged. This reduces the pressure of air in the buccopharyngeal cavity. Hence fresh air from outside rushes into the buccopharyngeal cavity through the respiratory tracts.

Now exchange of gases takes place between the blood of the mucous membrane and the air of the buccopharyngeal cavity.

Now the throat is raised. This increases the pressure of air in the cavity. Hence the air goes out from buccopharyngeal cavity through the respiratory tract. The process is repeated regularly.

During buccopharyngeal respiration the external nostrils remain open; the mouth and the glottis are kept closed; and the lungs remain idle.

3. Pulmonary Respiration

In pulmonary respiration, the ***lungs*** are used. It is a ***terrestrial*** respiration where air is used.

The pulmonary respiratory system consists of ***respiratory tracts*** and ***lungs***.

There are two respiratory tracts. Each respiratory tract starts from an ***external nostril.*** It opens into a ***nasal chamber***. The nasal chamber opens into the ***buccopharyngeal cavity***.

The buccopharyngeal cavity leads into a sac called ***laryngotracheal chamber*** through a slit-like opening called ***glottis***.

The laryngotracheal chamber opens into the lungs through a pair of short ducts called ***bronchi***.

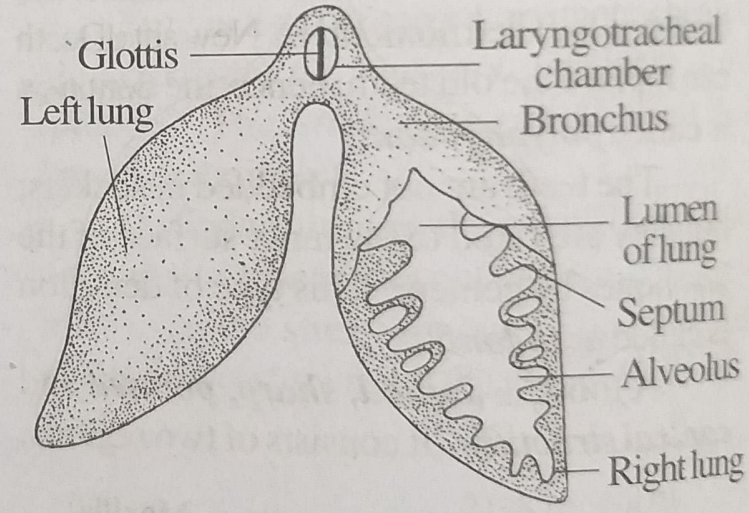

Fig.5.54: Frog - Lungs.

The lungs are thin-walled oval sacs. They lie one on either side of the heart. The walls are ***elastic*** and ***highly vascular***.

The inner lining of the lungs has a number of ridges called ***septa***. The septa enclose cavities called ***alveoli***.

The alveoli are lined with ***epithelium*** rich in ***blood capillaries***.

Mechanism of Respiration

The process of pulmonary respiration consists of three steps. They are,

1. Aspiration

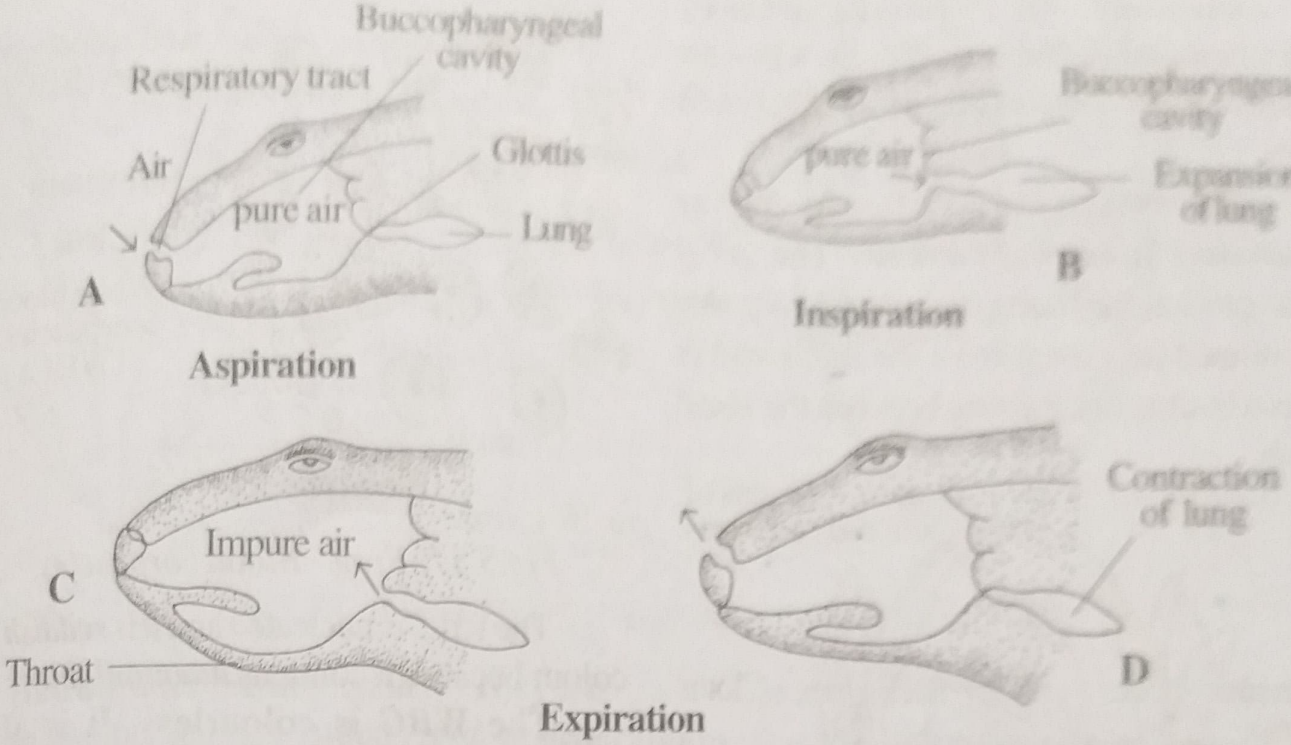

Fig.5.55: Frog - Mechanism of pulmonary respiration.

2. Inspiration

3. Expiration.

1. Aspiration: *The entry of the air into the buccopharyngeal cavity* is called ***aspiration***. During this process, the mouth is closed and the external nostrils are kept open.

The throat is lowered. The buccopharyngeal cavity is enlarged. So air from outside enters the buccopharyngeal cavity through the respiratory tracts.

2. Inspiration: *The passage of air from the buccopharyngeal cavity into the lung* is called ***inspiration***.

During inspiration the external nostrils are tightly closed. The throat is raised. The cavity of the buccopharyngeal cavity is decreased. So the air is forced through the glottis into the lungs.

Oxygen from the air diffuses into the blood of alveoli. From the blood of alveoli ***carbon dioxide*** diffuses into the lungs.

3. Expiration: *The passage of impure air from the lungs to the exterior* is called ***expiration***. During expiration the throat is lowered. The volume of the buccopharyngeal cavity increases.

Air from the lungs enters the buccopharyngeal cavity through the glottis. Now the throat raises; the external nostrils open; and the impure air is expelled out.

Sound Producing Organ

The ***laryngotracheal chamber*** functions as the ***sound producing organ***. It lies between the glottis and the bronchi. It is in the form of a sac.

The wall is supported by three cartilages, namely a ***cricoid cartilage*** and two ***arytenoid cartilages***.

The cricoid cartilage is in the form of a oval ring. It has a ***median process*** at the hind end and two ***lateral processes***.

The two lateral processes are joined by a ***transverse bridge*** on the ventral side of the laryngotracheal chamber. The arytenoid cartilages are ***semilunar*** in shape.

The lining of laryngotracheal chamber is produced into a pair of horizontal folds called

small and *worm*-like with a peculiar skull.

3. Parental Care in Amphibia

The nursing of eggs and embryos by the parents is called ***parental care.*** It is well developed in ***Amphibia.***

1. Nests

The parents construct a nest into which the eggs are laid. Four types of nests are encountered.

a. Mud Nests

i. Hyla faber: Female makes a nest in the mud in shallow waters. The female lays eggs about 2 days after nest building.

ii. Heptadactylus ocellatus: It builds small mud bunds near the edge of the pond water and spawns in that enclosure.

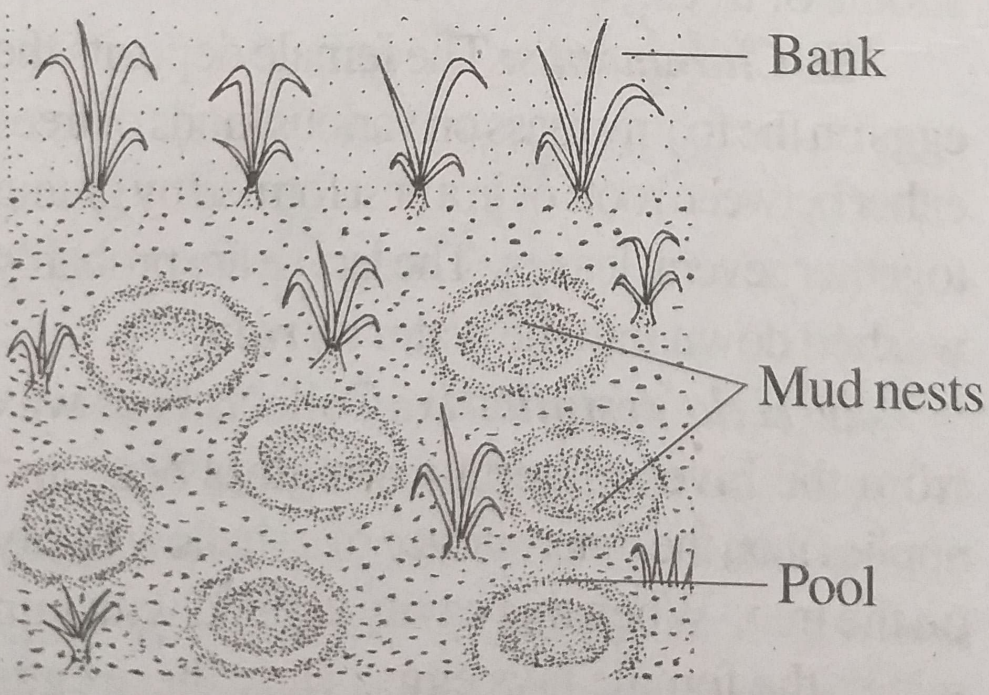

Fig.5.167: Mud nests of Hyla faber.

iii. Rhacophorus schlegeli: (Arboreal frog of Japan): The female makes a spherical hole of 6-9 cm wide in mud banks of ponds.

iv. Desmognathus fucus: It is an urodele amphibian. It constructs an underground burrow and protects her eggs.

b. Tree Nests

i. Phyllomedusa deposits the egg in the leaf nests. The leaf nests are constructed by folding the margin of the leaves.

Leaf margins are glued together by cloacal secretion. These leaf nests are seen in the branches of trees overhanging the water. After hatching the larvae jump into the pond.

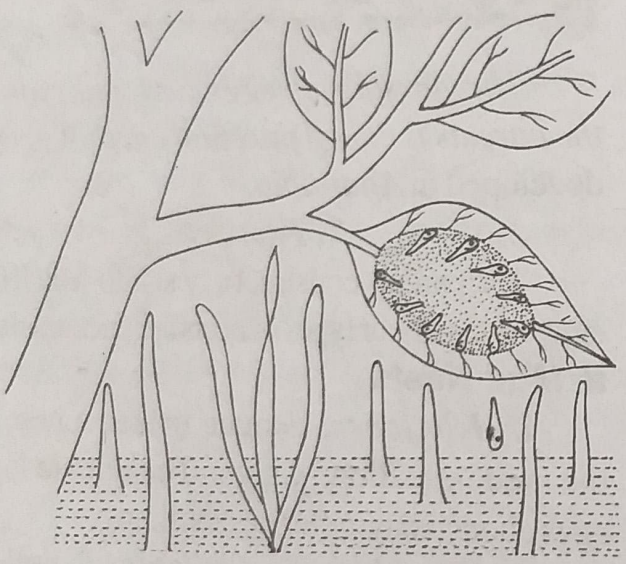

Fig.5.168: Leaf nest of Phyllomedusa.

ii. Triton constructs the nest using the shoots of trees.

iii. *Chiromantis:* The female deposits the eggs on the foamy mass on various kinds of trees either between roots or in a nest formed by gluing together several leaves. The larvae are probably washed down into the water by ***rain***.

iv. Hyla resinfictrix: Collects bees wax from the hives of certain stingless bees and applies it on the inner surface of a shallow cavity on the tree. When this cavity is filled with rain water, the female lays eggs. Here these eggs develop into tadpoles and are free from predators.

c. Foam Nests

Rhacophorus schlegeli is a ***Japanese tree frog.*** It digs a hole or tunnel and lays eggs there. In a frothy mass to avoid desiccation. During rains hatching tadpoles are washed down the slopping tunnel into the pond or river for further development.

Leptodactylus mystracinus, the ***South American tree frog*** (female) digs a hole near water and fills it with a frothy mass of mucous. The eggs are laid on this.

d. Gelatinous Bags

Phrynixalus birol secretes a ***sausage***-shaped transparent gelatinous membranous bag and it lays its eggs in it.

Salamandrella keyserlingi lays its eggs in a gelatinous bag which is fastened to aquatic plants.

2. Direct Caring by the Parents

Some species of amphibians directly care their eggs and youngones:

1. *Desmognathus fucus:* It is a ***tailed amphibian.*** The male carries the eggs around the neck in the form of a string.

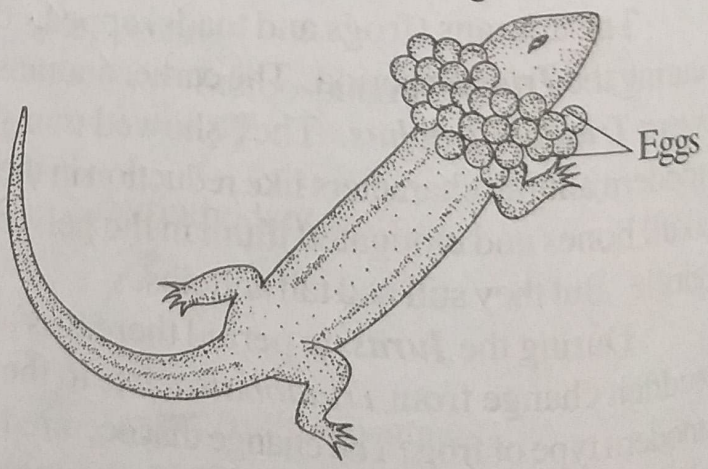

Fig.5.169: Desmognathus fucus with eggs on the neck.

2. *Dendrobatus:* They carry their tadpoles on their back, to which they are attached by a peculiar secretion.

3. *Phyllobatus*: Male carries its tadpoles on its back. The youngones get fixed

themselves by means of their suckers. The tadpoles are carried from one pond to another.

4. *Alytes obstetricans* (Mid-wife toad): The males of this toad show a peculiar type of parental care. This toad is abundant in ***France*** and ***Italy***.

Several males collect around a female. One of the males becomes successful to grasp round the waist of the female.

The male then lubricates the cloacal region of the female where upon the female discharges the eggs. The eggs are fertilized.

Fig.5.170: Mid wife toad.

After fertilization the eggs are wrapped round the back of the thigh of the male and the male withdraws himself into a hole near the pond. Now and then the male carries the egg to the water to moisten them.

When the eggs are nearly ready to hatch, he takes them to the water where the larvae come out and further development and metamorphosis take place.

5. *Hyla goeldii*: The female carries the eggs on its back.

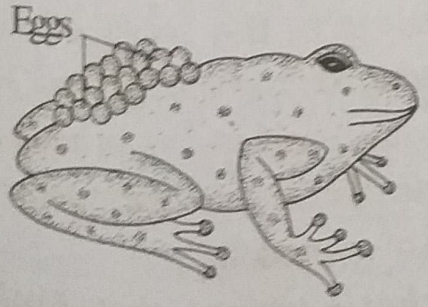

Fig.5.171: Hyla goeldii carrying eggs.

6. *Pipa pipa*: In this species, the skin on the dorsal side has small pockets into which the eggs are placed.

7. *Pipa dorsigera*: In this species, small cutaneous pits develop on the dorsal skin of the female. The male places the eggs on these small pits. Each pit has an operculum which covers the pit. The partition between the pits is highly vascular.

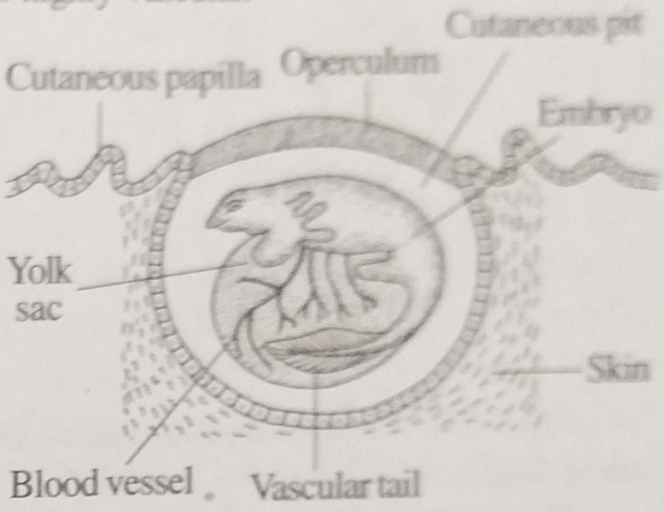

Fig.5.172: Pseudoplacentation in Pipa dorsigera.

The larvae develop inside these brood pits. The developing larvae attain a vascular tail. Physiological exchange of materials between the developing larva and the mother occur in this animal. The tadpole larva comes out of the pit in about 80 days.

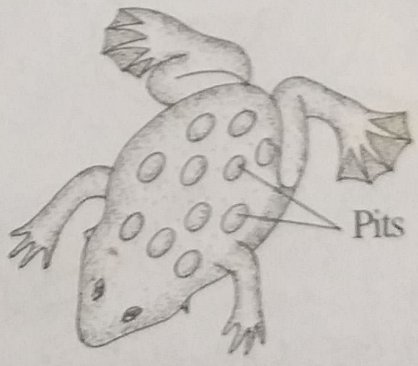

Fig.5.173: Pipa showing dorsal pits.

8. *Rhinoderma darvini*: In this frog, the vocal sac of the male opens by 2 slits one on either side of the tongue. During breeding season the vocal sacs enlarge and the eggs are put into them.

The eggs remain in the vocal sacs upto hatching or even upto the completion of metamorphosis.

9. *Nototrema marsupium* (Marsupial toad): The eggs are deposited in a pouch on the back with one opening at the posterior end.

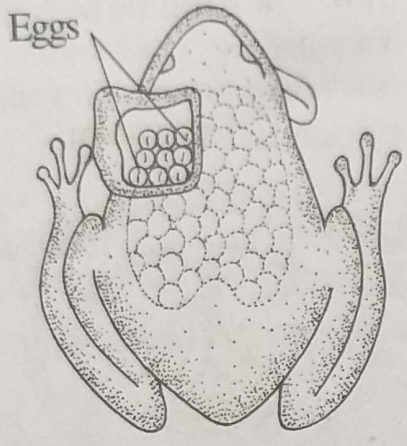

Fig.5.174: Nototrema marsupium with brood pouch.

10. *Ichthyophis*: It is a burrowing, limbless amphibian (apoda) coils around the egg mass until they are hatched.

The female takes the eggs into the water shortly before hatching.

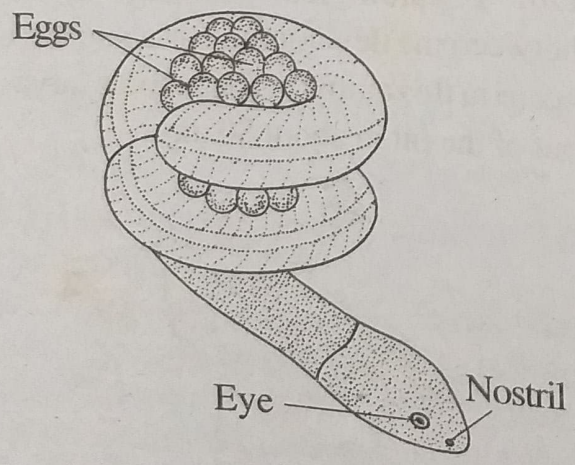

Fig.5.175: Ichthyophis glutinosa- coiling around eggs.

11. Ovoviviparity: Some amphibians are ***ovoviviparous.*** The females retain their eggs in the oviduct and they give birth to youngones.

Eg. *Toads* like *Nectophrynoides* and *Pseudophryne*, salamanders like *Salamandra salamandra* and *S.atra* and apodans like *Typhlonectes, Geotrypetes, Dermophis*, etc.

4. Neoteny in Amphibia

Reproduction is a common phenomenon of animals. They start reproducing when they become adult. But certain animals begin to reproduce when they are in ***larval stage.*** This phenomenon is called ***neoteny***. It is a rare phenomenon. It is not only exhibited by invertebrates but also by a few chordates.

The retention of larval characters by the adults is called ***neoteny.*** By this process the larvae develop sexual organs before the completion of other changes to become the adult. Hence these animals are called ***permanent larvae***.

In extreme cases, the animal is able to breed while maintaining its larval form. This phenomenon is called ***paedogenesis*** or ***paedomorphogenesis***. The neotenous animal is said to be ***young but old*** or ***old but young.***

Neotenous Chordates

Neoteny is normally seen in the following amphibians:

1. *Axolotl*
2. *Necturus*
3. *Proteus*
4. *Typhlomolgi*
5. *Siren*, etc.

1. Axolotl

Axolotl is the larva of the ***tiger salamander,*** *Ambystoma tigrinum.* Formerly, *Axolotl* was considered as an ***adult urodele.*** But ***Cuvier*** for the first time stated that it was the larva of an urodele.

Duheril proved that *Axolotl* can metamorphose into a lung-breathing and land dwelling, adult *Ambystoma.*

1. Calotes

Phylum	:	*Chordata*
Subphylum	:	*Vertebrata*
Superclass	:	*Gnathostomata*
Class	:	*Reptilia*
Subclass	:	*Diapsida*
Order	:	*Squamata*
Suborder	:	*Lacertilia*

Calotes versicolor is a true ***land vertebrate***. It is a ***lung breathing***, ***cold blooded***, ***scale-bearing***, ***oviparous***, ***creeping tetrapod***. Hence it is included in the class ***Reptilia***. As this reptile has two pairs of ***pentadactyl limbs***, it is included in the suborder ***Lacertilia***.

Calotes is commonly called ***garden lizard*** because it is commonly available in the garden areas. It is also called ***blood sucker*** but it does not suck the blood. In the case of males, the ***head is bluished red*** and hence the name blood sucker.

It is widely distributed. It spends most of the time on trees. Hence it is an ***arboreal animal***. It is a ***good climber***. It is often seen running swiftly on the ground. It can also swim in water if needed.

It is an ***insectivorous*** animal. It lays eggs hence it is ***oviparous*** in habit.

The body of *Calotes* is divisible into four regions, namely, ***head, neck, trunk*** and ***tail***.

The head is triangular in shape. The anterior end of the head is produced into a projection called ***snout***. The ***mouth*** is situated at the anterior end of the snout. It is bounded by two jaws, namely an ***upper jaw*** and a ***lower jaw***. A pair of ***external nostrils*** is situated dorsal to the mouth. There are ***two eyes*** located behind the nostrils. Each eye is protected by two eyelids, namely an ***upper eyelid*** and a ***lower eyelid***. A transparent membrane covers the eye. It is called the ***third eyelid*** or ***nictitating membrane***. A ***tympanic membrane*** is situated behind each eye.

The neck is short and narrow and it joins the head with the trunk.

The trunk is elongated and sub-cylindrical. The trunk bears two pairs of ***limbs***. The hind limbs are longer than the forelimbs.

The fore limb consists of the upper arm (***brachium***), the fore arm (***antebrachium***) and the hand (***manus***). The hand is further divided into 3 regions, namely a ***wrist*** (***carpus***), a ***palm*** (***metacarpus***) and 5 ***fingers*** each ending in a ***claw***. The first digit is called ***pollex***.

The hind limb consists of the ***thigh*** (***femur***), the ***shank*** (***crus***) and the ***foot*** (***pes***). The foot is further divided into 3 regions, namely an ***ankle*** (***tarsus***), an ***instep*** or ***metatarsus***

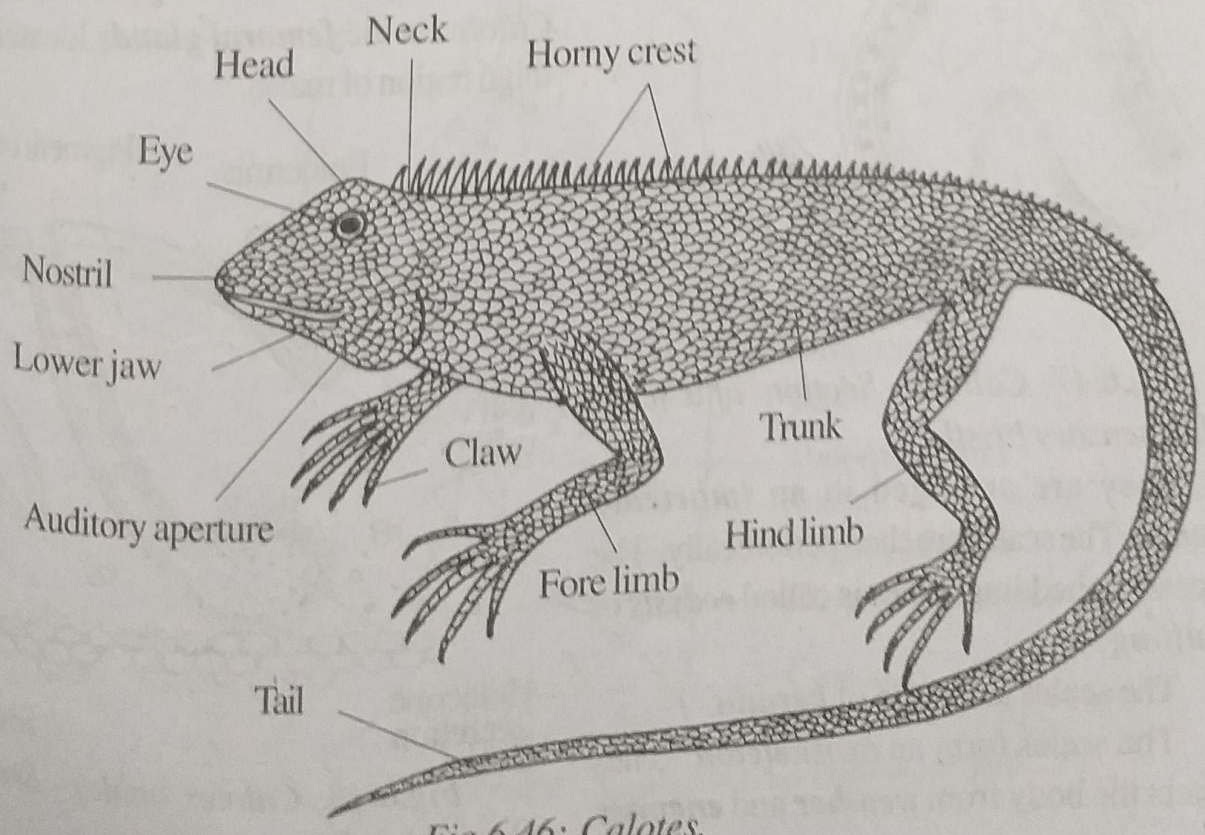

Fig.6.46: Calotes.

and 5 toes each ending in claws. The first digit is called ***hallux***.

The ***tail*** is long and tapering towards the end. On the ventral side of the animal in between the trunk and the tail there is a transverse slit, called the ***cloacal aperture***.

Scales

The entire body of *Calotes* is covered by ***scales***. The scales develop from ***epidermis***. Hence they are ***epidermal*** in origin. The scales are of two types, namely ***larger scales*** and ***smaller scales***. The smaller scales are located at the margin of the larger scales. Some larger scales are provided with a ***sensory bristle*** called ***prototrix***. Scales situated on the mid-dorsal line of *Calotes* are modified into pointed structures called horny ***crest*** or ***frills***.

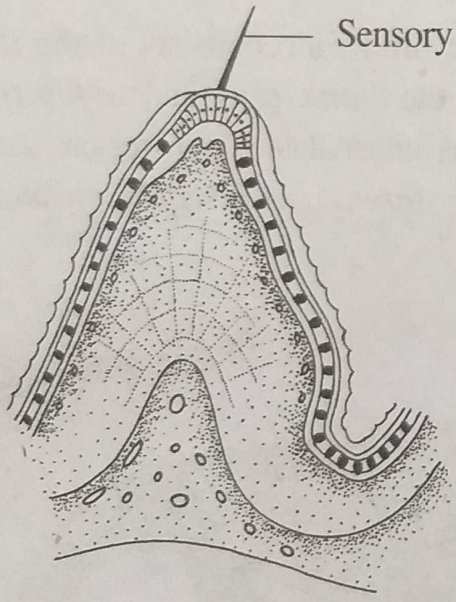

Fig.6.47: Calotes - Section of a scale with a sensory bristle.

They are arranged in an ***imbricate manner***. The scales are shed periodically. The process of shedding scales is called ***ecdysis*** or ***moulting***.

The scales are made of ***keratin***.

The scales form an ***exoskeleton***. They protect the body from ***weather*** and ***enemies***.

Colour Changes

Calotes can change its colour. This ability is brought about by the ***pigment cells*** present in the skin. These pigment cells are called ***chromatophores***.

Skin

The skin is composed of three layers, namely an outer ***epidermis***, a middle ***basement membrane*** and an inner ***dermis***.

The epidermis is thicker and is formed of three layers, namely an outer ***stratum corneum***, an inner ***stratum germinativum (Malpighian layer)*** and a middle ***transitional layer***.

The stratum corneum becomes thickened over the scales, while between the scales this layer remains thin.

The basement membrane is formed of a ***fibrous connective tissue***.

The dermis is thin and it is formed of two layers, namely an outer ***stratum spongiosum*** and an inner ***stratum compactum***.

Most of the skin glands are absent from *Calotes*. The only skin gland available in *Calotes* is the ***femoral glands*** located in the thigh region of males.

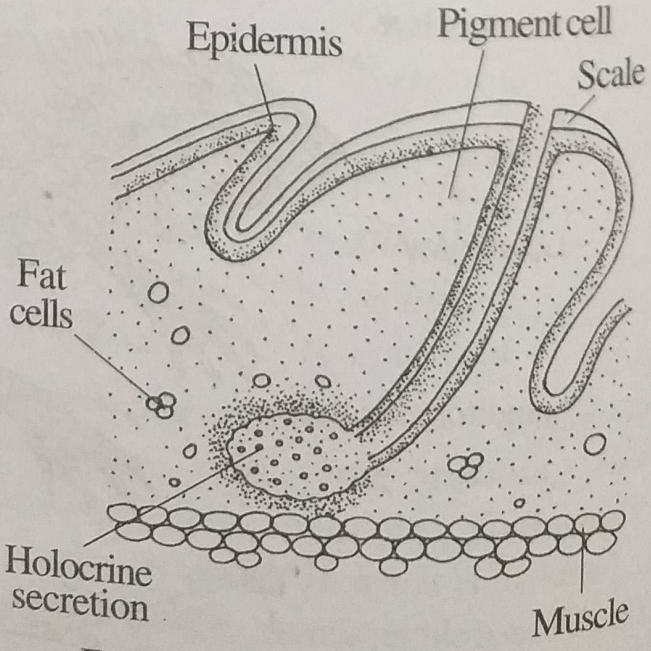

Fig.6.48: Calotes (male) - Section of skin with a femoral organ.

acculus produces a ***finger***-like
called ***lagena*** (rudimentary
t contains a special hearing organ
lla basilaris.

Organs of Jacobson

es has two Jacobson's organ
below each nasal chamber. It is a

trailing prey and in locating the opposite sex.

Excretory System

The excretory system is concerned with the removal of nitrogenous waste products. It is similar in both sexes. It consists of a pair of ***kidneys***, a pair of ***ureters***, an ***urinary bladder*** and an ***urinogenital aperture***.

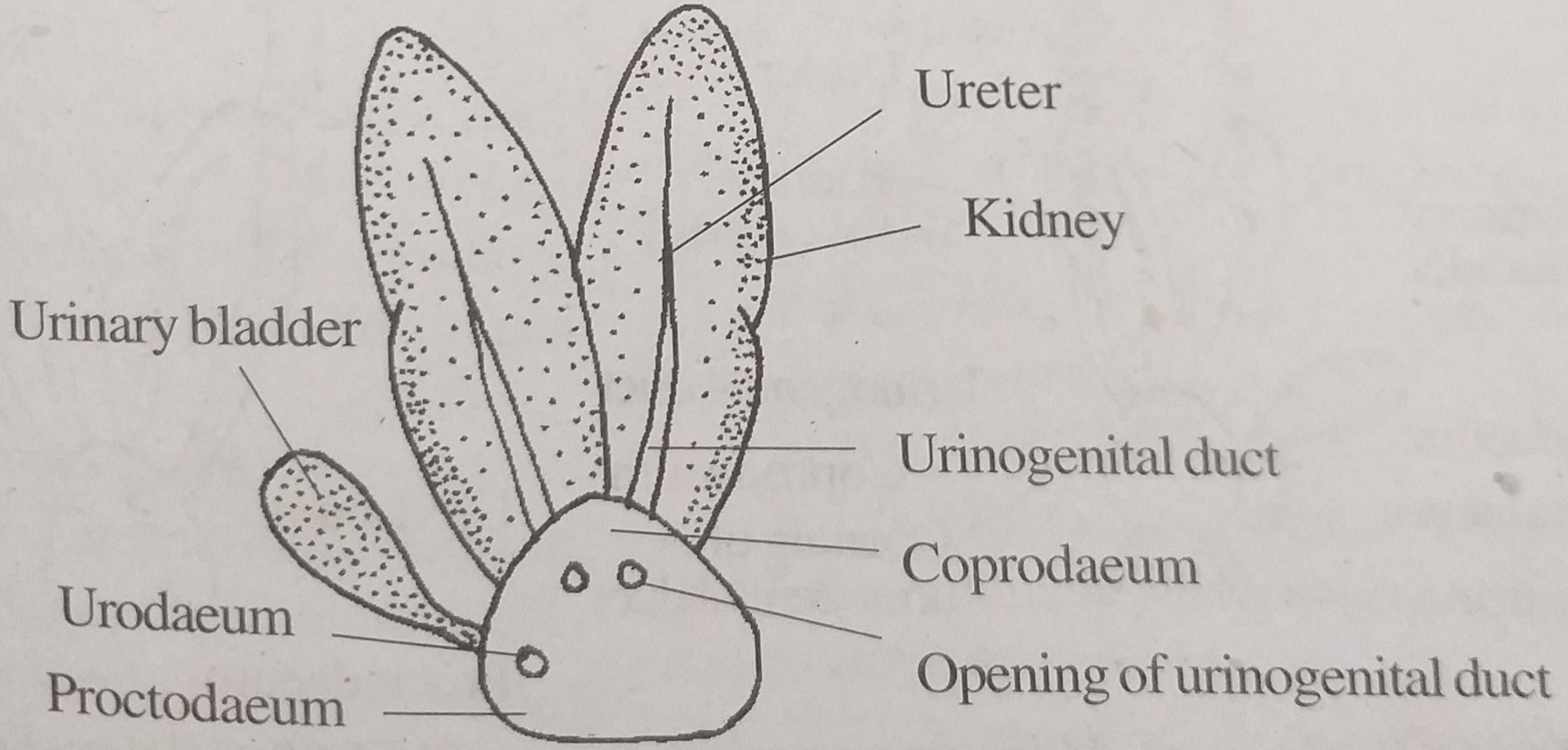

Fig.6.66: Calotes - Urinogenital system.

The kidneys are ***metanephric*** type and are ***dark red*** in colour. They are situated in the abdominal cavity. The kidney is formed of two lobes.

The two kidneys are united posteriorly but free anteriorly. The kidney has a peripheral region called ***cortex*** and a central portion called ***medulla***.

The medulla contains numerous ***uriniferous tubules*** or ***nephrons***. One end of the nephron contains a ***Malpighian corpuscle***. The other end gets connected with a ***collecting duct.***

The collecting ducts of each kidney open into an ***ureter***. The ureter runs backwards and opens into the ***cloaca***. The cloaca contains an ***urinary bladder***.

In the male *Calotes*, the ureter does not open directly into the cloaca. But it opens into the vas deferense to form ***urinogenital duct***. The two urinogenital ducts open into the cloaca.

The urine of *Calotes* is ***semisolid*** in nature and it contains ***uric acid***. Hence *Calotes* is an ***uricotelic animal.***

Reproductive System

In the case of *Calotes*, sexes are separate.

Male Reproductive System

The male *Calotes* has two ***testes***. The right testis is large and is situated slightly anterior to the left testis. The testis is suspended from the body wall by a membrane called ***mesorchium***.

From each testis arise numerous ***vasa efferentia***. All the vasa efferentia of a testis are connected together to form an ***epididymis***. The epididymis is highly coiled and it runs backwards as the ***vas deferens***.

The vas deferens gets connected to the ***ureter*** of the corresponding side. The common duct thus formed is called the ***urinogenital duct***.

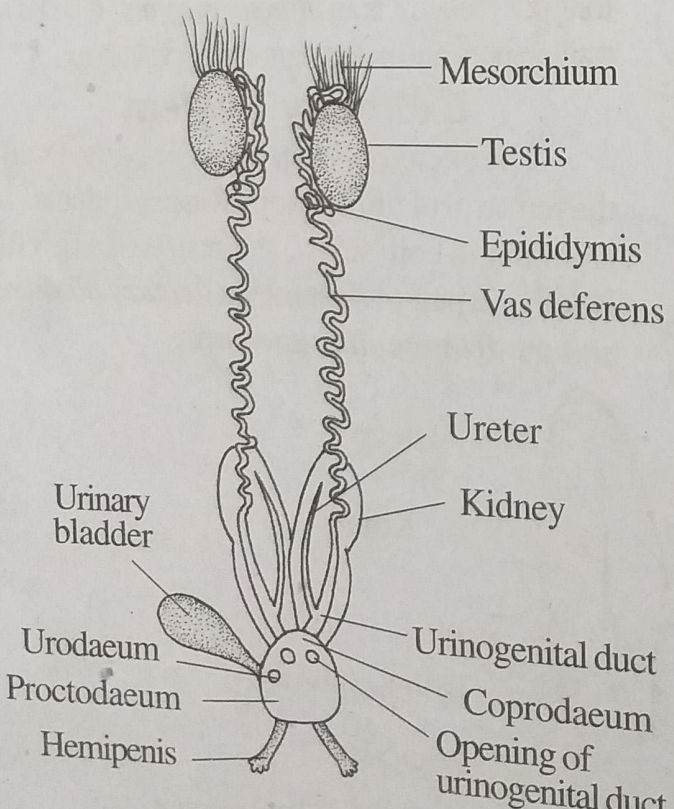

Fig.6.67: Calotes - Male urinogenital system.

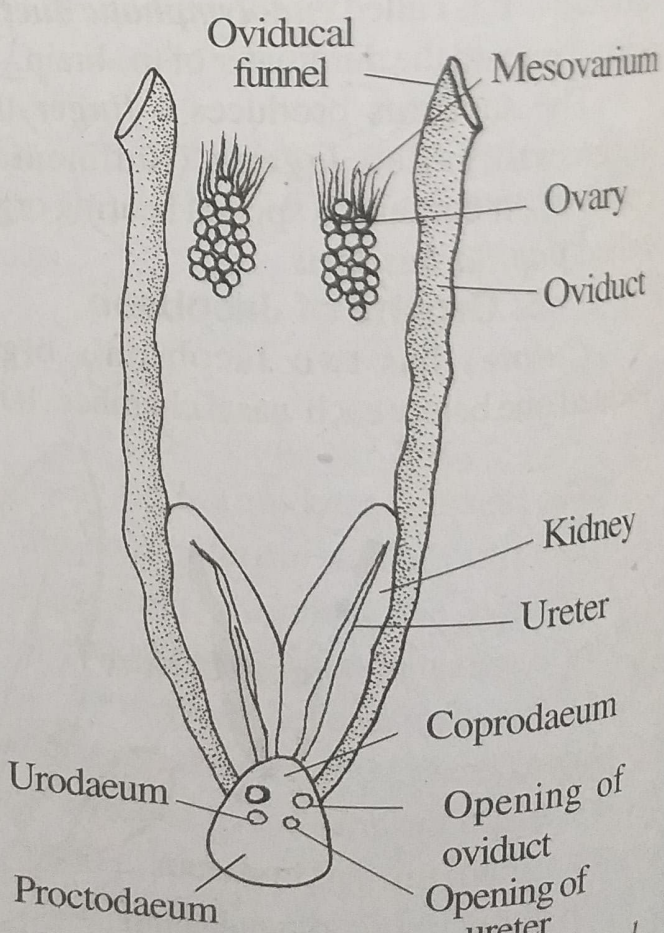

Fig.6.68: Calotes - Female urinogenital system.

The two urinogenital ducts open into the ***cloaca.*** The ***cloaca*** has a pair of ***penes***. They are enclosed in ***copulatory sacs***. Each ***hemipenis*** consists of a ***stalk*** and a ***head*** or ***glans***. The head is large and rounded. The distal end of the hemipenis has spines. A ***longitudinal groove*** extends all along the hemipenis. During copulation the hemipenes are introduced into the cloaca of the female and the semen flows through the groove into the cloaca of the female.

Female Reproductive System

The female *Calotes* has a pair of ***ovaries***. The right ovary is situated slightly anterior to the left ovary. The ovary is attached to the

The egg contains large amount of yolk. Hence it is ***megalecithal***. *Calotes* lays eggs. Hence it is ***oviparous***.

The eggs are hatched with the help of the heat of the environment. The youngones hatched from the egg are resembling the adult. Hence the development is ***direct***.

Skeletal System

The skeletal system is broadly divided into two groups, namely ***axial skeleton*** and ***appendicular skeleton***.

The axial skeleton lies in the long axis of the body. It includes the ***skull***, the ***vertebral column***, the ***ribs*** and the ***sternum***.

The appendicular skeleton lies in the transverse axis and it includes the ***girdles*** and the ***limbs***.

Endoskeleton