D.N.R.COLLEGE (A), BHIMAVARAM

Department of Zoology

Study material

Semester II

Animal Diversity- Biology of Chordates

UNIT-1

LONG ANSWER QUESTIONS

1A1.Define Chordata. Give an account of general characters of Chordates.

Phylum chordata is the largest group of Deuterostomes. Blastopore develop into Anus during embryonic development. Most of the present day Chordates are familiar vertebrates like fishes, amphibians,reptiles,birds and mammals besides marine mammals like Dolphins and Whales. Nearly 49,000 species of chordates are recorded.

Distribution: Chordates are found in the marine waters, fresh water and in the air. Birds and mammals could go and live in the cold climate because they have a constant body temperature (stenothermic).

Important fundamental Chordate Characters:

(1) Notochord

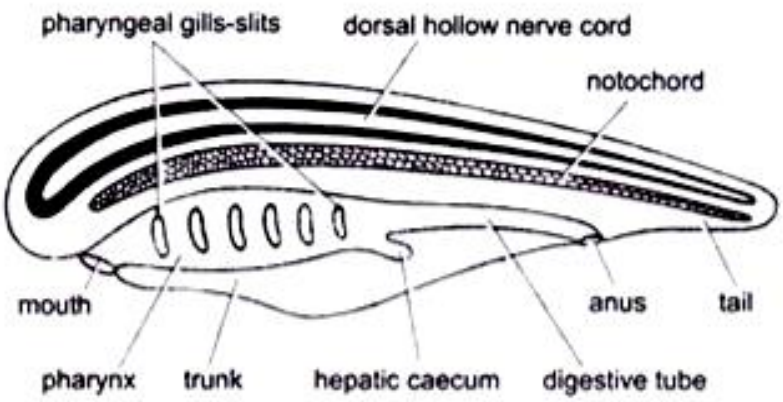
(2) Dorsal tubular nerve cord

(3) Pharyngeal gill slits

(4) Post anal tail

Notochord or chorda dorsalis:

- It develops from the Endodermal layer of embryonic archenteron.
- It consists of large vacuolated notochord cells containing gelatinous matrix.
- It is surrounded by outer fibrous sheath and inner elastic sheath.
- Notochord is present as an elongated rod-like, flexible structure running all along the length of the animal.



- It is situated immediately below the nerve cord and just above the alimentary canal.
- The notochord serves as a supporting internal skeleton which differs with the nerve cord both in its structure and function.
- In Protochordates it is present even in adults but in higher vertebrates it is replaced by vertebral column. Presence of notochord is a fundamental chordate character.

Dorsal Nerve cord:

- Dorsal nerve cord represents the central nervous system of the chordates.
- The nerve cord is a hollow tubular structure which is parallel to the notochord and present above it.
- The hollow cavity of the cord is called as Neurocoel which is derived from the ectodermal neural plate of the embryo. The main function of the nerve cord is to maintain the integration and co ordination of activities of an animal.
- In chordates (Vertebrates) the anterior part of the nerve cord enlarges into a vesicle which forms the brain and the posterior part becomes the spinal cord in the adult, enclosed within the Vertebral column.

Pharyngeal gill slits:

- In all chordates during their developmental stages, just behind the mouth in the pharyngeal wall, series of lateral gill slits or gill clefts are formed and they are termed or named as pharyngeal, branchial and visceral clefts or pouches.
- These structures help in passing out of water from pharynx over the external gills to outside. The water current also helps in filter feeding of the by filtering food particles present in water.
- In protochordates and in all fishes the gill slits are persistent or remain throughout the life carrying aquatic or gill respiration. In higher vertebrates they disappear during developmental stages and modified to acquire pulmonary respiration.
- During early embryonic life of all chordates the above said three characters are present. These characters are rarely persist in the adult chordates (e.g., Branchiostoma) and either modified or lost in the adult stage.
- In many chordates the notochord disappear but the nerve cord and the pharyngeal clefts remain in the adult.

Post anal tail:

It is an extension of the body to the anus. In chordates, the tail is composed of **skeletal muscles** which help in locomotion in fish-like species. It is absent in most of the adult Chordates.

Other characteristics of chordates include

1. Bilaterally symmetrical, triploblastic, coelomic and segmented body.
2. The body design is complex and well-differentiated.
3. The body has an organ system level of organization.

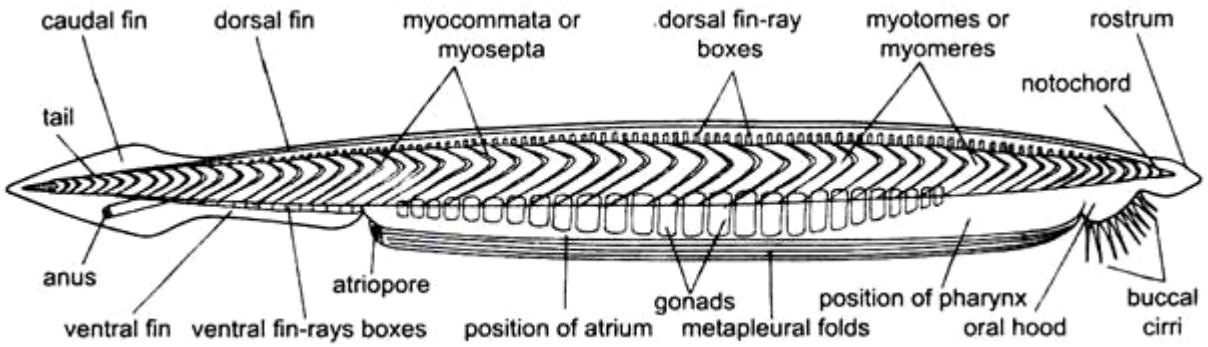
GENERAL CHARACTERISTICS

- Aquatic, aerial or terrestrial all free living with no fully parasitic forms. Bilaterally symmetrical and metamerically segmented.
- Exoskeleton often present well developed in most vertebrates.
- Bodywall triploblastic with 3 germinal layers: ectoderm, mesoderm and endoderm.
- Coelomate animals with a true coelom, enterocoelic or schizocoelic in origin.
- A skeletal rod, the notochord, present at some stage in life cycle.
- Digestive system complete with digestive glands.
- Blood vascular system closed. Heart ventral with dorsal and ventral blood vessels. Hepatic portal system well developed.
- Excretory system comprising proto –or meso-or meta-nephric kidneys.

1A2.List out general characters of Cephalochordates.

Cephalochordates are also called as lancelets (Branchiostoma) - Amphioxus is the sole representative of the subphylum Cephalochordata.

- These are slender, laterally compressed and translucent animals about 5 to 7 cm in length. There are about two dozen species of this genus found distributed all over the world.
- Surface of the body has V-shaped myotomes visible externally.
- It burrows in sand and spends most of its time buried tail down in sand with only its head including the mouth exposed above the surface. During breeding season it usually comes out of sand at night and swims.
- It feeds upon organic particles and small plankton which are brought to the mouth by the inhalant current of water.
- During feeding, the cilia lining the oral funnel create an inhalant current. Water is then drawn into the mouth through a membranous velum which bears twelve short tentacles.



- The current of water passes into a large branchial chamber formed by the pharynx, closely comparable to that of Urochordates.
- The branchial chamber bears gill slits used for breathing.
- The cilia lining the gill slits allow water to enter into a groove on the floor of the branchial chamber known as endostyle The food particles present in the water are trapped by the mucous secreted in the endostyle.
- The mucous then travels through two ciliated grooves to the dorsal side of the pharynx to enter into the intestine. Here the smallest food particles are separated from the mucous and passed into hepatic caecum, where these particles are phagocytized and digested intracellularly.
- The filtered water then passes into atrium and leaves the body by an atriopore similar to the excurrent siphon of tunicates.
- Circulatory system is closed and blood flow pattern is similar to that of primitive fishes, although there is no heart. Blood is pumped forward in ventral aorta,then passed upward through branchial arteries and then to dorsal aortae which terminate into a single dorsal aorta.
- The blood is then served to the body tissues, collected in the veins which return it to ventral aorta. The blood is devoid of erythrocytes and hemoglobin.
- Nervous system consists the nerve cord lying above the notochord. Brain is a simple vesicle at the anterior end of the nerve cord. Pairs of spinal nerve roots emerge at each my metric (muscle) segment of the trunk.
- Sense organs are the unpaired bipolar receptors present in the various parts of the body.
- Excretion is by means of nephritis - a feature not usual in chordates.
- In the lancelets the sexes are separate. Eggs and sperms pass to the exterior through the atriopore.
- Fertilization is external and takes place in water during late spring or early summer.

  Examples: *Branchiostoma (Amphioxus), Asymmetron*.

1A3.Describe the structure of Amphioxus and add a note on affinities.

Systematic Position

Phylum:Chordata
Group:Acrania
Subphylum:Cephalochordata
Class:Leptocardii
Family:Branchiostoma (Amphioxus)

- Amphioxus is a small marine animal found widely in the coastal waters of the warmer parts of the world and less commonly in temperate waters.
- It is more than 8 cm (3 inches) long and resembles small, slender fishes without eyes or definite heads. Amphioxus spends much of its time buried in gravel or mud on the ocean bottom, although they are able to swim.
- When feeding, the anterior part of the body project from the surface of the gravel so that they can filter food particles from water passing through their gill slits.
- Amphioxus is not buoyant, and they sink quickly when they stop swimming. A dorsal fin runs along the entire back, becomes a caudal fin around the tip of the tail, and then continues as a ventral fin; there are no paired fins.
- The notochord runs through the body providing a central support.
- Blood flows forward along the ventral side and backward along the dorsal side, but there is no distinct heart.
- The oral cavity of amphioxus is furnished with a hood whose edges are lined with cirri; these are finger like structures that form a coarse filter to screen out particles too large to be consumed.
- Water is directed through the small mouth into the pharynx by the action of cilia on the gill slits. Food particles in the passing water are caught by the mucous lining of the gill basket and pass into the gut, where they are exposed to the action of enzymes.
- Unlike other chordates, Amphioxus is capable of a digestive process called phagocytosis, in which food particles are enveloped by individual cells.
- Above the pharynx is the excretory system made up of the nephridia, which opens into an excretory canal leading to the atrium.
- The endostyle corresponds to the thyroid in vertebrates, since it seems to produce iodinated, tyrosine molecules, which may function as regulatory substances, much like hormones.

- Breeding takes place several times a year in tropical regions but only once in temperate areas. Sacs containing eggs or sperm burst and discharge their contents into the water through an opening on the underside of the body. Eggs are fertilized in the water, and after about two days microscopic ciliated larvae develop from the fertilized eggs.
- The larvae are carried with ocean currents for several weeks before metamorphosing into juvenile amphioxi and taking up life in sandy sediments.

Affinities of Amphioxus with Mollusca:

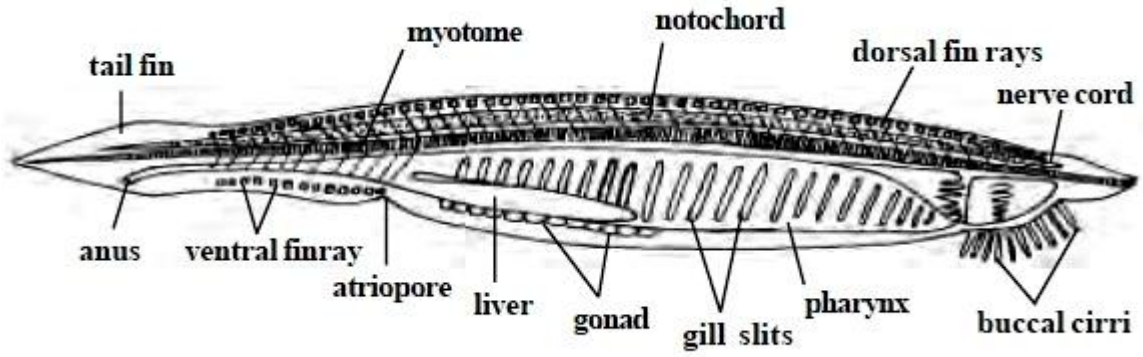
- Molluscs and Branchiostoma differ widely.
- Superficial resemblances in ciliary feeding and respiratory mechanism (no gill slits in molluscs) have no phylogenetic significance.

Affinities of Amphioxus with Echinodermata:

Similarities:

- Early development cleavage, gastrulation and mesoderm formation.
- Three separate enterocoelic cavities.
- The pores of the calyx of some fossil carpoid echinoderms are similar to the gill slits of Branchiostoma.
- Presence of creatine phosphate and phosphagens.

- At present, the echinoderms are not considered as an ancestor of chordates. The similarity is presumably due to a remote common origin of both the groups.



AMPHIOXUS

Affinities of Amphioxus with Hemichordata:

Similarities:

- Pharyngeal apparatus.
- Feeding and respiratory mechanism.
- Origin and development of enterocoelic coelomic pouches.

Affinities of Amphioxus with Urochordata:

Similarities: (Tadpole larva and Amphioxus)

- Body shape and a fin-bearing tail.
- Notochord extends nearly whole body length.
- A hollow nerve cord above notochord.
- Pharynx with endostyle, pharyngeal and epipharyngeal grooves.
- Feeding and respiratory mechanism.

Affinities of Amphioxus with Cyclostomata:

Similarities:(Amphioxus and ammocoete larva):

- Body elongated bearing a continuous dorsal.
- Presence of an oral hood.
- Velum guards the mouth.
- Presence of endostyle.

Affinities of Amphioxus and Cyclostomata:
Similarities:

- Presence of myotomes.
- Presence of gill slits.

Dissimilarities:

- Absence of vertebral column and paired sense organs in Branchiostoma.

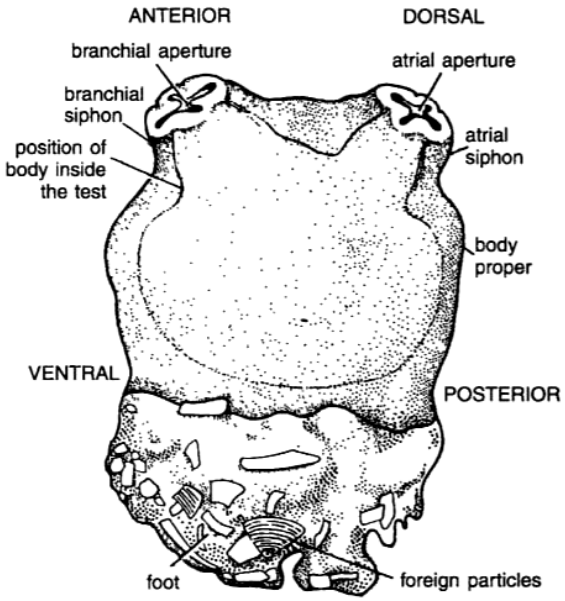
Affinities of Amphioxus with Vertebrata:

Similarities:

- Presence of pharyngeal gill slits.
- Presence of notochord.
- Presence of dorsal, hollow, tubular nerve cord.
- Presence of phosphocreatine and phosphoarginine, the sources of energy supply for muscular activity.

1B1. Give an account of general characters of Urochordates.

- Body shows variation in size and form.
- Urochordates is also called as Tunicates
- These are sessile.
  - ✓ Some are solitary (e.g.Herdmania,Salpa) or
  - ✓ Some are colonial (e.g. Botryllus, Pyrosoma), or
  - ✓ Some are free-swimming and pelagic(Thaliacea).
- These are marine. Body is covered by a tunic, or test composed mainly of tunicine, which is similar to cellulose.True test is absent in Larvacea.
- Body wall shows one-layered epidermis, dermis is made by connective tissue and muscles, and atrial epithehum.
- Notochord is confined to the larval tail and is absent in the adult.
- Dorsal nerve cord is present in larval stage. It is reduced to dorsal ganglion in the adult.
- Branchial aperture leads into the pharynx.
  - ✓ Pharynx is large in Ascidia and
  - ✓ Relatively smaller and has fewer gill slits in Thaliacea.
- Coelom is absent. An ectoderm-lined cavity called atrium surrounds the pharynx. Gill-slits, anus and genital ducts open into atrium which opens out by an atrial aperture.
- Endostyle, present on the ventral wall of the pharynx, helps in filter-feeding.
- Circulatory system is of open type. Heart is tubular and is unique in reversing the blood flow periodically. Thus the heart functions alternately as systemic heart and branchial heart.
- In some forms, certain blood corpuscles called vanadocytes contain vanadium chromogen, a respiratory pigment having vanadium extracted from sea water.
- Excretion is by neural gland, nephrocytes etc.
- Some Urochordatans exhibit Bioluminescence.Ex:Pyrosoma
- They are hermaphroditic. Fertilization is cross and external.
  Development includes a tailed larval stage that undergoes
  - ✓ Retrogressive metamorphosis as in Herdmania,
  - ✓ Alternation of generations occurs in Salpa and Doliolum and
  - ✓ Larvaceans are paedomorphic, i.e. the sexually mature form retains larval form of their ancestors.

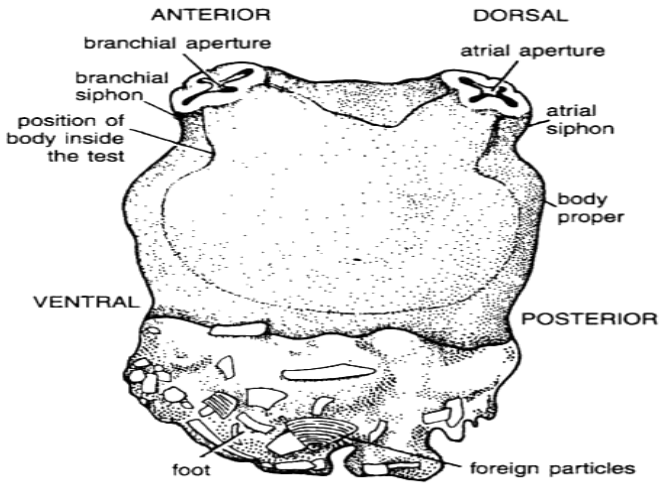


1B2. Explain the structure of Herdmania.

Shape, Size and Colouration:

The body of Herdmania pallida is oblong in outline, narrower at its attached than at its free end, with two external openings—the branchial and atrial apertures. The average size of the adult is about 9.5 cm long, 7 cm broad and 4 cm thick.The foot has a length of 3 to 4 cms.

Bright red patches, formed of ampullae are present in the blood vessels of the test. The test is soft and leathery. It is transparent in a young animal, but in an adult becomes opaque.



Body Divisions:

The body is divided into two parts, body proper and foot, and the entire animal is covered by the test.

1. Body Proper
2. Foot

1.Body Proper:

- It is the distal free portion of the body. The branchial aperture marks the anterior end of the animal; the opposite end attached to the substratum is the posterior end.
- The side on which the atrial aperture is placed marks the dorsal side of the body. The side opposite to that on which the atrial opening is placed is ventral side.
- The branchial and atrial apertures are situated on short protuberances of the body called branchial and atrial siphons respectively. When fully extended, the atrial siphon is longer than the branchial.
- In a large-sized animal the atrial siphon measures about 1.5 cm, while the branchial siphon is only about 1 cm in length.
- The atrial siphon is almost always directed upwards, the atrial aperture being more or less upright, while the branchial siphon is always bent a little outwards and the branchial aperture opens more or less laterally, always directed away from the atrial aperture.
- At the base of branchial siphon,a ring of long branchial tentacles and at the base of the atrial siphon a ring of atrial tentacles are present.
- The test of the siphons is very elastic and can contract to close the apertures at the slightest disturbance of sea water.

2. Foot:

- The foot, when present varies in character according to the nature of the substratum which the animal inhabits.
- If the substratum is of fine sand, the foot has an oval shape and a smooth surface and the test is quite hard in consistency. But if the substratum

consists of coarse and the broken shell-pieces, the foot is irregular in outline and more or less soft in consistency.

Test or Tunic:

- Body of the animal is covered by test or tunic composed of tunicine, a substance similar to cellulose of plants.
- The foot is made entirely of test. It acts as a receptor as well as a respiratory organ. It is about 4-8 mm thick. It is ectodermal in origin.

The test has,

(1) Matrix
(2) Cells of various shapes,
(3) Interlacing fibrils,
(4) Calcareous spicules, and
(5) Branching vascular vessels.

Matrix:
It is gelatinous and made of a polysaccharide called tunicine.

Cells:
These are mesodermal in origin and have migrated into the test.Eosinophilous, granular, amoeboid and nerve cells are present.

Interlacing fibrils:
These form a fine network in the test and resemble with smooth muscle fibres.

Blood vessels:
These blood vessels form a network in the test and end in bulb-like dilations called vascular ampullae. The vascular ampullae form vascular areas of bright red patches on the test. Vascular vessels and ampullae transport blood and, thus bring food to the test; they also act as accessory respiratory organs. The ampullae are also receptor organs.

Spicules:

There are two types of spicules found in the body- small microscleres and large megascleres. They are all calcareous and have a definite shape.

Microscleres:

- The microscleres are found only in the test and lie scattered throughout its substance. Each spicule consists of a rounded knob-like head and an elongated tapering body.
- The head has few spines on its sides and the body bears a large number of rings of spines.
- These rings of spines run round the body of the spicule, nearly equidistant from one another. The spines always pointing towards the head of the spicule.
- The size of the spicule varies according to the stage of its growth, the average size being 50 microns, while very large ones measure about 80 microns.

2. Megascleres:

The megascleres are of two kinds:

(i) Spindle-shaped and

(ii) Pipette-shaped spicules.

Both these types of spicules are much larger than the microscleres.

The spindle-shaped spicules are lie scattered throughout the body of the animal; but they are regularly arranged in the posterior half of the test.

They are also very abundant in the mantle, very dense in the region of the stomach and the gonads and also at the bases of siphons, and are quite well represented in the intestine but are less at the base of the longitudinal muscles.

The pipette-shaped spicules are larger than those of the spindle-shaped.The characteristic feature of each spicule is the presence of a large spherical swelling in the middle which gives it the shape of a pipette when it is straight.

They are more in the mantle, specially in the region of the gonads and lobes of the liver.

The spicules keep the test firmly attached to the mantle and stiffen the walls of the vessels and prevent their collapse.

Mantle or Body Wall:

Inside the test is the body wall or mantle. The mantle secretes the test.

The mantle encloses a large atrial cavity or Prebranchial zone atrium, containing water. Histologically the mantle has an outer layer of ectoderm, middle layer of mesoderm, and an inner layer of endoderm forming the outer lining of atrial cavity.

1. Outer Ectoderm:
It is formed of a single layer of flat, hexagonal cells. It turns inside at pericardium the branchial and atrial apertures and extends up to the base of the siphons forming stomodaeum and proctodaeum respectively.

2. Inner Ectoderm:
It is formed of single layer of flat polygonal cells and forms the lining of the atrium.

3. Middle Mesoderm:
It lies beneath the outer ectoderm. It is composed of connective tissue traversed by muscle fibres (annular muscles longitudinal muscles and Branchioatrial muscles), blood sinuses and nerve fibres.

1B3. What is Retrogressive metamorphosis? Discuss with special reference to the life history of Herdmania.

Retrogressive Metamorphosis: The type of metamorphosis which shows degeneration from larva to adult is called as retrogressive metamorphosis. It is because sedentary mode of life of the adult.

The free swimming life of the tadpole larva is very short (about 3 hours) and in that period it does not feed.

It is negatively geotrophic and positively phototrophic and swims in the surface sea water. Later it becomes positively geotrophic and negatively phototrophic by settling down to the bottom and becomes sedentary.At this stage the larva exhibit upside-down posture. Rapid metamorphosis takes place after an hour of its attachment to a substratum by undergoing the following morphological changes.

Retrogressive changes

(1) A part of the tail is cast off and the remaining part of it is gradually absorbed by phagocytes.

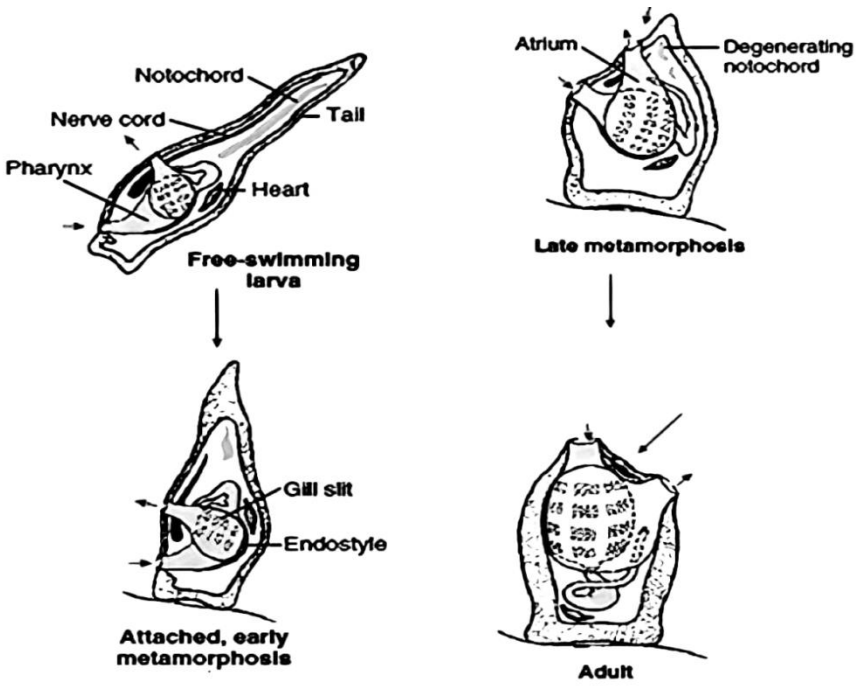
(2) Notochord, nervecord and tail muscles are slowly withdrawn into the main body where it is eaten away by the phagocytes.

(3) The ectodermal cells of the larva secrete a test or Tunic made up of Tunicine ($C_6H_{10}O_5$) which forms an outer covering.

(4) The pharynx enlarged to form a branchial sac, the number of stigmata increase.

(5) Stomach becomes large and tubular

(6) Intestine increase in length and the lobes of the liver make their appearance



(7) The ectodermal layer at the four corners of the attached an terior end of the body grows out into prominent ectodermal ampullae covered by the test

(8) Adhesive papillae disappear

(9) Larval sense organs like ocelli and otocyst and sensory vesicle disappear.

(10) Anterior region between point of attachment (adhesive papillae) and mouth shows rapid growth, while original dorsal side with atriopore stops growth. This causing shifting of mouth through 90°. Therefore the final position of branchial and atrial apertures in the adult represents the original anterior and dorsal sides of larva.

(11) Reproductive organs begin to form in the loop of the intestine.

(12) The muscular system breaks down and the muscle cells are absorbed by the phagocytes.

As a result of the above changes a sedentary adult ascidian is developed from a free swimming tailed larva.

The significant point about the ascidian metamorphosis is that the larva loses almost all the important chordate characters in the process.

This type of metamorphosis in which the adult, instead of acquiring advanced characters, loses important structures and appears as a degenerated form is known as Retrogressive metamorphosis.

The important chordate characters that are lost during the retrogressive metamorphosis of tadpole larva are as follows:

(1) Complete disappearance of tail and notochord.

(2) Complete loss of sensory vesicle, sense organs and the hollow nerve cord.

(3) Enlargement of the branchial sac and increase in the gill slits (stigmata)

(4) Loss of metameric segmentation due to the disintegration of tail muscles of the larva

(5) The body undergoes rotation thereby losing its bilateral symmetry.

Progressive changes :

Some larval structures necessary for survival become more elaborated and specialized in the adult. They are:

(1) Due to loss of tail, the trunk becomes pear shaped and four ectodermal ampullae grow out of its four corners and help in attachment of the metamorphosing tadpole to the substratum. They also help in respiration as a blood like fluid keeps circulating through them.

(2) Adult neural gland and nerve ganglion formed by neural tube and trunk ganglion come to lie mid-dorsally between mouth and atriopore. The trunk ganglion itself persists as visceral nerve.

(3) Due to absorption of test covering the mouth, the mouth becomes functional and exhibit ciliary mode of feeding.

(4) Pharynx increases in size, develops blood vessels and stigmata increase in number forming a branchial sac.

(5) Stomach enlarges, intestine increases in length and liver lobes develop.

(6) Atrial cavity increases in size.

(7) Heart and pericardium develop and definite circulatory system is established.

(8) The entire animal body is covered by Test or Tunic.

Significance of Ascidian tadpole:

The presence of Tadpole larva in the life history of Herdmánia and in other ascidians is significant in the following ways:

1. Taxonomic significance : The Tadpole larva of ascidian exhibit true chordate characters like, notochord, dorsal tubular nerve cord which are absent in the adult. This shows that ascidian Tadpole gives an evidence for the inclusion of ascidian under chordata group

2. Phylogenetic significance: According to the Recapitulation theory (Haeckel) the Tadpole larva is considered as a relic of the free swimming ancestral vertebrates.

3**. Dispersal:** The adult ascidian is a sedentary form, the free swimming habit of the larva provides the only means of dispersal and survival of the race.

SHORT ANSWER QUESTIONS

6. a) Affinities of Amphioxus

Affinities of Amphioxus with Hemichordata:

Similarities:

- Pharyngeal apparatus.
- Feeding and respiratory mechanism.
- Origin and development of enterocoelic coelomic pouches.

Affinities of Amphioxus with Urochordata:
Similarities:(Tadpole larva and Amphioxus)

- Body shape and a fin-bearing tail.
- Notochord extends nearly whole body length.
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Affinities of Amphioxus with Cyclostomata:

Similarities:(Amphioxus and ammocoete larva):

- Body elongated bearing a continuous dorsal.
- Presence of an oral hood.
- Velum guards the mouth.
- Presence of endostyle.

Affinities of Amphioxus and Cyclostomata:
Similarities:

- Presence of myotomes.
- Presence of gill slits.

Dissimilarities:

- Absence of vertebral column and paired sense organs in Branchiostoma.

Affinities of Amphioxus with Vertebrata:

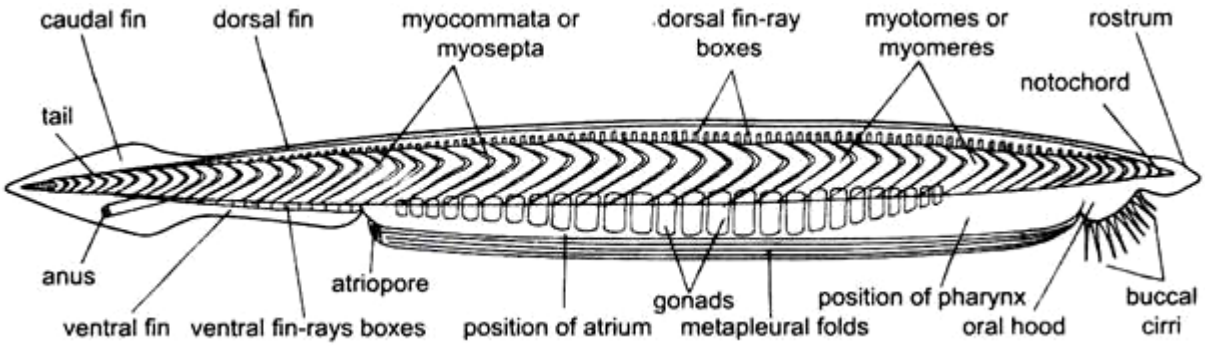
Similarities:

- Presence of pharyngeal gill slits.
- Presence of notochord.
- Presence of dorsal, hollow, tubular nerve cord.
- Presence of phosphocreatine and phosphoarginine, the sources of energy supply for muscular activity.

6.b) General characters of Cephalochordates

- This includes lancelets. These are marine forms.
- Body is small, fish-like and translucent. Median fins are present. Paired fins are absent. Dorsolateral muscles are thick and segmented into myotomes.
- Notochord extends from the posterior end to the anterior end of the body, beyond the nerve cord. All the fundamental chordate characters are retained throughout life.
- Special respiratory organs are absent. Exchange of respiratory gases occurs by diffusion.Enterocoelom is present.
- Pharynx is surrounded by atrium into which gill-slits, protonephridia and gonads open. Endostyle is present on the ventral wall of the pharynx.
- Circulatory system is of closed type. Heart, blood corpuscles and respiratory pigment are absent.
- Excretory organs are paired protonephridia with solenocytes.

- Sexes are separate. Many pairs of gonads, without gonoducts, are present. Fertilization is external. Development is indirect and includes a ciliated free-swimming larva.
- Examples: Branchiostoma (Amphioxus), Asymmetron.



Amphioxus

6.c) Structure of Herdmania

Shape, Size and Colouration:

Herdmania pallida is oblong in outline, narrower at its attached than at its free end,with two external openings—the branchial and atrial apertures. Bright red patches are present in the blood vessels of the test.The test is soft and leathery. It is transparent in a young animal, but in an adult becomes usually opaque.

Body Divisions:

The body is divided into two parts, body proper and foot, and the entire animal is covered by the test.

1.Body Proper
2.Foot

1.Body Proper:

- It is the distal free portion of the body. The branchial aperture marks the anterior end of the animal; the opposite end attached to the substratum is the posterior end.

- The side on which the atrial aperture is present on the dorsal side of the body. The atrial opening is placed is ventral side.

- The branchial and atrial apertures are situated on short protuberances of the body called branchial and atrial siphons respectively. When fully extended, the atrial siphon is longer than the branchial.

- The atrial siphon is almost always directed upwards, the atrial aperture being more or less upright, while the branchial siphon is always bent a little outwards and the branchial aperture opens more or less laterally, always directed away from the atrial aperture.

- The test of the siphons is very elastic and can contract to close the apertures at the slightest disturbance of sea water.

2. Foot:

- The foot, when present varies in character according to the nature of the substratum which the animal inhabits.

- If the substratum is of fine sand, the foot has an oval shape and a smooth surface and the test is quite hard in consistency. But if the substratum consists of coarse and the broken shell-pieces, the foot is irregular in outline and more or less soft in consistency.

Test or Tunic:

- Body of the the animal is covered by test or tunic composed of tunicine, a substance similar to cellulose of plants.

- The foot is made entirely of test. It acts as a receptor as well as a respiratory organ. It is about 4-8 mm thick. It is ectodermal in origin.

The test has,

Matrix:
It is gelatinous and made of a polysaccharide called tunicine.

Cells:

These are mesodermal in origin and have migrated into the test

Interlacing fibrils:
These form a fine network in the test and resemble with smooth muscle fibres.

Blood vessels:
These blood vessels form a network in the test and end in bulb-like dilations called vascular ampullae. The vascular ampullae form vascular areas of bright red patches on the test.

Spicules:

There are two types of spicules found in the body- small microscleres and large megascleres. They are all calcareous and have a definite shape.

Microscleres:

- The microscleres are found only in the test and lie scattered throughout its substance. Each spicule consists of a rounded knob-like head and an elongated tapering body.

- The head has few spines on its sides and he body bears a large number of rings

- These rings of spines run round the body of the spicule.

2. Megascleres:
The megascleres are of two kinds:

The spindle-shaped spicules are lie scattered throughout the body of the animal.They are very abundant in the mantle ,very dense in the region of the stomach and the gonads

The pipette-shaped spicules are larger than those of the spindle-shaped. They are more in the mantle, specially in the region of the gonads and lobes of the liver.

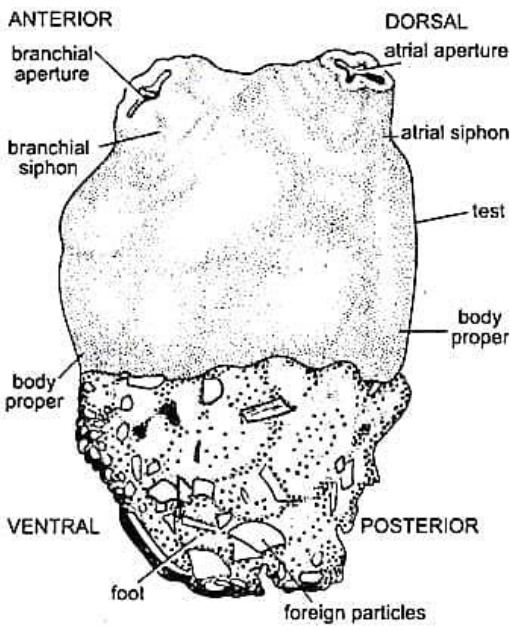
Mantle or Body Wall:

The mantle secretes the test. The mantle is attached only at the branchial and atrial apertures where it forms branchial and atrial siphons.

The mantle encloses a large atrial cavity, containing water. The mantle has an outer layer of ectoderm, middle layer of mesoderm, and an inner layer of endoderm forming the outer lining of atrial cavity.

1. Outer Ectoderm: It is formed of a single layer of flat, hexagonal cells.
2. Inner Ectoderm: It is formed of single layer of flat polygonal cells and forms the lining of the atrium.

3. Middle Mesoderm: It is composed of connective tissue traversed by muscle fibres, blood sinuses and nerve fibres.



Herdmania pallida. External features.

UNIT II

LONG ANSWER QUESTIONS

2A1.List out the differences between Petromyzon and Myxine.

Petromyzon	Myxine
1. Petromyzon live in rivers and seas.	1. Myxine is exclusively marine.
2. Petromyzon have two unpaired dorsal fins and a tail fin.	2. The fin of Myxine is confined to tail.
3. Sensory structures in the complex, slimy, pigmented skin.	3. Numerous large glands are present in the complex slimy skin of Myxine.
4. Buccal funnel is present in Petromyzon, surrounded with papillae.	4. Buccal funnel is absent in Myxine. The mouth is edged with tentacles supported by cartilage.

5. Teeth many, yellow and horny. The tongue also bears horny teeth.	5. A single median tooth and two rows of smaller teeth present on the tongue.
6. Eyes are hidden and retarded in the larva, exposed and complete in the adult Petromyzon.	6. Eyes of Myxine are hidden and rudimentary.
7. Seven pairs of gill pouches, opening directly to the exterior and less directly into the adult gullet.	7. Six pairs of gill pouches opening directly into the gullet and less directly to the exterior.
8. Ear of Petromyzon is more complex and has a sacculus in addition.	8. Ear with an utriculus and two semicircular canals.
9. The nostril unpaired, dorsal and ends blindly in the pituitary sac.	9. The nostril large, unpaired, dorsal and opens into the pharynx through a passage, the pituitary sac.
10. A velum guards the respiratory tube from the buccal cavity.	10. A velum separates the buccal cavity from the pharynx.
11. The intestine is without convolution. Typhlosole and slight spiral valves present.	11. The intestine of Myxine is very wide and bears longitudinal ridges.
12. A urinogenital sinus and two genital pores.	12. No urinogenital sinus, only one genital pore.
13. Skull of Petromyzon is very imperfectly roofed.	13. Skull of Myxine is without any roof.
14. Hints of vertebral arches, cartilaginous branchial basket round gill pouches.	14. Skeletal system of Myxine is less developed, only a hint of a branchial basket.
15. All the components of the brain are distinct and well-marked.	15. Cerebrum and cerebellum rudimentary.
16. Sexes are separate in Petromyzon.	16. Protandrous,hermaphrodite.
17. Ova of Petromyzon is small and spherical, threads.	17. Ova of Myxine is large and oval with attaching threads.
18. Cleavage holobastic.	18. Cleavage meroblastic in Bdellostoma.

19.Development with a meta - morphosis.	19. Development is direct in Bdellostoma.

2A2.Describe the digestive system of Scoliodon.

The digestive system of scoliodon consists of the alimentary canal and the digestive glands. The alimentary canal starts with the mouth and terminates in the anus.

Mouth:

Mouth is a ventral crescentic opening guarded by upper and lower lips which are folds of integument.

Buccal Cavity:

The mouth leads into buccal cavity. It is bordered with jaws. The buccal cavity is raised into tongue.The teeth are all alike in shape, homodont and polyphyodont.The teeth are used to catch the prey and prevent its escape but not to crush or masticate it.

Pharynx:

The buccal cavity opens into pharynx. The pharynx on either lateral side have five internal gill-slits of gill- pouches.

Oesophagus:

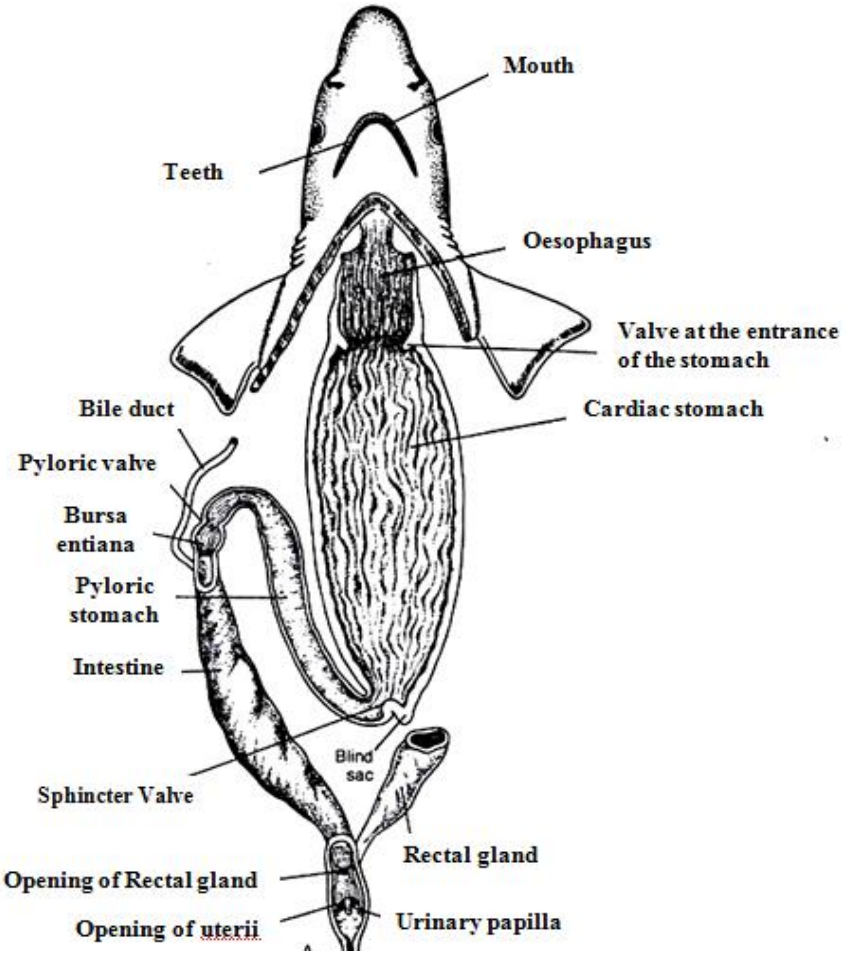
The pharynx narrows posteriorly to form the short and wide oesophagus. The oesophagus has thick muscular walls.

Stomach:

The oesophagus widens posteriorly to form the large muscular stomach. The stomach is divided into cardiac stomach and pyloric stomach.

At the junction of cardiac and pyloric limbs there are blind sac and sphincter valve. The oesophageal opening into the cardiac stomach is guarded by an oesophageal valve.

At the end of pyloric stomach there is a muscular bursa entiana. The opening of pyloric stomach into the bursa entiana is guarded by the pyloric valve.



DIGESTIVE SYSTEM OF SCOLIODON

Intestine:

The bursa entiana continues into the intestine. The internal mucous living of the intestine is folded anti-clockwise to form scroll valve.

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

Rectum:

Rectum is the last part of the alimentary canal. The tubular rectal (caecal) gland opens into the rectum. Its function is not known. The rectum opens into the cloaca through anus. Into the cloaca also open the urinogenital ducts.

Glands of the Alimentary Canal:

The glands of alimentary canal (digestive glands) are liver and pancreas.

Liver, Rectal Gland, and Spleen:
The liver consisting of two lobes which are united anteriorly and separated at the posterior end. The right lobe of the liver carries a V-shaped thin-walled sac, the gall bladder, which stores the bile secreted by the liver.

The gall bladder communicates with the anterior end of the intestine through bile-duct. The liver produces bile, stores glycogen and fat. It also destroys worn-out red blood corpuscles since Kupffer cells are present.

Pancreas:
The pancreas is bilobed gland situated in between the cardiac and pyloric stomach. It consists of dorsal lobe running parallel to the posterior part of the cardiac stomach and a ventral lobe lying closely applied to the pyloric stomach. The pancreatic duct opens into the intestine just opposite to the opening of the bile-duct.

Rectal Gland:
The rectal or caecal gland arising from the dorsal wall of the rectum. It is richly vascularised and formed of lymphoid tissue. It discharges a fluid into the intestinal lumen but the physiological effect of the fluid is unknown.

Spleen:
It is a large lymphoid organ attached with the cardiac and pyloric stomach. It produced lymphocytes and, thus, has no physiological relation with the alimentary canal.

2A3.Explain the structure of gill and mode of respiration in Scoliodon.

Respiratory system in Scoliodon:

Scoliodon is an aquatic Elasmobranch fish living in sea water. It depends upon the dissolved oxygen present in sea water for respiration. This respiration is aquatic and carried on entirely by gills, since the skin is impermeable due to the presence of scales.

Respiratory organs-Gills

- The respiratory organs in scoliodon consist of 5 pairs of gill pouches containing gills.
- In the adult five gill pouches are present on either side in the lateral wall of pharynx.

- Each gill pouch is open into pharynx by a large internal branchial aperture. Gill pouch open to outside by a narrow vertical external branchial aperture or gill slit.
- Gill slits are separated from each other by Interbranchial septum or Gill septum containing blood vessels and nerves.
- The Gill septa are covered on either side by mucous membrane. The Interbranchial septa are supported by cartilagenous branchial arch.
- The mucous membrane of the branchial septa is raised into Branchial lamellae or Gill lamellae or Gill filaments. These constitute the gill proper and richly supplied with blood capillaries of afferent and efferent branchial vessels.

Each Inter branchial septum has two sets of gill lamellae, one on the anterior and the other on the posterior face of the septum. The posterior lamellae are longer than the anterior lamellae.

If an inter branchial septum is having two sets of lamellae, such gill is called as **Complete gill or Holobranch.**

A single set of gill lamellae considered as Half gill or **Demibranch** or **Hemibranch.** The posterior demibranch of a septum has longer lamellae than those of the anterior demibranch. Thus a branchial pouch will have a posterior demibranch of one gill and the anterior demibranch of succeeding one.

Thus in scoliodon a demibranch formed by the posterior face of the Hyoid arch and four helebranchs formed in the first four branchial arches are present.

The fifth gill arch is gillless, hence called as **Abranch**.

The gills of scoliodon are described as **Lamelliform** as their lamellae are attached to the septa by the entire length.

In scoliodon Vestigeal gill pouch is present.In other elasmobranch fishes the vestigeal gill contains minute gill lamellae, hence it is called as False gill or pseudobranch.

Each Interbranchial seplum is extended into a thin external branchial flap. It is provided with vertical and horizontal muscles.The vertical muscle helps in contraction of pharynx. The horizontal muscle helps in the contraction of branchial septum.

Respiratory mechanism:

Respiration is a continuous process. During respiration, the water from outside enter through the mouth, passes through internal gill slits over the gill lamellae and passes

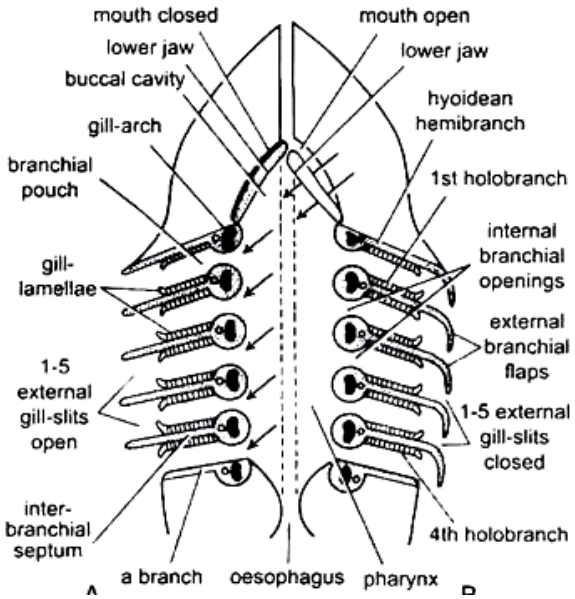
out through the external gill slits. Respiration takes place in two stages i.e. Inspiration and expiration.

Inspiration

During inspiration the coraco mandibular, coraco hyal and coraco branchial muscles contract so that the **mouth is wide open**, floor of the buccal cavity is depressed and the floor of the pharynx is lowered. Simultaneously the **external branchial apertures are closed.** Because of the **reduced pressure** in the enlarged buccal and pharyngeal cavities, the water from outside will enter through the mouth into the Bucco- pharyngeal cavity.

Expiration

The mouth is closed by the contraction of the adductor mandibular muscles. **External branchial apertures are opened**.The space inside the pharyngeal cavity will be reduced by the contraction of constrictor muscles. This **increases the internal pressure** and forces the water through the internal branchial apertures into the branchial pouches from there to outside through the external branchial apertures or gill slits.



During respiratory activity the oesophagus is kept closed and prevent entry of water into the stomach, Pharynx acts as a sort of force pump. At intervals the direction of the respiratory water current is violently reversed in order to clear the branchial lamellae of foreign particles.

Physiology of respiration:

Afferent branchial and efferent branchial arteries play an important role in oxygenation of blood. Afferent branchial arteries bring venous blood to the gill lamellae and efferent branchial arteries will carry arterial blood (oxygenated) from the gill lamellae.

Each gill lamella is having large number of sinusoids which receive venous blood from an afferent branchial artery and pass it on to an efferent artery.

While the venous blood is passing through the net work of blood capillaries, it becomes oxygenated. Fresh sea water that enter into the pharyngeal pouch contain nearly 3-5% of dissolved oxygen. This oxygen passes by endosmosis through the thin membranous and permiable blood capillary walls into the venous blood.

At the same time carbondioxide (CO_2) of venous blood passes out by exosmosis into out going or excurrent of water. This process is external respiration.

As this oxygenated blood is passing through the blood vessels in the body, its oxygen is used by tissues and body cells to oxidise reserve food materials and CO_2, thus formed is given to blood as such the blood again becomes venous blood.

This blood is carried away finally by afferent branchial arteries to the gill pouches. This process is called **internal respiration.**

2B1.Explain the structure of Heart and course of blood circulation in Scoliodon.

The circulatory system of scoliodon consists of blood, the heart, the arteries and the veins.

Blood

The blood consists of colourless plasma and corpuscles of two types the RBC and the WBC. Haemoglobin is present in the erythrocytes. The leucocytes are amoeboid in structure.

Heart

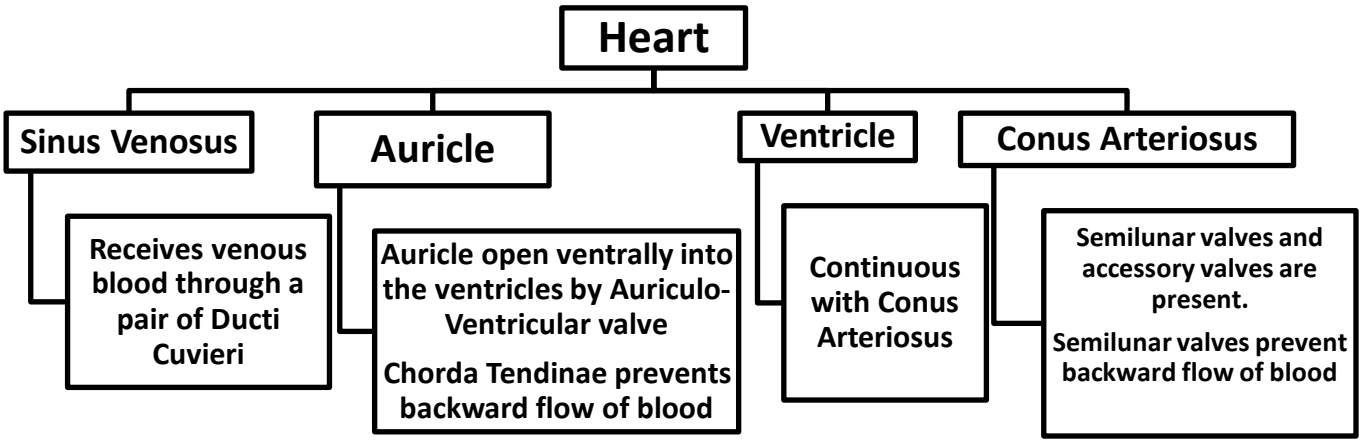
Heartconsists of sinus venosus,auricle,ventricle and a conus arteriosus . The heart is situated on the ventral side of the body between two series of gill pouches.

Sinus Venosus

It is a thin-walled tubular chamber,beating of the heart originates from this part. Two veins, the ductus Cuvieri, open into the sinus venosus, one on each lateral side. Two hepatic sinuses enter the sinus venosus posteriorly. The sinus venosus opens into the auricle by sinuauricular aperture which is guarded by a pair of valves.

Auricle

It is a large, triangular chamber situated dorsal to the ventricle.The auricle communicates with the ventricle through a slit-like auriculo-ventricular aperture guarded by two lipped valves.



Ventricle

It has a very thick muscular wall. Its inner surface gives many muscular strands.

Conus arteriosus

Conus arteriosus is a muscular tube arising from the ventricle.The lumen of the conus arteriosus is provided with two semilunar valves.The free ends of the valves are attached to the ventricular wall by chordae tendinae. The conus arteriosus is continued forward as the ventral aorta.

Arterial System

The arterial system of Scoliodon is divided into afferent branchial arteries arising from the ventral aorta which bring the deoxygenated blood to gills for oxygenation and the efferent branchial arteries which originate from gills and convey the oxygenated blood to the different parts of the body.

Ventral aorta and Afferent branchial arteries:

The ventral aorta is situated on the ventral surface of the pharynx.The ventral aorta divides into two branches called innominate arteries, which again bifurcates into the first and second afferent branchial arteries.

Ventral aorta → Innominate arteries → I and II afferent branchial arteries

Efferent branchial arteries

The afferent branchial arteries divided into capillaries in the gills. From the gills the blood is collected by efferent branchial arteries.There are nine pairs of efferent branchial arteries.

Afferent branchial arteries → Capillaries → Efferent branchial arteries

The first eight arteries form a series of four complete loops around the first four gill slits. The ninth efferent branchial artery collects blood from the demi branch of the fifth gill pouch.

Anterior arteries

The head region gets the blood supply from the first efferent branchial artery and partly from the proximal end of the dorsal aorta.

Arteries from the first efferent branchial (hyoidean efferent) are:

The external carotid,the afferent spiracular, and the hyodean epibranchial.

Dorsal aorta and its branches

The dorsal aorta is formed by the union of epibranchial arteries. It runs posteriorly and is situated ventral to the vertebral column. It is continued up to the tip of the tail as the caudal artery.

Along the anteroposterior direction the following arteries have their origin from the dorsal aorta:

Several buccal and vertebral arteries,A pair of small subclavian arteries

The subclavian artery gets the epicoracoid artery on its way and divides into

A branchial artery to the pectoral girdle and pectoral fin,An anterolateral artery to the body musculature and A dorsolateral artery to the dorsal musculature.

A large coeliacomesenteric artery,a lienogastric artery,an ovarian or spermatic artery ,a posterior intestinal artery,a posterior gastric arteryand splenic artery and series of paired parietal arteries.

Hypobranchial chain

Efferent branchial arteries ⟶ Hypobranchial chain ⟶ 4 Commissural vessels ⟶ Hypobranchialis ⟶ Median coracoid artery ⟶ Coronary artery + Pericardial artery ⟶ Epicoracoid arteries ⟶ Single Subclavian artery

Venous System

The deoxygenated blood from the different parts of the body is returned to the heart by veins which form irregular blood sinuses throughout their courses.

Cardinal system

Anterior cardinal system

This system collects blood from the head region and consist of a pair of internal jugular veins and anterior cardinal sinuses. The anterior cardinal sinus enters the ductus Cuvieri.

Posterior cardinal system

The blood from the posterior region is collected by a pair of posterior cardinal sinuses. The anterior and posterior cardinals unite to form a transverse sinus called ductus Cuvieri.

Hepatic portal system

A large number of small veins carrying blood from the alimentary canal and its associated glands unite to form the hepatic portal vein. The hepatic portal vein receives the lienogastric vein, and anterior and posterior gastric veins.

The hepatic portal vein breaks up into capillaries in the liver. From the liver, blood is collected by another set of capillaries which unite to form two large hepatic sinuses opening into the sinus venosus.

Cutaneous system

This system consists of a dorsal, a ventral and two paired lateral cutaneous veins.

Ventral system

This system comprises of—anterior ventral veins and posterior ventral veins. The anterior ventral veins pour blood into the ductus Cuvieri through inferior jugular sinuses. The posterior veins discharge through the subclavian vein.

Blood Circulation:

Working of Heart:

- The sinus venosus receives the deoxygenated blood from the body parts through a pair of cuvierian ducts .
- When the sinus venosus is filled with blood it contracts so that the venous blood passes into the auricle.After receiving venous blood the auricle contract and the venous blood passes into the ventricle.
- When the auricle contract, the sinus venosus relaxes but the blood cannot enter into the sinus venosus since the sino-auricular valves prevent backward flow of blood.
- When the ventricle is filled with venous blood, it contracts with the help of thick muscular walls, pushing the blood into the conus arteriosus. When the

ventricle contract, the auricle relaxes, the auriculo - ventricular valve prevent the blood to flow back into the auricle.

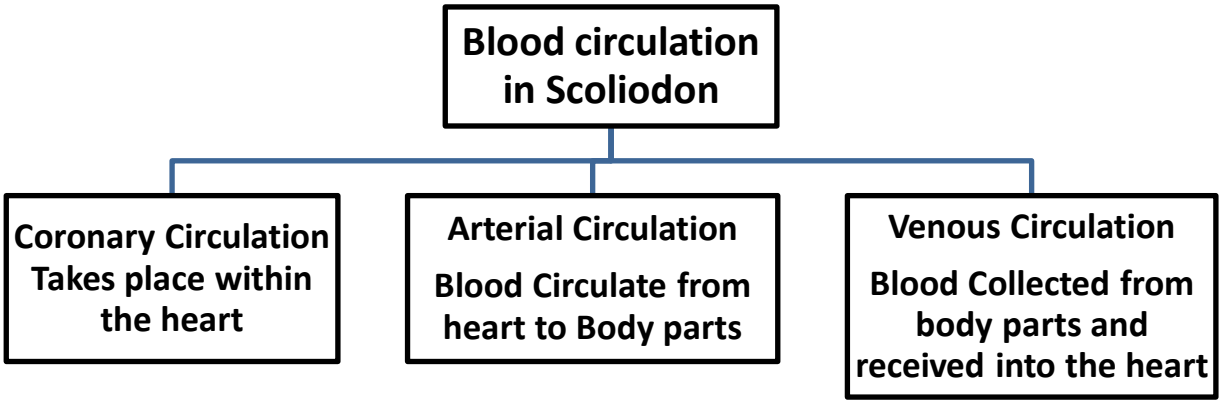
- From the ventricle the wave of contractions passes over the conus arteriosus and the semilunar valves present in the conus arteriosus check the return of blood into the ventricle. On contraction of the conus arteriosus the venous blood passes into the ventral aorta and into the branchial region for oxygenation.

- Thus only venous blood passes through the heart, and hence the heart in scoliodon is termed as "Venous Heart" and the circulation is known as **single circulation**.

- In this process the chambers in the heart contract starting from sinus venosus towards conus arteriosus. Each contraction is called, Systole, it is followed by a relaxation called, Diastole.

- Different valves present in the heart help in forward flow of blood. The heart walls are being supplied with oxygenated blood through coronary arteries.

- The heart in Scoliodon is under the control of muscular system for its contraction and relaxation such heart is termed as "Myogenic heart". The heart beat is initiated and regulated by the sino auricular node.



- The wave of contractions start from this node and spread over the wall of sinus venosus and successively pass on to the auricle, ventricle, conus arteriosus and to the ventral aorta.

- A cardiac centre present in the medulla oblongata of the brain innervate the sino-auricular node by way of Autonomic nervous system for this purpose.

Coronary Circulation :

Heart of Scoliodon receives venous blood or deoxygenated blood from body parts into the sinus venosus through Cuvierian ducts. It is necessary that the heart walls should get oxygenated blood for its proper functioning. A pair of coronary arteries arising from the hypobranchial plexus will bring oxygenated blood to the heart walls. The deoxygenated blood from the heart walls is collected by Coronary Veins which open directly into the sinus venosus. The coronary arteries and veins constitute the coronary circulation.

2B2.Write about different types of scales found in Fishes.

Scales in Fishes:

A fish scale is a small rigid plate that grows out of the skin of a fish. The skin of most jawed fishes is covered with these protective scales, which can also provide effective colouration, as well as possible hydrodynamic advantages.

Types of scales in fishes,

Placoid scales
Cycloid scales
Ctenoid scales
Presence of placoid scales is the characteristic feature of elasmobranch fishes.

Placoid Scale:

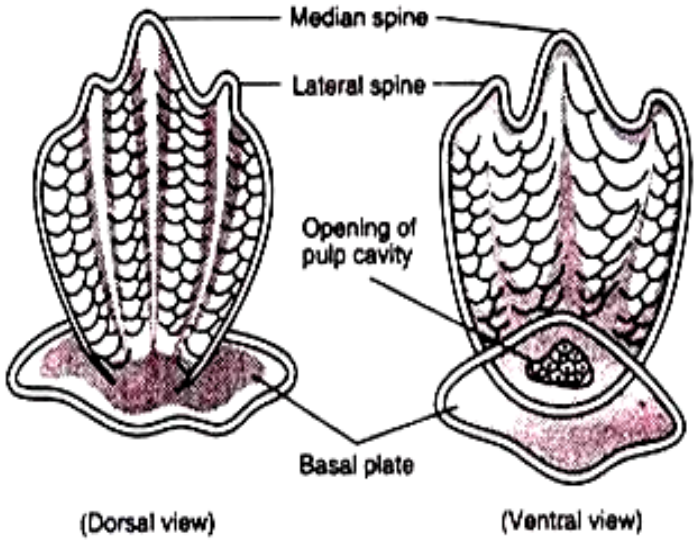
A typical placoid scale of scoliodon consists two parts-

(a) a wide rhomboidal basal plate and

(b) a trident spine. Median spine.

- The basal plate of placoid scale is formed of cement. The basal plate is firmly attached to the stratum compactum by strong connective tissue fibres called, SHARPLEY'S FIBRES.
- The trident spine by one median and two lateral spines which is composed of dentine. It is having branched canals vitrodentine (formerly is considered as enamel).

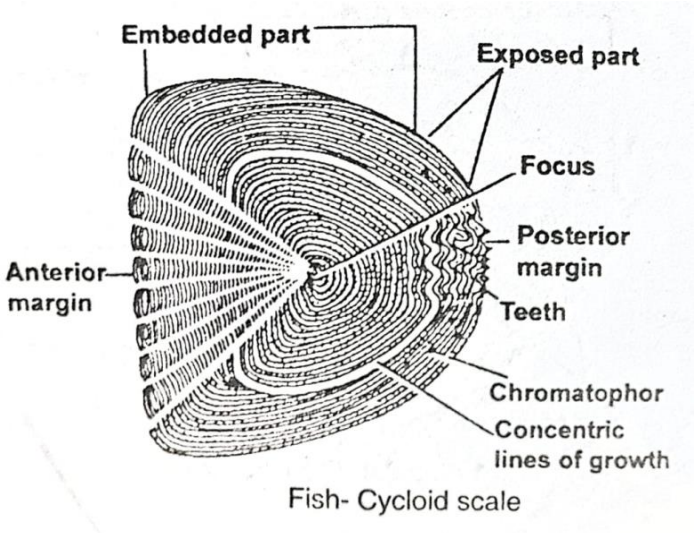
- The surface of the spine exhibit numerous small plates arranged in transverse rows. Each spine pierces through the stratum laxum and project out of the skin. The spines of all the scales project backwards, while the spines on the claspers project forwards.
- In a vertical section each spine shows a central pulp cavity containing blood vessels, nerve endings and lymph channels. At the basis of a spine dentine forming cells called, odontoblasts or Scleroblasts are present.



The placiod scales are produced by the mesodermal cells of the dermis and can be replaced any number of times, when worn out of lost. The placoid scales are homologous with the vertebrate teeth as both show the similarity in their development and nature.

Cycloid scales:

> These scales are present in bony fishes like Carps and Dipnoi.



Fish- Cycloid scale

> Scales are thin and circular in outline

> Anterior part of the scale is embedded in the skin while the posterior part is exposed and overlaps the scale present posterior to it.Each scale has a central focus and a number of concentric lines namely the lines of growth. They help in knowing the age of the fish.

> Scales protect the fish from external injuries and infections.

Ctenoid scales:

> These scales cover the body of bony fishes like Anabas

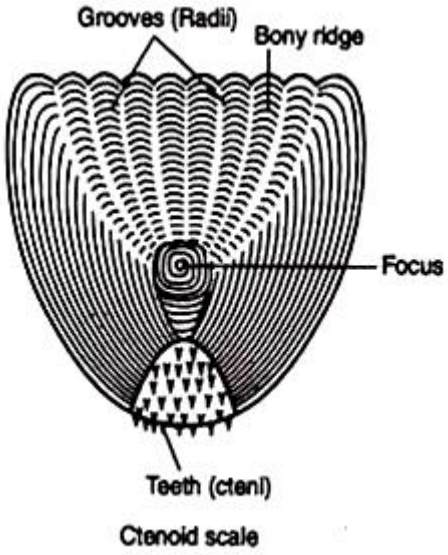
> The posterior part of one scale covers the anterior embedded part of the next scale.

> The imbricate arrangement of the horny scales over the body not only provides flexibility and smoothness but also protects the fish from all the external injuries and infections.

> They resemble the cycloid scales in all respects except for the presence of the horny teeth along the wavy posterior margin.

> Anterior margin is conical and is embedded in the body.

> Scales have chromatophores which give colour to the body.



Ctenoid scale

2B3.Define migration.Write about fish migration.

Introduction:
Migration is mainly seen in animals like fishes and birds, they travel long distances leaving their home ground and return to the same place after some time.
This movement of large number of fishes to far off places either for feeding or breeding is known as Migration.

If the movement is restricted from deeper layers of water to the surface it is defined as **vertical migration.**
The migration may be up the stream or down the stream.

If the migration is in **search of food and water** it is called, **Alimental migration.**

If it is for breeding it is termed as **Gamete migration.**

If the movement is in search of more suitable climate then it is named as **Climatic migration.**

Usually fishes migrate either for food or to breed.Some fishes breed at one region and feed and grow at another region. Some important migratory fishes are Herring,Salmon,Cod,Eel and Hilsa.

Types of Migration:

- **Migration by drifting :** In this type of movement the fishes will be carried by the water currents.
- **Orientated swimming movements :** The fishes move in a particular direction.Either towards or away from the source of stimulation or at some imaginary line between them and the source of stimulation.

If the movement or migration of the fish is with the flow of water or current then the movement is called as **Denatant movement**.

If the fish swim against the current it is known as **Contranatant movement.**

Mayers in 1949 classified migration into different types -

(1) Diadromous,

(2) Potamodromous and
(3) Oceanodromous.

Diadromous:

This is a movent performed by fishes between sea and fresh water. In this again we can see three categories.

Catadromous migration:

The type of migration from fresh water to the sea is called catadromous migration.
Example: Fresh water eel Anguilla anguilla.

Anadromous migration:

The fishes migrate from sea to river. But they spend most of their lives in the sea and migrate to river for breeding. Hilsa ilisha and Salmon are the best examples for this migration.

Amphidromous:

The fishes belonging to this type of migration move from sea to fresh water and also from fresh water to sea. This movement occurs at some or other stage of life of the fish.

Ex. Migration of gobies.

Potamodromous :

Fishes like **carps** migrate for long distances and their migration is restricted to fresh water only. This movement is done for finding the suitable breeding grounds.

Oceanodromous:

If the fishes live and perform migration in the sea, it is called oceanodromous migration.

Ex. Herring, Mackerls and Tunas.

Benefits of migration :

The spawning grounds may be short of food material to sustain the offsprings which will be in lakhs. So the fish have separate spawning and breeding grounds. As the breeding and feeding grounds are suitable places they have different conditions and the young adapt themselves to those conditions but the adults die.

Factors influencing the Migration :

Factors like physical, chemical and biological factors influence the migrations in fishes.

- **Physical factors** like depth of water, temperature, light penetration, photoperiod, turbidity, velocity of the current may cause migration.
- **Chemical factors** are pH and Salinity.
- Salinity of water plays an important role in fish migration. Most of the fresh water fishes remain in fresh water as they are stenohaline i.e. they can not tolerate great variations in salinity. But the species which are euryhaline like Anguilla, Salmon, and Hilsa undertake migration as they can tolerate wide ranges of Salinity.
- **Biological factors** are hormonal action, maturity of the gonads, food, blood pressure etc. Sometimes presence of predators in the area also may influence the migration in fishes.
- **Intensity and duration of light** also effect the migration. Fishes like Herrings migrate during full moon and sturgeon fishes migrate in night time.
- **Water currents** also influence the phenomenon. Eggs and tiny young ones lead a pelagic life and drifted by currents. After breeding the spent fishes of salmon are carried into the sea by the currents produced in the river.

Important factor that controls migration among fishes are maturity of gonads and hormones.

SHORT ANSWER QUESTIONS

7. a) General Characters of Cyclostomes

(1) Body is elongated and Eel - like.

(2) Skin is soft, smooth having unicellular mucus glands.

(3) Exoskeleton is absent, Endoskeleton is cartilagenous.

(4) Paired fins are absent, median fins with cartilagenous fin rays.

(5) Mouth ventral in position, suctorial and circular, hence the name cyclostomata.

(6) Jaws are absent (Agnatha).

(7) Body is divided into trunk (including head) and tail. Muscles are segmented into myotomes separated by myocommata.

(8) Digestive system lacks a stomach, Intestine with a fold, typhlosole. Pancreas and spleen are absent.

(9) Mode of feeding is by using epidermal teeth (Rasping tongue).

(10) Gill respiration is common.

(11) Single mid-dorsal nostril is present.

(12) Single median olfactory sac is present.

(13) Internal ear consists of 1 or 2 semi circular canals.

(14) Heart is two chambered having one Auricle and one Ventricle.

(15) There is no conus arteriosus. Many aortic arches are present in the gill region.

(16) In the blood Leucocytes and nucleated circular erythrocytes are present.

(17) Renal portal system is absent.

(18) Poikilothermic (cold blooded) animals.

(19) Notochord persists, throughout the life of animal.

(20) Imperfect neural arches (arcualia) over notochord represent rudimentary vertebrae.

(21) Excretion is carried by a pair of mesonephridia (kidneys) with ducts.

(22) Dorsal nerve cord with distinct brain is present.

(23) 8 to 10 pairs of cranial nerves are present.

(24) Unisexual or hermaphrodites. Gonad is single, large, without gonoduct, but segmental ducts are present.

(25) Fertilization is external. Development is either direct or indirect with prolonged larval stage.

(26) Found in fresh water and salt water and always ascend to fresh water streams to breed.

7.b) Chondrichthyes

1. Class Chondrichthyes is commonly called as cartilagenous fishes as their skeleton is made of cartilage.

2. Body is spindle shaped or stream lined.

3. Skin is rough and provided with placoid scales embeded in the skin.

4. Paired and unpaired fins are present supported by fin rays.

5. Tail fin is heterocercal.

6. Mouth is ventral in position and is provided with jaws.

7. Intestine is provided with spiral value.

8. 5 to 7 pairs of gills help in respiration. They open out by gill slits in the pharyngeal region.

9. Heart is provided with sinus venosus, one auricle, one ventricle and conus arteriosus. Heart is called venous heart as always deoxygenated blood flows in it.

10. Brain with large olfactory lobes.

11. Ten pairs of cranial nerves are present.

12. Only internal ear is present which has three semicircular canals.

13. Sexes separate, fertilization internal.

14. Development is direct without larval stage.

Ex: Scoliodon,Pristis.

7.c) Osteichthyes

General characters of Osteichthyes:

1. Osteichthyes are called bony fishes as their body skeleton is made of bones.

2. Body spindle shaped and stream lined.

3. These fishes live in marine, fresh and brackish waters.

4. Fins are of two types - paired and unpaired. All of them are supported by fin rays.

5. Body covered with cycloid or ctenoid scales.

6. Mouth terminal and supported by jaws having teeth.

7. Separate openings for digestive and urinogenital systems.

8. Four pairs of gills protected by operculum help in respiration.

9. Air bladder is present. In some it is modified as lung.

10. Heart consists of sinus venosus, one auricle, one ventricle and conus arteriosus.

11. Kidney mesonephric.

12. Olfactory lobes of brain are small.

13. Ten pairs of cranial nerves are present.

14. Internal ear consists of three semi circular canals.

15. Lateral line system is well developed.

16. Sexes separate. External fertilization.

17. Mostly oviparous.

Ex: Latimaria,Anguilla.

8a.)Fish Brain

Brain:

In Scoliodon the brain lies enclosed within the chordrocranium and is made of the same three basic parts of the vertebrate brain-forebrain, midbrain and hindbrain.

Forebrain:

It consists of two parts, anteriorly cerebrum and posteriorly diencephalon. Cerebrum bears peduncle.

Each peduncle terminating into a large bilobed olfactory lobe lies in olfactory sac. The sac opens to outside through the nostrils .The mid-ventral surface of cerebrum has a neuropore. Two terminal nerves, come out of neuropore to innervate the mucous membrane of the olfactory sac.

Diencephalon has thin, membranous and vascular roof is called the anterior choroid plexus.
Pineal stalk terminating into pineal body or epiphysis of unknown function extends upwards.Ventrally its anterior margin bears optic chiasma of two optic nerves. Just behind the chiasma,infundibulum is situated on the floor.

At the posterior part of the infundibulum hypophysis is present,both constitute pituitary body.

Mid brain:

It is remains covered dorsally by cerebellum and ventrally by the infundibular outgrowths.

It consists optic lobes or carpora bigemina, which are the centres of sight and hearing. Ill and IV cranial nerves arise from midbrain.

Hind brain:

It consists of two parts cerebellum and medulla oblongata. Cerebellum is large, elongated structure and divided into three lobes .

Medula oblongata, the last part of the brain and continues posteriorly into the spinal cord.

Medulla is roofed over by a thin, non-glandular and vascular membrane, the posterior choroid plexus.

Spinal Cord:

It is the extension of medulla oblongata upto the end of tail, within the neural canals of vertebral column.

It encloses a central canal and inner grey matter covered by outer white matter. Its transverse section shows that it is made up of two halves connected together by a bridge.

8.b)Placoid Scale

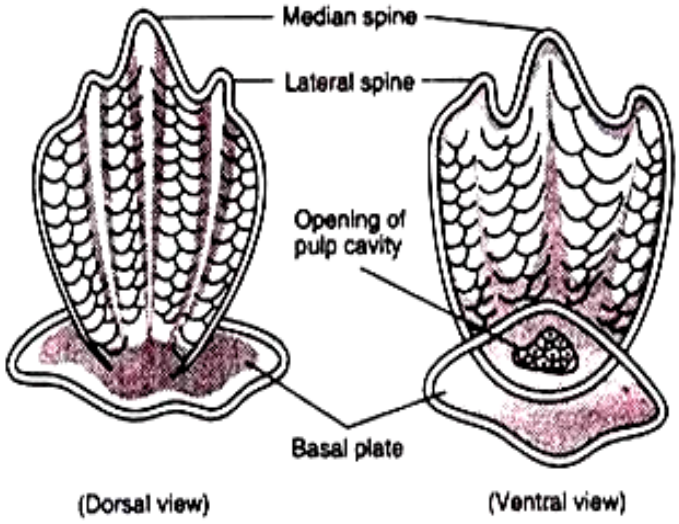
Placiod scales or dermal denticles embedded in the skin arranged in regular oblique rows. Presence of placoid scales is the characteristic feature of elasmobranch fishes.

Placoid Scale: A typical placoid scale of scoliodon consists two parts-

(a) a wide rhomboidal basal plate and

(b) a trident spine. Median spine.

- The basal plate of placoid scale is formed of cement.



- The basal plate is firmly attached to the stratum compactum by strong connective tissue fibres called, SHARPLEY'S FIBRES.
- The trident spine is formed by one median and two lateral spines. The spine is largely composed of a very hard material, the dentine. It is having branched canals or canliculi and covered by a still harder layer of vitrodentine.
- The surface of the spine is not smooth but exhibit numerous small plates arranged in transverse rows in an imbricate manner.
- Each spine pierces through the stratum laxum and project out of the skin. The spines of all the scales project backwards, while the spines on the claspers project forwards.
- In a vertical section each spine shows a central pulp cavity containing blood vessels, nerve endings and lymph channels. At the basis of a spine dentine forming cells called, odontoblasts or Scleroblasts are present.

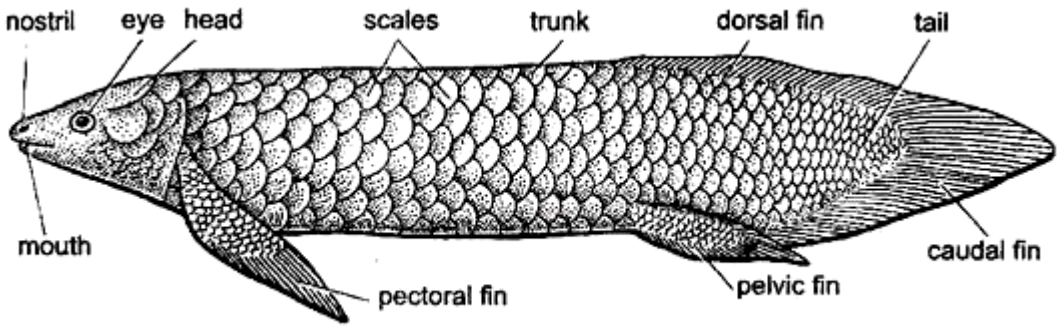
The placiod scales are produced by the mesodermal cells of the dermis and can be replaced any number of times, when worn out of lost. The placoid scales are homologous with the vertebrate teeth as both show the similarity in their development and nature. The reason for the homology is that the mouth lining is simply in turned skin and therefore possess skin structures.

8.c) Characters of Lung fishes

Lungfish, also known as ***salamanderfish***, are freshwater fish belonging to the class **sarcopterygii.**

- Dipnoi is a small order of fresh water bonyfishes.
- 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 diphycercal 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.



Neoceratodus

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.

Protopterus lives in large lakes and rivers of tropical Africa. It is commonly called as 'Nile lungfish' or African lung fish.

Lepidosiren 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. Diphycercal tail.

6. Ventral inferior nostril.

7. Persistent notochord without any constriction.

8. Cartilaginous autostylic skull.

Specialized 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 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 finrays.
- The tail is diphycercal (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.

UNIT III

LONG ANSWER QUESTIONS

3A1.List out the general characters of Amphibia and classify them upto orders with examples

General characters of Amphibia

1. First tetrapods to invade land.

2. Live both in water and on land.

3. Cold blooded or poikilothermic animals.

4. Body divisible into head and trunk. Neck may or may not be present.

5. Two pairs of pentadactyle limbs are present.

6. Skin smooth, moist and glandular. Scales if present are embeded in the skin.

7. Skeleton bony and skull dicondylic.

8. Heart with two auricles and one ventricle. Sinus venosus present.

9. Respiration is carried on by skin, buccal cavity and lungs. Gills are seen in larval stage. May be seen in some aquatic adults also.

10. R.B.C. are biconvex, or oval and nucleated.

11. Mesonephric kidneys are present.

12. 10 pairs of cranial nerves are present.

13. Sexes separate. In some copulatory organ is seen in males.

14. Cloaca is common opening for digestive, excretory and reproductive systems.

15. Fertilization mostly external. Larval stage called "Tad pole is seen in life history.

Classification :

Class Amphibia is divided into two subclasses.

(1) Stegocephalia,

(2) Lisamphibia.

Sub Class: Stegocephalia

1. This group includes extinct amphibians.

2. Skin is provided with scales and bony plates.

3. Vertebrae show variation.

4. Skull solid and bony.

Sub Class Stegocephalia is divided into three orders –

(1) Labyrinthodontia,

(2) Phyllospondyli,

(3) Lepospondyli.

Order 1: Labyrinthodontia:

1. These animals have fish ancestry.

2. Skull completely roofed with bones

3. Teeth found on both the jaws with folded dentine

4. Salamander or Crocodile like animals.

Eg. Eryops

Order 2: Phyllospondyli:

1. Small and Salamander like animals

2. Vertebrae tubular.

3. Well marked transverse processes and stout ribs.

4. Notochord and spinal cord present in a common cavity.

Eg. Branchiosaurs

Order 3: Lepospondyli:

1. Animals are small salamander or eel like.

2.Ribs are present which articulate intervertebrally.

3. Lived in carboniferous and permian periods

Eg. Diplocaulus

Sub-Class: Lissamphibia

These are living Amphibians This subclass is divided into three orders

(1) Gymnophiona (Apoda).

(2) Urodela (Caudata).

(3) Salientia (Anura),

Order 1: Gymnophiona:

1.Primitive burrowing forms.

2. Body elongated and eel like

3. Limbs and tail absent.

4. Cloaca terminal in position.

5. Skin is provided with transverse grooves

6. In some forms scales are present embeded in the skin

7. Males are provided with copulatory organ

8. Parental care is observed, where female coils round the eggs

Eg: Ichthyophis, Uraeotyphlus

Order 2: Urodela:

1. Body divisible into head, trunk and tail.

2. Limbs are equal in size.

3. Scales are absent.

4. Both the jaws bear teeth.

5. Larva are aquatic and resemble adults.

6. Neoteny is observed.

Eg. Necturus, Siren, Proteus.

Order 3: Salientia (Anura):

1. Body short and broad.

2. Neck and tail are absent in adult.

3. Fore limbs are shorter than hind limbs.

4. Gills absent in adults. Respiration by skin and lungs.

5. Skin without scales and loosely placed.

6. Fertilization is external.

Eg. Alytes, Rana, Hyla, Rhacophorus.

3A2.Describe the digestive system in Rana.

The digestive system of frogs comprises the alimentary canal or digestive tract along with the related digestive glands.

Alimentary Canal

In frogs, the alimentary canal is said to be complete. It is a coiled and long tube having different diameters extending from the mouth to the cloaca. It comprises –

- Mouth
- Buccal cavity
- Pharynx
- Oesophagus
- Stomach
- Small intestine
- Large intestine
- Cloaca

Mouth

Mouth is a very wide gap extending from one side of the snout to the other. Two bony jaws covered by the immovable lips. The upper jaw is fixed, while the lower jaw is flexible – it can move up and down to open or close the mouth.

Buccal Cavity

The mouth opens into the buccal cavity which is wide, large and has mucous glands which secrete mucus used for food lubrication. The frogs do not have salivary glands.

Teeth

There are two more patches of teeth present on either side of the roof of the buccal cavity called vomerine teeth. The vomers also comprise two groups of vomerine teeth. These teeth are not utilized to chew but check the escape of captured prey. Teeth are similar in shape, they are homodont and **polyphyodont** – teeth get replaced many times in their life span.

Internal Nostrils

In its roof near the vomerine teeth, the buccal cavity comprises two openings – the posterior or internal nares associated with the nasal cavities through which respiratory gases move to and from the buccal cavity at the time of respiration.

Tongue

The tongue in frogs is large, sticky, muscular and protrusible. It is found at the base of the mouth cavity. The anterior end of it is attached to the inner border of the lower jaw while the posterior end is free.

The upper surface has taste buds and mucous glands of which the secretions cause the tongue to be sticky.

Orbit-Bulging

Behind the vomerine teeth, the roof of the buccal cavity has two oval and large pale areas, the bulgings of the eyeballs. At the time of swallowing food, eyes are pressed down into the buccal cavity, pushing the food into the pharynx.

Pharynx

The buccal cavity opens into pharynx. This, in turn, opens into the oesophagus. The pharynx and the buccal cavity at times are referred to as the buccopharyngeal cavity. At the roof of the pharynx on each of the lateral sides, a wide Eustachian tube can be found with an opening that communicates with the middle ear.

The glottis is always open and closes at the time of swallowing. In male frogs, two openings of the vocal sacs which serve as resonators during croaking.

Oesophagus

Oesophagus is extremely short as a result of the absence of the neck however, highly distensible as their inner lining into numerous longitudinal folds that enables enough expansion of the oesophagus at the time of passage of ingested food via it to the stomach.

Stomach

It is present on the left side of the body cavity which is attached to the dorsal body wall by a mesogaster. Digestion of the ingested food occurs by some digestive

enzymes which are secreted by the digestive glands.The stomach can be split into two parts – posterior pyloric stomach and anterior cardiac stomach.

Gastric glands that secrete pepsinogen enzymes. Hydrochloric acid is secreted by the unicellular oxyntic glands. The pyloric end of the stomach is narrowed. Their opening into the small intestine is shielded by a circular ring-like muscle – the sphincter which regulates the food passage from the stomach into the intestine.

Intestine

The stomach directs into the tubular, long and coiled structure – the intestine which also is attached to the dorsal body wall by the mesentery. It comprises two parts –

- Small intestine
- Large intestine

Small intestine

The anterior part of the small intestine curves upwards forming duodenum. The other part of it continues as the ileum which is coiled. A common hepato pancreatic duct opens into the duodenum from the liver and the pancreas which brings the pancreatic and the bile juice. The inner mucous lining is thrown into the low transverse folds.

The mucosal lining of the small intestine apart from the intestinal glands comprise two types of cells –

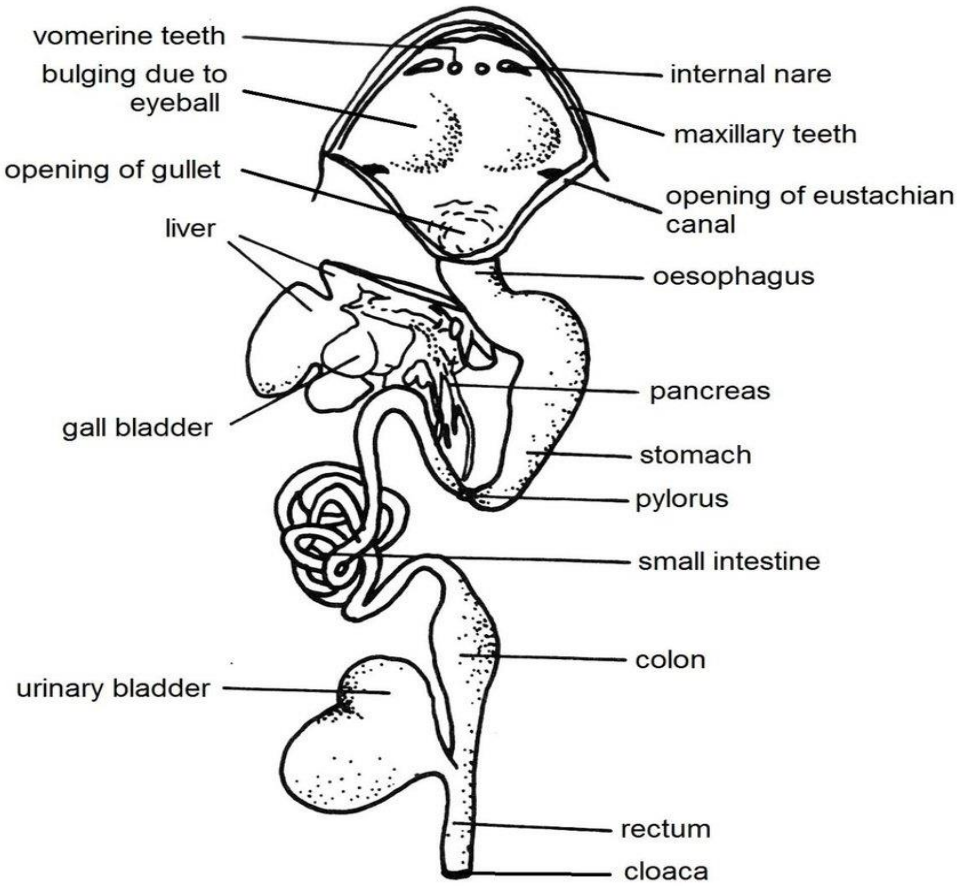
- **Goblet cells** – large cells possessing granular substances and oval vacuoles producing mucus. The nucleus is found in them near the base of the cell
- **Absorbing cells** – these are distinguished as small cells with nuclei found near the base

Large intestine

The ileum forms a narrow, long coiled tube where its lower end directs into the structure of the large intestine – the rectum. The internal mucous lining of the ileum forms many longitudinal folds. The glands, true villi and crypts of the higher vertebrates are not seen. It is in this part that absorption and digestion of food occurs. The lower terminal leads to the cloaca by the sphinctered anus. Their mucosal lining goes on to form the low longitudinal fold.

Cloaca

These are tiny sac-like structures receiving the openings of the anus and the urinogenital apertures. The cloaca leads to the exterior through the cloacal opening or vent located at the posterior end of the body.



Physiology of Digestion in Frogs

Food Digestion in Frogs

Peristaltic movements of the alimentary canal cause physical changes while the enzymes acting as organic catalysts bring about chemical changes.Proteins are digested by proteolytic enzymes, fats by lipolytic enzymes and carbohydrates by diastatic enzymes.

3A3.Write an essay on parental care in Amphibia.

Introduction:

Parental care is the phenomenon in which the parents take care of their eggs and young ones till they become well dependent and self sustainable.
Parental care is very diversified in amphibians.They adopt many methods in this phenomenon and no group shows more diversity than the amphibians.Parental care of Amphibians can be categorised in three ways,
(1) Protection by parents by means of nests or nursaries
(2) Direct caring by parents
(3) Viviparity

1.Nests and Nurseries:

Many Amphibians build nets and Nurseries to protect the Progeny

In enclosures in the water

A Brazilian tree frog **Hyla faber**, protects its progeny by constructing a basin shaped nursery with the mud.The bottom of the pit is levelled by it's belly and hands. The inner surface of the wall is smoothened by feet. The eggs are deposited in the pit and the parent protects early larvae from enemies.

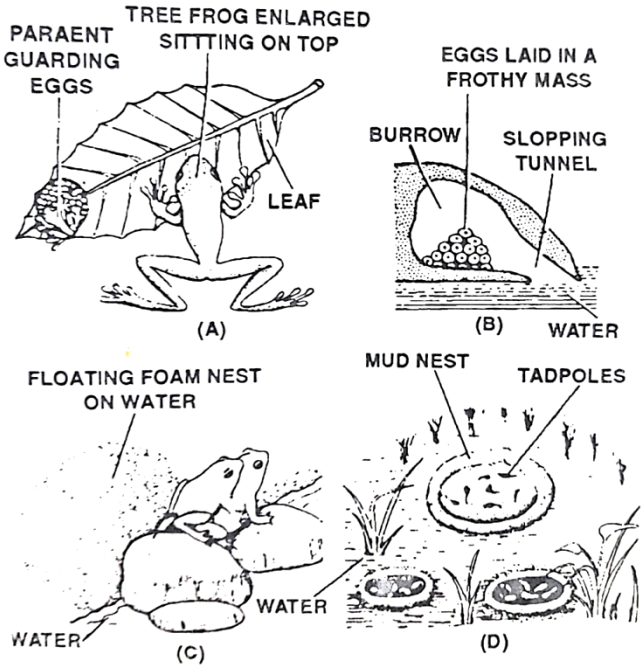
In holes of water

Rhacophorus schlegelii adopts another method. Male and female frogs burry themselves in a pit at the bottom of the pond,above water level. Female release eggs and the male releases the sperms. Later the frogs get separated.The larvae to come out of the pit and complete its life history.

In nests on trees or rocks overhanging water:

Some tree frogs like **Phyllomedusa** ,**Rhacophorus malabaricus** and **Chiromantis** lay their eggs on trees, in nests made of froth which is attached to one or many leaves of branch over hanging the water. The larvae move in the froth. They fall into the water after external gill stage and complete the life cycle.

Another tree frog **Hyla resinfictrix** selects cavities present on the trees and covered the cavity with bee wax. When the cavity is filled with rain water the female lays eggs. The young develop in this microhabitat.



Protection by nests, nurseries or shelters

Gelatinous Bags in the water:

Female frog of **Phrynixalus biroi** prepares sausage shaped transparent gelatinous membranous bags and lay large eggs in them and leave it in mountain streams. After the completion of development small frogs come out of the bag.

Salamandrella keyserlingii lays 50 to 60 small eggs in a gelatinous pouch and attaches it to aquatic plants.

On trees away from water:

Many species of **Hylodes**, deposit the eggs in damp places under stones, or leaves of the plants. The eggs are large in size.Entire development is completed there only.

Defending territories:

Male frogs of **Rana clamitans** guard its territory by attacking the intruders - while female protect the eggs.

Mud nests:

In **Hyla fabre** a Braziliam tree frog, male digs a hole in mud in shallow water and the female lays the eggs there.

2. Direct nursing by Parents :

Direct development:

In some frogs like **Eleuthero dactylus, Arthroleptis, Hylodes** etc. the eggs directly hatch into small frogs. So larval mortality is prevented.

Transportation of Tadpoles :

Frogs like **Phyllobates** and **Dendrobates** carry the well developed tadpoles on their back. The tadpoles hold the frogs with sucker - like lips.

Protection of eggs by male :

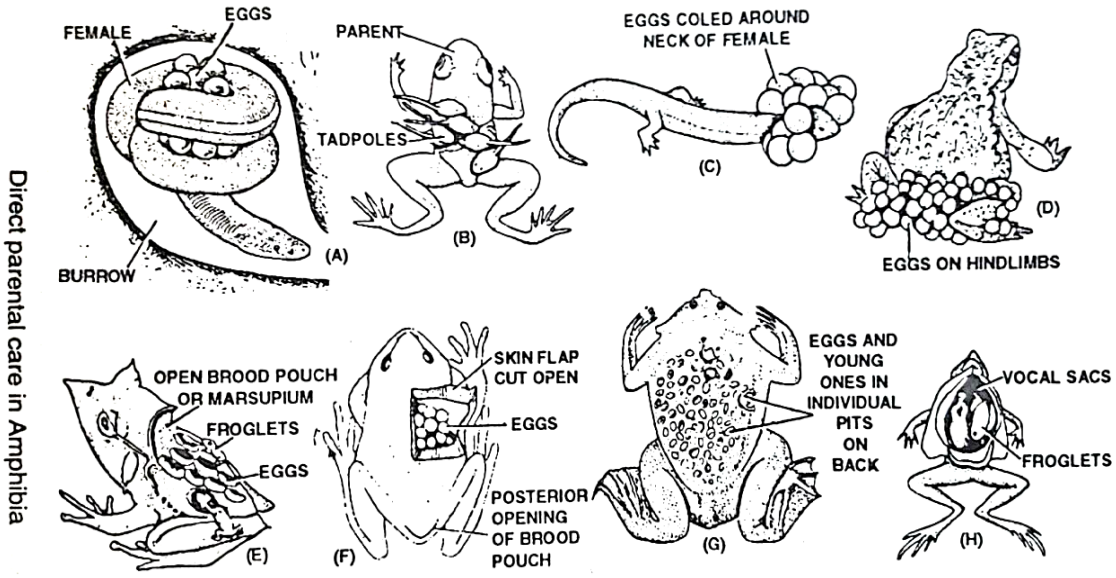
The eggs of **Austrochaperina robusta** are attached to the body by gelatinous envelope. The male sits on the group of eggs and hold them with hands.

In **Alytes obstetricans** the female lays eggs and the male coil them around its hind legs. It carries them till they are ready to hatch.

Eggs in Pouches:

In **Pipa Americana** the eggs are carried on the back of the mother. The skin grow round the eggs in the form of a pouch which is finally covered by a lid. Metamorphosis is carried on in the pouch.

In **Nototrema** the eggs are covered by skin forming a large brood pouch which opens out posteriorly near cloaca.



3.Viviparity:

Two small East African toads **Pseudophryne vivipara** and **Nectophryne tornieri** are viviparous and give rise to young ones. They retain eggs in oviducts.

Urodela:

In some forms of parental care is observed by building nests or directly taking care by the parent.

Protection by means of nests will be taken up by two methods

In holes on land or in trees:

A urodel by name Autodax lays the eggs in a hole on ground or selects a hole on a tree and there it lays eggs. Both the parents take care of the young ones which remain for a considerable time in the pit.

In transparent bags:

Salamandrella deposits its eggs in a gelatinous bag which is attached to an aquatic plant present below the water level. The larvae remain at the bottom of the bag.

By direct nursing of parent:

The female of **Plethodon** lays in groups of five under the stones and coils around them on the contrary in **Megalobatrachus maximus** male coils round the eggs and guards them.

Viviparity:

In **Desmognathus fusca** eggs are laid in the form of strings. It bounds round the body of female and nourishes the young to small young ones.

The female **Ichthyophis glutinosus** digs a hole in damp ground near the bank and deposits the eggs in a bunch. The mother coils round them and protects the eggs from enemies.

3B1.Explain digestive system of Calotes.

Calotes is an carnivorous and insectivorous terrestrial tetrapod.It feeds upon insects,insect larvae.
As in any other vertebrate the digestive system consists of Alimentary canal and digestive glands.

Alimentary canal:

The alimentary canal is a long,coiled lobe and comprises of

Mouth → Bucco-pharyngeal cavity → oesophagus →→ stomach →small intestine → large intestine → Anus → cloaca

Mouth:

The mouth is terminal and bounded by non muscular immovable lips. The lower lip is round and the upper is little larger than the lower lip.

Buccal Cavity :

It is also called as Bucco-pharyngeal cavity because there is no distinct partition between buccal cavity and pharynx.

The buccal cavity is narrow at the anterior end but broad at its posterior end.The other structures present in the buccal cavity are teeth, tongue and internal nares.

The teeth are **Acrodont** and **Homodont.**

A well developed muscular and protrusible tongue is present attached to the floor of the buccal cavity. The mid-dorsal groove of the tongue is covered with glandular papillae and taste buds.

Pharynx:

The buccal cavity continues posteriorly into pharynx, whose mucus lining is thrown into longitudinal folds. A Glottis is present which opens into trachea.

A pair of Eustachian tubes are opening into the pharynx on the roof.The pharynx open into the oesophagus.

Oesophagus:

It is a narrow tube that passes straight into the stomach through the neck. Its inner surface has close longitudinal folds which expand during swallowing of food.

Stomach:

The stomach lies on the left side of the body cavity and remains suspended by Mesogaster.

The anterior broader part is called, the cardiac stomach and the posterior narrow part is pyloric stomach.

Posterior end of pyloric stomach has a circular muscle called, the pyloric sphincter.

Small intestine:

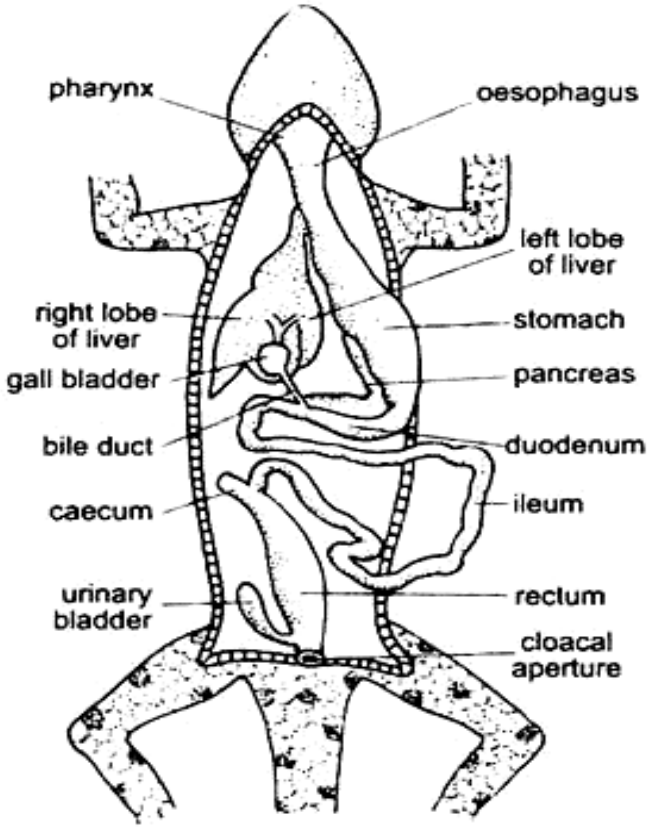
It is a long and narrow coiled tube divided into anterior Duodenum which receives bile and pancreatic ducts and posterior longest part is called, the Ileum.

Large Intestine:

The large intestine comprises of proximal colon and distal rectum. The anterior part of colon is expanded into a large blind sac called, the caecum.

The wall of caecum and colon is thin, hence the faecal matter inside could be seen from outside.

Rectum is a short, tubular and thick walled, which stores the faecal matter. The rectum and cloaca are separated by a sphincter.



Cloaca:

The cloaca is divided into 3 chambers called

(a) Coprodaeum..... Anterior chamber which receives the rectum.

(b) Urodaeum.....Middle chamber which receives the Ureters and genital ducts dorsally and Urinarybladder on the ventral side.

(c) Proctodaeum..... Posterior chamber which opens to outside by the cloacal aperture.

- The cloaca serves in absorption of water present in the faecal matter and urine.
- The dehydrated faecal matter is excreted out in the form of cylindrical castings or pellets through the cloacal aperture.

Associated digestive glands

Salivary glands:

There are no true salivary glands are present in the buccal cavity. Salivary glands which are opening into the buccal cavity are probably be the mucus glands.

Gastric glands:

The gastric glands secrete gastric juice into the lumen of the cardiac stomach and contain pepsin and HCl .

Liver:

Liver is present in between the two elastic lungs and behind the heart. It is a large, Trilobed (right lobe, left lobe and dorsal lobe) gland which is dark red in colour.

Liver secretes Bile which is alkaline in nature and does not contain any digestive enzymes.

Pancreas :

It is a whitish gland present in between the limbs of duodenum. Pancreas is a exocrine and endocrine gland secreting both enzymes and hormones.

Intestinal glands:

Large number of microscopic intestinal glands are present in the mucus membrane of the small intestine which secrete intestinal juice.

3B2.Give an account of Calotes heart and explain mechanism of circulation.

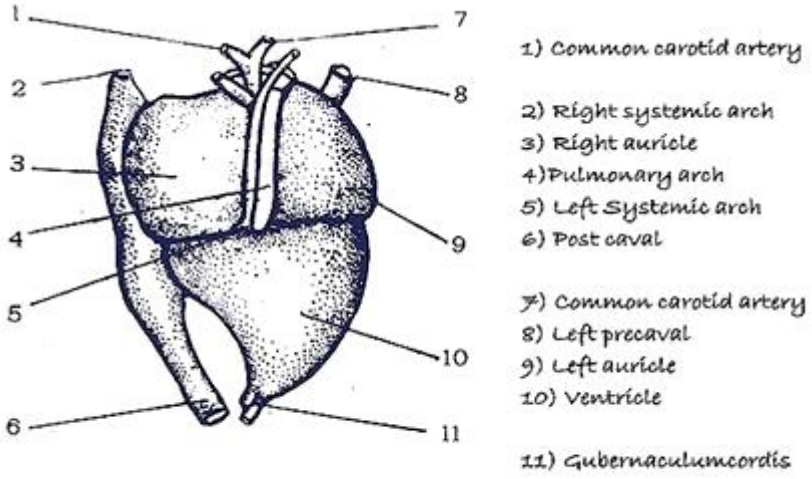
Cardiovascular system of Calotes includes
(a) The heart,
(b) The blood,
(c) Arteries and
(d) Veins.

(a) Structure of Heart:

External Structure

- The heart is enclosed in a thin transparent membrane, the pericardium.
- The space between the heart and pericardium is filled with pericardial fluid.
- The heart is triangular in shape and three-chambered-two auricles and a ventricle.

- Heart is a triangular, red-coloured and 3-chambered muscular organ. The right auricle is larger than the left auricle.



Calotes - Heart (Dorsal View)

- The anterior two auricles are separated by a transverse auriculo-ventricular groove. The thin-walled sinus venosus present dorsally upon the auricles. It is formed by the fusion of the three venae cavae.

- These three venae cavae empty independently into the sinus venosus.

- The smaller left lobe of sinus venosus is formed by the left precaval, while the larger right lobe is formed by the union of right precaval and the postcaval.

- The apex of the ventricle is attached with the liver by a thin, white cord of tissue, the gubernaculum cordis.

Heart: Internal structure.

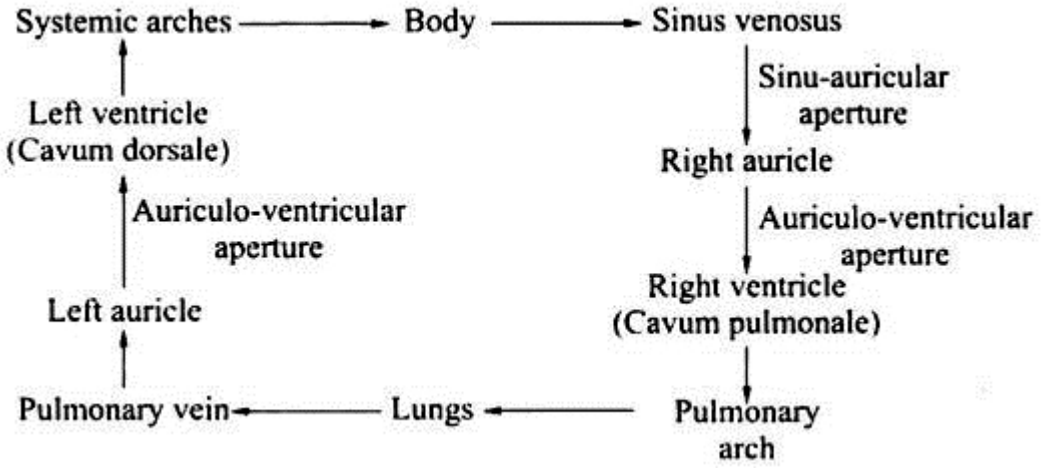
- Internally the two auricles are separated by a thin, muscular and vertical interauricular septum.

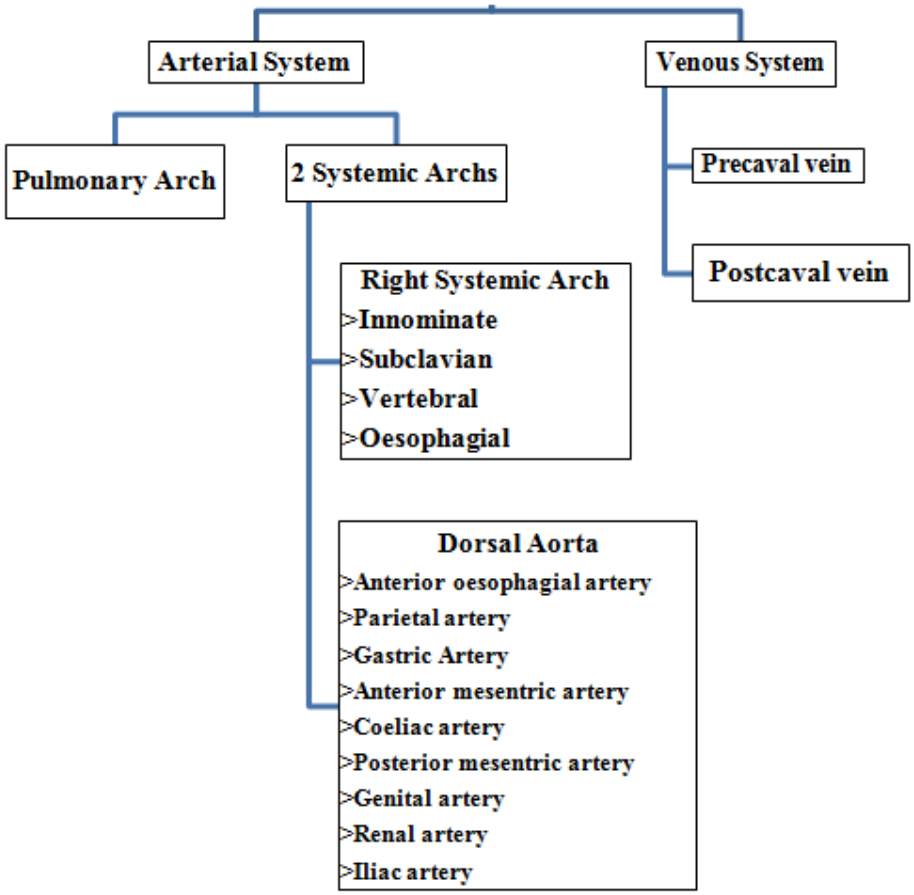
- Right auricle is larger and darker. Its thicker wall is raised internally into small ridges, the musculi pectinati.

- Sinus venosus opens into its dorsal wall by a large semicircular sinuauricular aperture, guarded by two flap-like sinuauricular valves. These valves

develop from the upper and lower margins of the aperture and their frilled free ends project into the lumen of right auricle.

- Left auricle is smaller, thin-walled and its roof receives a small circular and valveless common pulmonary aperture of pulmonary veins.
- **Ventricle** has thick, spongy muscular walls internally projecting into interlacing ridges, called columnar carneae.
- The two auricles open into ventricle' through right and left auriculo-ventricular apertures guarded by auriculo-ventricular valves. The flaps of these valves are attached to columnae carneae by thread-like muscles, the chordae tendineae.
- An incomplete interventricular septum divides the lumen of ventricle incompletely. This partition has become complete in crocodiles except for an aperture, called foramen of Panizza.
- The foramen of Panizza is a communicating aperture between the left and right systemic arches just at the point of crossing after their emergence from the ventricle.
- Three arches, right and left systemic and pulmonary, arise from ventricle.Each arch has paired semilunar valves at its base to check return of blood. The walls of the heart are provided with three layers viz., tunica intima, tunica media and tunica adventitia, out of these tunica media is made of cardiac muscles and is innervated with cardiac branch of 10th cranial nerve.





Blood

- Blood of Calotes is red in colour and is made up of plasma and blood cells.
- The red blood corpuscles are biconvex, elliptical in outline and each bears an elliptical nucleus.
- The white blood corpuscles are irregular in outline, non-pigmented and each bears a spherical nucleus.

Working of heart:

- In the garden lizard (Calotes), the circulation of blood is double.
- The deoxygenated blood of the sinus venosus enters the right auricle through sinu-auricular aperture.
- The oxygenated blood from the lungs enters the left auricle by the pulmonary vein.
- The left auricle pours its blood into the left part of cavum dorsale of the ventricle through the auriculo-ventricular aperture.The right auricle also pours its blood into the right portion of cavum pulmonale or ventrale of the ventricle through the auriculo-ventricular aperture.

- The oxygenated blood from the cavum dorsale goes principally through both carotid arches and the right systemic arch.
- Some of the right systemic blood may be added via the ductus caroticus to that of the internal carotid.
- While the deoxygenated blood from the cavum pulmonale passes into the pulmonary arteries for reoxygenation in the lungs.
- The blood in the right part of the cavum dorsale goes into the left systemic arch and probably passes through the ductus caroticus on that side into the carotid.

3B3.What are the identification characters of poisonous snakes.

- Poisonous snakes are generally brightly coloured.
  Shape of head− Head long, triangular and the posterior portion is wide.
- Neck of poisonous snake is always constricted.
- **Hood**− Present in majority cases; highly developed in Cobra group (Naja spj; absent in Coral snakes, Krait, Russell's viper etc.
- **Tail**− Tail tapers abruptly. In sea snakes (Hydrophidae) the tail is flattened to form an oar-shaped structure and in land snakes the tail is cylindrical.
- **Head scales**− Scales on top of the head are usually small.
- **Dorsal scales**− Dorsal surface scales are smaller but the spinal (vertebral) scales are larger and hexagonal in kraits.
- **Ventral scales**− Ventral scales are usually completely across the belly, but in sea snakes ventral scales are present not across the body.
- **Loreal shield** is present and shapes may be variable in poisonous snakes.
- **Mental shield**− Fourth one is large.
- **Caudal scales**− Mostly undivided except in coral and cobra snakes.
- **Teeth**− Most of the teeth are solid and uniform except maxillary teeth which are large, and provided with groove or canal. These large teeth are called 'Fangs'.

- **Poison gland**– Present. Paired poison glands are on upper jaw.
- Poisonous snakes have less-developed muscular system.
- **Lungs**– One of the lungs has either been reduced or absent.
- **Hypophysis**– Hypophysis developed throughout the vertebral column
- **Streptostylism**– Well-marked
- Examples– Saw Scaled Viper (Echis carinatus), Common Krait (Bungarus caeruleus), Banded Krait (B. faciatus), Russel's Viper (Vipera russelli), King Cobra (Ophiopagus Hannah), Indian Monocled Cobra (Naja naja kaothia) etc..

SHORT ANSWER QUESTIONS

9.a) Urodela

- Urodela is also called Caudata.
- These are the organisms with a tail.
- They are found under leaf litter, in the soil, or in water.
- The body is elongated with four equally sized limbs.
- Body divisible into head, trunk and tail.
- Scales are absent.
- Both the jaws bear teeth.
- Larva are aquatic and resemble adults.
- Neoteny is observed.
- The skin is smooth with poison glands.
- They feed on insects and worms. Eg., Salamanders
- In the southern US, they reproduce primarily in winters.
- Very little differences between male and female.
- Fertilization is internal.Spermatophores are utilized for internal fertilization.
- They possess hidden gills

Ex. Necturus, Siren, Proteus.

9.b) Bucco pharyngeal respiration

In **Bucco pharyngeal respiration** the buccal cavity in frog communicates with the exterior by Respiratory tracts. The respiratory tract consists of external nares, nasal chamber and internal nares. The bucco pharyngeal cavity is lined by a thin mucous membrane which is always moist by mucous, permeable to gases (O_2 and CO_2) and richly vascular.

Mechanism : In buccal respiration the mouth remains permanently closed, while the external nares are wide open. The floor of the buccal cavity is alternately raised or lowered. Lowering of the floor of the buccal cavity results in the increase of the space and reduces the pressure of air in the cavity. So the air from higher pressure (outside) will pass through the respiratory tract into bucco- pharyngeal cavity.

The O_2 present in the air that entered into the cavity dissolves in the thin film of mucous, covering the lining of the Bucco pharyngeal cavity. The dissolved O_2 diffuses through the mucous lining and passes into the blood capillaries. At the same time the CO_2 from the blood capillaries diffuses into air present in the cavity.

After exchange of gases by diffusion the floor of the Bucco pharyngeal cavity is now raised and this reduces the internal space of the bucco-pharyngeal cavity and increases the pressure on the foul air and it is move outside through the respiratory tracts. Thus the frog in rest, exhibit rhythmic lowering and raising of the floor of bucco- pharyngeal cavity by the contraction of sternohyal and pterohyal muscles.

During expulsion of air,the external nostrils remain mouth and glottis are kept closed and the lungs remain idle.

Significance: The Bucco-pharyngeal respiration supplements the cutaneous respiration in summer, when the frog leads an active life. This mode of respiration is exhibited when the frog is on land or when it floats in water with snout kept above the level of water.

9c).Brain of Frog

The nervous system includes:

(i) A central nervous system comprising the brain and spinal cord,

(ii) A peripheral nervous system consisting of cranial and spinal nerves

(iii) An autonomic nervous system made of two ganglionated sympathetic nerves.

Central Nervous System:

Brain:

The brain of frog is elongated, white coloured structure situated in the cranial cavity of the skull. It is surrounded by the inner piamater and duramater. These two membranes are called meninges.The space between the piameter and duramater is filled with cerebro-spinal fluid.

The brain of frog is divisible into three main parts:.

(1) Forebrain:

It is the largest part of the brain consisting of a pair of anteriorly directed olfactory lobes, a pair of cerebral hemispheres, and a diencephalon.

(a) Olfactory Lobes:

The olfactory lobes are anterior small, spherical structures gives off an olfactory nerve and possesses a small cavity rhinocoel.

(b) Cerebral Hemispheres:

The two cerebral hemispheres are long, oval structures.Each cerebral hemisphere has a paracoel which is continuous anteriorly with the rhinocoel. Posteriorly the lateral ventricles communicate with each other and with the ventricle of diencephalon called diocoel by an opening, foramen of Monro.

Each cerebral hemispheres has corpus striatum containing a network of white medullated nerve fibres and nerve cells. The corpora striata of two hemispheres are joined by anterior commissure and is the hippocampal commissure.

(c) Diencephalon

It is situated behind the cerebral hemispheres. It’s floor is called hypothalamus and roof is anterior choroid plexus.

Behind it arises a pineal stalk or epiphysis is present.On the ventral side of diencephalon is the optic chiasma is present.

The hypothalamus is an important centre regulating the whole endocrine system as well as other parts of the brain.

(2) Midbrain:

It is well developed consisting of two optic lobes. The optic lobes are centres for impulses coming from the eyes. Their cavities are called optocoels communicating with each other and the fourth ventricle, the iter.

Below the optic lobes crura cerebri is present. These connect diencephalon and medulla. These form the floor of midbrain. Between the diencephalon and optic lobes posterior commissure is present.

(3) Hindbrain:

It consists of the cerebellum and the medulla oblongata:

(a) Cerebellum

It is a rudimentary and present behind the optic lobes. Its function is to regulate the vestibulo-oculomotor system controlling movements of the eyes.

(b) Medulla oblongata

It is short and triangular structure.Its cavity called fourth ventricle which is continuous with the central cavity of the spinal cord. Its roof called the posterior choroid plexus.

10a).General characters of Reptiles

- Study of reptiles is called Herpetology.
- Cold blooded animals living primarily on land. Secondarily invaded water.
- Live creeping, burrowing or live on trees.
- Body is covered with horny scales. No skin glands. 5. Body, divisible into head, trunk and tail. Head and trunk are joined by neck.
- Two pairs of pentadactyle limbs are present provided with claws. Limbs are absent in snakes.
- Endoskeleton is bony and skull is monocondylic.
- Mouth terminal provided with jaws having teeth.
- 'T' shaped inter clavicle is present in the pectoral girdle.
- Heart is three chambered. Ventricle is partly divided. In crocodiles heart is four chambered.
- Respiration is by a pair of lungs.

- Metanephric kidney is present. Excretory product is uric acid. Hence uricotelic animals.
- Twelve pairs of cranial nerves are present. 11th pair is spinal accessory and 12th pair is hypoglossal.
- Sexes are separate. Males are provided with a muscular copulatory organ.
- Internal fertilization takes place. Lay eggs. Egg is protected externally by calcareous shell and inside by foetal membranes like Amnion, Allantios, Chorion and Yolk sac.

10b).Chelonia

1. Animals can live on land and in water.

2. Limbs are paddle like, provided with claws.

3. Trunk is enclosed in a bony box having carapace on dorsal and plastron on ventral sides.

4. Tail is present.It can be retracted into the shell.

5. Thoracic vertebrae and ribs are fused with shell.

6. No temporal opening in the skull.

7. Teeth are absent on jaws. They are provided with horny sheaths.

8. Copulatory organ is present in male.

Eg. Testudo and Trionyx.

10c).Crocodilia

1. Body is large and aquatic animals.
2. Exoskeleton with horny epidermal plates & scutes.
3. Tail is laterally compressed, help in locomotion.
4. Teeth are thecodont.
5. Abdominal ribs present.
6. Skull diapsid.
7. Limbs are powerful provided with claws.
8. Heart is divided into four chambers,divided by inter ventricular septum Ventricle is completely.
9. Male has a copulatory organ.

Eg. Crocodile, Alligator, Gavialis.

UNIT IV

LONG ANSWER QUESTIONS

4A1. Explain about digestive system of Pigeon.

The digestive system of pigeon is well developed and includes an alimentary canal and the digestive glands.

Alimentary Canal:

The alimentary canal of pigeon comprises mouth, buccal cavity, pharynx, oesophagus, stomach, small intestine and large intestine which opens to the exterior by cloacal aperture.

Alimentary canal consists of
Foregut or Stomodeum,
Midgut or Mesenteron and
Hindgut or Proctodeum.

1.Foregut or Stomodeum:

The portion of alimentary canal from mouth to stomach region is lined by ectodermally derived layer.

It includes following organs:

Mouth:

The anterior most opening of alimentary canal is called mouth. In pigeon, mouth is a wide slit-like aperture, bounded by the upper and the lower horny beaks having no teeth. The mouth is followed by buccal cavity.

Buccal Cavity:

Buccal cavity is a large, narrow, triangular having the tongue at its floor. The tongue has few taste buds and mucous glands, and has the function of manipulation of food. The buccal cavity is followed by pharynx.

Pharynx:

The posterior part of buccal cavity is called the pharynx. The posterior nares, opens in the roof of the pharynx. Just behind the posterior nares eustachian tubes are present. At the floor of the pharynx glottis is present. The glottis opens into the trachea.Pharynx opens into the oesophagus.

Oesophagus and Crop:

Oesophagus is a large, thin-walled and non-glandular sac. The crop store quickly swallowed food for later digestion.Crop is specially large in graminivorous (gram-eating) birds such as pigeons, finches, buntings, parrots, etc.

The epithelial lining of the crop in both sexes thickens and sheds "crop milk" during the breeding season on which the youngs are fed by both parents. Pigeon milk is produced under the control of prolactin hormone.

Stomach

The stomach is differentiated into an anterior glandular proventriculus and a posterior muscular gizzard.

(a) Proventriculus:
The proventriculus is a small, thick- walled and glandular structure.Its thick mucus lining secretes the gastric juice. The spleen is attached to the right side of the proventriculus.

(b) Gizzard:
It is large hard, muscular.Its narrow lumen have minute tubular glands, which secret a fluid (koilin). Its yellow or green colour .

The cavity of gizzard always contains small stones help the gizzard in grinding the food. The gizzard into small intestine and the opening of gizzard into small sphincter, called the pyloric valve.

2. Midgut or Mesenteron:

The midgut, mesenteron or small intestine is a narrow tube.The small intestine is divided in an anterior duodenum and a posterior ileum. The bile and pancreatic ducts usually open into the distal limb of duodenum.

Duodenum:
The duodenum arises from the dorsal side of gizzard.The duodenum forms a U-shaped loop enclosing the pancreas between its two limbs.

Ileum:
The portion of the small intestine behind the duodenum is called ileum.Ileum is a long and coiled tube.Its inner epithelial lining has villi, which greatly increase its area of secretion and absorption.

3.Hindgut or Proctodaeum:

The ileum continues into large intestine having colic caeca. The rectal caeca absorbs some water from digestive food. The large intestine or hindgut (proctodaeum) is a short tube and comprises an anterior rectum and a posterior cloaca.

(a) Rectum:

The rectum is narrow .It opens into cloaca. Its opening into cloaca is guarded by an anal sphincter.

(b) Cloaca:

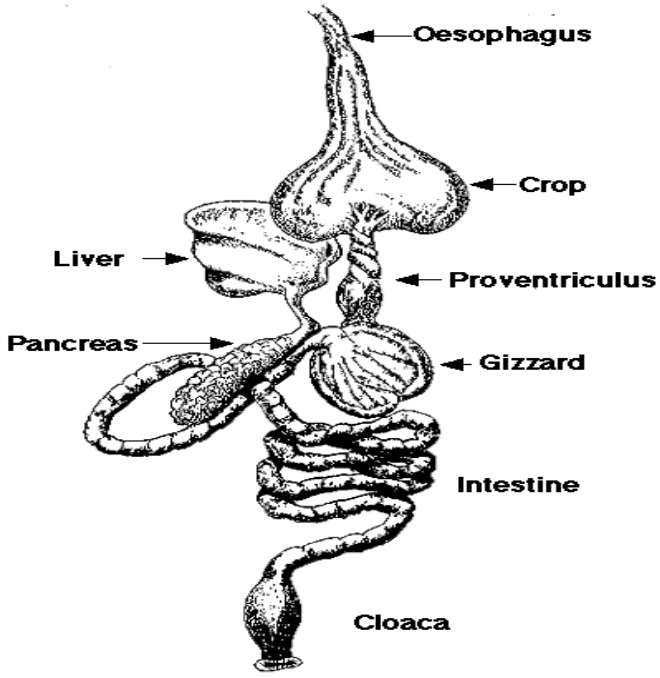
The cloaca is a large chamber and divided into an anterior coprodaeum,middle urodaeum and a proctodaeum which opens to the outside by the cloacal aperture.

The bursa Fabricii is also called cloacal thymus because, like thymus, it produces lymphocytes.

Digestive Glands:

(i)Buccal Glands:

These glands secrete mucus to moisten the food and probably the amylase enzyme. The tongue has few mucous glands.



Digestive System of Pigeon

(ii) Gastric Glands:
The epithelial lining of proventriculus contains many gastric glands which secrete certain gastric juices containing peptic enzymes.
(iii) Liver:

The liver of pigeon is large, compact and containing a large right lobe and a small left lobe. From each lobe of the liver arises a bile duct.The liver secretes bile Juice.

(iv) Pancreas:
Between two limbs of the duodenum is a large, compact, reddish digestive gland, the pancreas. Pancreas gives off three separate pancreatic ducts which pour the pancreatic secretions containing many enzymes into the distal limb of duodenum.

(v) Intestinal Glands:
The epithelial linings of intestine have many glands which secrete many enzymes. The duodenum is lined with villi and single or branched crypts of Lieberkuhn. Goblet cells are also present.

4A2. Describe respiratory system in Pigeon.

Respiratory System in a Bird:

Birds are aerial in habit and exhibit pulmonary respiration only.The activity of flight demands large supplies of oxygen, so that the respiratory system of birds is more complicated.The respiratory system consists of respiratory tract and respiratory organs.

Respiratory tract

1. **Nares or Nostrils:**

- A pair of external nares are present at the base of the upper beak (upper jaw).
- These openings are covered by an operculum.
- The external nares open behind into a short olfactory sacs .
- The olfactory sacs open behind by a pair Internal nares into the posterior part of the bucco pharyngeal cavity.
- On the floor of the Bucco- pharyngeal cavity glottis is present.

2. Trachea:

- The Glottis leads posteriorly into Trachea.At the anterior end of Trachea Larynx is present.
- Thyroid cartilage and vocal cords are absent in bird, hence the Larynx does not produce sounds.
- Larynx open behind intoTrachea.
- On entering the thoracic cavity trachea expands into a syrinx (voice box) and then divide into right and left bronchi.
- The Trachea and bronchi are supported by Tracheal rings which prevent collapsing of tracheal wall.

3. Syrinx (or) voice box:

- Syrinx is an expanded part of trachea where it divided into right and left bronchi. Cavity of the syrinx is called as Tympanum.
- At the junction of the two bronchi a bony ridge, Pessulus is present.
- It supports syringeal membrane. The songs and call of birds is produced by vibrations of this membrane when air is forcebly go outside from the lungs.
- The nature of the sound is changed by the differential vibration of this membrane through the action of Intrinsic syringeal muscles and Sterno-tracheal muscles.
- The syrinx is absent in ostriches, storks and some vultures.
- Pessulus is absent in columba livia.

Respiratory Organs

Lungs:

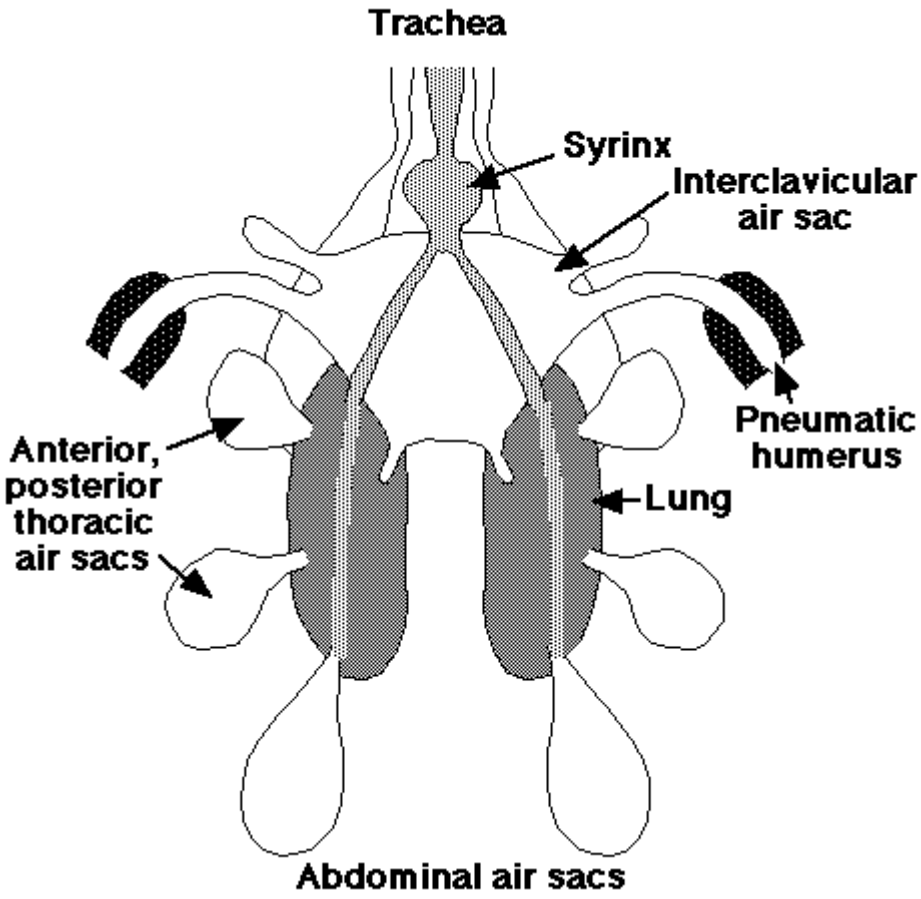
Respiratory organs in bird are a pair of lungs situated close to the dorsal body wall and are covered by pleura. Ventral surface of the lungs is covered by peritoneum.

- Lungs in a bird have system of respiratory tubes called Bronchial intercom.
- The bronchus that enter into the lung is called the **primary bronchus** then reaches up to its posterior end of lung and becomes the **Mesobronchus.**
- Mesobronchus divided into number of smaller branches, the **secondary bronchi.** Depending upon their position the lateral bronchi are distinguished as dorsal, ventral and lateral. Alveoli are absent.
- The secondary bronchi (dorsobronchi and ventrobronchi) gives out many branches, the **Tertiary bronchi** or parabronchi. Each parabronchus gives off to air capillaries or **Bronchioles.**

- The lung parenchyma together with air capillaries forms a **central parabronchus,** surrounded by a system of associated air capillaries with interlacing blood capillaries of both pulmonary artery and vein.
- Each air capillary open at both the ends into a parabronchus.
- Since the parabronchi and air capillaries join together leaving no space in the lung, the inner vascular surface of the air capillaries act as respiratory membrane for the exchange of gases.
- Inspite of its small size and inelasticity, the avian lung is more efficient than that of any other vertebrate.

Air sacs :

In Pigeon, Five branches from the mesobronchus form the air sacs. Of these three enter into the lung and open into the interclavicular, cervical and the anterior thoracic air sacs.



From the hind end of the mesobronchium the posterior thoracic and Abdominal air sacs are formed. Air sacs are paired in origin but in Pigeon, the two Inter clavicular air sacs fuse early in development.
Thus there are 9 major air sacs in pigeon. They are named according to their location in the bird body as

Interclavicular - 1
Cervical – 2
Anterior thoracic - 2
Posterior thoracic - 2
Abdominal - 2

Air sacs are large in size, thin walled membranous, non muscular and non- vascular. Their total volume is several times greater than that of the lungs and extended into some of the larger bones.

Interclavicular :

It is unpaired, triangular air sac connected with both the lungs. It is situated between the two limbs of the furcula. It gives out on either side a diverticulum and an extraclavicular air sac.The air sacs communicate with the pneumatic cavities of the bones.

Cervical:

A pair of small cervical air sacs arise one from each lung from its anterior end lie at the root of the neck and gives off minor saccules in the neck.

Anterior thoracic :

A pair of anterior thoracic air sacs are present at the anterior part of the chest and ventral to the lungs. They are in close contact with the ribs and the pericardium of the heart. They extend posteriorly and overlap the posterior thoracic air sacs.

Posterior thoracic :

A pair of small posterior thoracic air sacs are present in the posterior part of the thoracic cavity. They lie infront of the abdominal air sacs. Each air sac overlaps the posterior end of its lung.

Abdominal:

A pair of large abdominal air sacs arise from the outer posterior angle of each lung. They lie along the dorsal wall of the abdomen, ventral to the kidneys.

Functions of air sacs :

- Air sacs are non- vascular, hence they do not play any important role in gaseous exchange.

- They increase the efficiency of the lungs by providing them fresh air during expiration.
- They cool the body by evaporation of fluid from their surface.This function is important in the absence of sweat glands.
- They act as balloons to provide lightness and buoyancy to the body.
- Act as the accessory breathing organs.

Mechanism of respiration :

Birds are flying vertebrates and use different mechanisms for respiration at resting stage and during flight.

Ventilation at rest :

- When the bird is resting, the sternum alternately raises and lowers.
- During **inspiration** the **sternum is lowered** resulting in the increase of body cavity and negative pressure is created in the body cavity.
- **Air sacs expand and the lungs are compressed,** as a result, fresh air passes through the respiratory tract into the posterior air sacs. At the same time the air already present in the posterior sacs will move into the anterior sacs of lung.
- During **expiration** the **sternum is raised**, the **air sacs are compressed and the lungs expanded.** This reduces the body cavity and causes pressure over the air sacs. This pressure forces the air from the air sacs partly through the recurrent bronchi into the air capillaries for exchange of gases and partly the secondary bronchi and respiratory tract to outside.

Bronchioles receive fresh air both during Inspiration and Expiration and that the entire air is being exchanged, leaving no air in them.
The aeration of blood is complete and this is responsible for the high metabolic activity and temperature of birds.
This quick respiration explains how the birds fulfill with small lungs their high oxygen requirement due to high metabolic rate.
During flight increase and decrease in the volume of the body cavity by the movement of the pectoral muscles.

Double respiration :

During inspiration the air from outside enter through the respiratory tract into the lungs and from there into the air sacs.Because of lack of blood vessels in the air sacs,exchange of
gases takes place in the lung between the blood capillaries of the lung and the O_2 present in the lung.
During expiration, the air with high percentage of O_2 content present in the air sacs will move into the lungs .Since the lungs recieve high O_2 content,air from air sacs for

the second time the exchange of gases takes place in the lungs. Thus in one inspiration exchange of gases takes place twice in the lungs and this is described as double respiration. This helps in continuous supply of O_2, to the bird to meet the high metabolic rate.

4A3. Write about the structure of Heart and course of blood circulation in Pigeon.

The circulatory system of pigeon includes heart, arteries, veins, the blood and lymphatic system:

1. Heart:

The heart is four chambered 2 auricles and 2 ventricles. The sinus venosus is absent.

External Structure:

- The heart of pigeon is large-sized, reddish in colour lies midventrally in the thorax. It is covered by pericardium.
- The pericardial wall is made of an outer parietal layer and an inner visceral layer. The two layers enclose a narrow pericardial cavity, filled with pericardial fluid.
- The pericardial fluid protects the heart from shocks and injuries.
- The auricles separated from ventricles by auriculo-ventricular groove.The two auricles are also separated by an inter-auricular groove.

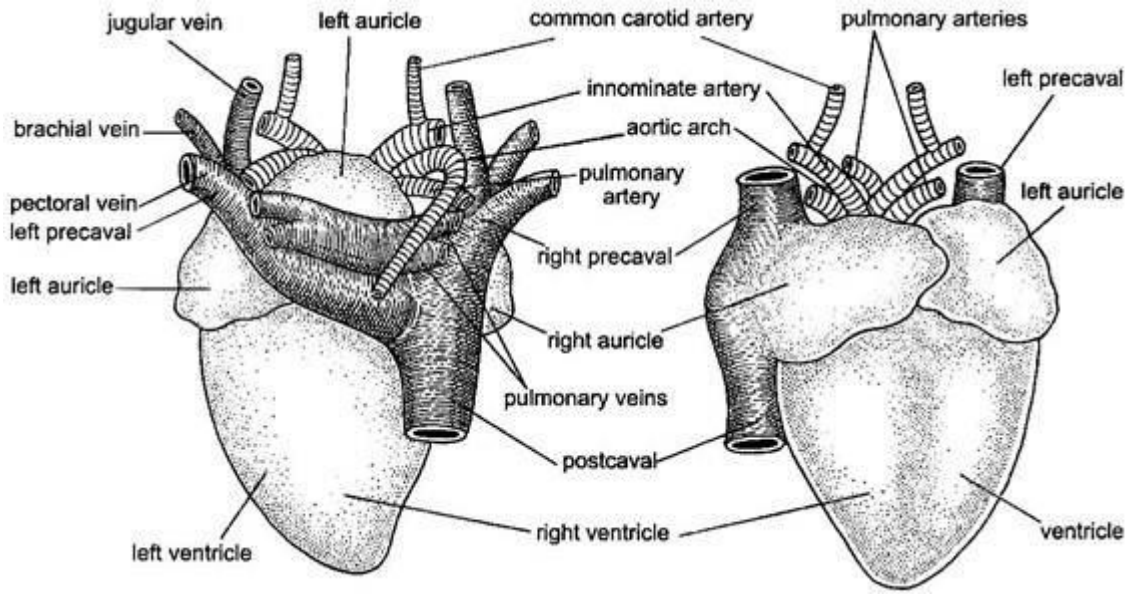
Internal Structure:

Internally, the two auricles are separated by inter-auricular septum. It has a small oval area in the middle, called the fossa ovalis

The two ventricles are also separated by inter-ventricular septum. The left ventricle is larger with muscular walls.

The right ventricle is smaller.The ventricles have bundles of muscle fibres arranged longitudinally to form columnae carneae.The right auricle is larger than left auricle and it receives the three large veins, the right and left precavals and the postcaval, in its dorsal wall.

The opening of the postcaval vein is gurarded by eustachian valve. The right auricle opens into the right ventricle by right auriculo-ventricular aperture.



Heart of Pigeon

Dorsal View **Ventral View**

This aperture is guarded by a pair of muscular flaps forming the right auriculo-ventricular valve. The right ventricle gives off a pulmonary aorta, which bifurcates into two pulmonary arteries, each going to a lung. The opening of the pulmonary trunk is guarded by three semilunar valves.

The left auricle is smaller and receives four pulmonary veins from the lungs. It opens into the left ventricle by a circular left auriculo-ventricular aperture. It is guarded by left auriculo-ventricular valve.The flaps are connected to the thick papillary muscles by the chordae tendinae.

The left ventricle gives rise to the single right systemic or aortic arch which crosses over to the right side of the heart and continues as dorsal aorta. The left aortic arch, which is present in the frog and lizard, is absent in birds. The opening of right aortic arch is guarded by three semilunar valves. The cavities of both ventricles are traversed by bars of muscles, called trabeculae or columnae carneae.

Functioning of Heart:

The heart pumps the blood to arteries. In pigeon, the venous and arterial blood well separated in heart it is four chambered.

The right half receives and discharges only venous (un-oxygenated) blood, while the left half only arterial or oxygenated blood. Thus, birds possess a complete double circulation which includes a pulmonary circulation and a systemic circulation.

(i) Pulmonary Circulation:
The right ventricle pumps venous blood into the lungs through the pulmonary aorta and its two pulmonary arteries. The oxygenated blood from the lungs is returned into the left auricle through four pulmonary veins.

(ii) Systemic Circulation:
The left ventricle sends blood into the right aortic arch, the dorsal aorta and through smaller arteries to the various organs and tissues of the body, where they break up into capillaries. These capillaries unite to form veins, which finally form three great veins, which return blood into the right auricle. From right auricle, the blood enters the right ventricle through right auriculo-ventricular aperture.

Heartbeats:

The heart of pigeon has two pacemakers, a sinu-auricular node and an auriculo-ventricular node.Purkinje fibres starts from the sinu-auricular node and goes to the auriculo-ventricular node.

2. Arterial System:
The heart pumps its unoxygenated blood to pulmonary aorta and oxygenated blood to aortic or systemic arch; both of which collectively constitute the arterial system of pigeon.

A. Pulmonary Aorta:
Arises From right ventricle and bifurcates into pulmonary arteries,which enters into a lung.

B. Systemic Aorta:
Systemic arch arises from the left ventricle, the left aortic arch absent in adult birds. The right aortic arch gives out two small coronary arteries which are divided into a pair of right and left innominate arteries. Each innominate artery divides into an anterior common carotid artery and a lateral subclavian artery.

Dorsal Aorta:
The right aortic arch gives rise to dorsal aorta.

The dorsal aorta gives off following branches to different body organs:

Coeliac artery
Anterior mesenteric artery
Two anterior renal arteries
A pair of femoral arteries
A pair of sciatic arteries
A pair of iliac arteries
An unpaired posterior mesenteric artery
At last the dorsal aorta continues into the tail as caudal artery.

3. Venous System:

The venous system of pigeon includes:

(i) The caval veins,

(ii) The pulmonary veins,

(iii) The hepatic portal system and

(iv) The renal portal system.

(i) Caval Veins:
The non-oxygenated blood of entire body of pigeon is collected and goes to the right auricle of the heart by three large veins, two precavals and one postcaval vein.

(ii) Pulmonary Veins:
From lungs two pulmonary veins return oxygenated blood into the left auricle.

(iii) Hepatic Portal System: The blood of various parts of alimentary canal is returned to liver by a hepatic portal vein which is formed by the union of gastro-duodenal, anterior mesenteric, posterior mesenteric, and coccygeo-mesenteric veins.

(iv) Renal Portal System:
The renal portal system of pigeon is greatly reduced and includes two hypogastric or renal portal veins, each of which gives off only a few afferent renal veins to each kidney and does not form capillary system in the kidney.

4. Blood:

The blood of birds is rich in red blood corpuscles. They are oval and nucleated. They carry a large amount of haemoglobin .The red corpuscles are smaller in actively flying birds than in the larger flightless birds.

The white blood corpuscles are more in number.

4B1. Write an essay on Pigeon Brain.

The nervous system of pigeon consists of the central nervous system comprising brain and spinal cord, peripheral nervous system including cranial and spinal nerves and autonomic nervous system comprising sympathetic and parasympathetic systems.

Central Nervous System:

1. Brain:
The brain of birds is much more highly developed.

External Structure of Brain:

The brain of pigeon is short, broad, rounded in form and whitish in colour. It completely fills the cranial cavity.

It is covered by an outer duramater and an inner pia-arachnoid rich in blood supply.The narrow space between two meninges has connective and fatty tissues, veins and cerebro-spinal fluid. The brain is divisible into forebrain, midbrain and hindbrain.

A. Forebrain:

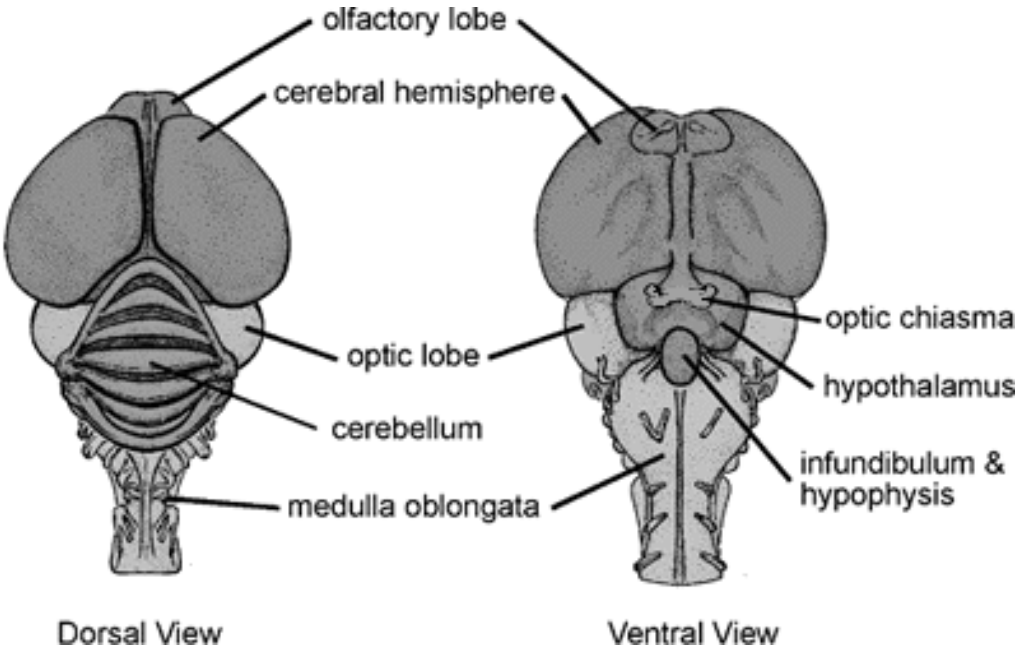
- The olfactory bulbs or lobes are extremely small and degenerated in birds.
- The cerebral hemispheres are large-sized, convex, and separated by a deep sagittal fissure.
- “Corpus striatum” is present. The diencephalon is covered completely on the dorsal side by the posterior extension of the cerebral hemispheres and anterior extension of the cerebellum.
- A small pineal body lies dorsally at the posterior part of sagittal fissure.
- On the ventral surface of the visible diencephalon, the two prominent and large optic nerves cross each other forming the optic chiasma.
- Behind the chiasma projects a median process the infundibulum, bearing a large hypophysis or pituitary gland, which lacks the intermediate lobe.

B. Midbrain:

- The midbrain is highly developed due to keen sight of birds, with two large very well developed optic lobes.
- These are lateral in position which meet posteriorly with the cerebellum. These are of large and rounded form.
- Both optic lobes remain connected together by a transverse optic commissure.

C. Hindbrain:

- The cerebellum is highly developed, large, folded and extends forwards. It is divisible into a large median lobe and two small,lateral lobes.
- The vermis has transverse grooves forming folds and ridges.



- The convoluted cerebellum indicates the delicate sense of equilibrium and the great power of muscular coordination belonging to birds.
- The cerebellum covering a large part of the medulla oblongata, which join the spinal cord.
- At the point of junction of medulla oblongata and spinal cord occurs a well-marked ventral flexure.

Internal Structure:

- The brain is a hollow organ and its cavities are called **ventricles**. Each major division of pigeon's brain has greatly reduced ventricles.

- The two cavities of cerebral hemispheres are called **lateral ventricles** or the **paracoels.** The ventro-lateral walls of cerebral hemispheres are very thick and formed of corpora striata or hyperstriatum.

- The corpora striata of both the lobes are interconnected by a transverse anterior commissure. They receive fibres from the thalamus and send fibres (crura cerebri) to the midbrain, cerebellum, medulla, and indirectly to the spinal cord.

- Posteriorly, each lateral ventricle or paracoel communicates by a small common aperture, the foramen of Monro, with the narrow, vertical cavity of the diencephalon, termed the **third ventricle or diacoel.**

- The thin roof of diacoel is called epithalamus. It contains a richly vascular tissue, the anterior choroid plexus located just in front of pineal body. The diacoel remains bounded laterally by the thick optic thalami, while its thick floor is termed hypothalamus.

- The diacoel remains separated from the narrow cavity of the midbrain, called iter, by posterior commissure. The iter communicates dorsally with the cavities of the optic lobes, called the optocoels.

- The cavity of the medulla oblongata is called **fourth ventricle or the metacoel** (or myelocoel). It sends a branch to cerebellum. Its roof is thin, highly vascular, called posterior choroid plexus, and its sides and floor are thick-walled.

- The anterior and posterior choroid plexes secretes the cerebrospinal fluid which fills in the ventricles of brain.

Histologically, the brain has a layer of grey matter, containing nerve cells, and a layer of white matter, containing nerve fibres. The grey matter is outer in the olfactory lobes, cerebrum, diencephalon and cerebellum, while in optic lobes and medulla it is internal.

Functions:

The functions of different parts of brain are following:

a. **Olfactory lobes**- Smell.

b. **Cerebral hemispheres**- Voluntary movement or conditioned reflexes, intelligence, will, memory, emotions, etc. The corpora striata are concerned in the control of the reflex behaviour governing the lives of birds, such as eating, locomotion, copulation, nest building and care of the young.

c. **Diencephalon-** Relay impulses to cerebral hemispheres, integrating centre of autonomic system and perception of extreme cold, heat, pain, etc

d. **Optic lobes**- Sight.

e. **Crura cerebri**- Conduction of sensory impulses.

f. **Cerebellum**- Voluntary movements and balance (equilibrium).

g. **Medulla oblongata**- Involuntary movements.

4B2. Explain about Bird Migration.

Definition:

Migration can be defined as a regular, periodic too and fro movements of birds either for feeding or breeding".

Types of Migration

Birds migrate in many ways. Ornithologists observed that the birds perform latitudinal migration, longitudinal migration, altitudinal migration, partial migration, irregular migration and seasonal migration.

Latitudinal migration :

Movement of birds in North - South direction and vice versa is called Latitudinal migration. Large land masses in northern hemisphere,are covered with snow in winter. So birds move to south during this period for shelter.

Ex: The American golden plover (Pluvialis)

Longitudinal migration :

Migration in the direction of east and west and vice versa is called longitudinal migration.

Ex: The patagonian plover travels to Falkland island for breeding.

Altitudinal migration :

This is also called as vertical movement. Birds spend summer in high mountains and return to low valleys in winter because of changes in the climate.

Ex: Birds like Woodcock and Scolopax rusticola migrate from planes to slopes of Himalayas and return to planes when the winter commences.

Total migration:

When all the members of a species take part in the migration, it is called total migration. The Arctic Tern population shows such a kind of migration.

Partial migration :

Not all but many members of birds of a particular Family do take part in migration.This movement is only for a short period and hence called partial migration and the birds are referred to as partial migrants.

Ex: Blue birds and blue jays of Canada and Northern United States travel southwards to join the native birds there.

Irregular migration :

Some birds like herons, cuckoos,after breeding the adults and the young disperse in all directions for a few hundred miles in search of food and to avoid enemies.

Seasonal migration:

Some birds migrates at different seasons of the year for food or breeding, called seasonal migration, e.g., cuckoos, swifts, swallows etc. They migrate from the south to the north during summer. These birds are called summer visitors. Again there are some birds like snow bunting, red wing, shore lark, grey plover etc. which migrate from north to south during winter. They are called winter visitors.

Diurnal migration:

Many larger birds like crows, robins, swallows, hawks, jays, blue birds, pelicans, cranes, geese, etc. migrate during daytime for food.

Nocturnal migration:

Some small-sized birds of passerine groups like sparrows, warblers, etc. migrate in darkness, called nocturnal birds. The darkness of the night gives them protection from their enemies.

Range of migration:

This varies from one or few miles to thousands of miles in different group of migratory birds. But constant for a particular group. The himalayan snow partridges cover one or two miles while chicades travel 8000 feet.

Ex: Some birds like golden plovers, swallows and Arctic tern migrates thousand of miles. These birds have lot of fat in their body as they have to undertake long journeys.

Altitude of flight:

- Most of the birds fly close to the earth while some go upto 3000 feet altitude from earth during their migration.
- Technology now show that there are some birds which migrate during nights go upto 5000 to 14000 feet from the Earth.
- Some species even cross Himalayas thus increasing their altitude to 20,000ft.
- These birds must have great strength and adaptations to reach that height as many problems arise like decrease in pressure, decrease in oxygen content etc. when the altitude increase.

Speed of Flight:

- Speed varies from individual to individual during migration.
- Speed and direction of the air in the atmosphere affects the movement of the bird to a great extent in migration.
- The average speed of most small birds is 30 miles per hour.Birds usually travel 5 to 6 hours a day, take rest for food and then continue the journey.

Routes of Migration :

- Migratory birds usually follow a definite route of flight. Generally this route is common for going and returning but sometimes the return route differs.
- Marine birds follow sea routes.
- Land birds cross around 400 miles at a stretch while crossing oceans.
- Coast routes; River - valley routes and Mountain ranges are also followed by some birds. These routes form good land marks for the migratory birds.

Regularity of Migration :

Birds maintain striking regularity, year after year in the timings of arrival and departure. Such birds which maintain this type of regularity are called instinct birds.

Order of Migration:

The birds follow a definite order during migration. Generally the adult or old ones start first and the young follow them.

However during return flight the order is reversed i.e. the young birds start and follow the same path while the adults follow them. In the migratory order the adult males will be at the forefront of the group, next comes the females then young ones and the wounded birds at the end of the flock.

Navigation for Migration

(a) Land marks:

Migrants use naturally available structures and topographical features as land marks during migration. For example rivers, valleys, coast lines, chains of ocean islands, mountain ranges etc.

(b) Earth's magnetic field:

Some ornithologists suggest that birds migrate in response to earth's magnetic field and by the rotation of earth.

(c) Celestial bodies:

Celestial objects like sun, stars help the birds to decide the direction of their travel.

(d) Homing instinct :

Some ornithologists say that the birds, have homing instinct to reach their goal.

Origin of migration:

Most convincing theory explains the migration as an evolutionary one. According to this theory in the past tropical birds lived in colder northern latitudes due to the abundance of food. But in winter they moved to south due to winter. This habit of movement became an inborn custom.

Stimulus for migration :

Environmental stimulus,ripening of gonads in birds cause a physiological change leading to an impulse in birds to migrate to breeding grounds.In others thyroid

hormones produce necessary changes in the metabolism of migratory birds and these changes make the birds to complete migration.

Physiology of migration :

Migrant birds deposite fats because they have to fly several hundreds of miles without food and water. Fat has a physiological advantage over glycogen because it produces more energy per unit weight than glycogen.

Advantages of migration:

- There is a strong survival value for the species.
- Arctic region where many migratory birds breed is habitable only for three months of the year. So they migrate from that region in the remaining period.
- Birds migrate from higher altitudes and latitudes during winter to protect themselves from severe cold and also for food.
- Again they go back to their home grounds where food is available in plenty at other seasons.

Disadvantages:

- When the birds migrate in search of food much of their energy and reserve food is utilised.
- They have to face many odd situations during their migration. They may also be exposed to their predators.
- Sometimes climate also becomes adverse so they may not reach destination.
- When the birds fly long stretches, when they cross oceans they may exhaust and fall down and die.

4B3. Give an account of flight adaptations seen in birds.

Birds are adapted to aerial life.There should be some requirements for an animal which spends the greater part of its life for adapting itself for flying.They are

> Organs to lift the animal up into the air.

> Minimum possible weight to facilitate easy flight.

> Great and sustained energy to enable the animal to fly for more time.

The modifications of the various body parts involved in such an adaptation are

Wings and Feathers:

(A) Wings:

- The fore limbs of the bird are modified into wings.
- The wings bear along their posterior edges a row of quill feathers called remiges. The remiges are so arranged as to form a continuous sheet which is impervious to air.
- Elevation of the bird and its propulsion in the air are brought about by a powerful downward and backward motion of the wings beating against the air below.
- Change of direction of flight is brought about by the working of the retrices or tail feathers.

(B) Muscles of flight:

Extremely powerful muscles are developed to work the wings during flight. There are three such muscles:

- **Pectoralis majo**r
- **Pectoralis minor**
- **Coracobrachialis**

Of these the pectoralis major and coracobrachialis serve to pull the wing downwards, while the pectoralis minor serves to pull the wing upwards.

Minimum weight and maximum rigidity:

- The reduction of body weight to facilitate easy flight is due to pneumatic bones.
- The attainment of rigidity of the skeletal framework to bring about unity of function, involves the following skeletal modifications.
- The bones of the adult skull are fused to withstand the effects of varying pressures of the air.
- The first three thoracic vertebrae are fused to form a firm fulcrum for the working of the wings.
- Total of 14 vertebrae are fused to form Synsacrum. This offers a surface for fusion of the anterior extensions of the ilia on both the sides.
- The fusion of the ilia with the synsacrum gives a long and strong grip on the back bone to the pelvic girdle. This condition facilitates the balance of the body on the apices of the legs.
- The last four caudal vertebrae fused to form the pygostyle . This offers short but strong basis for the attachment of the retrices.

- The sternum or breast bone has a keel or carina offering a surface of attachment for pectoral muscles.
- The clavicles and interclavicles of both sides have fused to form a V-shaped bone called furcula.This acts as a spring to keep the wings well apart.
- The double-headed ribs and sternum form a coherent sterno costal-vertebral basket giving protection for the viscera.

Sources of Sustained energy:

- Birds needs a large amount of energy for flight,which is gained only when there is a continuous oxygenation of the blood in the respiratory organs.
- The blood is oxygenated even during the expiratory phase of respiration.
- As air is expelled out of the bronchioles of the lung mass during expiration, the unused air from the air sacs passes through the bronchioles to the outside.

In addition to the above principal modifications,certain other necessary modifications can be noticed. They are

Shape and body covering:

(i) The body is boat-shaped or spindle-shaped with the absence of all avoidable protuberances, and is adapted for the movement of the bird in air.

(ii) The contour feathers and filoplumes form a nonconducting covering, preventing the undue loss of heat during flight.

Alimentary canal:

(i) Mouth is very wide bounded by the beaks which facilitate easy ingestion of food even during the flight.

(ii) The rectum, where, the fecal matter is stored, is very much reduced in length, since the birds can not fly freely by the presence of too much of fecal matter.

Respiratory organs:

The lungs are solid, spongy organs, which are closely fitted into the spaces between the ribs, not hanging within the thoracic cavity.

Circulatory system:

The caliber of the pectoral artery is larger than even that of the dorsal aorta, as it has to supply larger amounts of blood to the powerful flight muscles.

Brain:

The brain is very much enlarged but it is short to maintain balance and muscular co-ordination which are useful for flight.

Sense organs:

(i) The eyes are very well developed with greater powers of vision due to the presence of pectin.

(ii) The eye of the bird has a series of sclerotic bony plates helping to protect the eye against the varying wind pressure.

(iii) The two eyes of the bird work independently of each other-a condition known as monocular vision-so that the bird can see two large separate visual fields at the same time.

SHORT ANSWER QUESTIONS

11. a) Aves general characters

Distinct characters are:

- Birds are warm blooded animals.
- Body is covered with feathers which form the exoskeleton. Body divisible into head, trunk and tail. Neck connects the head and trunk.
- Jaws are without teeth and modified into horny beak.
- Tail is short provided with feathers and help in flight.
- Pentadactyle limbs are present. Fore limbs are modified into wings. Help in flight. Hind limbs are strong. Used for walking, perching and swimming. They bear four toes with claws of which one toe is directed backwards.
- Skin is without glands except the preen gland or oil gland on the tail.
- Pectoral muscles are well developed and help in flying.
- Bones are pneumatic to keep the body light. It is one of the flight adaptations of birds.
- Vertebrae are heterocoelous. A few thoracic, lumbar, sacral and a few caudal vertebrae fuse to form Synsacrum.Posterior few caudal vertebrae form Pygostyle.
- Ribs are double headed and are provided with uncinate processes.Sternum large, broad and bears a keel which forms a surface for the attachment of pectoral or flight muscles.Clavicle of two sides unite to form furcule which is 'y' shaped.Distal carpals and metacarpals unite to form carpometacarpus.

- Proximal tarsals unite with Tibia bone to form Tibiotarsus. Distal tarsals fuse with metatarsals and form tarsometatarsus.Proventriculus and gizzard are present in the digestive system.
- Lungs are spongy and not distensible.Nine air sacs are present which are connected to lungs.
- Larynx does not have vocal cords as in other vertebrates. Birds have a special voice box called Syrinx.
- Heart is four chambered. Double circulation is present.Only right aortic arch is present.
- Kidneys are metanephric. Urinary bladder absent.
- Optic lobes well developed.
- Twelve pairs of cranial nerves are present.
- Sexes separate. Sexual dimorphism is present.
- Fertilization internal. Calcareous eggs are laid.
- Eggs are macrolecithal as they have large amount of yolk.Fetal membranes are present.
- Parental care is present in this group.

11.b) Ratitae

Palaeognathae :

1. These birds are also called Ratitae birds.
2. Flightless birds as wings are reduced or absent. They can walk and run.
3. Feathers are without interlocking mechanism.
4. Tail vertebrae are free and oil gland is absent except in a few.
5. Keel is absent in sternum.
6. Pectoral muscles poorly developed.
7. Clavicles are small or totally absent.
8. Syrinx is absent.
9. Shows discontinuous distribution.
10. Young ones are precocious.
11. Male has a long erectile penis.

Palaeognathae is divided into seven orders

(1) Struthioniformes;
(2) Rheiformes;
(3) Casuariformes ;
(4) Apterygiformes ;
(5) Diornithiformes;

(6) Aepyornithiformes;
(7) Tinamiformes.

11.c) Carinatae

Super order Neognathae is also called as Carinatae.

1. All the modern birds with capacity to fly are included in this super order.

2. Teeth are absent.

3. Wings well developed with feathers of interlocking system.

4. Oil gland is present.

5. Skull is neognathus type in which vomer is short and meet palatines.

6. Sternum has a well developed keel and pectoral muscles are also well developed.

7. Pygostyle is present.

8. Ribs with uncinate processes.

9. Clavicles form furcula.

10. Copulatory organ is absent.

Neognathae has been divided into Nineteen orders,some of ‘em are

Order 1 : Passeriformes : eg. Passer domesticus (Sparrow)

Order 2 : Columbiformes: Eg. Columba livia (Pigeon)

Order 3 : Piciformes: Eg. Dinopium benghalensis (Wood pecker)

Order 4 : Psittaciformes : Eg. Psittacula krameri (green parrot)

Order 5 : Galliformes: Eg. Gallus (fowl) Pavo cristatus (Peacock)

Order 6: Anseriformes: Eg. Duck and Swan.

Order 7 : Cuculiformes: Eg. Eudynamous, Cuculus (Cuckoo).

Order 8 : Coraciiformes: Eg. Ceryle rudis (King fisher)

12.a) Archaeopteryx

- Archaeopteryx was a primitive bird.

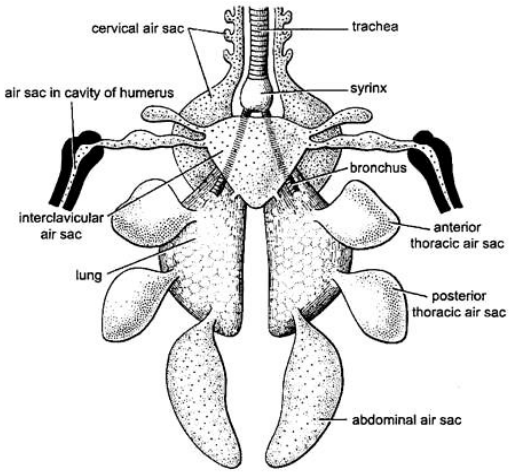
- Archaeopteryx is considered a transitional fossil between dinosaurs and modern birds. Its German name is “Urvogel”.
- They lived in the Late Jurassic around 150 million years ago.

Characteristic features of Archaeopteryx

- Archaeopteryx consists jaw with a full set of sharp teeth.
- They had a flat sternum (breastbones), a long bony tail, and gastralia
- Archaeopteryx possessed three fingers with claws
- The feathers, wings, furcular and reduced fingers are all characteristics of modern birds.
- It has hyperextensible second toes ("killing claw").
- As they had wings but it is not clear whether Archaeopteryx was capable of flapping flight or simply a glider.
- Despite the presence of numerous avian features, Archaeopteryx had many non-avian Theropod dinosaur characteristics.
- Unlike modern birds, Archaeopteryx had small teeth as well as long bony tails, features which Archaeopteryx shared with other dinosaurs of the time.
- Because the Archaeopteryx had common features of both birds and non-avian dinosaurs, it has often been considered a link between them.

12.b) Air sacs in Pigeon

Presence of air sacs is the characteristic feature of avian lung. Five branches from the **mesobronchus** lead into the air sacs.
Of these three arises near its entrance into the lung and open into the interclavicular, cervical and the anterior thoracic air sacs.
From the hind end of the mesobronchium arise two air sacs and open into the posterior thoracic and Abdominal air sacs.
Air sacs are paired in origin but in Pigeon, the two Inter clavicular air sacs fuse early in development. Thus there are 9 major air sacs in pigeon. They are named according to their location in the bird body as



Interclavicular - 1
Cervical - 2
Anterior thoracic - 2
Posterior thoracic - 2
Abdominal - 2

Air sacs are large in size, thin walled membranous, non muscular and non- vascular. Their total volume is several times greater than that of the lungs and extended into some of the larger bones.

Interclavicular :

It is unpaired, triangular air sac connected with both the lungs. It is situated between the two limbs of the furcula. It gives out on either side a diverticulum and an extraclavicular air sac. The air sacs communicate with the pneumatic cavities of the bones.

Cervical:

A pair of small cervical air sacs arise one from each lung from its anterior end lie at the root of the neck and gives off minor saccules in the neck.

Anterior thoracic :

A pair of anterior thoracic air sacs are present at the anterior part of the chest and ventral to the lungs. They are in close contact with the ribs and the pericardium of the heart. They extend posteriorly and overlap the posterior thoracic air sacs.

Posterior thoracic :

A pair of small posterior thoracic air sacs are present in the posterior part of the thoracic cavity. They lie infront of the abdominal air sacs. Each air sac overlaps the posterior end of its lung.

Abdominal:

A pair of large abdominal air sacs arise from the outer posterior angle of each lung. They lie along the dorsal wall of the abdomen, ventral to the kidneys.

Functions of air sacs :

(1) Air sacs are non- vascular, hence they do not play any important role in gaseous exchange.

(2) They increase the efficiency of the lungs by providing them fresh air during expiration.

(3) They cool the body by evaporation of fluid from their surface and dissipation of heat into the air. This function is important in the absence of sweat glands.

(4) They act as balloons to provide lightness and buoyancy to the body.

(5) Act as the accessory breathing organs

12.c) Types of migration in Birds

Migration can be defined "as a regular, periodic too and fro movements of birds either for feeding or breeding".

Types of Migration

Latitudinal migration :

Movement of birds in North - South direction and vice versa is called Latitudinal migration.

Ex: The American golden plover (Pluvialis)

Longitudinal migration :

Migration in the direction of east and west and vice versa is called longitudinal migration.

Ex: The patagonian plover travels to Falkland island for breeding.

Altitudinal migration :

This is also called as vertical movement. Birds spend summer in high mountains and return to low valleys in winter because of changes in the climate.

Ex: Birds like Woodcock and Scolopax rusticola.

Total migration:

When all the members of a species take part in the migration, it is called total migration. The Arctic Tern population shows such a kind of migration.

Partial migration :

Not all but many members of birds of a particular Family do take part in migration.This movement is only for a short period and hence called partial migration and the birds are referred to as partial migrants.

Ex: Blue birds and blue jays.

UNIT – V

LONG ANSWER QUESTIONS

5A1. Give an account of general characters of class Mammalia.

GENERAL CHARACTERS OF MAMMALS

1. These are **homeotherms**. Body is covered by hair which is epidermal in origin. Hair is reduced in whales, armadillos, etc. but is present at least at some stage of development in all mammals. Claws, nails, hooves are the accumulations of keratin that protect the terminal phalanges of digits.

2. Epidermal glands in the skin include sebaceous glands, sweat glands, etc. Sweat (sudoriferous) glands assist in excretion and thermoregulation. Sebaceous glands are associated with hair follicles. They produce an oily secretion, sebum, which lubricates hair and skin. Mammary glands are the modified sweat glands.

3. Skull is dicondylic. Vertebrae are acoelous (amphiplatyan). Each half of lower jaw is formed of a single bone, the dentary that articulates with the squamosal bone of skull. Most mammals have seven cervical vertebrae [six in two-toed sloth, Manatee (Trichechus); nine in three-toed sloth]. Most are double-headed.

4.Coelom is present as a small pericardial cavity, a pair of pleural an abdominal cavity. A muscular diaphragm separates thorax and abdomen.

5. Dentition is **thecodont** (enclosed in jaw sockets), mostly **heterodont** (different types i.e. incisors, canines, premolars and molars) and **diphyodont** (formed twice; milk set and permanent set). Molars are not preceded by milk teeth.

6.Palatine processes of premaxilla, maxilla and palatine bone form a complete secondary palate that separates nasal passage and oral passage. It enables mammals to chew and breathe simultaneously. Salivary glands open into buccal cavity.

7.Respiration is pulmonary. Glottis is guarded by epiglottis. Diaphragm and intercostal muscles aid in ventilation. Larynx is the sound producing organ.

8.Heart is four-chambered with two atria and two ventricles. Each atrium has a unique, ear-like lobe called the auricle. Complete double circulation occurs. Truncus arteriosus and sinus venosus are absent. Sinus venosus is incorporated into right atrium as the sinoatrial node, which acts as the pace maker. There are two aortic arches: the left systemic arch and the pulmonary arch. Renal portal system is

absent. Mature erythrocytes are enucleated, biconcave and circular (elliptical in camels and llamas).

9. Functional adult kidneys are metanephros. Excretion is ureotelic. Nephron has loop of Henle which helps in formation of concentrated urine. Urinary bladder is present.

10.Mammals have three meninges : outer dura mater, middle arachnoid mater and inner pia mater. The dorsal part of cerebral cortex is enlarged to form neopallium. In eutherians, the two cerebral hemispheres are connected by a transverse band of nerve fibres called corpus callosum. Optic lobes (corpora quadrigemina) are transversely divided. **Cranial nerves are twelve pairs.**

11.External ear lobe, or pinna is present except in monotremes, cetaceans and sirenians. Middle ear has three ear ossicles: **malleus, incus and stapes** (modified articular, quadrate and hyomadibula respectively). Stapes is the smallest bone in mammals. Cochlea of internal ear is coiled. Echolocation is exhibited by bats, whales, manatees, seals, and shrews.

12.Testes are extra-abdominal, placed in scrotal sacs except in monotremes, some marsupials and some eutherians such as cetaceans, sirenians, elephants, rhinoceros, etc. The female reproductive cycle of humans and many other primates is called menstrual cycle and that of other viviparous mammals is called oestrous cycle. **Menstrual cycle** involves the shedding of endometrium whereas **oestrous cycle** involves the reabsorption of endometrium. Four extraembryonic membranes appear during the development.

5A2. Briefly explain general characters of Prototherians.

- The term Prototheria is derived from Greek words **Protos** means first and **ther** means beast.
- Most of the animals in this group are extinct.This includes the only order with living animals is **Monotremata.** (Gr=mono: one; trema = hole).
- These are primitive, reptile-like, oviparous mammals. Mammae are without nipples.
- Pinna is absent. Interclavicle is present.
- In the pectoral girdle,coracoid is well-developed. Epipubic bones extend from pelvis. Ribs are single-headed, without tuberculum.
- Teeth are absent in adult; present in juveniles.
- No carpus callosum in brain.

- Rectum and urinogenital sinus open into a common cloaca (hence the name Monotremata).
- Cochlea is simple. Testes are abdominal. Penis is present in the cloacal floor and is used only for the passage of semen.
- Two uteri open into urinogenital sinus. Vagina is absent.
- They deposit their eggs in a nest (platypus) or in a temporary abdominal pouch (echidna) and incubate them.
- Eggs are large, megalecithal and undergo meroblastic cleavage.
- A grooved erectile poison spine occurs on the tarsus of male platypus.
- These are distributed in Australia and New Guinea.

Examples: Ornithorhynchus anatinus (duck-billed platypus),

Tachyglossus aculeatus (short nosed echidna),

Zaglossus bruijni (long-nosed echidna).

Affinities of Monotremes :

Prototheria resemble the reptiles and birds with some advanced characters over them,

Reptilian Affinities:

1. Presence of cloaca.
2. Ribs are single headed.
3. Cervical ribs are present.
4. Thoracic ribs are single headed.
5. A median T-shaped interclavicle present.
6. Acetabulum in echidna is perforated.
7. Ureters lead into an urinogenital sinus.
8. Corpus callosum is absent and anterior commissure is well developed.
9. Testis abdominal.
10. Oviparous and meroblastic segmentation.

Presence of strong reptilian features in Monotremata speaks of its primitiveness. These primitive mammals have failed to cope up with many of the evolutionary transformations which culminated in the establishment of better characteristics in higher mammals.

Avian affinity:

1. Beak of the platypus resembles that of birds.

2. Teeth in adults are absent.

3. Presence of webbed feet.

4. Oil gland is present.

The relationship between monotremes and birds does not stand on a solid ground. The converging characters seen in them are due more to the fact that both possess common reptilian ancestry.

5A3. List out differences between Prototherians and Metatherians.

PROTOTHERIANS	METATHERIANS
This includes the order Monotremata. (Gr=mono: one; trema = hole).	Metatherians are traditionally considered as a single order, Marsupialia.
These are primitive, reptile-like, oviparous mammals.Mammae are without nipples.	Mammary glands are modified sebacious glands and bear nipples.
In the pectoral girdle,coracoid is well-developed. Epipubic bones extend from pelvis.	Epipubic bones (sometimes wrongly called marsupial bones) are present in the pelvic girdle.Marsupium is supported by epipubic bone
Teeth are absent in adult; present in juveniles. Each jaw has three premolars and 4 molars in each half.	Typical (maximum) marsupial dental formula is i 5/4, e 1/ 1, pm 3/3, m4/4. Marsupials replace only the last premolars.
Pinna is absent. Interclavicle is present.	Ear with pinna is present.
Ribs are single-headed, without tuberculum.	Ribs bear two heads,
Rectum and urinogenital sinus open into a common cloaca (hence the name Monotremata).	Anus and urinogenital aperture are closely appositioned and are operated by a common sphincter.
Do not have true placenta	Most marsupials have only choriovitelline placenta. Perameles has a chorioallantoic placenta also.
Testes are abdominal. Penis is present in the cloacal floor and is used only for the passage of semen.	Testes descend into scrotal sacs.Penis is behind scrotum. Glans penis is forked.

Two uteri open into urinogenital sinus. Vagina is absent.	Uteri and vaginae are double.
Oviparous	Viviparous
They deposit their eggs in a nest (platypus) or in a temporary abdominal pouch (echidna) and incubate them. Eggs are large, megalecithal and undergo meroblastic cleavage.	The embryos are born very young. They crawl into the marsupium, attach to teats and suckle.
Incubation lasts about 12 days. The young, which are tiny and at a very early stage of development when they hatch.	The duration of gestation period is shorter than that of oestrous cycle (shortest in opossum; 12-14 days).
These are distributed in Australia and New Guinea.	Most of them are found in Australia, which is described as 'Land of Marsupials'. Some are found in North, Central and South America.
Examples: Ornithorhynchus anatinus (duck-billed platypus), Tachyglossus aculeatus (short nosed echidna).	**Examples:** Macropus (kangaroo), Didelphis (opossum;).

5B1. Classify Eutherians upto order level with examples.

Sub Class: **Eutheria;**

1. Mammary glands are well developed and possess nipples.

2. Mammary glands are modified sweat glands.

3. Marsupium is absent. Epipubic bone is not present. 4. Ribs are double headed.

5. Cloaca is absent.

6. Corpus callosum is present.

7. Testes descend down into scrotal sas in adults.

8. Vagina is single.

9. Viviparous individuals.

10. Placenta is present between mother and child.

11. Parental care is seen.

Class Eutheria is divided into Sixteen orders.

(Write any 8 Orders)

Order 1-Insectivora:

1. Small, hairy animals.

2. Snout elongated.

3. Teeth sharp and pointed.

4. Nocturnal animals.

5. Feet plantigrade.

Eg. Mole (Talpa)

Order 2- Chiroptera:

1. Commonly called flying mammals,

2. Fore limbs are modified into wings which are supported by patagium.

3. Hind limbs are short. Possess clawed digita

4. Eyes are small and wars have large pinnas

5. Sternum has keel

6. Nocturnal animals.

Eg. Bats

Order 3-Dermoptera:

1. Commonly called as flying lemurs

2. All the four limbs are of equal size.

3. Membrane stretched between forelimbs and hind limbs.

4. Nocturnal in habit

Eg. Galacopithecus.

Order 4 Primates:

1. Body covered with hair and arboreal mammals.

2. Limbs bear five digits each with flat nails.

3. Thumb and toe or first digits are opposable, an adaptation for holding things.

4. Plantigrade animals (foot parallel to ground while walking)

5. Orbits directed forward.

6. Cerebrum is large and convoluted.

7. Testes abdominal in young and descends into scrotune present outside in the adults.

Eg. Loris, Monkeys, Man.

Order 5-Edentata:

1. Teeth present or absent. If present incisors and canines always absent.

2. Feet with large curved claws.

3. Testes are abdominal.

Eg. Sloths, Armadillos.

Order 6 - Pholidota:

1. Commonly called as scaly ant eater.

2. Hair is present between the scales.

3. Tongue is long, sticky and protrusible.

4. Teeth are absent and snout elongated.

5. Nocturnal and burrowing in habit.

Eg. Manis.

Order 7- Lagomorpha :

1. Canines are absent. Place is represented as diastema and two pairs of incisors in the upper jaw.

2. Toes bear claws and they are hairy.

3. Tail is short.

4. Pinna are large.

Eg. Rabbits and Hares.

Order 8- Rodentia :

1. Small sized mammals.

2. Limbs with five toes bearing claws.

3. Canines are absent. One pair of chisel - like incisors present which grow throughout the life.

4. Diastema is present.

Eg. Rat, Mouse, Squirrel.

Order 9- Tubulidentata:

1. Body stout, snout pig - like.

2. Tongue slender and protrusible

3. Ears long, errect and pointed.

4. Incisors and camines are absent.

eg. Orycteropus.

Order 10-Cetacea:

1. Large sized aquatic mammals.

2. Fore limbs modified into flippers or paddles for swimming.

3. Eyes small. No external ears.

4. Hind limbs are absent.

5. Tail long and divided at the end into two fleshy flukes.

6. Bones of skull are spongy and contain fat.

7. A thick layer of fat called blubber present below the skin.

Eg. Whales, Dolphins.

Order 11- Carnivora:

1. Teeth are with cutting edges and canines large and well developed. Incisors are small and three on each half of the jaw.

2. The digits have well developed pointed claws.

3. Mammae are abdominal.

Eg. Lion, Tiger, Dog, Cat.

Order 12- Sirenia:

1. Commonly called as sea cows. Aquatic mammals.

2. Body spindle shaped.

3. Fore limbs like paddles and hind limbs absent.

4. Tail flat with lateral fluker.

5. Nostrils on the upper surface of the snout.

6. External ears absent.

Eg. Manatees, Dugong.

Order: **Proboscidea**

1. Largest terrestrial mammals.Skin is thick and with less hair,

2. Large head and big ears which are fan like.Small eyes,

3. Nose and upper lip modified into an elongated proboscis

4. Incisors of upper jaw developed into tusks which are large.Canines are absent. Molars lophodont type.

5. Two pectoral mammae present.

6. Testes abdominal in position.

Eg. Elephants.

Order 14- Hyracoidea:

1. Small guinea pig like animals with a split snout.

2. Tail and ears are small.

3. Fore limb has four and hind limb has three digits.

4. Testes abdominal.Six pairs of mammae present

5. Canines absent.

Eg. Hyrax.

Order 15- Perissodactyla :

1. Large sized body with hoofs on digits.

2. Toes are odd in number (1 or 3).

3. Middle digit of the fore and hind limbs bear most of the weight of the body.

4. Stomach simple.Caecum large and sacculated.

Eg. Equas (Horse), Rhino.

Order 16 - Artiodactyla :

1. These are even toed animals. Hoofs divided (2 to 4 digits)

2. Teeth are bunodont.Stomach is complicated and four chambered.

3. Horns present on head in many individuals.

4. Except pig all groups ruminate the food.Body weight is born by third and fourth digits of both limbs.

Eg. Hippopotamus, Sus (Pig), Camel (Camelus) Cow, Buffalo.

5B2. Write an essay on dentition in Mammals.

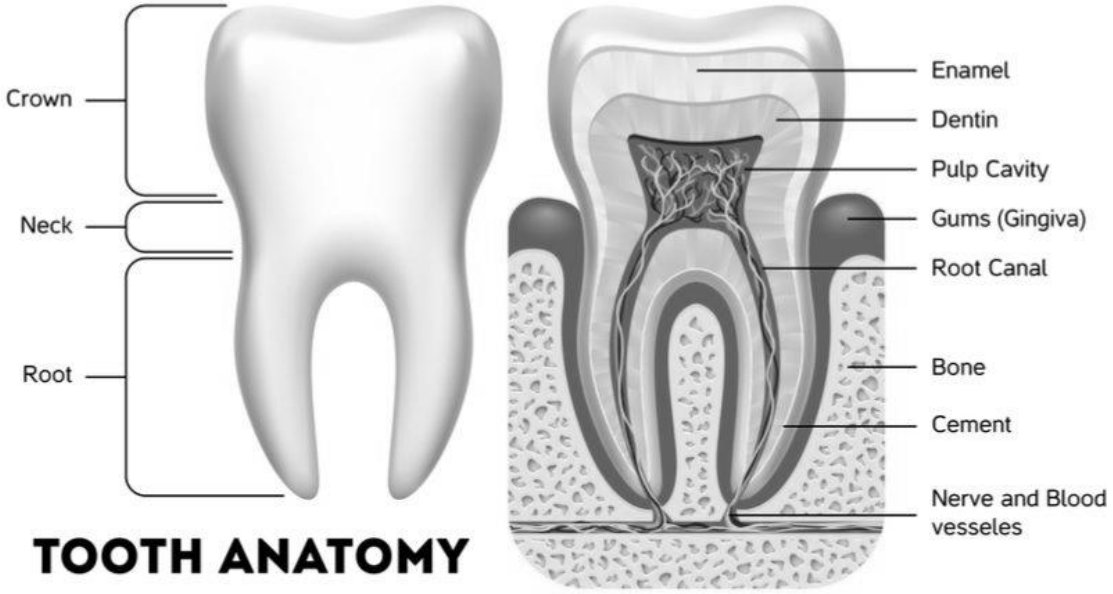
All the gnathostomates have jaws in the mouth. **The development and arrangement of teeth on the jaws is called dentition.**

Structure of tooth:

The tooth of any mammal is made of three main parts namely : crown, neck and root.

- **Crown:** is the exposed part of the tooth which is glistening white in colour.
- **Root:** is the part present in alveolus or socket of the jaw.
- **Neck:** is the junction place of crown and root.
- **Dentine:** It is the substance by which tooth is formed.

- **Enamel:** The crown part of dentine is covered by enamel which is the hardest part of the body of any vertebrate.
- **Cement:** It surrounds the denting of the root portion of the tooth. It is bony in nature.



Development of tooth:

- A tooth is usually developed from three calcified tissues called dentine, enamel and cement. The bulk of the tooth is made of dentine.
- The free surface of tooth is covered by a layer of enamel which is the hardest tissue in the body. The cement covers the part of tooth embedded in the tissue. On the inner end of the tooth a cavity called pulp cavity, is present. This is richly supplied with nerves and blood vessels.
- Among mammals teeth are formed from the soft tissue.Enamel of the tooth is formed from the epidermis. The remaining part that is dentine, cement and pulp are formed from dermis or mesenchyme.
- Along the margin of the jaw ectoderm is formed. The basal layer of ectoderm called Malpighian layer forms a vertical invagination into the dermis. This part forms the dental lamina.
- Mesodermal cells present beneath the dental lamina divide into tooth germs whose number will be equal to the number of milk teeth. Each bud becomes enamel organ which is highly supplied with blood.It has odontoblasts and ameoblasts.

- Enamel is absent on the root of the tooth. Cement which is a modification of bone is deposited around the root. When tooth is completely formed the odontoblasts become inactive except in some animals like rodents in which they are active throughout the life.
- Predentine secreted by odontoblasts and enamel matrix formed on this predentine layer from ameoblasts. Later these two give rise to dentine and enamel after whose formation enamel organ degenerates but the dental papilla change into pulp of the developed tooth.
- After the roots are formed the crown of the tooth is errupted out which is known as cutting of tooth. In mammals there will be an opening in the root at the base. Through this opening nerves and blood vessels enter the pulp.

Types of teeth:

Based on permanancy

Monophyodont: Only one set of teeth are present throughout the life.

Eg. Platypus, Marsupials, Moles etc.

Polyphyodont: Teeth are replaced any number of times as and when they are worn out.

Diphyodont: Where two successive sets are formed in the life time. The first set is called deciduous or milk teeth which are formed after birth.When the milk teeth are lost permanent teeth are formed which last throughout the life.

Based on attachment on jaw bone

Acrodont: In this type of dentition, the teeth have no roots and they are fused to the edge of the jaw bone. Acrodont dentition is seen in lower vertebrates like amphibians and reptiles but not in mammals.

Pleurodont: In pleurodont dentition, the teeth are attached to the rim of jaw. This type of dentition is found in lizards and not in mammals.

Thecodont: In thecodont dentition, the teeth have roots and the roots are embedded in sockets of jaw bone. Thecodont dentition is seen in all mammals.

Based on morphology

- **Homodont -** Teeth are all about the same shape (most vertebrates, few mammals).

- **Heterodont -** Teeth have different form and functions in different parts of the tooth row (mammals, a few fishes)

Types of Teeth In heterodont dentition

There are four different types of teeth,

1.Incisors occupy the front portion of the mouth. They will be lodged on the premaxilla in the upper jaw and lower incisors are placed opposite to them in the lower jaw. They are having only one root but the crown is having a sharp edge for biting and cutting the food material.

In some groups like rodents and lagomorphs they grow continuously throughout life.

In elephants the upper incisors are modified into tusks.

In lemurs they are like comb which help in cleaning the fur.

2.Canines are present one in each half of the jaw. The upper canine is the most anterior tooth of maxilla, and lower canines will be next to incisors on dentary. Canines are also single rooted with a sharp crown. They are meant for offence, defence, for piercing and tearing the food.

In male mush deers canines are present only in upper jaw.

In rabbits and rats the canines are absent and a space called diastema is left representing their position in the jaw.

3.Premolars and molars are together called as cheek teeth or grinders. The crown has broad surface with ridges and tubercles These teeth are used for grinding, chewing and crushing.

4.Molars do not have milk predecessors and they have two roots.

In Carnivora last premolars in upper jaw and first molars in lower jaw are modified into Carnasial teeth which are used for breaking the bones.

In man last pair of molar teeth are called wisdom teeth as they are errupted late.

The check teeth are provided with number of cusps having different shapes. Different terms are used to denote the varieties of grinders

Based on cusps patterns of Molars

Triconodont: In this type of tooth three cones are arranged in linear manner. These are represented in fossil Mesozoic mammals.

Bunadont: In this type of teeth the cusps remain separate and bounded. These are found in Man, Monkey, Pigs which take mixed type of food. They are used for crushing food.

Trituberculate type: In this type three cones are arranged in a triangular shape. These are also seen in fossil mammals.

Selenodont type: This type of teeth is found in grazing mammals. The teeth are provided with crescentic cusps.

If they have low crowns and short roots they are termed as **brachyodont.**

In mammals like horse and cattle teeth are elongated with high crowns and low roots. This type is called **hypsodont** type.

Lophodont: If the cusps join to form ridges, the ridges are called lophos and the tooth is a lophodont type. In this type of teeth intricate folding of enamel and

dentine will be seen. This type of teeth are seen in elephants and are used to grind plants and grass.

Dental formula:

The number of teeth for each species is constant. So the number of various sets of teeth present in the jaws is expressed by a dental formula. In this formula different kinds of teeth like incisors, canines, premolars and molars are indicated by the first letter i.e. **i, c, p and m.**

The dental formulae of some common mammals are giv below:

a) Man & Monkey $I\frac{2}{2}, C\frac{1}{1}, Pm\frac{2}{2}, M\frac{3}{3} = \frac{2123}{2123} \times 2 = 32$

b) Rabbit $I\frac{2}{1}, C\frac{0}{0}, Pm\frac{3}{2}, M\frac{3}{3} = \frac{2033}{1023} \times 2 = 28$

c) Cow & Goat $I\frac{0}{3}, C\frac{0}{1}, Pm\frac{3}{3}, M\frac{3}{3} = \frac{0033}{3133} \times 2 = 32$

d) Dog $I\frac{3}{3}, C\frac{1}{1}, Pm\frac{4}{4}, M\frac{3}{2} = \frac{3142}{3143} \times 2 = 42$

e) Rat & Mouse $I\frac{1}{1}, C\frac{0}{0}, Pm\frac{0}{0}, M\frac{3}{3} = \frac{1003}{1003} \times 2 = 16$

f) Elephant $I\frac{1}{0}, C\frac{0}{0}, Pm\frac{3}{3}, M\frac{3}{3} = \frac{1033}{0033} \times 2 = 26$

g) Kangaroo $I\frac{3}{2}, C\frac{1}{0}, Pm\frac{2}{2}, M\frac{4}{4}, = \frac{3124}{?4} \times 2 = 34$

h) Sheep $I\frac{0}{3}, C\frac{0}{1}, Pm\frac{3}{3}, M\frac{3}{3} = \frac{0033}{3133} \times 2 = 32$

Since two halves of each jaw is identical, teeth of one half of each jaw are represented in the dental formula. Always numerator indicates the upper jaw and the denominator indicates the lower jaw.

5B3. Briefly Answer the following

A) Metatherians

B) Formation of tooth.

A) Metatherians

- Metatheria (Gr. meta= after; ther= beast)

- Metatherians are traditionally considered as a single order, Marsupialia. Females have a marsupial pouch. Epipubic bones (sometimes wrongly called marsupial bones) are present in the pelvic girdle.
- Typical (maximum) marsupial dental formula is **i** 5/4, **c** 1/ 1, **pm** 3/3, **m** 4/4. Marsupials replace only the last premolars.
- Anus and urinogenital aperture are closely appositioned and are operated by a common sphincter.
- Penis is behind scrotum. Glans penis is forked. Uteri and vaginae are double.
- Most marsupials have only choriovitelline placenta. Perameles has a chorioallantoic placenta also.
- The duration of gestation period is shorter than that of oestrous cycle (shortest in opossum; 12-14 days).
- The embryos are born very young. They crawl into the marsupium, attach to teats and suckle.
- Most of them are found in Australia, which is described as 'Land of Marsupials'. Some are found in North, Central and South America.

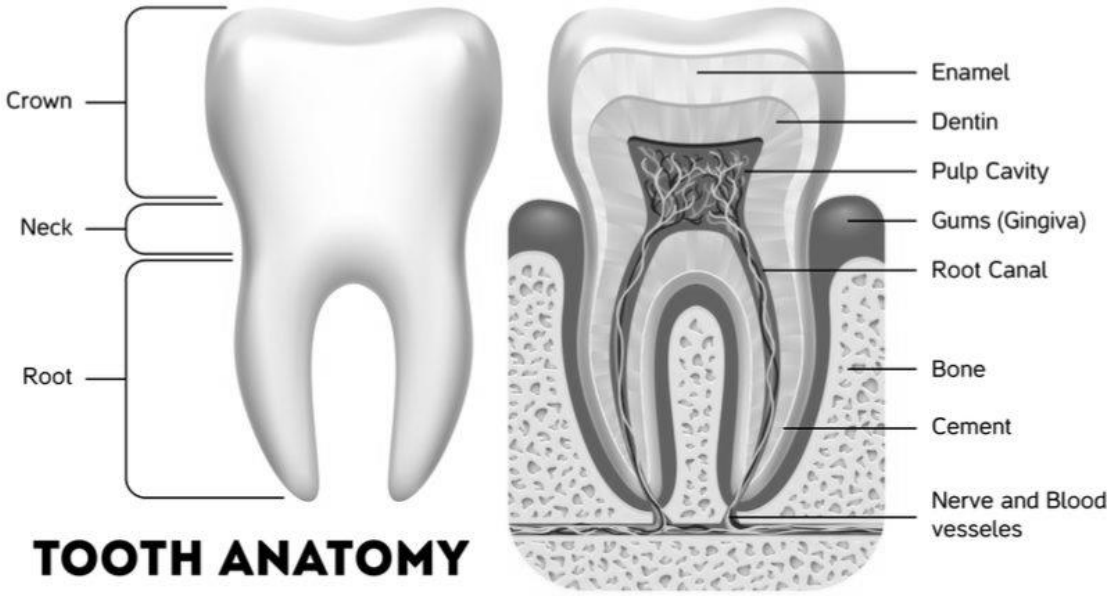
Examples: Macropus(kangaroo), Didelphis(opossum), Caenolestes (opossum),Perameles .

B) Formation of tooth

Structure of tooth:

The tooth of any mammal is made of three main parts namely : crown, neck and root.

- **Crown:** is the exposed part of the tooth which is glistening white in colour.
- **Root:** is the part present in alveolus or socket of the jaw.
- **Neck:** is the junction place of crown and root.
- **Dentine:** It is the substance by which tooth is formed.
- **Enamel:** The crown part of dentine is covered by enamel which is the hardest part of the body of any vertebrate.
- **Cement:** It surrounds the denting of the root portion of the tooth. It is bony in nature.



Development of tooth:

- A tooth is usually developed from three calcified tissues called dentine, enamel and cement. The bulk of the tooth is made of dentine.
- The free surface of tooth is covered by a layer of enamel which is the hardest tissue in the body. The cement covers the part of tooth embedded in the tissue.
- On the inner end of the tooth a cavity called pulp cavity, is present. This is richly supplied with nerves and blood vessels.
- Among mammals teeth are formed from the soft tissue.Enamel of the tooth is formed from the epidermis. The remaining part that is dentine, cement and pulp are formed from dermis or mesenchyme.
- Along the margin of the jaw ectoderm is formed. The basal layer of ectoderm called Malpighian layer forms a vertical invagination into the dermis. This part forms the dental lamina.
- Mesodermal cells present beneath the dental lamina divide into tooth germs whose number will be equal to the number of milk teeth. Each bud becomes enamel organ which is highly supplied with blood.It has odontoblasts and ameoblasts.
- Enamel is absent on the root of the tooth. Cement which is a modification of bone is deposited around the root.
- When tooth is completely formed the odontoblasts become inactive except in some animals like rodents in which they are active throughout the life.

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- In mammals there will be an opening in the root at the base. Through this opening nerves and blood vessels enter the pulp.

SHORT ANSWER QUESTIONS

13a) Egg laying mammals

Order Monotremata of subclass Prototheria includes Egg laying mammal.

- These are primitive, reptile-like, oviparous mammals. Mammae are without nipples.
- Pinna is absent. Interclavicle is present. In the pectoral girdle,coracoid is well-developed. Epipubic bones extend from pelvis. Ribs are single-headed, without tuberculum. Cochlea is simple.
- Teeth are absent in adult; present in juveniles.
- Rectum and urinogenital sinus open into a common cloaca (hence the name Monotremata).
- Testes are abdominal. Penis is present in the cloacal floor and is used only for the passage of semen. Two uteri open into urinogenital sinus. Vagina is absent.
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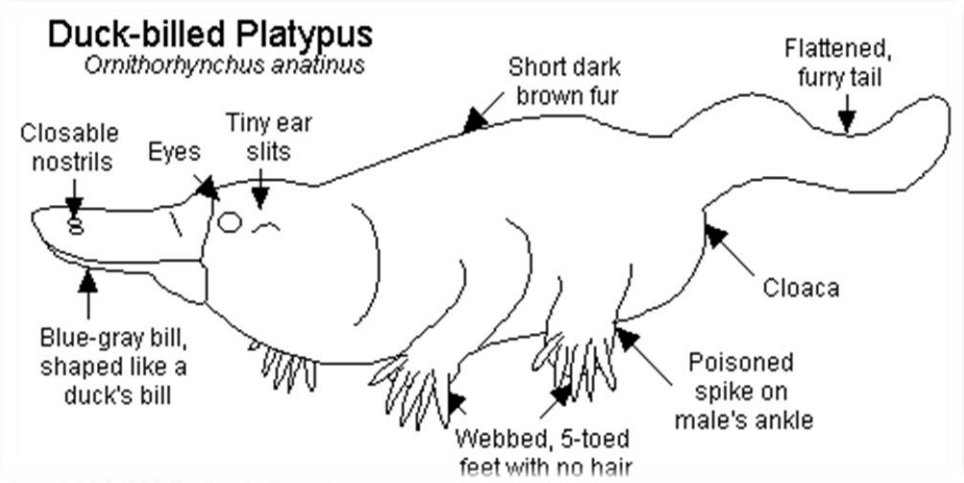

13b) Metatheria

Metatherians are traditionally considered as a single order, Marsupialia.

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- Most of them are found in Australia, which is described as 'Land of Marsupials'. Some are found in North, Central and South America.

Examples: Macropus (kangaroo),
Didelphis (opossum).

13c) Different types of teeth.

Types of teeth:

Based on permanancy

Monophyodont: Only one set of teeth are present throughout the life.

Eg. Platypus, Marsupials, Moles etc.

Polyphyodont: Teeth are replaced any number of times as and when they are worn out.

Diphyodont: Where two successive sets are formed in the life time. The first set is called deciduous or milk teeth which are formed after birth.When the milk teeth are lost permanent teeth are formed which last throughout the life.

Based on attachment on jaw bone

Acrodont : In this type of dentition, the teeth have no roots and they are fused to the edge of the jaw bone. Acrodont dentition is seen in lower vertebrates like amphibians and reptiles but not in mammals.

Pleurodont : In pleurodont dentition, the teeth are attached to the rim of jaw. This type of dentition is found in lizards and not in mammals.

Thecodont : In thecodont dentition, the teeth have roots and the roots are embedded in sockets of jaw bone. Thecodont dentition is seen in all mammals.

Based on morphology

- **Homodont -** Teeth are all about the same shape (most vertebrates, few mammals).
- **Heterodont -** Teeth have different form and functions in different parts of the tooth row (mammals, a few fishes)

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In some groups like rodents and lagomorphs they grow continuously throughout life.

In elephants the upper incisors are modified into tusks.

In lemurs they are like comb which help in cleaning the fur.

2.Canines are present one in each half of the jaw.They are meant for offence, defence, for piercing and tearing the food.

In male mush deers canines are present only in upper jaw.

In rabbits and rats the canines are absent and a space called diastema is left representing their position in the jaw.

3.Premolars and molars are together called as cheek teeth or grinders. The crown has broad surface with ridges and tubercles These teeth are used for grinding, chewing and crushing.

4.Molars do not have milk predecessors and they have two roots.

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In man last pair of molar teeth are called wisdom teeth as they are errupted late.

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Bunadont: In this type of teeth the cusps remain separate and bounded. These are found in Man, Monkey, Pigs which take mixed type of food. They are used for crushing food.

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If they have low crowns and short roots they are termed as **brachyodont.**

In mammals like horse and cattle teeth are elongated with high crowns and low roots. This type is called **hypsodont** type.

Lophodont: If the cusps join to form ridges, the ridges are called lophos and the tooth is a lophodont type. In this type of teeth intricate folding of enamel and dentine will be seen. This type of teeth are seen in elephants and are used to grind plants and grass.