Biyani's Think Tank

Concept based notes

Structure and Function of Chordate Type

Zoology Paper- I

B.Sc. Part-III

Dr B. L. Sharma

Dr Priyanka Dadupanthi

Deptt. of Scienge

Biyani Girls College, Jaipur

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Sector-3, Vidhyadhar Nagar,
Jaipur-302 023 (Rajasthan)
Ph : 0141-2338371, 2338591-95 • Fax : 0141-2338007
E-mail : acad@biyanicolleges.org
Website :www.gurukpo.com; www.biyanicolleges.org

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Preface

I am glad to present this book, especially designed to serve the needs of the students. The book has been written keeping in mind the general weakness in understanding the fundamental concepts of the topics. The book is self-explanatory and adopts the "Teach Yourself" style. It is based on question-answer pattern. The language of book is quite easy and understandable based on scientific approach.

Any further improvement in the contents of the book by making corrections, omission and inclusion is keen to be achieved based on suggestions from the readers for which the author shall be obliged.

I acknowledge special thanks to Mr. Rajeev Biyani, *Chairman* & Dr. Sanjay Biyani, *Director* (*Acad.*) Biyani Group of Colleges, who are the backbones and main concept provider and also have been constant source of motivation throughout this endeavour. They played an active role in coordinating the various stages of this endeavour and spearheaded the publishing work.

I look forward to receiving valuable suggestions from professors of various educational institutions, other faculty members and students for improvement of the quality of the book. The reader may feel free to send in their comments and suggestions to the under mentioned address.

Author

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Section- A

Chordates

Q.1 Write the characteristics of chordata and give outline classification with examples.

Ans.: **Chordata** is the most advanced group of animals. Humans belong to this phylum. Characteristics of chordates:

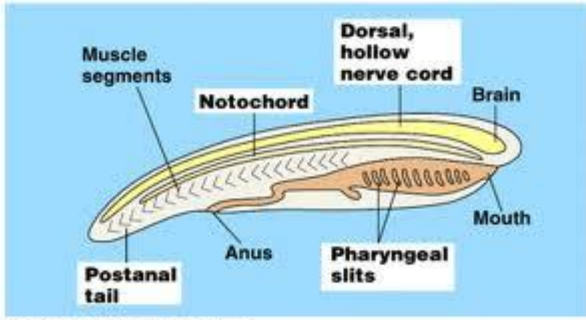
(1) NOTOCHORD - The notochord is a solid unjointed, stiff rod located in the middorsal line between the alimentary canal and the nerve cord in the embryo. The phylum derives its name from this structure (Gr. Noton = back: L.chorda = a cord) It provides support and points for muscle attachment. It persists throughout life in the lower chordates. But in the higher ones, it is replaced partly or fully, in the adult by a vertebral column.

(2) DORSAL HOLLOW CENTRAL NERVOUS SYSTEM - The central nervous system consists of a single tubular, fluid- filled, non ganglionated nerve cord situated along the mid dorsal line above the notochord. The nerve cord persists throughout life in most chordates. A few forms, however, lose it in the adult stage.

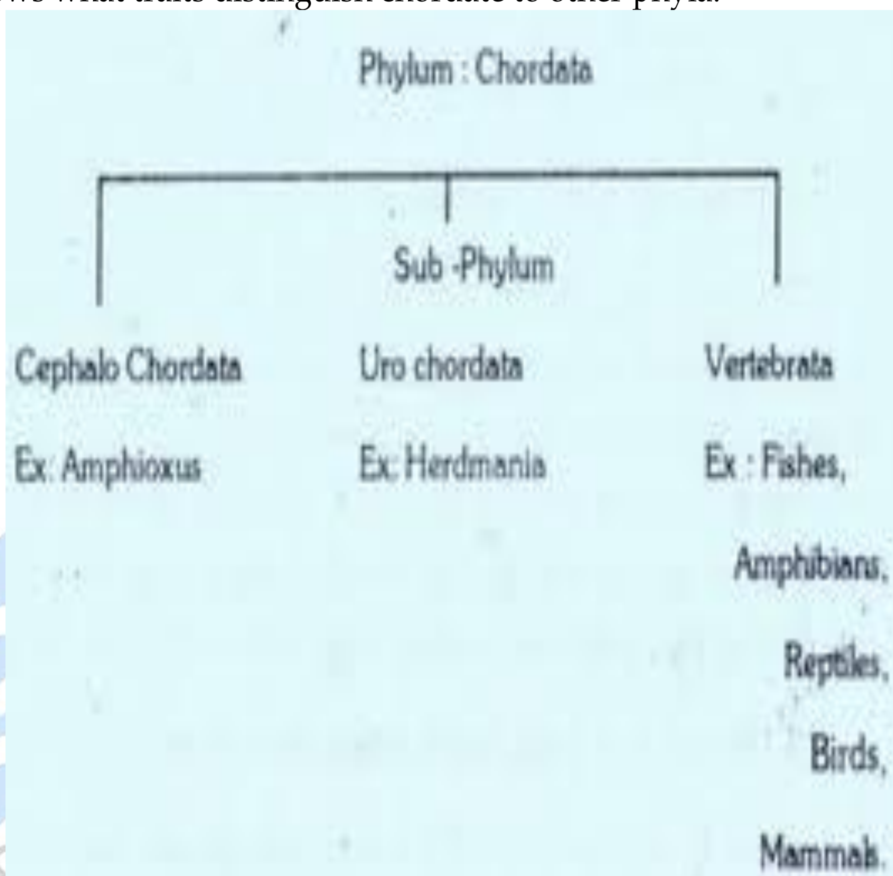
(3) GILL SLITS- The gill slits are paired openings leading from the pharynx to the exterior. They help in feeding or respiration.

(4) TAIL – Tail is the part of the body behind the cloacae or anal opening. It serves a variety of functions. It is absent in the adults of some chordates.

Other characters are bilateral symmetry, three germ layers, organ-system level of organization, segmentation, cephalization, endoskeleton, coelom, complete digestive tract, closed circulatory system, special organs for respiration and excretion, separate sexes, gonads with gonoducts and lack of asexual reproduction.



Above picture shows what traits distinguish chordate to other phyla.



Q.2 What are the general characters of mammalian? Classify upto subclass with characteristics. Also give examples.

Ans: The general characters of class mammalia are:

(1) The skin is covered by hairs.

(2) Sweat glands are present, whose function is to cool the body surface.

(3) Sebaceous glands are present which keeps the hair and the skin soft

(4) Presence of mammary gland.

(5) Teeth are heterodont i.e. differentiated into incisors, canines, molars and premolars.

(6) They are thecodont i.e. embedded in bony socket.

(7) They are diphyodont i.e. two sets of teeth in life i.e. milk teeth set and permanent teeth set.

(8) Skull is dicondylic i.e. two occipital condyles.

(9) Lower jaw is made up of 2 denteries.

(10) The articular and quadrate bones.

(11) Turbinal bones are introduced in to the nasal passages, probably to warm the in-breathed air and to catch bacteria and dust.

(12) Long bones have epiphyes and diaphyses, that aid in the growth of bones.

(13) Ribs are double headed, capitulum and tuberculum for articulation.

(14) The body of vertebra is composed of three pieces, the centrum and two epiphysis.

(15) Cartilaginous discs or inter vertebral disks separate the centra of adjacent vertebrae.

(16) Neck with 7 cervical vertebrae.

(17) Except monotremes, the coracoids and precoracoids are reduced in all other mammals.

(18) The tympanic bones are fused to form the periodic bone which is further modified in to tympanic bulla.

(19) The heart is completely 4 chambered.

(20) The red blood corpuscles are biconcave and enucleate.

(21) Only left aortic arch is present.

(22) The cerebrum and cerebellum are highly developed and have much grey matter in them.

(23) There are 4 solid optic lobes forming corpora quadrigemina.

(24) The external ear or pinna is present in mammals except in monotremes and aquatic mammals.

(25) The external auditory meantus is present.

(26) Three ear ossicles- malleus, incus, stapes are present to connect middle ear and internal ear.

(27) Kidneys are metanephric.

(28) The ureters open in to the urinary bladder instead of cloaca. The cloaca is present in monotremes.

(29) A male external copulatory organ penis is always present.

(30) Tests located outside the body cavity in most males, during breeding season only in some.

(31) Eggs with little or no yolk, so called as alecithl or microletithal.

(32) The eggs mature in graffian follicles.

(33) Two oviducts fuse to form uterus or paired uteri.

(34) Uterine gestation is the rule, except egg-laying monotremes.

(35) Allantoic placenta is a nutritional link between mother and foetus

(36) Viviparous i.e. give birth to young ones.

(37) Abdominal and thoracic cavities are separated by a muscular diaphragm. It helps in breathing.

(38) Homoiothermous i.e. warm blooded animals, constant body temperature.

In short mammals-

Classification of class mammalia – the class mammalian is divided into two sub – classes :-

(I) Prototheria and (II) Theria

Prototheria – The prototherians are primitive egg-laying (oviparous) mammals. They retain cloaca. They are confined to Australia and adjacent islands.

Example – Ornithorhynchus, Tachyglosssus

Theria – The therians are young – producing (viviparous) mammals. They lack cloaca. Eggs are with little yolks. They develop in the uterus and living young are delivered. The subclass Theria is divided into two infraclasses :

Metatheria and Eutheria.

Metatheria – The metatherians found in Australia and neighbouring islands and in north and south America. The female has a pouch, the **marsupium,** for rearing the young ones. Therefore, the metatherians are called **pouched mammals or marsupials.** Placenta is small and simple. Hence, intrauterine development is brief and the young are born in a very imperfect condition. **Examples –** Macropus – the kangaroo, Didelphys – *the opossum.*

Eutheria – The eutherians occur all over the world. The anal and urinogenital apparatus have separate sphincters. Placenta is well developed. The young have a prolonged intrauterine development. The eutherians are called placental mammals on account of having a typical placenta.

Q. 3 Write short notes on the following:

(a) Salient features of petromyzon

(b) Ammocoete larva

(c) Affinities of branchiostoma and cephalochordate

Ans: (a) Salient features of petromyzon –

Habit and habitat- Petromyzon commonly known as lamprey, enjoys world wide distribution. It is found in fresh as well as sea waters. It is an ectoparasite found attached to the under surface of fishes with the help of suctorial buccal funnel. With the raspinig tongue it screatches off the flesh from fish body.

Size- The size varies from few inches to four feet. Petromyzon marinus attains size over 3 feet.

Shape- The body is elongate and cyclindrical with eel-like appearance. The head and trun kare cylindrical but the tail is laterally compressed.

Colour- The dorsal surface of the body is greenish brown to bluish but the ventral and lateral sides are white or silvery.

External structure- The slimy, eel -like body is distinguished into an incipient head a trunk and a tail.

The anterior end of the body, making the head, posseses a ventrally situated cup-like depression, the buccal funnel, which serves as an organ of adhesion. It is suctorial in nature and its margins or lips are papillated. At the bottom of the funnel is the narrow slit like mouth surrounded by horny epidermal teeth arranged in definite rows. Protruding out through the mouth in to the funnel is a powerful piston-like rasping tongue. Its surface is also provided with horny epidermal teeth. The teeth are conical and can be replaced when worn out. The tongue is used for rasping flesh and the funnel for sucking blood and mucus. The distinct jaws are abent but the lips are supported by cartilaginouous strips. Dorsally, the head carries a single media nasal aperture. The nasal sac distally communicates with a blind naso-hypophysial sac. Behind the nasal apereture is pineal eye. The pineal eye is sensitive to light. Parallel to this on either lateral side is the eye. The eyes are small and covered with thin transparent skin.\

In the trunk region, immediately behind the eyes are present seven pairs of gill clefts. These lead internally in to the paired gill pouches.

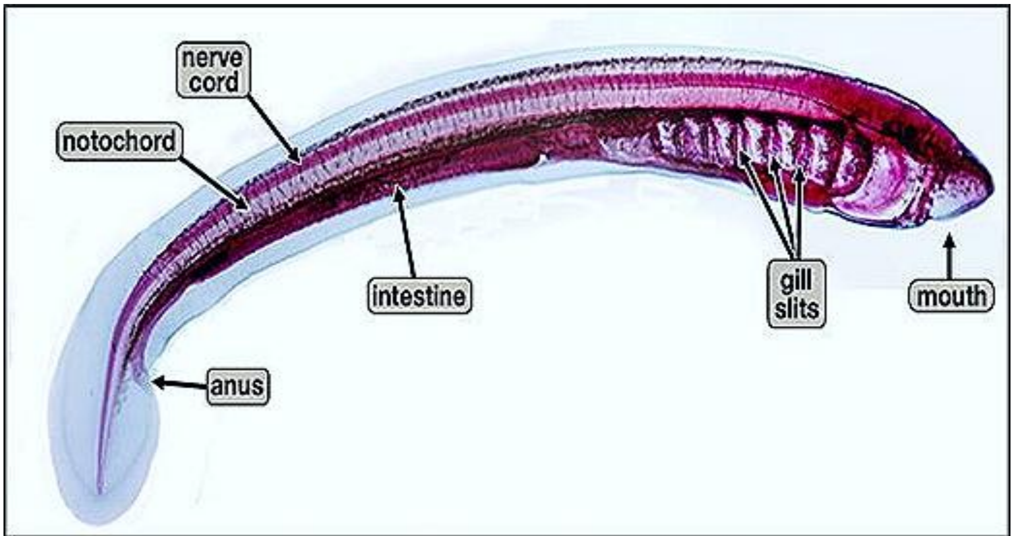
The paired fins are absent, but there are two dorsal fins and a caudal fin. The second dorsal is continuous with the caudal fin. The caudal fin is supported by cartilaginous fin-rays.

The integument is slimy and contains numerous unicellular mucous glands. The skin in the region of head and sides of trunk is perforated by pores of lateral line system but a proper line is absent. At the junction of trunk and tail on the ventral side is located the anal opening.

The sexes are separated and can be differentiated by the shape of dorsal fin in the mature specimens and additional anal find in case of female.

(b) Ammocoete larva: In lampreys the egg hatches out as ammocoete larva. It is about 10 mm. long but may reach up to 170 mm. It lies buried in U-shaped burrows in the sand after which it metamorphoses in to the adult.

The body is elongated worm – like with a continuous median fin. The mouth is a vertical aperture surrounded by semicircular hoodlike upper lip. The suckers and teeth of the adult are wanting. The oral aperture is surrounded by set of buccal tentacles. The anterior wall of the pharynx behind the tentacles is provided with velum, the endostyl and peripharyngeal grooves are also present. The feeding current is produced by the muscles. It possesses a liver, a bileduct and a gall bladder which are lost during metamorphosis. The head region is inconspicuous and bears a median nostril and an underdeveloped eye. The trunk carries seven pairs of branchial apertures. The ammocoete larva possess functional pronephrose, which is supported by matanephros in the adult.



Ammocoetes larva of a lamprey

Metamorphosis – After leading a prolonged larval existence for about 7 to 8 years, the larva undergoes metamorphosis. The mouth changes in to a suctorial funnel, the buccal region elongates to accommodate the rasping tongue and the tentacles are replaced by teeth. The valum reduces and skeleton develops in the pharyngeal region to form a filter and eyes become prominent. The nasohypophysial sac enlarges and the endostyle changes in to thyroid. The continuous dorsal fin breaks off into two dorsal and a caudal fins.

(c) Affinities of Branchiostoma and Cephalochordate: Branchiostoma shows affinities, (i) with Non-chordates, (ii) with tunicates, and (iii) with the verterbrates.

(i) Non-chordate relationship – Enterocoelic development of coelom and curious asymmetries in the anatomy bring Branchiostoma nearer the Echinoderms. Gastrulation by invagination and nephridia like those of the polychaetes and microphagous (filter feeding) habit like polychaetes and molluses bring it still closer to Non-chordates. But these similarities become super imposed by three primary chordate characters that Branchiostoma retains throughout its life.

(ii) Tunicate relationship – Branchiostoma resembles in having a similar type of cleavage and gastrulation, feeding apparatus involving a large number of gill-slits and a spacious pharynx and atrium in which the gill-slits open.

(iii) Vertebrate relationship: The fish- like form of the body of Branchiostoma, segmentally arranged myotomes, gill-slits in the pharynx, concentration of important sense organs in the anterior part of the body, an endostyle similar to that found in ammocoete larva of laprey and a coleom, lead us to believe that Branchiostoma, if not the ancestor of vertebrates, is something like the ancestral vertebrate, but for the following important features of contrast:

1. No true head but a degenerate or primitive jaw less head.

2. A notochord but no vertebral column.

3. Gill-slits, but in very large numbers opening into the atrium.

4. A dorsal tubular nerve-cord but no divisons in the brain.

5. Sense organs, but unpaired.

6. Segmented musculature, but segmentation extending to the far anterior.

7. Fins, but not paired.

8. Two layered skin, but outer layer only one cell thick.

9. Only one hollow gut-diverticulum and no other endodermal diverticula.

10. Similar aortic arches and venous channels, but no heart.

11. Blood, but colourless.

12. A sinus venosus, but without cardiac muscles.

13. A true coelom, but restricted.

14. Kidneys (nephridia), but ectodermal protonephridia, and

15. It can swim with its myotomes like a fish, but essentially it is a burrower.

Branchiostoma is a generalized or primary type of chordate. The earliest recognizable chordates, of which fossil remains are known, include jamoylius from Silurian period.

Q.4 Write affinities of hemichordeta.

Ans. J.F. Eschscholtz who discovered *Balanoglossus* in 1825 in Mashail Island described it as a worm-like holothurian. The discovery of gill-slits in this animal by Kowalewsky (1865) led to creation of a special class Enteropneusta by Gegenbaur (1870). Bateson (1885) included them in Phylum Chordata. Hyman (1959), however, placed them near Echinodermata and gave Hemichordata a status of an independent phylum.

This simple organism shows affinities with several diverse groups.

1. Affinities with Nemertinea (Proboscis worms)

Nemertines resemble flatworms and possess a long protrusible proboscis. *Balanoglossus* shows similarity with nemertine in burrowing and feeding habits. The proboscis of nemertines is compared with proboscis of *Balanoglossus*. These similarities are superficial as the proboscis of *Balanoglossus* is not protrusible as in nemertines. The *Balanoglossus* also does not have lateral nerve cord of nemertines.

2. Affinities with Phoronida

These are worm-like tube-dwelling animals living in the bottom of shallow seas.

The paired sacs given off from the stomach of phoronids are compared with buccal diver ticulum of *Balanoglossus*.

The nervous system in both the groups is intraepidermal.

The power of regeneration is seen in both the groups.

The actinotroch larva of Phoronis is similar to tornaria larva of *Balanoglossus*.

In spite of these similarities following differences present between these two groups show that these groups are not closely related:

1) Absence of gill-slits in Phoronis.

2) Presence of lateral nerve cord in Phoronis.

3) Formation of coelom by splitting of the mesoderm in Phoronis (schizocoelic).

The study of development of Phoronis by Selys-long Champ (1909) convincingly proved that *Balanoglossus* cannot be placed with Phoronida.

3. Affinities with Pogonophora (Beard worms)

These are marine tube-dwelling animals having anteriorly one or more tentacular arms.

The most striking similarity of this group with *Balanoglossus* is its method of formation of mesoderm and coelom. The mesoderm is formed from endoderm in the form of hollow pouches which come to lie between ectoderm and endoderm; the cavities of the pouches form the coelom. Such animals are called enterocoelomate since the mesoderm and coelom arise from the gut.

The other characters in which beard worms resemble Balanoglossus are:

1) Presence of protocoel with external pore.

2) Location of gonads in the trunk.

3) Intraepidermal nervous system.

4) Transformation of coelomic epithelium into muscle fibers and connective tissue.

They differ in the following characters:

1) The central nervous system is located in protosome of Pogonophora and in mcsosome in *Balanoglossus*.

2) The tentacular apparatus which is present in some hemichordates is of mgsosomal (collar) oriain while that of Pogono-phora is of protosomal origin.

The fact that only a few invertebrate groups are enterocoelomate suggests that Pogonophora appears to be fairly closely related to hemichordates.

4. Affinities with Annelida

Spengel (1893) suggested affinities of *Balanoglossus* with annelids.

The two groups show following similarities:

1) Shape of the body.

2) Proboscis of *Balanoglossus* resembles prostomium of earthworm.

3) Burrowing and feeding habits.

4) Ventral nerve cord.

5) Dorsal and ventral blood vessel.

6) Direction of flow of blood.

7) Resemblance between trochophore larva of annelida and tornaria larva of Balanoglossus in the following characters:

a) Apical plate with eyes, sensory cilia and attached muscles.

b) Differentiation of alimentary canal into oesophagus, stomach and intestine.

c) Two anterior pairs of mesodcrmic vesicles.

d) The preanal ciliated ring of trochophore corresponds with principal ciliated ring of tornaria.

The two groups differ in the following characters:

1) The dorsal nerve cord and gill-slits are not present in annelids.

2) The metamerically arranged nephridia of annelids are not present in *Balanoglossus*.

3) The cleavage of egg of annelids is spiral and determinate while that of *Balanoglossus* is radial and indeterminate.

4) The gastrulation in annelids occurs by epiboly and in *Balanoglossus* by emboly.

5) The coelom of annelid is schizocoelic while that of *Balanoglossus* is enterocoelic.

6) The blastopore becomes mouth in annelid larvae, and anus in development of *Balanoglossus*.

7) A pair of primitive kidneys of trochophore are absent in tornaria.

8) The pre-oral coelom of tornaria is absent in trochophore. These differences between the two groups suggest no definite relationship between them. These two groups of animals might have originated from a remote ancestral stock. The annelidan aflffmities of *Balanoglossus* have, therefore, been given up.

5. Affinities with Echinodermata

The affinities of *Balanoglossus* with echinoderms were first suggested by Metchnikoff (1865).

There are no similarities between adults of echinoderms and *Balanoglossus* except in the presence of intraepidermal nervous system.

However, the striking resemblance between the larval forms of the two groups misled Muller to regard tornaria larva as a larva of starfish.

The similarities between tornaria larva and bipinnaria and other larval forms of echinoderms are as follows:

1) They are pelagic and transparent.

2) The early development follows the same pattern.

3) The blastopore becomes anus.

4) The coelom is enterocoelic as in pogonophores.

5) The coelom when first formed is divided into three antero-posterior parts, the protocoel, mesocoel and metacoel in *Balanoglossus* and axocoel, hydrocoel and somatocoel in echinoderms. The hydrocoel opens to exterior by pore as the protocoel and mesocoel does in *Balanoglossus*. The proboscis pore of *Balanoglossus* is compared with waterpore.

6) The heart vesicle of *Balanoglossus* is compared with madreporic vesicle of echinoderm larvae. These structures are closely related with excretory structures, the glomerulus in *Balanoglossus* and axial gland in echinoderms.

7) The alimentary canal is divided into three parts, oesophagus, stomach and intestine.

8) The resemblance in ciliated bands of these larval forms is regarded as a superficial character.

The larval forms show the following dissimilarities:

1) The absence of apical plate with eye spots, cilia in echinoderm larvae.

2) The protocoel is paired in echinoderm larvae and unpaired in tornaria.

The likeness between the larval forms of these two groups suggests strong affinity between them and their origin from a common ancestor. They must have evolved along different lines in response to different modes of life they were called upon to lead.

Affinities with Chordata

Bateson (1885) was the first to advocate chordate aflinities of Enteropneusta and include them into Phylum Chordata. They were supposed to possess the notochord, the gill-slits, and the dorsal tubular nerve cord which are three unique characters of the chordates.

(1) Notochord- Bateson called the buccal diverticulum of *Balanoglossus* as notochord for the following reasons:

(a) It is derived from the dorsal region of the endoderm.

(b) It has some relation to the skeletal function.

(c) It is made up of vacuolated cells.

This structure, as predicted by Newman, has ceased to be regarded as notochord due to the following reasons:

(1) The notochord is never formed as a diverticulum. It is cut off from the roof of the archenteron because of the formation of coelomic pouches on either side of it. The buccal cavity is usually lined with ectoderm. So it is doubtful if buccal diverticulum is an endodermal structure. The true notochord is always a solid structure.

(2) The notochord of chordates extends backwards from the head and not forwards only. It is argued that the notochord extending throughout the length of the body will be disadvantageous to the animal whose movements depend upon the lengthening and shortening of the body.

(3) The buccal cavity is lined by vacuolated cells which are continued in its diverticulum.

According to Newell (1952) the 'notochord' of *Balanoglossus* differs from that of the true chordates in the following characters:

1. The true notochord is enclosed in a sheath which is lacking in *Balanoglossus*.

2. The buccal diverticulum of *Balanoglossus* has no relationship to blastopore.

3. The diverticulum is not rigid enough to serve the skeletal function.

4. The notochord of chordate lies above the dorsal blood vessel while that of *Balanoglossus* lies below the central blood sinus of the proboscis.

5. The presence of cavities in it.

Silen (1957) calls buccal diverticulum as some sort of pre-oral gut while acccording to Ganguli and Mukherji it is nervous in nature.

(2) Gill-slit- The closest relationship between *Balanoglossus* and the true chordates exists due to presence in it of a number of pairs of gill-slits. There is close similarity in gill-slits of *Balanoglossus* and Amphioxus. The primary gill-slits of Amphioxus are divided into two slits by a tongue bar which grows down from the dorsal side. The tongue bar of *Balanoglossus*, however, does not completely divide the slit. The skeletal rods supporting the gill bars are also more or less similar in these two animals. The urochordates which are more closely related to Amphioxus do not have this type of gill-slits. Some authors doubt whether the gill-slits of *Balanoglossus* really are pharyngeal clefts as in one species of *Balanoglossus*, there are as many as 700 pairs of gill-slits. In higher chordates, the pharyngeal region is very short with generally 5 or 6 pairs of gill-slits.

(3) Dorsal tubular nerve cord- The portion of the dorsal nerve cord in the collar region of *Balanoglossus* is the dorsal tubular nerve cord. The anterior and posterior openings of this collar cord are called the anterior and posterior neuropores respectively.

Except for this region the rest of the nervous system of *Balanoglossus* is distinctly of invertebrate type. The ventral nerve cord of *Balanoglossus* never exists in chordates.

Thus except for gill-slits the alleged chordate characters of *Balanoglossus* seem to be decidedly questionable.

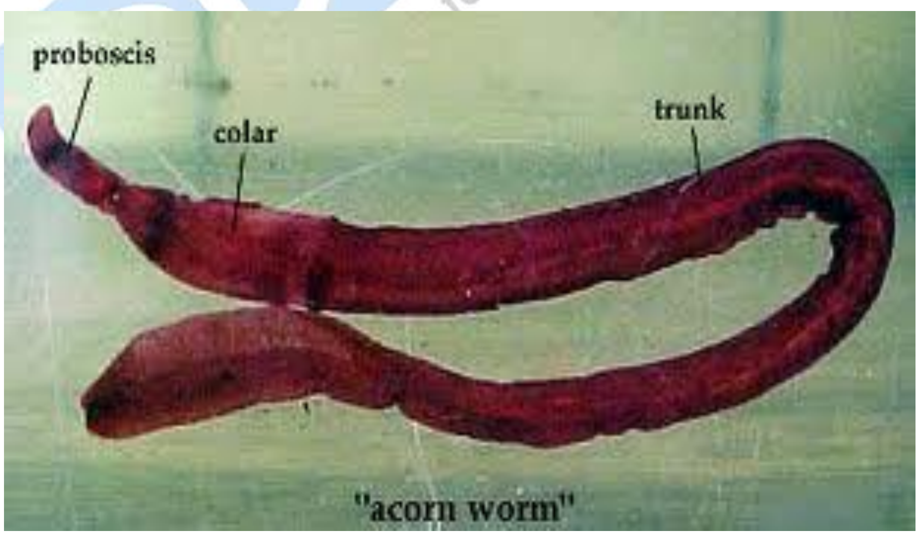
The five coelomic cavities of *Balanoglossus* constituting the trisegmental condition are also found in an embryonic stage of Amphioxus. The enterocoelic origin of coelom in *Balanoglossus* and Amphioxus is also of greater phylogenetic significance than the resemblances in the gill-slits, and so-called notochord and dorsal tubular nerve cord.

The chordates are metamerically segmented animals while *Balanoglossus* retains in adult stage, the trisegmental character of their larvae. According to Newman, *Balanoglossus* thus retains throughout life a larval organization while Amphioxus and vertebrates have secondarily introduced metamerism by division of posterior coelom into a long series of segments.

The epidermis of hemichordate is ciliated whereas it is nonciliated in chordates.

The direction of the flow of blood in dorsal and ventral blood vessel is similar to that of invertebrate like earthworm.

The resemblances between *Balanoglossus* and true chordates in some adult structures and embryonic and larval stages show that the hemichordates and the true chordates are, without question, related, however distantly. They are, as mentioned above, closer to invertebrate phyla Echinodermata and Phoronida in their morphology and development than to the Chordates.

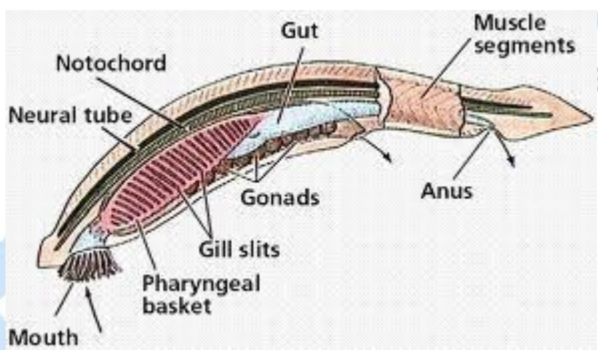


Q.5 Write Short notes on-
A. Urochordeta.

Ans. The Urochordata, sometimes known as the Tunicates, are commonly known as "sea squirts." The body of an adult tunicate is quite simple, being essentially a sack with two siphons through which water enters and exits. Water is filtered inside the sack-shaped body. However, many tunicates have a larva that is free-swimming and exhibits all chordate characteristics: it has a notochord, a dorsal nerve cord, pharyngeal slits, and a post-anal tail. This "tadpole larva" will swim for some time; in many tunicates, it eventually attaches to a hard substrate, it loses its tail and ability to move and its nervous system largely disintegrates. Some tunicates are entirely pelagic; known as salps, they typically have barrel-shaped bodies and may be extremely abundant in the open ocean.

B. Cephalochordate-

Ans. This class includes the several species of lancelets, or amphioxi, small, fishlike, filter-feeding animals found in shallow water. A lancelet has a long body, pointed at both ends, with a large notochord that extends almost from tip to tip and is present throughout life. At one end is a mouth surrounded by prominent bristles and leading into a pharynx. The pharynx has gill slits, an endostyle similar to that of a sea squirt, and an atrium surrounding the pharynx. Water enters the mouth and leaves through the gill slits, and food is trapped in the pharynx. The dorsal, tubular nerve cord is slightly enlarged in the anterior region, forming a rudimentary brain. Nerves extend from the nerve chord to other parts of the body. The muscles, as in fishes, are a series of cone-shaped blocks that fit into each other like stacked paper cups. This is the most primitive occurrence of the segmental body wall structure characteristic of lower vertebrates. The colorless blood moves forward through a ventral vessel and back through a dorsal vessel, in the typical chordate pattern. There is no major heart, although many small enlargements of the vessel serve the function of hearts. There are no blood cells and no respiratory pigments. The excretory system, like that of many invertebrates, consists of segmentally arranged nephridia; there is no kidney. The gonads, unlike those of any other chordate, are numerous and segmentally arranged.



Q. 6 Write difference between Cephalochordate and Urochordata.

Ans. Difference between Cephalochordate and Urochordata are sated below:

Cephalochordate

1. Marine, solitary forms, generally found buried in sand in the intertidal zone of coast.

2. Body is small, fish like.

3. Notochord is persistent and runs through out the body.

4. Nerve chord is dorsal and tubular.

5. Pharynx is performed by numerous gill slits.

6. Coelome is well-developed.

7. Body shows segmentation.

Urochordata

1. Exclusively marine.

2. Body is covered with a cuticular tunic or test.

3. Notochord is present in the posterior half.

4. Nerve chord is dorsal and tubular.

5. Pharynx is performed by numerous gill slits.

6. Coelome is well developed.

7. Body is degenerated unsegmented.

Q.7 Write a detailed note on retrogressive metamorphosis.

Ans: Retrogressive metamorphosis – Retrogressive metamorphosis' is a peculiar type of metamorphosis in the life history of certain individuals, in which certain advanced characters shown by the larva disappear in the adult leading towards the simplification of its organization. Since certain larval organs like notochord, nerve chord, cerebral vesicle, otocyst etc. degenerate during metamorphosis to assume the adult organization.

Larva hatches out of the egg within two to three days after fertilization. It is known as ascidian tadpole. It exhibits highest degree of chordate organization at this stage, since it possesses following notable features:

1. Presence of notochord.
2. Possesses a dorsal tubular nervous system extending the whole length of the body dorsal to the notochord. It dilates in the anterior region to form a short of brain.
3. The median eye derived from the hollow cerebral vesicle.
4. Presence of statocyst as an organ of balance.
5. Well-developed pharynx with endostyle and stigmata.
6. Tail with well developed dorsal and ventral fin-folds.

7. Heart and pericardium develop a diverticulum from the stomach.

Changes during retrogressive metamorphosis:

The larva swims freely for few hours to few days, adheres to some substratum by its adhesive papillae and undergoes rapid metamorphosis to attain the organization of the adult. The important changes taking place during this process are summarized as under:

1. The tail along with the caudal fin, muscles, notochord and nerve cord begins to reduce and finally disappears.
2. The adhesive papillae are lost. The animal develops a test which enormously increases in size and forms the foot at the posterior end of the body for attachment.
3. The cerebral vesicles with otolith and ocelli are lost and a visceral ganglion of the trunk is reduced to a small ganglion placed above the neural gland.
4. The neural gland arises as a proliferation from the wall of hypophysial duct.
5. The larval trunk ganglion forms the visceral nerve of the adult.
6. The pharynx grows enormously and the number of stigmata increases accordingly. It is now known as branchial sac.
7. The pharyngeal opening of the ciliated funnel is transformed into the ciliated funnel.
8. The stomach and intestine become longer and looped and liver is formed.
9. The vascular system of the adult is assumed in due course.
10. Gonads develop from the mesodermal cells of the larva.
11. The body between the point of fixation and mouth (branchial aperture) increases rapidly and causes its rotation through 180 degree so that the branchial siphon is carried to the opposite end.

    Thus an active, free swimming larva with complex organization and chordate characters (i.e. possessing notochord, nerve cord and organs of special sense) metamorphoses in to sedentary adult ascidian having simple degenerate organization with no traces of chordate characteristics. The larva is photosensitive and geonegative and is changes into a photonegative and adult. This metamorphosis is known as retrogressive metamorphosis.

Section- B

Comparative anatomy

Q. 1 Describe the blood vascular system of Amphioxus. In what respect does it resemble that of a typical lower vertebrate?

Ans: The blood vascular system of amphioxus is simple and closed. It is peculiar in the absence of heart and hemoglobin. Due to the absence of heart (a pumping structure) the main arteries have muscular contractile walls. Some of them are called arteries and other veins. The vascular system mainly consists of –

1. Sinus venosus
2. Ventral aorta
3. Dorsal aortae
4. Portal system
5. Cardinal veins

1. **Sinus venosus:** The sinus venosus is a thin walled sac situated below the hind end of pharynx. It receives blood returning from the various parts of the body through veins and pours it into ventral or branchial aorta.
2. **Ventral aorta –** The ventral aorta is a thick walled highly contractile blood vessel, running midventrally in the wall of pharynx below the endostyle. It gives out paired lateral branches to the primary gill-bars. These are known as afferent branchial arteries.

   These have small dilations at their bases which pump the blood up in the vessels. The secondary gill-bars receive blood indirectly from the afferent branchial arteries through transverse vessels running in the synapticulae.

   Dorsally, a series of afferent branchial arteries collect blood from the primary and secondary gill bars and empty it into a pair of dorsal aortae. While travelling though the branchial arteries the blood is exposed to respiratory water current, but there is no proof of oxygenation since the blood is devoid of respiratory pigment.
3. **Dorsal aortae:** In the anterior half of the body the dorsal aorta consists of paired vessels, which lies on either side of the epipharyngeal grove in the

roof of pharynx. Anteriroly, these are continued in to the shout as paired internal carotid arteries and supply the oral hood region. These are collecting vessels which collect blood from the pharynx though efferent branchial arteries.

Posteriorly, the two dorsal aortae unite behind the pharynx to form an unpaired dorsal aorta, which extends backward mid-dorsally between the notochord and intestine upto the caudal region. Here it is known as caudal artery. It acts as distributing vessel and sends off several minute branches to the intestine. These branches form plexus in the intestinal wall.

4. **Portal system:** The blood from the tail is collected by a caudal vein which extends forward below the intestine as subintestinal vein and receives blood from the intestinal blood plexus through a series of blood vessels. The sub intestinal vein enter the trunk and ramifies in the wall of hindgut in the form of a plxus. The blood from the hindgut plexus is collected into the hepactic portal vein. It extends along the ventral side of the liver and breaks up to form a plexus in the liver. From the liver blood is collected in a hepatic veins which extends along the dorsal aspect of the digestive gland and curves downwards and forward to open into the sinus venous.

   A pair of parietal veins lying above the gut drown blood from the dorsal body wall and empty into the sinus venosus. Paired transverse veins convey blood to the ventral aorta.

5. **Cardinal veins :** A pair of anterior cardinal veins collect blood from the anterior part of the body through paired segmental vessels. These run along the lateral body wall at the level of gonads. Similarly a pair of posteriorly, the posterior cardinals are joined to the caudal vein. Anteriorlly, the anterior and posterior cardinals of each side unite to form a common cardinal or ductus cuvieri. The two ductus cuvieri empty into the sinus venosus. The renal and hepatic portal system are absent due to the absence of kidney and true liver.

Peculiarities of circulatory system:

1. Absence of heart.
2. The vessels have contractile walls and the ventral vessel acts as a pumping organ.
3. The dorsal aorta is represented by paired vessels in the anterior part.
4. Beginning of hepatic portal system.

5. Replacement of ventral aorta in the posterior part of the body by a sub intestinal vein.
6. Flow of blood is forward in the ventral aorta and backward in the dorsal aorta.
7. Presence of afferent and efferent branchial vessels and plexus in the intestine and liver.

Resemblance to that of a typical lower vertebrate

A number of similarities can easily by traced out in the blood vascular system of Amphioxus and a typical lower vertebrate. These are –

1. The median contractile ventral vessel corresponds to the ventral tubular heart formed in the early stages of development of lower vertebrates.
2. The median contractile ventral vessel corresponds to the ventral tubular heart formed in the early stages of development of lower vertebrates.
3. The backward flow of blood in the unpaired dorsal vessel which corresponds to the main artery of vertebrates.
4. A beginning of hepatic portal system is found as the blood collected from the intestinal wall is carried to the liver and passes through a capillary network before it reaches the ventral aorta.
5. Presence of anterior and posterior cardinals is parallel to the similar cardinals of fishes.

Course of blood circulation – The blood flows in forward direction in the parietal, sub intestinal vein. Posterior cardinal vein and ventral aorta. It flows in backward direction in dorsal aorta and anterior cardinal veins.

Q. 9 Describe the digestive system of Herdmania and compare it with amphioxus.

Ans. The digestive system of Herdmania includes –

(1) Alimentary canal (2) digestive glands

(1) Alimentary canal: It is complete and coiled. It is divisible into four zones:

(a) Ingressive zone: Includes mouth and buccal cavity

(b) Progressive zone: Includes pharynx, eosophagus and stomach

(c) Degressive zone: Includes intestine

(d) Engressive zone: Includes rectum

(a) Ingressive zone: (1) Mouth – The mouth or branchial aperture lies on the top of branchial siphon. It is bordered by 4 lips formed by the test. These lips are contractile in nature. Mouth leads in to buccal cavity.

(2) Buccal cavity - It lies in the branchial siphon. At the base of buccal cavity lies a strong branchial sphincter. Just above the sphincter lies the circle of highly branched branchail tentacles.

The tentacles are about 64 in number and are of 4 sizes: 8 large, 8 medium, 16 small, 32 smallest. Each tentacle is bipinnately branched bearing several symmetrically paired lateral branches called tentacles. Each tentaculet bears secondary and tertiary branches. Tentacles working as sieve and straining the water current passing in to branchial sac. They also taste the quality of water thus act a hermoreceptor. It leads into pharynx.

(b) Progressive zone: (3) Pharynx – The pharynx is large sac – like structure and occupies the major part of atrial cavity. It is differentiated into two very unequal zones-

(i) Prebranchial zone

(ii) Branchial sac

(i) **Prebranchial**: It is a small anterior region just behind the branchial sphineter. It is demarcated from the branchial sac by two circular parallel ciliated ridges called anterior and posterior peripharyngeal bands. Between the bands there is a narrow ciliated groove called peripharyngeal groove. The anterior peripharyngeal band is a complete ring while the posterior peripharyngeal band is incomplete. Dorsally it is continuous with dorsal lamina or hypopharyngeal groove of branchial sac and ventrally with endostyle. Just above the anterior peripharyngeal band on dorsal side lies a swollen horse-shoe shapped structure the dorsal tubercle.

ii. Branchial sac – It is a large spacious structure. Its lateral walls are perforated by numeious elongated gill slits or stigmata. The stigmata establish communication between pharynx and the atrial cavity. The stigmata are arranged in several transverse rows. The epithelial lining of the stigmata bears long cilia, called lateral cilia. Food particles do not escape through them. Between the stigmata are external transverse and internal longitudinal vessels, through which blood flows.

The entire inner surface of branchial sac beasscilia. These cilia are shorter than frontedcilia. The outer wall of branchias sac is connected to the montle.

On the ventral side, there is a mid-ventral longitudinal groove, the endostyle or hypobranchial groove. It starts from the ventral margin of the posterior peripharyngeal band running ventrally and terminating into a pit, and short distance from the esophageal opening on the dorsal side. The endostyle is lined with five longitudinal tracts of ciliated cells alternating with four longitudinal strips of non-ciliated cells i.e. glandular mucus secreting cells. The cilia of the median tract are much longer than other cilia.

On the dorsal side, a thin flap called hyper-pharyngeal band or dorsal lamina hangs in the branchial sac. Anteriorly it starts from the posterior peripharyngeal band and extends posteriroly upto the right lip of esophageal opening. The posterior most region of branchial sac has a small, circular esophageal area behind the dorsal lamina. It is devoid of longitudinal folds and stigmata but has two semicircular lips guarding the esophageal opening.

(4) Esophagus – The branchial sac posteriorly opens into the esophagus. It is a short, thick and curved tube without stigmata. It bears four longitudinal ciliated grooves on its inner surface for the passage of food.

(5) Stomach – It is a wide, thin walled tube with almost smooth inner surface. It bears sphincters at each end. It is surrounded on either side by left and right lobes of liver.

(c) Degressive zone-

(6) Intestine – the stomach passed into intestine which is a thin walled "U"shaped tube consisting of a proximal limb and a distal limb. The proximal limb runs along the ventral side, then takes a sharp turn to dorsal side to become the distal limb, leading into the rectum. Between to limbs are lodged the gonads.

(d) Egressive zone –

(7) Rectum – It is the small terminal part of alimentary canal that curves dorsally to open in the atrial cavity by the aus. The rectal lining is made up of flagellated epithelium.

(2) Digestive glands –

(a) Liver- The liver of Herdmania is a large chocolate coloured bilobed gland. Its left lobe is larger than the right. Both the lobes lie on either side of stomach. Each lobe is made of a large number of tubules embedded in a connective tissue matrix and contain blood sinuses. It secrets s dark yellowish brown secetion which is poured in the stomach by 10 or 11 fine ciliated hepatic ducts. Each duct opens independently. The secretion contains amylse, protease and mild lipase enzymes.

(b) Pyloric gland – It consists of a large number of branching tubules in the wall of stomach and intestine. The tubules of gland open into a duct and a number of ducts unite to form a single duct which opens into the middle of proximal limb of intestine. Most probably this gland performs excretory function as well as pancreas of higher vertebrates.

Comparison of alimentary canal of Herdmania and Amphioxus –

Herdmania and Amphioxus are marine animals and exhibit ciliary mode of feeding. Due to similar mode of feeding various regions of the alimentary canal exhibit marked similarities in structural and histological details. The only difference exists in the details of form and appearance due to different forms of the body. The comparison can be made as under –

Q.7 Give an account of blood vascular system of Herdmania and describe the course of circulation.

Ans: Blood vascular system of Herdmania – The blood vascular system is well developed, closed and highly specialized because of large brabchial sac and the test as an accessory respiratory organ. It consists of:

1. Heart and pericardium
2. Dorsal aorta
3. Ventral aorta
4. Branchio - visceral vessel
5. Cardio - visceral vessel

1. Heart and pericardium – The heart is an elongated, thin-walled, contractile tube of white colour, enclosed in pericardium. It is devoid of proper wall and represents infolding of pericardium. The heart is open at both the ends and is continued into the aorae. It lacks valves but a pear shaped body in the pericardinal cavity, controls the flow of blood in and out of the heart.

The pericardium is a thick walled closed tube about 7 cm long and 3 mm wide which lies on the right side between the endostyle and right liver lobe ventral to the gonad. The pericardinal cavity is filled with a colourless fluid containing corpuscles.

Working of heart is peculiar. The peristaltic waves of contraction arise from one end and move to the other.

2. **Ventral aorta –** The ventral aorta arises from the ventral end of the heart and immediately

   It bifurcates into the anterior and posterior branches running along the ventral wall of the endostyle. Both of them give off a large number of paired transverse vessels the branchial race and deticate channels to the endostyle and mantle. The transverse vessels are of four different sizes. The posterior branch ends blindly while the anterior branch is continued into the peripharyngeal vessels. It gives a subtentacular vessel to the branchial tentacles and is continued as a siphonal vessel in the wall of branchial siphon. The peripharyngeal vessels give rise to a series of longitudinal vessels which run in between the internal longitudinal folds of the wall of branchial sac and terminate blindly around the oesophageal area. The ventral aorta also sends a ventral test vessel to the test at the junction of ventral aorta and heart.

3. **Dorsal aorta –** It lies in the dorsal wall of the branchial sac just outside the hyperpharyngeal groove. It gives off a series of paired transverse vessels to the branchial sac along its length. The transverse vessels are equal in number to the similar transverse vessels of the ventral aorta and join them. At its anterior end the dorsal joins the peripharyngeal vessels and after sending a branch to the tentacles extends in the wall of branchial sac as siphonal vessels.

4. **Branchio – visceral vessel –** The branchio-visceral vessel is a small vessel arising from the posterior end of the dorsal vessel. Shortly after its emergence, the branchio visceral vessels divide imto a right oesophageal vessel and left ventro intestinal vessel. The oesophageal vessel is very short and extends on the right side of the oesophagus. The ventro-intestinal vessel runs along the ventral side of the intestine and supplies the left liver lobe left side of oesophagus, stomach, intestine, rectum and the gonads.

5. **Cardio - visceral vessel –** It arises from the dorsal end of the heart and immediately issues two minor branches on its right side. These are : (i) hepatic branch to the right liver lobe, and (ii) oesophageo-test branch to the oesophagus and test, the main vessel curves to the left and divides in to three branches – (i) median dorsal branch supplies the test, lip of the oesophageal area, right gonad and the base walls of the artial siphon, (ii) left gonadial goes to the left gonad, and (iii) gastro-intestinal test branch bifurcates into a dorso-intestinal vessel forming plexus in the dorsal wall of the intestine, stomach and left liver lobe; and a dorsal test vessel to the test.

Composition of blood – The blood is reddish more or less transparent fluid having numerious nucleated corpuscles of different kinds. There are a few colourless leucocytes and large number of pigmented corpuscles with yellow, green, brown or orange pigments.

Course of circulation – No valves are present in the heart of Herdmania to regulate the flow of blood which is maintained by peristaltic waves and the small pear shaped body. However, the ascidian heart is unique in the animal kingdom for changing the direction of flow of blood through it by reverse peristalsis at regular intervals. The arteries and veins change when reversal of flow of blood occurs periodically.

When the heart beat ventro-dorsally, its oxygenated blood, collect through ventral aorta from branchial sac and test, is pumped into the cardiovisceral vessel and distributed to the various parts of the body (rest and viscera).

The deoxygenated blood from viscera is collected by the branchiovisceral vessel with passes it to the dorsal aorta from where it goes into the transverse branchial vessels to become oxygenated once again to undergo a fresh cycle.

During reversal of heart beat in dorsoventral direction, the deoxygenated blood collected through cardiovisceral vessel from viscera, is pumped into ventral aorta and distributed into transverse branchial, peripharyngeal, subtentacular and test vessels. The blood now oxygenated, is collected by dorsal aorta and distributed once again to viscera through branchiovisceral vessel. Deoxygenated blood from viscera is collected by cardio-visceral vessel and brought back to the heart to restart the cycle.

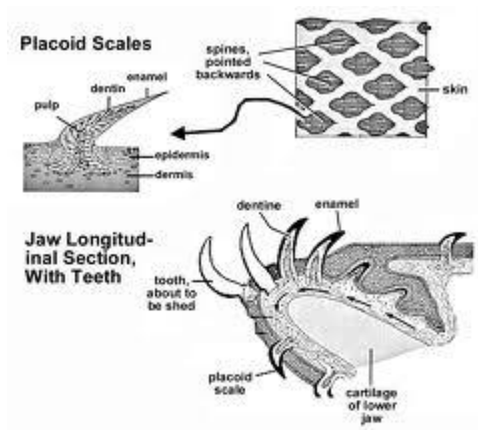
Q. 8 (a) Describe the structure and development of placoid scales.

(b) Describe the structure and development of mammalian hair.

Ans: **(a) Structure of placoid scale -** The placoid scales or the odontoids are minute dermal denticles of dentine embedded in the dermis of scolicdon and are arranged in regular oblique rows. These form the exoskeleton and cover the entire body surface. A typical placoid scale is distinguished into the basal plate and spine.

(i) **Basal plate –** It is rhomboidal or diamond- shaped plate formed of a cement-like substance. It lies embedded in the dermis and is firmly attached to it by strong fibres of connective tissue. The basal plate is perioriated by a small opening which leads into the pulpcavity of the spine. In living condition the blood vessels, nerve fibrres and lymph channels enter the pulp cavity through this opening. The pulp cavity is filled with numerous odontoblast cells, connective tissue fibres, nerve and blood vessels etc which collectivity form the pulp.

(ii) **The spine –** It is a flat, backwardly directed trident structure projecting out of the integument and giving it roughnes. The spine is composed of hard canaliculized substance, the dentine, coated with a hard enamel-like substance, the vitrodentine.



Development of placoid scale

The development of placoid scale starts by the accumulation of mesenchyme cells of the dermis at localized spots immediately below the epidermis. The cells proliferate upwards and form a dermal papilla. The growing papilla is nourished by blood capillaries so that its development is very fast and the papilla protrudes out on the surface of the integument. The cells of stratum germinativam or the basal layer of epidermis overlying the dermal papilla divide to form a two-layered epidermal structure, the enamel organ. The cells of inner layer of enamel organ are known as neoblast. These secrete the enamel or vitrodentine. The mesenchyme cells of the papilla lying opposite the ameoblasts start secreting the dentine. These form two subsequent layers one above the other. The mesenchyme cells secreting the substance of scale are known as odontoblasts or scleroblasts. The middle part of the papilla remains soft and vascular and forms the pulp cavity, consisting of odontoblast cells, blood vessels, nerve fibres an connective tissue fibres. The dentine of the spine is canalized by numerous fine canals, the canaliculi. The papilla grows and assumes trident spine-like appearance by subsequent depositions of dentine. When fully formed, the spine pushes through the enamel organ, pierces the epidermis; the basal plate and the dentine of the spine are derived from the dermis, while the enamel is secreted by the epidermal cells.

(c) Structure of hair

Hair are complex cornified epiderma derivatives formed of keratinized epidermal cells, which are deeply sunken in the dermis and are enclosed in the tubular downgrowths of malpighian layer.These are known as hair follicles.

The hair is distinguished into two parts –

(1) Basal part – It is enclosed in the hair follicle and lies embedded in the dermis. at the base of the follicle the hair root is expanded into a bulb or inverted cup. It encloses the dermal papilla. The dermal papilla contains connective tissue, blood vessels and nerve fibres. The cells of hair root are living and posses power of divisions. These newly budded off cells add to the size of hair and gradually undergo keratinization.

(2) **Hair shaft –** It is the slender, cylindrical part of the hair which projects out of the hair follicle and lies above the epidermis. It is formed of non living cornified cells. It central part is formed of medulla surrounded by cortex and enclosed in a thin covering of cuticle. The cells of medulla are pneumatic, while those of cortex are flattened and contain pigment.

The space between the hair follicle and the shaft and root is occupied by certain additional layers. The innermost layer lying in contact with the cuticle of the shaft is the cuticle, which is followed by two sheaths. The inner sheath is known as huxley's sheath and the outer as Henle's sheath. The two sheaths are separated by a layer of nerve plexus. Outside the Henle's sheath is the wall of hair follicle formed of stratum germinativum. This is protected by a fibrous dermal sheath. The follicular wall is interrupted by the opening of sebaceous gland, which secrets in oily substance into the follicular cavity.

Development of hair

The development of hair in mammals is similar to the development of scale in reptiles or a feather in birds. Due to the division of cells of malpighian layer, a thickening is formed in the epidermis which soon grows down into the dermis as column of cells, known as hair germ. The cells of dermis beneath the hair germ concentrate and enter the hair germ forming the hair papilla. It is traversed by blood vessels which bring nourishment to the developing hair. The cells of stratum malpighii lying immediately over the papilla multiply rapidly producing new cells which cornify and form the hair shaft. A space develops around the hair shaft separating it from the malpighian layer forming the hair follicle. The cell of hair follicle bud off and form sebaceous gland in the form of finger-like outpushings. The cells covering the rudiment of shaft give rise to follicle sheaths. The shaft grows in size by the addition of more cornified cells being formed by the division of cells of malpighian layer of hair papilla. Eventually, it pierces through the skin surface completing the development. The hair grow throughout life since the cells of hair-root immediately above the papilla remain active throughout life. Some of the mesenchymal cells of dermis outside the hair follicle differentiate into muscle fibres constituting arrector pili.

Q. 9 Give an account of aortic arches in the vertebrates.

Ans: The embryos of all the craniates possess six pairs of aortic arches developed in relation with each visceral cleft. These arise from the ventral aorta and run sideways. Laterally, the aortic arches are united to form the dorso-lateral aortae of radix aoratae on the respective sides. The radix aortae also join medially to form the common dorsal aorta. These six pairs of aortic arches are named as:-

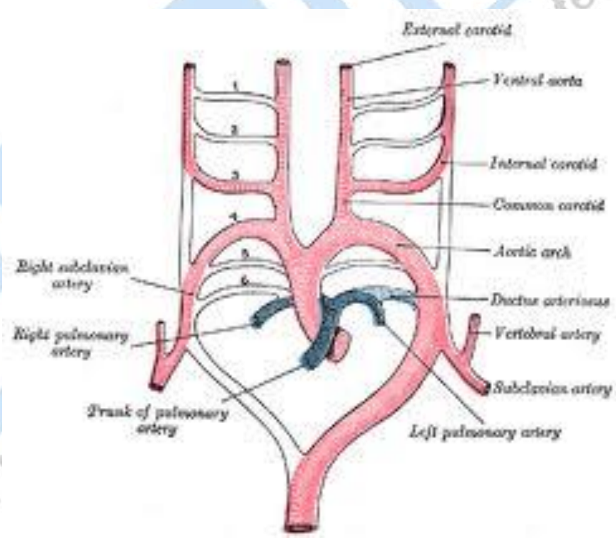
1. First –mandibular arch
2. Second-hyoid arch
3. Third, fourth, fifth, and sixth-branchial arches

Usually the first, second and third aortic arches develop from the paired ventral aortae formed by the bifurcation of median ventral aorta, which give rise to fourth, fifth and sixth branchial arches.

Modification of aortic arches – In various adult vertebrates the arterial system appears to be different from their embryonic aortic arches, but a study of development shows that they are built on the same fundamental plan. There is a progressive reduction in the number of aortic arches in the vertebrate series. In most elasmobranchs the mandibular aortic arch is modified or lost, so that there are only five aortic arches present in the adult. In most bony fishes both the mandibular and hyoid arches disappear or are much reduced. In cyclostomes and fished each remaining aortic arch has two parts, an afferent branchial artery taking blood from the ventral aorta to a gill where it forms capillaries, and an efferent branchal artery arising from the gill capillaries and taking oxygenated blood to the lateral dorsal aorta. In elasmobranchs and dipnoi each complete gill or holobranch has one afferent and two efferent branchial arteries (formed by splitting), in bony fishes each holobranch has one afferent and one efferent artery. In Dipnoi and pulmonary artery arises on each side from the sixth aortic arch or dorsal aorta and takes blood to the air bladder (lung).

In tetrapoda there is further reduction in the number of aortic arches and they do not break up into afferent and efferent parts because true internal gills are absent. In all tetrapoda the first and second arches disappear.

In urodeles there are external gills present as respiratory organs in addition to lungs. The 3rd, 4th, 5th and 6th aortic arches are present, though the fifth pair is much reduced. The aortic arches are not broken by the external gills into afferent and efferent portions because branches arising from 4th, 5th, and 6th aortic aroches form capillaries in the external gills. The lateral dorsal aortae between the 3rd and 4th aortic arches persist, and each is known as a ductus caroticus. From the 6th aortic arch a pulmonary artery grows out on each side taking blood to a lung, the portion of the 6th aortic arch between the pulmonary artery and lateral dorsal aorta is known as ducttus arrteriosus. In urodeles the ductus arteriosus also persists on each side.



In anura and all emniotes the 5th aortic arch also disappears, only the 3rd, 4th and 6th aortic arches are present. In anurans the third aortic arch along with a part of the ventral aorta becomes the carotid arch. The fourth aortic arch along its lateral dorsal aorta forms the systemic arch. The lateral dorsal aorta between the third and fourth aortic arches(ductus caroticus) also disappears. The sixth aortic arch becomes the pulmocutaneous arch and ductus arteriosus disappears during metamorphosis.

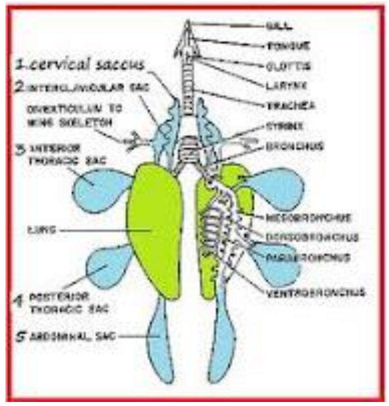
Only the 3rd, 4th and 6th aortic arches are retained by amniotes. In reptiles with the partial separation of the ventricle into two parts the distal portion of the conusarteriosus and the entire ventral aorta are split into three vessels, they establish connections with the right an d left 4th and 6th aortic arches to form systemic and pulmonary aortae respectively. The right systemic and pulmonary aortae respectively. The right systemic aorta arises from the left side of the ventricle, while the left systemic and pulmonary aortae take their origin from the right side of the ventricle. The 3rd aortic arch forms the carotid arch, the common carotid arteries of both sides connect with the right systemic aorta. The ductus caroticus disappears, but it persists in snakes and some lizards. The doctus arteriosus disappears in most reptiles though it persists in a reduced form in Sphenodon and some turtles.

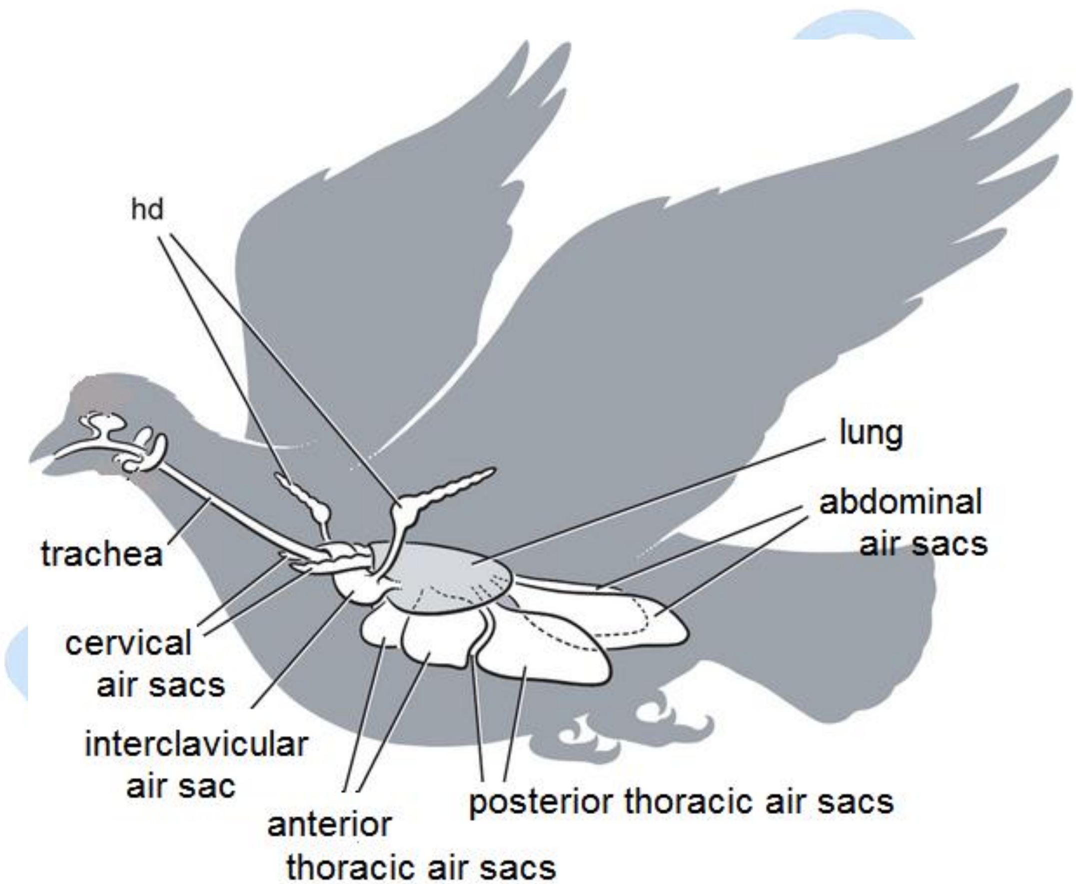
In birds the 3rd, 4th and 6th aortic arches are present, they follow the general pattern of reptiles with some differences. With the complete division of the ventricle into two parts the conus arteriosus and ventral aorta have split to form two vessels,systemic aorta arising from the left ventricle and a pulmonary aorta from the right ventricle. Third aortic arch forms the carotids, fourth aortic arch forms the systemic aorta on the right side only, part of the fourth aortic arch of the left side form the left subclavian artery, the rest along with its lateral dorsal aorta disappears. The sixth aortic arch forms the pulmonary aorta.

In mammals also the 3rd, 4th and 6th aortic arches persist. The ventricle is divided completely into two parts, the conus arteriosus and ventral aorta split to form two vessels, a systemic aorta arising from the left ventricle and a pulmonary aorta from the right ventricle. The third aortic arch forms the carotid arch. Fourth aortic arch forms the systemic aorta on the left side only, while on the right side its proximal portion forms an innominate and right subclavian artery, the rest along with its lateral dorsal aorta disappears. The sixth aortic arch forms the pulmonary aorta. The ductus arteriosus degenerates but it persists in a reduced form of the left side as a thin ligamentum arteriosum.

Q.10 Describe the respiratory system of Aves?

Ans. **The avian respiratory system** delivers oxygen from the air to the tissues and also removes carbon dioxide. In addition, the respiratory system plays an important role in thermoregulation (maintaining normal body temperature). The avian respiratory system is different from that of other vertebrates, with birds having relatively small lungs plus nine air sacs that play an important role in respiration (but are not directly involved in the exchange of gases).



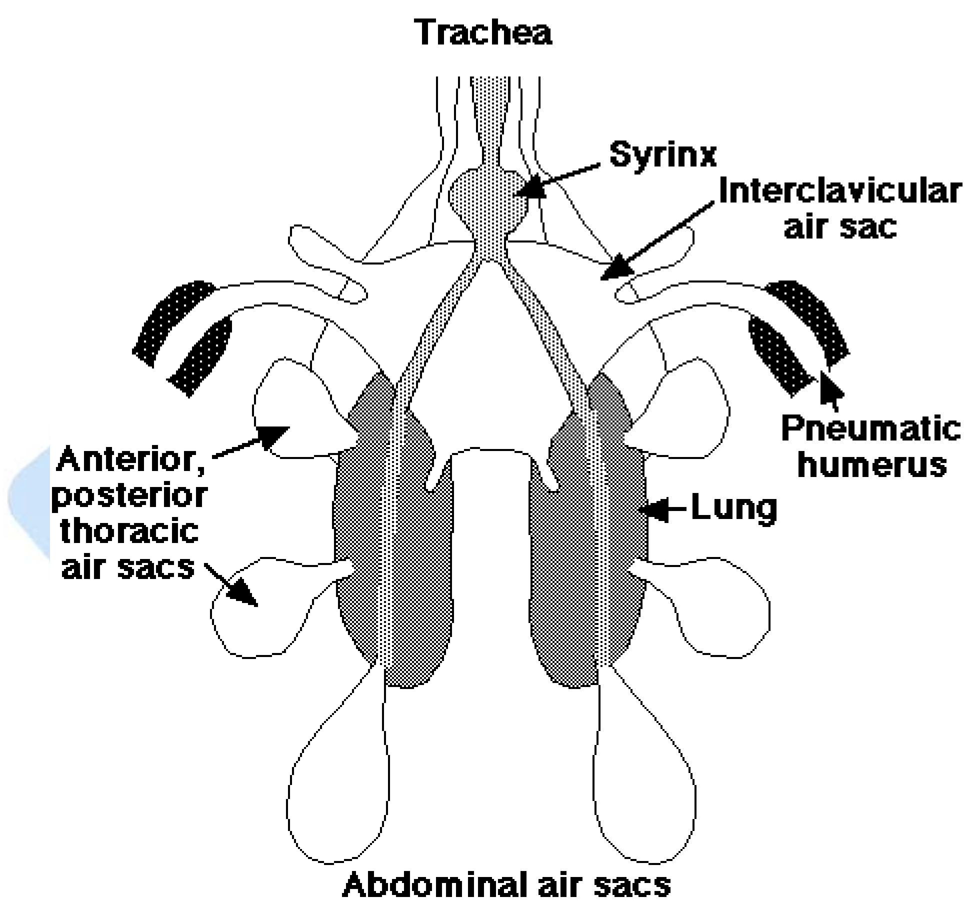


The air sacs permit a unidirectional flow of air through the lungs. Unidirectional flow means that air moving through bird lungs is largely 'fresh' air & has a higher oxygen content. In contrast, air flow is 'bidirectional' in mammals, moving back and forth into and out of the lungs. As a result, air coming into a mammal's lungs is mixed with 'old' air (air that has been in the lungs for a while) & this 'mixed air' has less oxygen. So, in bird lungs, more oxygen is available to diffuse into the blood.

Most birds have 9 air sacs:

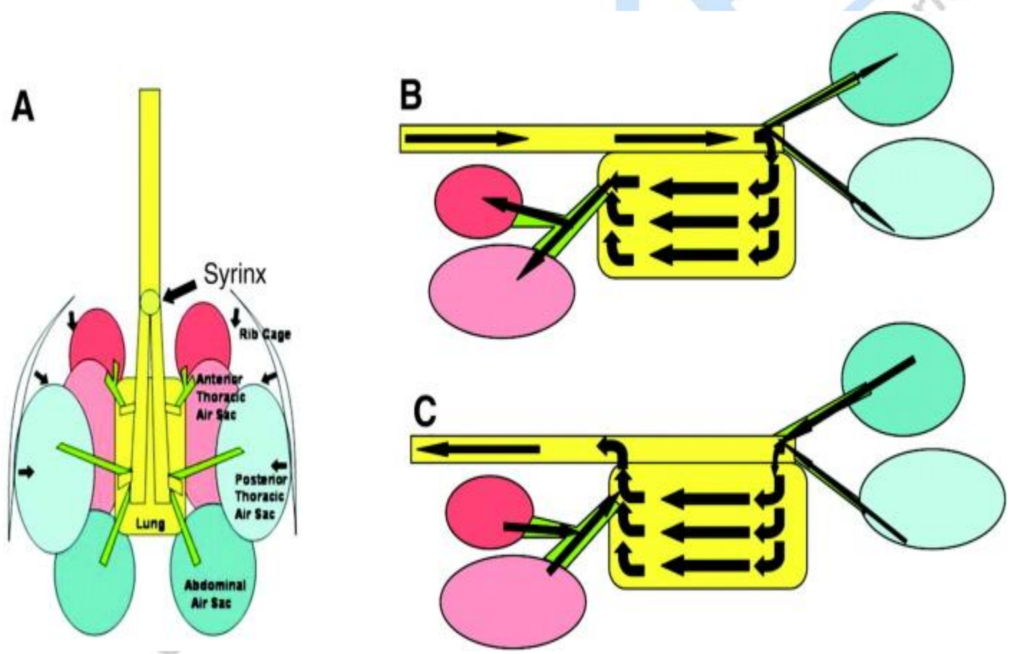
- one interclavicular sac
- two cervical sacs
- two anterior thoracic sacs
- two posterior thoracic sacs
- two abdominal sacs

Functionally, these 9 air sacs can be divided into anterior sacs (interclavicular, cervicals, & anterior thoracics) & posterior sacs (posterior thoracics & abdominals). Air sacs have very thin walls with few blood vessels. So, they do not play a direct role in gas exchange. Rather, they act as a 'bellows' to ventilate the lungs.



Birds can breathe through the mouth or the nostrils (nares). Air entering these openings (during inspiration) passes through the pharynx & then into the trachea (or windpipe). The trachea is generally as long as the neck. However, some birds, such as cranes, have an exceptionally long (up to 1.5 m) trachea that is coiled within the hollowed keel of the breastbone (shown below). This arrangement may give additional resonance to their loud calls.

The trachea bifurcates (or splits) into two primary bronchi at the syrinx. The syrinx is unique to birds & is their 'voicebox' (in mammals, sounds are produced in the larynx). The primary bronchi enter the lungs & are then called mesobronchi. Branching off from the mesobronchi are smaller tubes called dorsobronchi. The dorsobronchi, in turn, lead into the still smaller parabronchi. Parabronchi can be several millimeters long and 0.5 - 2.0 mm in diameter (depending on the size of the bird) (Maina 1989) and their walls contain hundreds of tiny, branching, & anastomosing 'air capillaries' surrounded by a profuse network of blood capillaries (Welty and Baptista 1988). It is within these 'air capillaries' that the exchange of gases (oxygen and carbon dioxide) between the lungs and the blood occurs. After passing through the parabronchi, air moves into the **ventrobronchi**.



A schematic of the avian respiratory system, illustrating the major air sacs and their connections to the lung. (A) The lateral and dorsal direction of motion of the rib cage during exhalation is indicated by arrows. (B) The direction of airflow during inspiration. (C) The direction of flow during expiration.

Q. 11 Describe the female urinogenital system of Aves?

Ans. Birds have a very different reproductive pattern than mammals, better suited to the peculiar hazards of being a bird. The biggest problem with being a bird is that everyone is trying to eat you. Whereas most mammals (especially primates) have adopted a strategy of having relatively few offspring and devoting a fair amount of parental energy and time to caring for those few, most birds (with some notable exceptions) have gone the other way: they produce lots of offspring, give them some minimal amount of raising—in some cases, none—then toss them to the winds, literally and figuratively. The avian strategy is one of more or less unrestrained fecundity.

A nice example of this pattern is the mourning dove. Population studies over the decades have clearly shown that whether or not it is hunted (in some states these are protected as songbirds, in some they are considered game birds) about 70% of the chicks hatched every spring are dead by the end of the year. They are prey to hawks, cats, crows and other birds, snakes, owls, squirrels, and a host of other predators. Most of them live only a few months. This doesn't even count the number of eggs that are smashed or dropped from the nest or never hatch. Nevertheless, come the next summer, the dove population is back at its original level, thanks to their prolific production of young. The female bird's reproductive tract shows striking differences from the mammals in consequence.

Avian Reproductive Pattern

Avian reproduction has been best studied in the domestic chicken and turkeys, and the modern poultry industry rests on its complete understanding of the cycle and how to control it.

Birds lay eggs in clutches. A clutch consists of one or more eggs, followed by a rest period of about a day, then another egg or eggs. Clutch size is species-specific and is held within fairly tight limits. Pigeons (*Columba livia*) almost always lay clutches of two eggs. A good domestic hen will lay five or more eggs in a clutch, with an interval of a day between clutches. Clutch size, as well as the numbers of clutches laid in a breeding season, will vary with species, but the principle is the same.

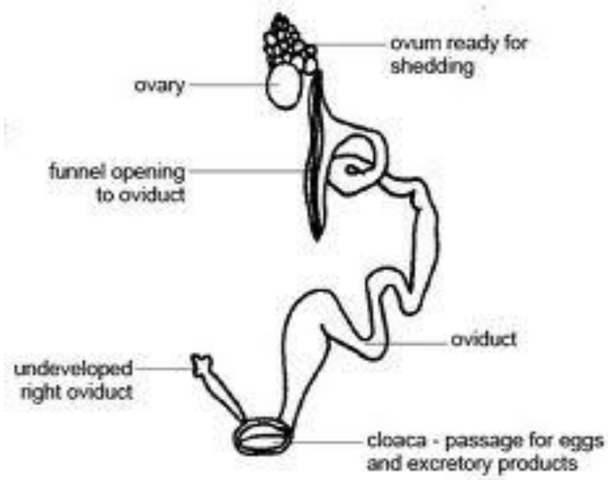
In hens, ovulation usually occurs in the morning, and almost never after 3:00 PM under normal daylight conditions. The total time to form a new egg is about 25-26 hours. This includes about 3-1/2 hours to make the albumen coats (the "white"), 1-1/2 for the shell membranes, and about 20 hours for the shell itself.

Ovulation for the next egg of the clutch occurs within an hour of laying the previous one, and so the hen gets later and later in her timing each day; she "runs behind," like a clock that is improperly adjusted. Eventually she gets so far behind schedule that she would have to ovulate later than 3:00 PM. Since hens don't do that, the next ovulation is delayed, laying is interrupted; the break between clutches takes place and the cycle repeats itself a day or so later.

Hens (like codfish and mammals) are equipped with tens of thousands of potential eggs which theoretically *could* be laid, but (as with the oocytes of mammals) most of them never develop to the point of ovulation. A commercial laying hen might have as much as a year or even two of active life during which she produces nearly an egg a day. But when her production level drops off all the fun and games are over, and it's off to the Campbell's factory for a date with the noodle soup man.

The Reproductive Tract

The reproductive tract in birds differs significantly from that in mammals, and most of the parts, although they bear similar names to mammalian organs, have widely different anatomical, histological, and physiological features.

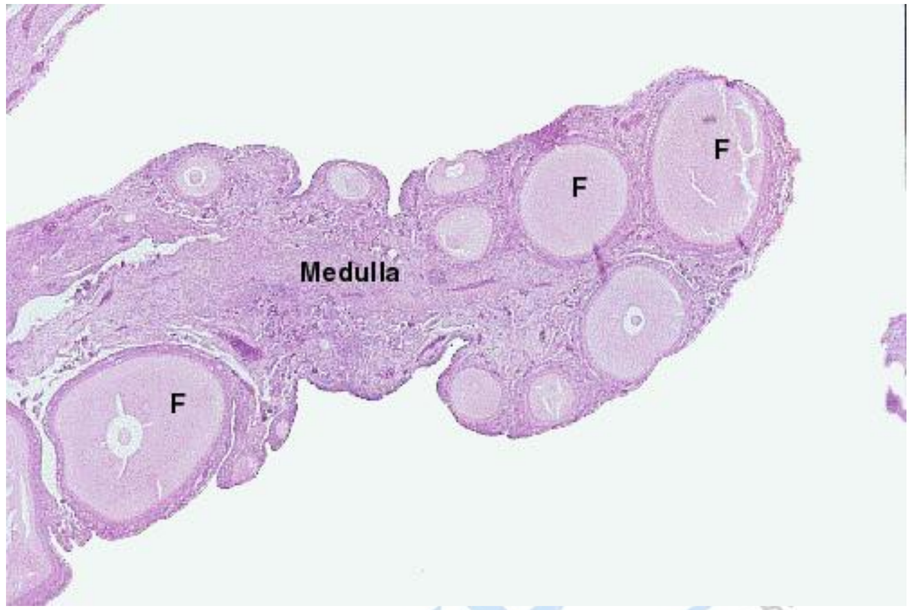


Ovary

As with mammals, eggs are produced in ovaries, or, more correctly speaking, *one* ovary. In the majority of avian species only the left ovary is functional. Although the right one is present embryologically, it regresses during development and is vestigial in the adult bird.

The ovary is grossly divisible into two lobes, each of which contains follicles depending from stalks. Incidentally, the "yellow" of the egg you eat at breakfast is the true oocyte. The surrounding white parts are coats that are added later, as the egg passes down the tract. The yellow of the egg is a *single cell* and the yolk represents a colossal lipid inclusion in its cytoplasm! The largest single cell in existence is the yolk of an ostrich egg, which can easily be 6" in diameter.

The "follicles" in birds bear little resemblance to mammalian ones, histologically. There is no antrum, and no follicular fluid; instead the entire follicle is filled with a very yolky egg. The mass of yolk grows very rapidly. It provides all of the nourishment for the developing embryo, diminishing in size as the embryo grows. In chickens, post-hatching nutrition is also mostly from the yolk for a short time, as it's not completely absorbed when the chick hatches out.



Each follicle is surrounded by a well developed system of blood vessels. At the time of ovulation of a follicle, a whitish area, the stigma, appears on the surface of the follicle, and the egg is expelled into the upper end of the reproductive tract. Nothing resembling the mammalian corpus luteum is formed in birds.

These features can be made out on slides 221 and 680, and the variation in sizes among the follicles is a reflection of their different stages of development. Released eggs pass into the oviduct, also present only on the left side. The various divisions of the oviduct are all continuous with one another.

Infundibulum

The expanded upper end is called, as in mammals, the infundibulum, seen on slides 207 and 702. The infundibulum has fimbriae, finger-like projections covered with cilia, as in mammals.

But the infundibulum is more than just a funnel-shaped structure to catch the egg. It also makes the first of the overlying egg coats, the chalazae. These are the suspensory ligaments of the yolk. If you break an egg carefully into a bowl, you'll these as whitish stringy material on opposite poles of the egg. They serve to keep the embryonic disc properly oriented.

Magnum

The next portion of the tract is the magnum, seen on slide 699 (from the Latin for "large," because it's the longest portion of the system). The magnum produces the bulk of the egg white. The mucosa of the magnum is composed of simple epithelium which may be cuboidal to columnar (in this slide it's cuboidal). Some of the cells are ciliated and some are not.

There are enormous glands in the lamina propria/submucosa, which in fact hardly contains anything else. Under moderately high power, you'll see vesicles containing the protein secretions waiting to be released.

Physical passage of the egg through the magnum is believed to stimulate the production and release of the albumen mechanically, and there is often enough to cover more than one egg. Hence the production of "double yolkers." This happens when two follicles mature and release their eggs at the same time. The eggs travel through the tract in tandem; if they're close enough together, they will be enveloped by the same albumen coat in the magnum (and later will be enclosed within one set of shell membranes and shell).

Isthmus

The third portion is the isthmus, seen on slide 700. The mucosal lining is intermittently ciliated simple columnar epithelium. Extensive glands in the lamina propria produce the soft shell membranes. These are the whitish ones which remain adherent to the shell when you break an egg into a bowl.

Shell Gland

The next portion, the shell gland manufactures the calcareous shell in which the egg is laid. The demand for calcium to make the shell is very high, and so the circulating levels of blood calcium in birds are greatly elevated compared to mammals, typically twice as much. The epithelium of the uterus is pseudostratified, rather than simple, and is intermittently ciliated; the mucosa is formed into deep straight crypts with well vascularized CT supporting the cores.

Vagina

The last portion of the tube is the vagina. This a muscular tube through which the egg is expelled to the outside world. The folds of the mucosa are short, and the lining is a tall columnar epithelium, again intermittently ciliated.

Near the junction of the vagina and the shell gland, there are deep glands lined with simple columnar epithelium. These are the sperm host glands, so called because they can store sperm for long periods of time (10 days to 2 weeks!). When an egg is laid, some of these sperm can be squeezed out of the glands into the lumen of the tract, whence they will migrate farther up to fertilize another egg. This is one of the really remarkable things about birds; they sperm remain viable at body temperature.

Q. 12 Discuss the evolution of kidney in vertebrates.

Ans: The kidneys are the organs of nitrogenous excretion and water regulation, found attached to the dorsal wall of the body cavity and covered by the coelomic epithelium. Basically, each kidney is formed of uriniferous tubules or renal tubules or the nephrons, which open into the urinary duct or ureter.

Basically, the excretory system consists of paired tubules opening on one hand into the coelom and on the other into a longitudinal duct. The coelomic opening is in the form of a ciliated funnel and is known as peritoneal funnel. The funnel leads in to a narrow neck which widens to form a thin-walled chamber, the Bowman's capsule. One side of Bowman's capsule is pushed in by a bunch of afferent and efferent arterioles of the vascular system which form the glomerulus. The Bowman's capsule and the glomerulus are collectively known as Malpighian body. But, in different groups of vertebrates these present varied forms. The variations are mainly correlated with different environmental conditions under which they have to live.

Ancestral kidney –

Now it is generally believed that the primitive vertebrate ancestor possessed a pair of archinephric kidneys or the holonephros, which consists of a pair of archinephric ducts located on the dorsal side of the body cavity and extending the length of coelom. Each duct received the openings of a series of segmentally arranged tubules. The tubules are therefore, paired segmental structure, each opening on one hand into the coelom by independent ciliated funnel the nephrostome, and on the other hand into the archinephric duct. In connection with each tubule is also present a cluster of capillaries the so called external glomerulus. A thin layer of peritoneal epithelium was reflected over the projecting surface of the external glomerulus.

Anamniotic kidney – The anterior part of the archinephric kidney has persisted in only a few vertevrates but appears in the embryos of most of the vertebrates as a transitory structure and is usually referred as the pronephros. When present in the adult it is known as head kidney. The remainder of the kidney posterior to the pronephros is known as opisthonephros. The kidney is usually called as the archinephros and its duct as the archinephric duct.

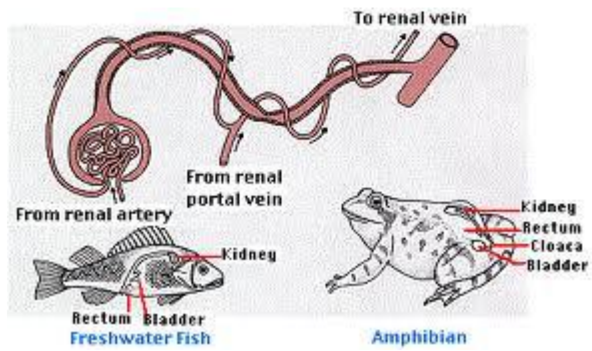
Pronephros – The pronephros in anamniotes consists of a varying number of anteriorly located pronephric tubules opening into a pair of archinephric ducts. These occupy dorso-lateral position in the mesoderm on either side of the mesentery supporting the gut. Developed in relation with their nephrostomes are internal glomeruli, surrounded by Bowman's capsules. The tubules communicate with the coelom through their nephrostomes.

Opisthonephros – the opisthonephros forms the functional kidney in lampreys, most fishes and amphibians. The kidney tubules arise segmentally from the intermediate cell mass (mesomere or nephrostome) which lies between the somite and the lateral plate mesoderm of the embryo. But the segmental arrangement is soon disturbed due to the development of secondary and tertiary tubules. The tubules do not have the nephrostomes and hence have lost communication with the coelom and the glomeruli are well distinct. The archinephric ducts persist in the adult as Mullerian ducts and the opithonephric duct which acts as an ueter is termed as Wolffian duct.

Amniotic kidney – In reptiles, birds and mammals, three types of kidneys are usually recognized; pronephros, mesonephros and metanephros. These appear in succession during embryonic development but only metanephros persist and becomes the functional adult kidney as a matter of fact the mesonephros and metanephros represent different levels of opisthonephros.

Pronephros – in all amniotes, the pronephros is present during very early stages of development. It develops in anterior 3rd to 15th or 16th segment s as segmentally arranged paired tubules opening into the body cavity and connected with the longitudinal pronephric duct. It is never functional and disappear soon.

Mesonephros – The mesonephros also known as the Wolffian body appears next in the series. It extends over a greater number of segments than does the pronephros and develops after its appearance. The mesonephric tubules develop in the intermediate cell mass posterior to the pronephric tubules exactly in the same manner as the pronephric tubules. These open into the Wolffian duct or mesonephric duct which is the original archinephric or pronephric duct.



In reptiles, birds and mammals the mesonephros exists only temporarily and its replaced by the metanephros. The remnants of the mesonephros, which are left after its degeneration, become associated with the reproductive system. The mesonephric duct acts as the mesonephros is functional. But, with the appearance of metanephros, it degenerates in the male.

Metanephros – The metanephros develops only in amniotes. It replaces the mesonephros and arises posterior to it. It is formed essentially of the same parts as the mesonephros, but is not connected with the gonads and develops quite late in the ontogeny. The tubules are not segmental an dthe kidney presents more compact appearance. The metanephric tubules do not open into the pronephric duct but in a newly formed ureter, which arises as an outgrowth from the base of pronephric duct. The tubules are secondary in nature and, therefore, lack peritoneal funnels.

The metanephric tubules are more complicated in structure and these have attained maximum complexity in mammals. These function in a manner similar to that of opisthonephros. Wastes are carried from the kidney by the ureter, which enter the cloaca or urinary bladder.

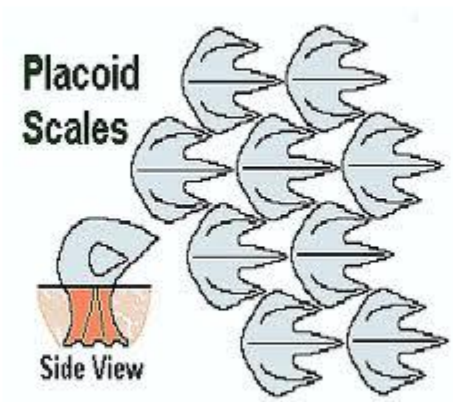
Section C

Chordate Adaption

Q. 1 Describe scales in fishes.

Ans: Although they comprise only a few basic structural types, scales exhibit many modifications that are often characteristics of groups or species. First, let us classify fish scales on the basis of shapes and then on the basis of structure.

I. One type is **plate like (placoid),** with each plate carrying a small cusp, as common among the sharks (Elasmobranchii).



II. A second type is **diamond-shaped (rhombic)** and characterizes the integument of the gars of North-America (Lepisosieidae) and the reedfishes (Polypterus) of the Nile. Such scales also occur on the tail of the sturgeons (Acipenseridae) of the Northern Hemisphere and of the American paddlefish (Polyodon).

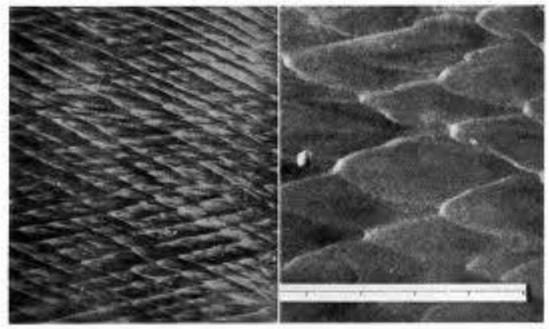
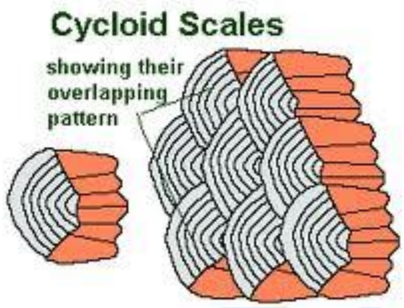
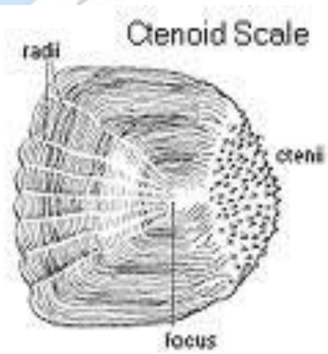


Fig. 1.—Rhomboid ripple marks, Sapelo Island, Georgia. Current flowed from right to left. Length of ripples about 4 inches.

III. A third type of fish scale on the basis of shape is **cycloid.**



IV. In the fourth type, **ctenoid** the posterior surface or margin is toothed or comblike. Cycloid scales are found on most soft-rayed bony fishes (Malacopterygii); ctenoid scales almost universally characterize the spiny-rayed bony fishes (Acanthopterygii).



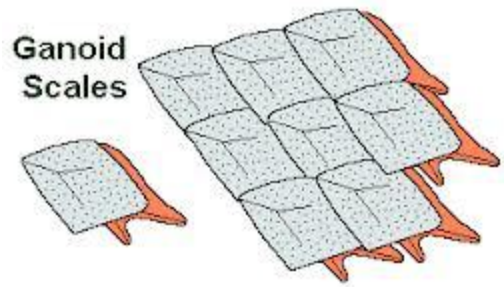
Structural types

Structurally, there are **two types of fish scales, placoid and non-placoid. Non-placoid scales are basically of three kinds – cosmoid, ganoid and bony-ridge.**

Placoid : Placoid scales, also **called dermal denticles,** have an ectodermal cap that is usually of **an enamel- like substance (**as on human teeth**)** termed vitrodentine. The cap is underlain by a body of dentine with a pulp cavity and dential tubules emanating from it. Each scale has a disc-like, basal plate in the dermis with a cusp projecting outward from it through the epidermis. Placoid scales occur among sharks and their relatives (Chondrichthyes).

Cosmoid : Cosmoid scales have a **thinner, harder, outer layer than the placoid ones.** Although the external material has a slightly different crystallographic auchitecture from that of enamel of placoid scales it also has been termed vitrodentine. **The layer beneath this enamel is also hard and non-cellular and has been called cosmine.** Thus is followed by and vascularized mid-layer that is a zone of perforate bony substance(termed isopedine). A further distinctive features of this type of scale is reportedly that growth is at the edge of the scale from beneath and not from within, because no living cells cover the surface. Cosmoid scales are found both in the living (Latimeria) and extinct lobefins. In Latimeria, the scales have a denticulate outer surface, almost ctenoid in gross aspect.

Ganoid: In a ganoid scale, **the outer layer is a hard inorganic salt substance(ganoine),** differing from vitrodentine. Beneath the ganoin cap there is a **cosmine-like layer.** The innermost lamellar bony layer is **isopedine.** Besides differing in structure from a cosmoid scae, a ganoid scale grow not only at the edges and from underneath, but also on the surface. Among living fishes ganoid scales are best represented in redfishes(Polyptens) and the gars(Lepisosteidae) where they invest the entire body. In rhombic shape they are also present on the upturned lobe of the tail of such chondrosteans as the sturgeons (Acipenseridae) and the paddlefishes (Polyodontidae).



Bony-ridge : bony-ridge scales are typically thin and transluscent, Lacking both with bony-ridges that alternate with valley-like depressions. The inner part of plate of the scale is made up of layers of criss-crossing fibrous connective tissue. Growth of these scales is both on the outer surface and from beneath.

Q. 2 Write an essay on "Migration of fishes".

Ans: From what is known about travel in fishes, it may be concluded that most species have relatively small home ranges to which they restrict most of their movements. However, some fishes are great travelers and seem to be continually on the move. Quite stationary but active are small stream, lake and inshore marine fishes. Very pelagic fishes and others are mobile which often travel great distances between fresh and marine waters. Included in the latter category are the salmons (Oncorhynchus and salmo) which do most of their feeding in the sea but spawn in fresh water and the cells which do the opposite.

Travels within streams have been termed **potamodromous** and are very diverse. They are spectacular among such riverine swimmers as the bocachica (Prochilodus). Most lake-dwelling suckers (catostomidae) and lampreys (petromyzontidae) ascend tributary streams for spawning. Stream dwellers among the suckers, lampreys, carps (Cyprinidae), and the trouts (Salmoninae) typically travel upstream for spawning . **Limnodromous** movements onshore with oncoming darkness and offshore with oncoming light, characterize such fishes as the trout-perch (Percopsis), yellow perch (Perca flavescens) and rock bass (Ambloplites) among many others.

Marine, **oceanodromous** travelers are as diverse in their movement habits as freshwater ones. The prevalent direction of travel in the North Temperate Zone is northward as the water warms and southward as it cools. Various herrings including true herrings (Clupea) and thee menhaden (Brevoortia) travel along the coasts in this pattern of direction.

Diadromous fishes that migrate freely between fresh and marine waters include the **anadromus** and **catadromous** kinds. Anadromous fishes are well exemplified by the striped bass (Roccus saxatilis), pacific salmons (Oncorhynachus), atlantic salmon (salmo salar), and the marine –run sea lampreys (Petromyzon). Of these, the greatest distances have been recorded for Pacificc salmons which may spawn hundreds of miles inland after having traversed several thousands of miles at sea during growth. The freshwater cells (Anguilla) of North America and Western Europe are classical example of catadromous fishes. In the autumn adults begin to run seaward from as much as 500 miles inland and from elevations including 7000 feet. In the sea some individuals travel over 3000 miles to find, by remarkable navigation, regions of the Sargasso sea for spawning. The young drift and swim back toward continental waters in a voyage requiring as much as three years. On arrival they metamorphose from their leptocephalus larval stage and ascend streams to complete growth to sexual maturity over a period of a dozen years or more before reversing their travel.

The life history of European eel falls into four phases as follows:

(i) **Pelagic eggs –** these are laid in the Sargasso sea, near Bermuda islands, hatch in spring as glassy leaf shaped larvae named leptocephali. They drift along the gulf stream seeking their homes in the rivers of Europe. At the end of the first year, they attain 25mm size, by the second year they grow upto 55mm and in the third year they reach the coast of Europe and reach upto 75mm in size.

(ii) **Elever stage –** Leptocephali stops feeding and become shorter and pencil shaped – known as glass eels or elevers.

(iii) **Yellow eel –** The elevers ascend the rivers and grow in size and change their colour to yellow.

(iv) **Silver eel –** The young eels attain sexual maturity, adorn the nuptial colour of bright silvery sheen and starts their journey to Sargasso sea from which they never return.

Generally, a migration is a more or less continuous and direct movement from one location to another. Such movement is under the **control of the fish, genetically determined and is influenced by environmental factors.** Typically, a migration includes one or more returns to the starting location (homing tendency); such species specific organization patterns most often involve aggregations of the fish and a sense of direction. Migrations are mostly for spawning or feeding and are generally time oriented, although sometimes they take place when fishes actively flee the adverse conditions.

Many factors influence migratory movements, including homing, of fishes; they may be grouped for convenience as physical, chemical and biological. Physical factors include bottom materials, water depth , pressure (water and atmospheric), current and tide, turbidity, topography, gradient, temperature and light – intensity, photoperiod, and quality. Among chemical factors are salinity, alkalinity, hydrogen ion concentration, dissolved gases, odours, tastes, and pollutants. Recognized as biological factors of migration are blood pressure, sexual development, phototaxis, social response, predators, competitors, hunger, food, memory, physiological clock, and endocrine state. The foregoing factors interact in various ways to continue, direct and arrest migrations and movements. Throughout, nervous and endocrine mechanisms are important in orientation and timing.

Among Indian fishes, there are hardly any which show such interesting migration as the eel and salmon except Hilsa hilsa. Hilsa hilsa is an inhabitant on Bay of Bengal and during the breeding season ascends the estuaries of the Ganges and reaches the fresh waters, sometimes as far off as Allahabad.

Q. 3 Write an essay on "Parental care in Amphibia".

Ans: In amphibians there are many devices for the protection during the early stages of development and in this way nature has practiced economy in the number of eggs, which varies in direct proportion to the chances of destruction.

These devices fall under two heads. Firstly, protection by the parents, either by means of nest or nurseries or by direct nursing ; secondly, shortening of the metamorphosis. The different modes of protection are given below.

Parental care in Anura

I. Protection by nest or nurseries

a. In enclosures in the water, e.g., Hyla faber.

b. In holes near water, e.g., Rhacophorus schlegellii.

c. In nests on trees or rocks overhanging the water, e.g. Phyllomedusa, Rhacophorus malabarious.

d. In a transparent gelatinous bag in the water, e.g., Phrynixalus biroi.

e. On trees or in moss away from water, e.g., Hylodes, Rana opisthodon.

II. **Direct nursing by parents**

a. Tadpoles transported from one place to another by males, e.g., Phylobates, Dendrobates.

b. Eggs protected by male who covers them with his body, e.g. Mantophryne robusta.

c. Eggs carried by parent.

i. Round the legs by the male, e.g., *Alytes.*

ii. On the back of the female:

- Exposed, e.g., Hyla goeldii.
- In cell – like pouches, e.g. Pipa americana
- In common pouch, e.g., Nototrema

iii. On the belly, exposed, by the female, e.g. Rhacophorus reticulatus

iv. In the mouth, or in gular pouch :

- By the male, e.g., Rhinoderma darwini
- By the female, e.g., Hylambates breviceps

d. Viviparous or viviparity, e.g., Pseudophryne vivipara.

Parental care in Urodela

Urodels show courtship of various types. In strict sense, there is no copulation but spermatozoa are absorbed by the female. During courtship, the male deposits spermatophores attached to the ground or stones which the female takes in by application of cloaca or by pressing the spermatophores between the legs. There are certain forms, e.g., Cryptobranchus, in which fertilization is external. In courtship they may or may not be copulating. Eggs are laid in gelatinous sacs pulled out into two long strings and are fertilized when the males deposit sperm masses near the egg laying females.

In the following text the forms of which the mode of reproduction is known are arranged according to their mode of pairing:

1. No amplexus (copulation) but a lengthy courtship in water, males are more brilliantly coloured than the female, ornamented with dorsal and caudal crests, e.g., Molge cristata, M. vulgaris, etc.
2. Amplexus takes place; no marked sexual differences of the colour; no dermal ornamental appendages.
    a. Amplexus of short duration and partly or entirely on land, e.g., Salamandra, Plethodon and Autodox.
    b. Amplexus of more or less lengthy duration and in water, e.g., Molge torosa, Molge montana.

    The coincidence of courtship and sexual ornaments in the male is highly suggestive of sexual selection. As in frogs and toads, the male takes forcible possession of the female.

    In some forms the eggs are small and larvae come out soon and no parental care is seen but in case of other forms the parental care is prominent like anurans.

1. **Protection by nests and nurseries**
    a. In holes on land or in trees, e.g., Autodax.
    b. In a transparent bag in water, e.g., Salamandrella keyserlingii.
2. **Direct nursing by the parent**
    a. Female coils round the eggs, e.g., Plethodon.
    b. Male coils round the eggs, e.g., Megalobatrochus maximus.
    c. Female carries the eggs on back or round the legs., e.g., Desmognathus fusca.
    d. Viviparous or viviparity, e.g., Salamandra maculosa, Salamandra atra.

Parental care in Gymnophiona or Apoda

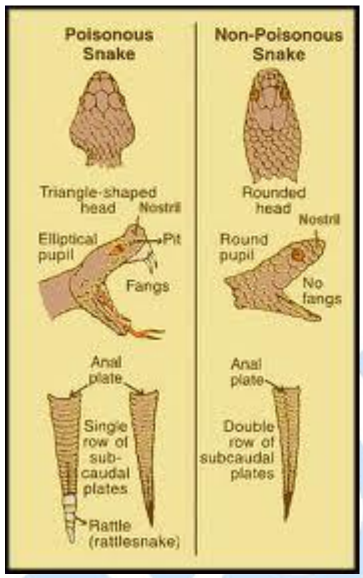
In Ichthyophis glutinosa, the female digs a hole close to the surface in damp ground near the water and deposits about a score of large yellow eggs, measuring eight to ten millimeters in diameter and forms a bunch round which the mother coils her snake-like body.

Thus the female keeps encircling the gelatinous fertilized egg mass to protect them from ground burrowing animals (enemies) and possible dessication until they hatch. Larva possesses three pairs of very long finely branched external gills.

Dermophis thomensis is viviparous.

Q. 4 Discuss poisonous and non-poisonous snakes. What is poison apparatus? Write a note on biting mechanism of poisonous snakes.

Ans: Poisonous and non-poisonous snakes



The majority of snakes are non-poisonous and harmless animals. Some of the common poisonous snakes of India are : cobra, king cobra, krait, pit-viper, Indian viper, rattle snake, russel's snake coral snake, and sea-snakes. The following key will serve to distinguish **poisonous snakes** from **non-poisonous snakes:**

1. If it is a marine snake with the tail laterally compressed, it is poisonous.
2. In a terrestrial snake the tail is rounded or cylindrical and not compressed.

   Examine its ventral scales:

   (i) If all the ventral scales are small or the ventral scales are somewhat broad, then it is a **non-poisonous** snake.

(ii) If the ventral scales are large transverse plates extending fully across the ventral side or belly, the snake may be poisonous or non-poisonous. To find out, examine the dorsal surface of the head.

(a) If all the dorsal scales of the head are small, then it may be a **viper.**

(b) If there be a loreal pit between the nostril and the eye, then it is a **pit-viper.**

(c) If the sub-caudals are double and there is a loreal pit, then it is a **russel's viper.**

(d) If dorsal side of the head has both small scales and large shields, the snake may or may not be **poisonous,** to ascertain look at the side of the head.

3. If the third supra-labial shield touches the nostril an deye, then it is a pisonous snake, may be **cobra, king-cobra or coral snake.**

4. If the upper side of the head has both small scales and large shields but there is no loreal pit and the third supra-labial shield does not touch the eye, then examine the back of the snake and ventral side of the lower jaw:

(i) The middle row of scales on the back called vertebrals may be larger than other.

(ii) ventral side of lower jaw has fourth infra-labial shield larger than the others. If both (i) and (ii) characters are present, then it is a **krait.**

5.If the snake has small scales and large shields on the head but does not have the characters of cobra, krait or coral snake, then it is **non-poisonous**

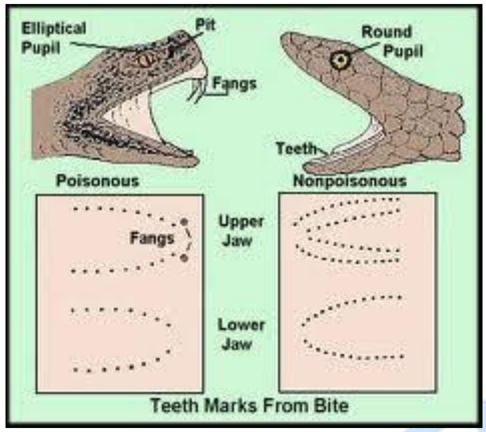
(1) **Non-poisonous snakes:** pythons, trinket snakes and racer snakes.

(2) **Poisonous snakes:** Cobra, Krait, Vipers, Russell's Viper, saw-scaledvipers.

The poisonous snake bites have two types of toxins present in the venom :

1. **Neurotoxins** and **(ii) Hemotoxins.** The neutrotoxins act on motor nerve cells and provoke muscular paralysis. In case of cobra snake venom, both convulsions and paralysis may occur. The hemotoxins result in **haemorrhages, destruction of tissue cells, red cells, blood vessels and specific organs.** The victim(patient) in both cases has respiratory difficulties and haemorrhages. As the poison is absorbed into the tissues, the patient feels dimness in vision. Pulse rate becomes rapid and weak. Convulsions are sometimes associated with vomiting. Benadryl acts as antidote to counteract the effect of hemotoxins, local

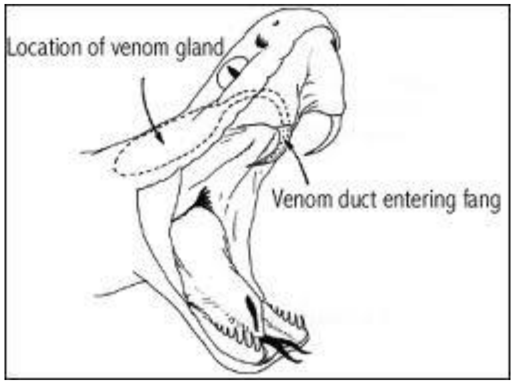
lesions are applied with Antisera. Medicines are injected intravenously.



Poison apparatus and biting mechanism of poisonous snakes

Poison apparatus

Structure: The poison apparatus consists of a pair of **poison glands,** their **ducts** and a pair of **fangs.** The poison glands are situated on one either side of the upper jaw. The poison glands are possibly the superior labial glands or parotid glands. Each poison gland is sac-like and provided with a narrow duct at its anterior end. The duct passes forward along the side of the upper jaw and loops over itself just infront of the fang and opens either at the base of the fang or at the base of the tunnel on the fang. The poison gland is held in position by ligaments. An anterior ligament attaches the anterior end of the gland to the maxilla. A posterior ligament extends between the gland and the quadrate. Fan – shaped ligaments are situated between the side walls and squamoso- quadrate junction. The fangs are sharply pointed and are enlarged maxillary teeth. The fangs regenerate when lost. Fangs are of two types : (i) open type, and (ii) closed type. In open type as in cobras, the poison groove is open and in closed type as in viper, the poison groove forms a tunnel having two openings one at the base and one near the apex.



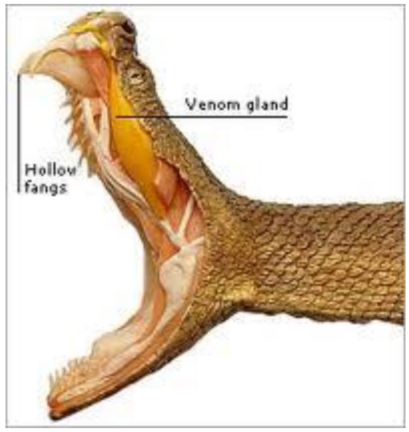
The poison apparatus is associated with specialized bands of three types of muscles. Viz., (i) **digastrics, (ii) sphenopterygoid or protractor- pterygoid and (iii) anterior and posterior temporalis. Digastric muscle** is attached to the lower jaw. **Sphenopterygoid** is attached anteriorly to the sphenoidal region and posteriorly to the dorsal surface of the pterygoid. It helps in pulling the pterygoid forward. **Anterior and posterior temporalis muscles** are attached to the side walls of the cranium and the lower jaw. They help in closing the lower jaw. The efficient venom apparatus depends on three things : (1) **the mechanism of injection of venom, (2) production of venom and (3) method of its delivery.**

Biting mechanism

The mechanism of biting can be described in the following three steps:

(1) Opening of the mouth : By the contraction of digastrics muscles the mouth is opened.

(2) Rotation of maxilla : as the mouth opens the lower jaw moves forward and a rotation of the squamosal, quadrate and mandible in relation to each other occurs. Now the sphenopterygoid muscles contract. This contraction results in the forward movement of pterygoid and up – pushing of the ectopterygoid. The upward movement of the ectopterygoid brings about a rotation of maxilla on its own axis round the lacrymal and as a result the fang is raised and becomes directed forward. The fang is nearly horizontal in position when the mouth remains closed. But during opening of the mouth to bite, the fang assumes almost vertical position.



(3) Closing of mouth : The closing of the mouth is brought about by the contraction of the temporalis and sphenopterygoid muscles. The point of fang is directed backward while the mouth is closed. It takes longer time to open the mouth than to close it.

Q. 17 Give detailed account on bird migration.

Ans : When movements result in the temporary or permanent absence from one home range and the establishment of a residence in another, the resulting movement is said to be a **migration (L., migrate –** to travel**).** Majority of birds have the inherent quality to move ferom one place to another to obtain the advantages of the favourable condition. Such birds are called **migratory birds.** Some birds such as bobwhite and other birds, however, do not migrate at all and they remain throughout the year in a country. Such birds are called **resident birds.** In birds, the migration means two – way journeys – onward journey from the 'home' to the 'new' places and back journey from the 'new' places to the 'home'. This movement occurs during the particular period of the year and the birds usually follows the same route.

the word migration is different from the terms such as "**mass movement,**" **"emigration" or "dispersal".** In migration, animals move from one place but return. However, in other types of movements animal does not return.

Types of avian migrations

1. **Latitudinal migration :** The latitudinal migration usually means the movement from north to south and vice versa. During winter, when the northern hemisphere becomes covered with ice and snow, these birds move towards south for shelter. The American golden plover (Pluvialis dominica) passes the nine months of winter 8000 miles south in the plains of Argentina, thus enjoying two summers each year and knows not a hint of winter.
2. **Vertical or altitudinal migration :** Certain birds, which live in mountainous areas, adjust to the changing seasons by migrating to the foot hills and valleys during winter and return to the high slopes and peaks with the approach of summer. The other examples found are : **Himalayan white-capped redastant and the Californian mountain quail.** In India a number of species during summer migrate from planes to the slopes of Himalayas ascending thousands of feet above sea level and return to planes on the commencement of winter, e.g., common wood-cock, Bush chat and Scolopax rusticola.
3. **Longitudinal migration :** longitudinal or east-west migration includes the migration of birds living in southern hemisphere, which is east-west direction. The Patagonian plover visits the Falkland island and south Patagonian in September and October for breeding.
4. **Partial migrations :** Many avian species **(e.g., blue birds and many blue jays of Canada and northern United States, etc.)** are only **partial migrants**. In such cases all the birds of a group of migratory birds do not leave the native land and hence are always represented by certain individuals. But these individuals are not always the same.

5. **Erratic migration :** The **erratic, vagrant, irregular or wandering** migration occurs in great blue heron, cuckoos, thrushes and warblers. In such birds, after breeding, the adults and the young may stray from their home to disperse in all directions over many or a few hundred miles in search of blood and safety from enemies.
6. **Cyclic migration :** Some migration of birds are seasonal but do not recur at regular intervals. The occasional migration of the snowy owl in the United States in winter depends upon three to five year lemning cycle as lemning is the chief food of snowy owl, which moves southwards.
7. **Daily migration :** Many birds make daily movements from a home base in response to such daily events as light and darkness or temperature changes. Birds make daily migrations from their resting sites to feeding areas. The house-sparrow although does not undertake long migrations, yet it moves out of permanent colonies for feeding.
8. **Lunar migration :** Several animals show a correlation between their reproductive cycle and moon-cycle. This sort of migration is not found in birds, however, it is evident in marine organisms.
9. **Seasonal migration :** Migrations of birds in response to seasonal changes are common. In tropical and sub-tropical areas, they occur in the beginning or end of the dry season. In temperate areas, the movements are more likely to be in response to temperature-changes. The birds, which rest in the **temperate** and **frigid zones,** go to warmer areas for the winter and then return to the breeding area, the following spring.

Characteristics of migration

1. **Time of migratory flights:** The migratory flights may occur during day time or night-time and accordingly two types of migratory birds can be recognized as follow:
   i. **Diurnal migrants:** Some birds fly mainly by day such as crows, swallows, robins, blackbirds, hawks, blue-birds, jays, cranes, loons, pelicans, geese, ducks, swans, etc.
   ii. **Nocturnal migrants:** These include mostly small-sized birds, such as sparrows, warblers, thrushes, etc. These birds prefer to fly at night, under the protective cover of darkness, to escape their enemies. By flying at night, they arrive at the day break, take rest, procure food during day time and then start again at the approach of night.
2. **Range of migration:** The range of migration commonly varies from one or few miles to thousand of miles in different groups of migratory birds but it is

almost constant for a particular group. There are some birds in which migrations to short distance take place : such birds migrate from Southern Canada and the Northern United States, e.g., vesper-sparrows, blue-bird and wood-cock. For example, the Himalayan snow partridges cover a distance of about one or two miles, Chicades travel about 8,000 feet.

3. **Altitude of flight:** Some birds fly at sea-level, other birds during migration fly above 900 meters and some at the height below 390 meters. Some birds, which are strong-fliers, such as **ducks** and **geese,** are found at a height of 1,500 meters to 2,700 meters. The speed of the migratory birds range from 20 to about 40 miles per hour in small song-birds, while in larger birds, such as ducks, geese, the speed is from 40 to about 60 m.p.h. thus, cranes, carrions, crows and finches flight with the speed of 30 miles per hour, while cross bill flights with the speed of 30 miles per hour. The maximum speed recorded so far is about 170 miles per hour, (e.g., Indian swifts). The velocity of flight is maintained in long flights. Speed can be more if birds meet enemies. However, the flying speed of a bird is much greater than the flying rate at the time of migration. The river valleys, mountain ranges and coastal routes provide good landmarks for the migrating birds, which enable the birds to recognize and remember the routes and entrances to the countries.

4. **Segregation during migration :** Some birds such as kingfishers, swifts, and night-hawks travel in separate companies, but certain other birds such as swallows, vultures, blue birds, turkeys, etc. usually travel in mixed companies of several species due to similarity in their size, method of search of food, etc. in some avian species, the male and female individuals travel separately. Males arrive first to build the nests. The young birds usually accompany their mothers.

5. **Order of migration:** Normally the adults migrate first and they are followed by youngs. It has been found that urge of migration occurs due to the maturity of gonads which instigate them to migrate towards their breeding grounds. During the back flight the order becomes reversed. In adult precedence, there is always a definite sequence, the adult males take the lead, adult females next in order and the birds of the year follow them and in the end come the weak and wounded birds.

6. **Regularity of migration:** Several species of migratory birds show a striking regularity, year after year, in their timings of arrival and departure. Inspite of long distances travelled or vagaries of weather, they are often punctual within a day or two in their time of arrival. Further, most migratory birds come back to the same breeding place year after year.

Causes of migration

(a) Environmental stimuli: External ecological stimuli such as growing scarcity of food, decrease of day length or sun glare, increased cold and stormy weather, increase of atmospheric pressure etc. are found to excite birds to migrate to the better suited places. The heat glare and drought also provoke migration among birds.

(b) Gonadial stimuli: It has been suggested that the ripening of sex organs in birds causes a physiological change, which leads to an impulse for migration and the bird is evoked to leave its winter quarters and reach the breeding grounds. According to **Rowan** (1922), the migration is stimulated by the hormones secreted by gonads (i.e., testes and ovaries) of birds.

(c) Thyroid hypothesis: Certain thyroid hormones produce certain necessary changes in the metabolism of migratory birds during the time of migrations and these changes compel the bird to migrate. The physiological state of the bird has been affected by the increased deviation of light, parts of the brain and pituitary gland. The anterior lobe secrets hormones, which induce growth of the reproductive organs and stimulate other endocrine glands.

(d) Metabolic hypothesis: Prior to migration fat deposition occurs due to changed metabolic processes. These changed metabolic conditions provoke migration.

2. Problem of way finding or navigation: Birds usually return to exactly the same locality during breeding and wintering time. From this it is evident that birds recognize their summer and winter homes and there must be some means by which they find their way from one to the other. It is an instinctive rather than learnt patterns of behavior. Humming birds fly non-stop for some 800 meters across the Gulf of Mexico without having known that there is land on the other side. It is also considered that birds have good memories, which help in migration. Various explanations have been given for what determines the direction and course of migration.

(i) The migratory birds utilize various natural structures or topographical features, such as great rivers, river valleys, coastal lines, chain of oceanic islands, mountain ranges, etc. as the landmarks during their flight.

(ii) A few naturalists have suggested that the birds learn by experience. Some older members, benefited by a tradition of following a path in past several years, become leaders to guide the younger generations. However, birds certainly do not learn their migratory route from elders, as some of them do not fly in flocks at all.

(iii) Some ornithologists such as **Von Middendroff and H.L. Yeaglev** advanced the idea that birds navigate through response to the earth's magnetic field and their inner ear reacts to the mechanical **coriolis effect** produced by the rotation of the earth.

(iv)The east-west and north-south gradients of gravity and the magnetic intensity are supposed to have some function in avian migration.

(v) **Matthews (1955)** and **Sauer (1957)** have emphasized the position of the sun (during day time) or stars (during night) helps the birds to navigate along definite route.

(vi) According to some naturalists, homing instinct and telluric currents enable the migratory birds to migrate along definite routes.

3. **Origin of migration:** This has remained a problem for biologists that what started migration or how and why phenomenon of avian migration is originated. One of the most important advantages is that it enables a species to occupy alternately two different areas at a time, when each area presents favourable conditions. Thus, over-crowding and excessive competition for food and nesting sites are avoided.

   Older explanation for migration is that it has resulted from the response of birds to a repetitive event in their racial history, with this response becoming hereditary.

Q. 18 Write a detailed note on adaptive radiations in mammals.

Ans: The first mammals appeared in Triassic times which were descendants of mammal like reptiles. These earliest mammals of late Triassic and Jurassic periods are known only from teeth and jaws. These mammals continued as small and minor members of Jurassic and cretaceous periods and they were completely overshadowed by Jurassic reptiles. It is not easy to determine the precise line of mammalian ancestors among the theriodonts, cynodonts, bauriamorphs and the ictidosaurs.

It is possible that the mammals may have had a polyphyletic origin. The several groups of mammal like reptiles contributed to the ancestry of the early mammals. What ever may have been the origin of mammals among mammal like reptiles the fact is that during Jurassic times the threshold crossed from reptiles to mammals and a new phase of the tetrapod evolution began.

The survey of the primitive mammals of Mesozoic times plus the monotremes gives an idea about first evolutionary development of mammals before their great expansion, which took place at the beginning of cenozoic times. The mesozoic mammals live for a long time and in this long period of late triassic, jurassic and cretaeeous time, the primitive mammals established the primary lines of evolutionary radiation that determined subsequent mammalian history.

The history of mammals can be considered in three phases of adaptive radiation :

I. Late Triassic and Jurassic periods

II. Cretaeous period

III. Cenozoic era

During the first phase of mammalian radiation following five mammalian orders appeared and developed:

Docodonta

Triconodonta

Symmetrodonta

Pantotheria

Multituberculata

During the second phase of mammalian radiation, all the mesozoic orders except the docodonts continued their development. During early cretaeeous the tricodonts, symmetrodonts and pantothere became extinct.

It appears that the pantotheres gave rise to the two great mammalian groups – **marsupials** and **placentals.** The development of these mammals from panthotheres probably occurred during early cretaeeous times. When these significant evolutionary changes were taking place, the multituberculates were flourishing in full vigour to survive into early cenozoic times.

During the third and final phase of mammalian radiations marsupials and placentals reached maximum heights of evolutionary development and the multituberculates became extinct. The monotremes which are known only during the final state of cenozoic history, probably persisted through all the three phases of mammalian radiation. The cenozoic radiation of mammals is the most interesting because it is during this phase the tetrapods evolved along the various lines that have led to the varied and successful mammals of tertiary, quaternary and recent times. The radiation of mammals can be indicated in the following chart:-

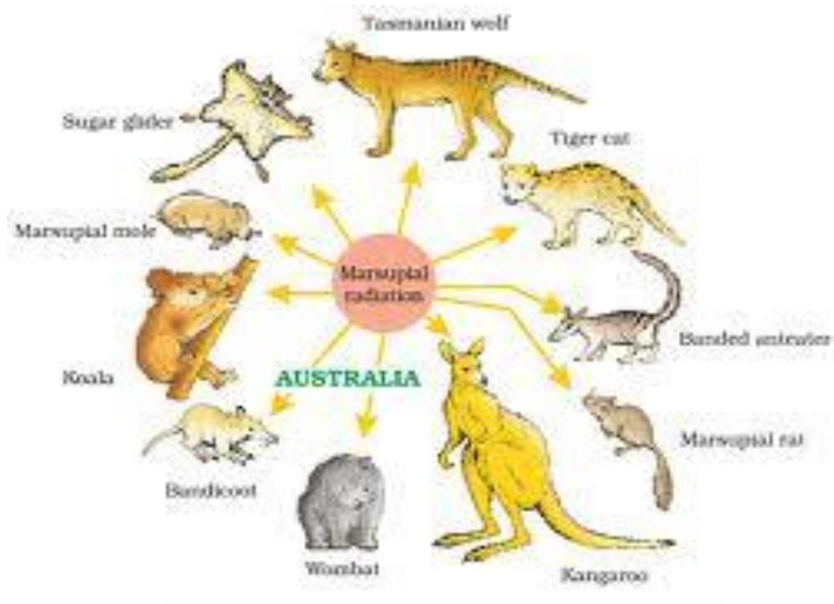


Figure 7.6 Adaptive radiation of marsupials of Australia

Law of adaptive radiation by Osborn: Each isolated region, if large and sufficiently varied in its topography, soil, climate and vegetation, will give rise to a diversified fauna. The larger the region and the more diverse the conditions, the greater variety of mammals will result. From a primitive stem form, adaptive radiation took place in four diverse directions. The adaptations were mainly of limbs, feet and teeth. The adaptations of teeth and feet do not necessarily run parallel.

Osborn's law of adaptive radiation was mainly to the mammals but it is equally true to other groups such as reptiles.

The main causes of adaptive radiations are –

(a) Need of food

(b) Need of shelter

(c) Over the earth's surface (cursorial)

(d) Beneath the earth's surface (fossorial)

(e) Into the air (areal)

(f) Into the water (aquatic)

Primary and secondary acquired adaptations: Adaptations are direct or primary if they lie in the original direction of adaptation along any of the four lines. But if adaptations are reversed then they are secondary adaptations. Once an organ is lost it can never be regained or a specialized form can never again become generalized **Local adaptive branching** is restricted to the differences arising with in a group of closely related forms whose life habits are similar.

Contemporaneous radiations are due to geographical distribution. The world's surface can be divided into three realms –

I. Northern hemisphere and Africa

II. South America

III. Australia

These three great realms have been the centre of three remarkable adaptive radiations of mammals during tertiary time when all three were isolated from each other.

Tooth radiation: The mammals are characterized by heterodont dentition with few exception e.g., cetacea, anteaters. The incisors are mainly prehensile, the canines grasping, tearing or for defense and offense, premolars for shearing and molar for grinding. The molars and premolars shows the greatest structural modifications to meet their owner's requirement. The incisors and canines show less variation.

In conclusion, there is a wonderful plasticity of living beings to find food and safety and become adapted in the course of time to all possible conditions of life-earth, air, water and have shown adaptation which are chiefly concerned with safety and food i.e., feet for safety and teeth for food.

Q. 19 Discuss dentition on mammals.

Ans: **Dentition in mammals :** Teeth are hard usually pointed structures usually found in the buccal cavity. In all the mammals teeth are formed. In some mammals like ant-eaters the teeth are found in the embryo which are later on shed off. In mammals teeth are most important because the classification of mammals is base on it. Typically a tooth is distinguished into a crown, a neck and a root.

The mammalian teeth can be distinaihed as homodont and heterodont; when the teeth are similar in shape and size, they are termed as homodont. Such condition is found in dolphins and porpoises. In contrast to these, a condition when the teeth are dissimilar in shape and size is termed as heterodont. In mammals when the condition is heterodont, the teeth are distinguished as incisors, canines, premolars and morals. The incisors are associated with the premaxilla, possess a single root and are associated with the premaxilla, possess a singed root and are adapted for seizing and cutting. The canines are teeth which lie immediately behind the suture between premaxilla and maxilla. In few mammals the canines are absent and the space present in between the incisors and premolars and molars. The premolars and molars are crushing and grinding teeth. The premolars lie anterior to molars. Their crown possess cusps and ridges. They may have two or more roots.

According to succession the teeth are distinguished as monophyodont and diphyodont. In whales only one set of teeth works throughout life, thus the dentition is termed as monophyodont. In others like man the first set of teeth is shed off and another set of teeth arises which starts functioning. The first set of teeth is termed as milk teeth while the other set is called as **permanent** set of teeth. This condition is termed as **diphyodont** condition.

Teeth of mammals are located in the socket of the jaw and this condition is called as the condont. Depending upon the shape of cusp teeth are named:

(i) **Triconodont:** When there are three cusps in one plane.

(ii) **Tritubercular:** When the three cusps are situated at three points of a triangle.

(iii) **Bunodont:** When the cusps are numerous, pointed or blunt.

(iv) **Lophodont:** When the cusps run into ridges.

(v) **Slenodont:** When the cusps form a crescent.

(vi) **Hyposodont:** When crown is long an neck is deeply situated in the socket.

(vii) **Brachyodont:** When crown is short and neck is at the surface of the gum.

Dental formulae

With few exceptions the right and left sides of the jaws have the same numbers of incisors, canines, premolars and molars. Consequently the"dental formula" as ordinarily written represents only one side of the whole dentition and total number of teeth is equal to twice the sum of the number in the "formula".

The number of teeth in a mammal are demonstrated by dental formula. A typical mammalian dentition includes 44 permanent teeth, which could be demonstrated as follows –

Incisors 3/3; canines 1/1; premolars 4/4; molars 3/3 = 44, this formula shows 11 teeth in one half of the jaw 11*4 = 44. Thus there are in all forty – four teeth. This formula is correct for horse, talpa, pig and can be written in a more simplified way as

Incisors

In more primitive insectivorous forms the incisors (3/3 on each side in primitive placentals and 5/4 in primitive marsupials) are small nipping teeth, suitable for catching insects; the lower centrals are slightly procumbent, the crowns simple with blunt points or slightly sharp edges. The vertical incisors of cat, giving a more powerful bite are fairly primitive.

Canines

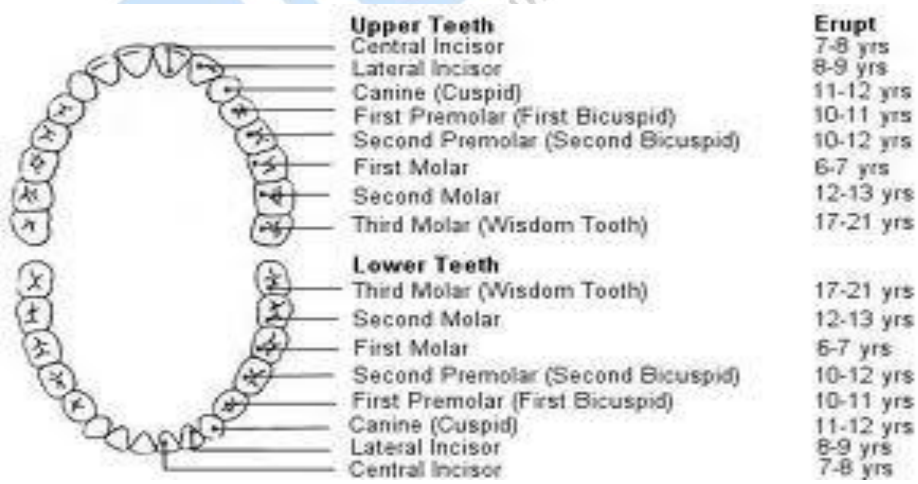
In cow the upper canines are replaced by a horny pad while the lower canines have spatulate crowns arranged in a semicircle adapted, with the horny pad above, pad for plucking herbage.

The canine teeth of carnivorous are peculiarly fitted for killing living prey. On the other hand in herbivorous forms the canine teeth are either reduced or adapted to some other function as in the lower canines or fitting tusks of the boar.

Molars

In primitive insectivore, molars are small and bear V- shaped cusps with sharp little blades, in omnivorous type either the cusps become rounded often connected with other cusps by low ridges as in anthropoid apes and man.

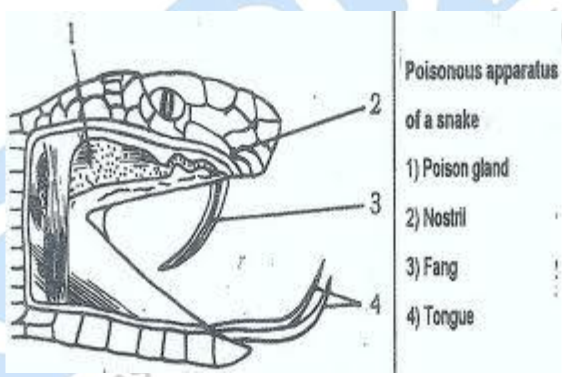
In herbivorous types the molar crowns acquire crests and hillocks arranged, to patterns characteristic of the different species.



Q.20 Define Snake venom.

Ans. **Snake venom** is highly modified saliva. The venom is part of a whole: the apparatus, which is made up of venom glands that synthesize venom; and an injection system, consisting of modified fangs with which to make the venom penetrate into a prey item or a possible threat or predator. The glands which secrete the zootoxins are a modification of the parotid salivary gland of other vertebrates, and are usually

situated on each side of the head below and behind the eye, encapsulated in a muscular sheath. The glands have large alveoli in which the synthesized venom is stored before being conveyed by a duct to the base of channeled or tubular fangs, through which it is ejected. Venoms contain more than 20 different compounds, mostly proteins and polypeptides. Snake venom has two main functions: first, the immobilization of prey and second, the digestion of prey. It is a complex mixture of proteins, enzymes, and various other substances. The proteins are responsible for the toxic and lethal effect of the venom and its function is to immobilize prey, enzymes play an important role in the digestion of prey, and various other substances are responsible for important but non-lethal biological effects. Some of the proteins in snake venom are very particular in their effects on various biological functions including blood coagulation, blood pressure regulation, transmission of the nervous or muscular impulse and have turned out to be pharmacological or diagnostic tools or even useful drugs.



Key Terms

Adaptation: A trait that functions to increase fitness and that evolved for that function.

Annelids: Member of Annelida, a phylum within the Lophotrochozoa. This group of segmented worms includes earthworms, leeches, and bristle worms

Ancestral characteristic: A trait found in both an organism being studied and the common ancestor of a group to which the study organism belongs.

Benthic: term used to designate aquatic organisms that are bottom dwelling.

Bilateral symmetry: The condition, found in many organisms, where one half of the body or structure is the mirror image of the other.

Bony fishes: Fish of the class Osteichthyes, characterized by a skeleton composed of bone in addition to cartilage, gill covers, and an air bladder.

Chordata*:* The phylum of animals that is characterized by elongated bilaterally symmetrical bodies. In some phase of their life cycle, they have a notochord and gill slits or pouches. Chordates also often have a head, a tail, and a digestive system with an opening at both ends of the body. The ***Chordata*** include fish, amphibians, reptiles, birds, mammals, and 2 **invertebrate** subphyla (tunicates and lancelets**).**

Chordate: A member of the phylum Chordata**.**

Cladistics: A method of classification that is based on the order of branching in a phylogenetic tree rather than on phenotypic similarity.

Cladogram: A phylogenetic tree in which the only information given is about the relationships among taxa (i.e., the length of the branches is not meaningful).

Deuterostome: Member of one of the two large groups of bilaterian animals including the echinoderms, hemichordates, and chordates. In this group, the initial embryonic opening becomes the anus.

Echinoderm: Member of a major phylum within the deuterostomes that includes sea urchins, starfish, crinoids, and sea cucumbers. Although they possess bilateral symmetry initially, adults usually show a fivefold radial symmetry.

Endoderm: One of three cell layers found in bilaterian embryos (the other two being the ectoderm and mesoderm). The endoderm goes on to form structures such as the lining of the digestive system and portions of organs such as the liver, lung, and pancreas.

Gynodioecious: A population that contains both females and hermaphrodites.

Hemichordate: Member of a diverse phylum of marine animals including the acorn worms and pterobranchs (phylum Hemichordata)

Hermaphrodite: An individual that produces both male and female gametes.

Monandrous: Where females mate with a single male.

Ostraderms: Primitive jawless fishes, covered by bony armor, that lived in the Cambrian through Devonian periods.

Phylogeny: The evolutionary history of organisms or genes.

Polyandrous: Describes females that mate with many males.

Universal homology: A homologous trait found in all cellular organisms.

Multiple-Choice Questions

1. Which group is most closely related phylogenetically to the first vertebrates?
a. echinoderms
b. arthropods
c. mollusks
d. annelids
e. nematodes
Ans: a

2. Which statement is NOT true?
a. All chordates have notochords.
b. All chordates have pharyngeal pouches or slits.
c. All chordates have dorsal tubular nerve cords.
d. All chordates are vertebrates.
e. Chordates are found in all major types of environments.
Ans: d

3. The notochord is most closely associated with the
a. nervous system
b. spinal cord
c. skeletal system
d. skin system
e. nervous system and spinal cord only
Ans: c

4. The chordate feature still present in the human adult is
a. pharyngeal gill slits
b. nerve cord
c. notochord
d. tail
e. all of the choices
Ans: b

5. Which of the following statements is false?
a. All vertebrates have a ventral nerve cord.
b. All vertebrates have a tail at some stage in their life cycle.
c. All vertebrates have a notochord at some stage in their life cycle.
d. All vertebrates have pharyngeal gill slits at some stage in their life cycle.
e. All vertebrates have a tubular nerve cord.
Ans: a

6. Which of the following is NOT a feature that is found exclusively among all vertebrates?
a. notochord
b. pharyngeal gill slits

c. four legs
d. post-anal tail
e. dorsal nerve cord
Ans: c

7. In filter-feeding chordates, which structure has cilia that create water currents and mucus sheets that capture nutrients suspended in the water?
a. notochord
b. differentially permeable membrane
c. filiform tongue
d. gill slit
e. jaw
Ans: d

8. Which of the following is a diagnostic feature of the sea squirts that forms the basis for its classification?
a. metamorphosis from a motile larva to a sessile adult
b. a heart that allows circulation of blood
c. a notochord located in the tail of the larva
d. sexual reproduction during the larval stage
e. the presence of a tunic or coat over the body of the adult
Ans: c

9. During the life of a tunicate, the notochord
a. is present throughout life
b. appears in the larva only
c. develops during adulthood
d. is completely absent
e. changes into the nerve cord
Ans: b

10. The "tunic" of tunicate refers to
a. a body covering
b. the type of food-gathering mechanism
c. muscle arrangements in the larva
d. the immature stage of a true fish
e. the protective cover of the brain
Ans: a

11. The feeding habits of lampreys are best described as
a. suspension feeding
b. predatory
c. parasitic
d. scavenging
e. all of the choices
Ans: c

12. The term *jawless fish* could be used to describe
a. ostracoderms

b. placoderms
c. hagfish
d. ostracoderms and hagfish
e. placoderms and hagfish
Ans: d

13. Which is NOT an anthropoid?
a. orangutan
b. lemur
c. spider monkey
d. human
e. chimpanzee
Ans: b

14. Humans are least closely related to the
a. chimpanzee
b. orangutan
c. gorilla
d. lemur
e. spider monkey
Ans: d

15. Which group includes all the others?
a. tarsioids
b. hominoids
c. prosimians
d. anthropoids
e. primates
Ans: e

16. Humans belong to all but which one of the following?
a. hominids
b. hominoids
c. prosimians
d. anthropoids
e. primates
Ans: c

17. Which of the following can be included in the group called "hominids"?
a. monkeys
b. humans
c. apes
d. humans and apes only
e. monkeys, humans, and apes
Ans: b

18. In the course of the evolution of existing primate groups, there has been a general decrease in
a. the number of offspring produced by a female

b. body size
c. life span
d. the duration of infant dependency
e. the age of sexual maturation
Ans: a

19. All but which factor were important evolutionary adaptations in primates?
a. enhanced daytime vision
b. upright walking
c. an opposable thumb
d. the development of a restricted or specialized diet
e. brain expansion and elaboration
Ans: d

20. Which feature is NOT characteristic of the evolutionary trends in primates?
a. longer life span
b. longer gestation period
c. longer infant dependency
d. longer periods between pregnancies
e. larger litters
Ans: e

21. Four of the five answers below are classes of living chordates. Select the exception.
a. hagfish
b. bony fish
c. reptiles
d. placoderms
e. cartilaginous fish
Ans: d

22. Four of the five answers below are related by a common group. Select the exception.
a. frogs
b. toads
c. tuataras
d. salamanders
e. caecilians
Ans: c

23. Four of the five answers below are principal characteristics of all chordates. Select the exception.
a. post-anal tail
b. bony vertebra
c. notochord
d. dorsal nerve cord
e. pharyngeal gill slits
Ans: b

24. Four of the five answers below are gas exchange regions in chordates. Select the exception.

a. skin
b. gills
c. tracheas
d. lungs
e. lining of pharynx and mouth

Ans: c

25. Four of the five adaptations below allowed animals to live on land. Select the exception.

a. eggs that can develop out of water
b. waterproof skin
c. lungs
d. ectothermy
e. internal fertilization

Ans: d

Rajasthan University Examination, 2012
B.Sc. (Part-III) EXAMINATION, 2012
(Faculty of Science)
[Also Common with subsidiary Paper of B.Sc.. (Hons.) Part-III]
(Three-Year Scheme of 10+2+3 Pattern) (For Regular)
ZOOLOGY
First Paper-(Structure and Functions of Chordate Type)

Time Allowed : Three Hours **Maximum Marks : 33**

Part I

1. **(a)** Write the common name of Herdmania.
   (b) What is Perching.
   (c) Pelvic girdle is composed of three bones. Write the names.
   (d) Name the excretory organ of Branchiostoma.
   (e) The tusks of elephant are-
   (f) Define Adaptive Convergence.
   (g) Write the name of Y-shaped bone of the caudal vertebrae of Varanus.
   (h) What is the difference between lymph and blood?
   (i) Birds which do not migrate at all are known as-

Part-II

Section A

2. Describe the digestive system of Branchiostoma and add a note on mechanism of feeding in it.
3. Describe the salient features and life cycle of Petromyzon.
4. Write short notes on-
   (a) Pharynx of Herdmania.
   (b) Retrograssive metamorphosis.
   (c) Protochordates

Section B

5. Describe the female urinogenital system of Aves and compare it with of Reptiles.
6. Write notes on-

(a) Different types of Centrum of Vertebrates.
(b) (b) Epidermal glands.

7. Give a detailed account of stomach in vertebrates which you have studied.

Section C

8. Discuss in detail the causes of Bird migration.
9. Describe the different types of scales and fins in fishes.
10. Write notes on-
 (a) Parental care in Amphibia
 (b) Biting mechanism of snake.

Rajasthan University Examination, 2011
B.Sc. (Part-III) EXAMINATION, 2011
(Faculty of Science)
[Also Common with subsidiary Paper of B.Sc.. (Hons.) Part-III]
(Three-Year Scheme of 10+2+3 Pattern) (For Regular)
ZOOLOGY
First Paper-(Structure and Functions of Chordate Type)

Time Allowed : Three Hours **Maximum Marks : 33**

Part I

1. (a) Write the three primary chordate characters.
(b) Which type of centrum is present in the vertebra of a frog?
(c) Name the outermost two layers of epidermis of a mammalian skin.
(d) In an adult bird how many ovaries are found?
(e) Define progressive metamorphosis.
(f) Write the names of lobes of lung of Rabbit.
(g) Name the cavity of pectoral girdle.
(h) Name first and fifth cranial nerves.
(i) What is a dental formula?

Part II

Section A

2. Describe the circulatory system of Herdmania and compare it with Branchiostoma.
3. Describe Retrogressive metamorphosis.
4. Compare the affinities of Hemichordata, Urochordata and Cephalochordata.

Section B

5. Describe the structure of integument of a mammal.
6. Describe the evolution of aortic arches of vertebrates with the help of diagram.
7. Describe the respiratory system of a bird and compare it with that of mammals.

Section C

8. Write an easy on Bird migration.
9. How can you distinguish between poisonous and non poisonous snakes?
10. Write notes on-
    (a) Scales in Fishes.
    (b) Parental care
    (c) Adaptive radiation in mammals

Rajasthan University Examination, 2010
B.Sc. (Part-III) EXAMINATION, 2010
(Faculty of Science)
[Also Common with subsidiary Paper of B.Sc.. (Hons.) Part-III]
(Three-Year Scheme of 10+2+3 Pattern) (For Regular)
ZOOLOGY
First Paper-(Structure and Functions of Chordate Type)

Time Allowed : Three Hours **Maximum Marks : 33**

Part-I

1. (a) Write the chordate characters of Hemichordate.

   (b) Write the Biological significance of Ammocoete larva.

   (c) Retrogressive metamorphosis.

   (d) Name the parts of alimentary canal of Pigeon.

   (e) Write down the correct sequence of vertebrae types, from ant to posterior, found in the vertebral column of Varanus.

   (f) Give the number and names of air sacs present in Pigeon.

   (g) Explain the structural peculiarities of Cobra.

   (h) Mention the advantages of Bird migration.

   (i) Write the Dental formula of Rabbit.

PART-II

SECTION-A

2. Describe the alimentary canal and digestive glands of Herd mania. Give an account of feeding and digestion in it.

3. Write short notes on any two of the following :
   (i) Affinities of Cephalochordate
   (ii) Primitive characters of Petromyzon
   (ii) Excretion in Amphioxus.

4. Describe the Blood Vascular system of Branchiostoma. Add a note on special features of this system.

SECTION-B

5. Give a comparative account of heart of Pigeon and Rabbit.

6. Draw labeled diagrams of any two of the following :
   (i) Urinogenital System of male Varanus.
   (ii) Dorsal view of Brain of Scioliodon
   (iii) Alimentary Canal of Rabbit.

7. Describe in detail the integument of Frog. How is it different from Varanus ?

SECTION-C

8. Write an essay on phenomenon of parental care in Anurans.

9. Write short notes on any two of the following :
   (i) Scales of fishes
   (ii) Adaptive radiations in marsupial mammals
   (iv) Attachment of teeth with jaw.

10. Describe in detail the Flight adaptation in birds.

Rajasthan University Examination, 2009

B.Sc. (Part-III) EXAMINATION, 2009

ZOOLOGY

First Paper – (Structure and Functions of Chordate Types)

Objective Part-I

Time allowed : One Hour **Maximum marks : 13**

I. Multiple Choice Type Questions.

1. The endostyle of urochordates is homologous to which structure of Vertebrates ?
   (a) Pancreas (b) Thyroid gland
   (c) Pituitary gland (d) Adrenal gland.

2. Excretory organs of Branchiostoma are -
   (a) Flame cells (b) Protonephiridium
   (c) Malpighian tubules (d) Nephridia.

3. Number of cervical vertebrae in the neck of Mammals are-
   (a) 5 (b) 6
   (c) 7 (d) 12.

4. Brunner's glands are found in –
   (a) Stomach (b) Duodenum
   (c) Ileum (d) Whole Alimentary Canal.

5. An example of catadromous migratory Fishers is –
   (a) Anguilla (b) Petromyzon
   (c) Hilsa (d) Alosa.

6. How many lobes are found in right lung of a Rabbit ?
   (a) 2 (b) 4
   (c) 5 (d) 6.

II. State True or False.

7. Embryonic mesonephric kidneys are replaced by metanephric kidneys in Amniotes.

   (True/False)

8. Sweat glands are found in the skin of Birds.

   (True/False)

9. Lower Jaw of Scoliodon is called Mackel's cartilage. (True/False)

10. Endoskeleton of Birds is built on the "hollow girder principle". (True/False)

11. In Pipa pipa the female presses fertilized eggs on male's back so that each sinks into a vascular pouch and is convered by a lid. (True/False)

12. In the Snakes, two rami of mandible are firmly united anteriorly and mouth non-exapansible. (True/False)

13. Wings are elevated or raised by pectorails minor muscles in Birds. (True/False)

III. Fill in the Blanks.

14. The Test of Herdmania is made up of a polysaccharide called ………………

15. In Branchiostoma, the muscle is arranged throughtout the length of the body in a series of blocks called ……………………..

16. Petromyzon destroy valuable fish by feeding on their …….. and ………..

17. The most characteristic feature is the presence of "Y" shapped bone of the Caudal Vertebrae of Varanus called. ………………

18. ……………. Pairs of Aortic arches are found in the Urodela Amphibians.

19. ………………. Plays an important role in perching mechanism.

IV. Very short answer type questions/one word answers.

20. Which glands are modified into Meibomian glands of Mammals ?

21. Write the biological significance of Ammocoete larva.

22. Write the name of larva of Balanoglossus.

23. Write the name of the bones making pelvic girdle of Varanus.

24. Write the common name of Herdmania.

25. Give the name of scientist who proved by experiments that birds get navigation through Sun during migration.

26. Give the dental formula of man.

Descriptive Part-II

Time Allowed : Two hours **Maximum marks** : **20**

1. Describe the digestive system of Branchiostoma **and** add a note on mechanism of feeding in it.

2. What do you understand by retrogressive metamorphosis ? Illustrate the phenomenon by giving an account of the development of an Ascidian.

3. Comment upon any two of the following :-

   (i) External features of Petromyzon
   (ii) Neural complex of Herdmania
   (iii) Affinities of Urochordata and Cephalochordata.

SECTION-B

4. Discuss the Evolution of Aortic Arches in major groups of vertebrates

5. Describe the pectoral girdles in Varanus, Fowl and Rabbit.

6. Write short notes on any two of the following :-
   (i) Structure and development of Placoid Scales
   (ii) Ruminant stomach and Symbiotic digestion.
   (iv) For brain or Prosen cephalon of Rabbit.

SECTION-C

7. Write an essay on Bird migration.

8. Discuss the Adaptive Radiations in Mammals.

9. Write short notes on any two of the following :-
   (i) Parental care in Amphibia
   (ii) Poison apparatus

(iii) Denition in Mammals.

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