Phylum Chordata

Introduction

The Domain Eukarya or Eukaryota is divided into four Kingdoms (Protista, Fungi, Plantae, and Animalia). The animal kingdom in turn is divided into several major animal groups called phyla (singular, phylum). Zoologists today recognize approximately 36 phyla of multicellular animals. The last major group of the animal kingdom is known as phylum Chordata.

Phylum Chordata was coined by the German scientist Ernest Haeckle (1874). The name of this phylum is derived from two Latin words; **chorde** meaning a cord and **ata** meaning bearing, where all members of the phylum, which are called chordates, due to having a stiff, supporting rod-like structure along the back, the **notochord** (in Greek, noton = back; in Latin, chorde = cord).

Four animal groups (chordates, invertebrates, vertebrates, invertebrate, chordates)

The animals belonging to all other phyla of the animal kingdom except chordates are often termed the non-chordates or the invertebrates, which do not possess a notochord and other 4 characteristics at a period of their lives and they lack endoskeleton. Chordates which have **endoskeleton** (cartilage or bone or both) are called vertebrates. 35 phyla of the animals are invertebrates, and they share, but in less number, the chordates in last phylum, the Chordata. The invertebrates belong to phylum Chordata are named invertebrate chordates to distinguish them from other invertebrates. They bear the five main characteristics of chordates at least at a stage of their lives. Of more than 65,000 living species of chordates, more than 90% are vertebrates and other less than 10% are invertebrate chordates. 65% of vertebrates are fishes.

Five main characteristics of the Phylum Chordata

Phylum Chordata comprising a vast variety of living animals ranging from small protochordates, less than one centimeter in length, to large higher chordate or vertebrate, which grows to 35meters long and 180 tons in weight. They dwell all environments: terrestrial, aquatic, aerial, arboreal, and underground. In spite of all these variations, all chordates must have the **five** basic characteristics at least in a period of their lives. The fate of each of these five characteristics are either: remain throughout life, replace or degenerate. These five main characteristics unite these

diverse animals under a common phylum. These characteristics are illustrated below in **Fig. (1).**

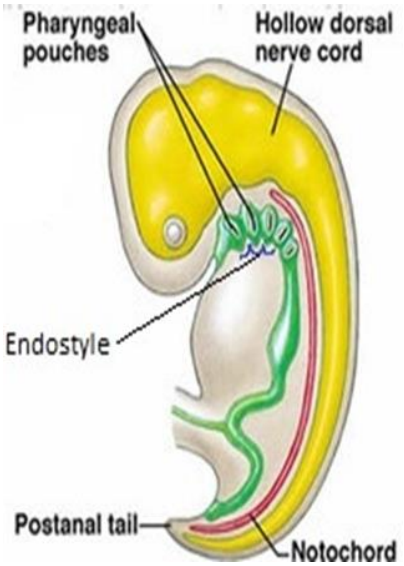


FIGURE 1: Five main characteristics of the chordates.

1. Notochord: is a flexible, rod-like structure, it is the first part of the endoskeleton to appear in the embryo. The notochord is an axis for muscle attachment.

2. Single dorsal hollow nerve tube: In chordates, the single nerve tube is dorsal to the alimentary canal and notochord, and is not solid but a tube. In vertebrates, the anterior end becomes enlarged to form a brain surrounded by a bony or cartilaginous cranium, thus vertebrates are called craniates or higher chordates. The remaining nerve tube is more often called the spinal cord which is protected by the vertebrae. Nerve tube mostly remain in chordates throughout their lives.

3. Pharyngeal pouches or slits: pharyngeal slits are openings that lead from the pharyngeal cavity to the outside. They are formed by in pocketing (invagination) of the outside ectoderm (pharyngeal grooves), or out pocketing (evagination) of the endodermal lining of the pharynx (pharyngeal pouches).

4. Endostyle or thyroid glands: the thyroid glands or their forerunner (predecessor), endostyle, is found in all chordates, but other animals lack it.

The thyroid glands like the endostyle, are involved in iodine metabolism. All chordates have either endostyle (urochordates, cephalochordates and larval stage of

lampreys) or thyroid gland (adult lamprey, but all other vertebrates larval and adult stages).

5. Post anal tail: a tail in the embryo (if not in adult), that extends beyond the anus, so called a post anal tail. The post anal tail and the stiffening notochord provide the motility for free-swimming. The tail is evident in humans, *Homo sapiens*, only as a vestige (the coccyx, a series of small vertebrae at the end of vertebral column) but most other mammals have a waggable tail as adults.

Traditional and Molecular Classification

Because organisms are great in number and diversity, it is helpful to have a classification system to group organisms into categories. Taxonomy (Gr., tasso= arrange, classify, and nomos= usage law) is a discipline of identifying and classifying organisms to be easy to study. Traditional classification depends on certain rules such as morphological similarity, structure, and embryonic development . Traditional classification has been accepted by most biologists for over a century. Biologists are now using a new molecular techniques to classify animals by comparing similarities in their DNA and the ribosomal RNA, especially sequences of nucleotides in the genes.

Criteria for traditional classification

The traditional classification of animals into phyla is based on the following criteria or rules **(Fig.2)**:

1. Symmetry (asymmetry, radial or bilateral symmetry).

2. Level of organization (cellular, tissue, organ or organ system level).

3. Coelom or body cavity (acoelomate, pseudocoelomate or coelomate).

4. Pattern of embryonic development (protostome or deuterostome).

5. Segmentation (segmented or non-segmented body).

According to these criteria chordates are: Coelomate, segmented, bilateral deuterostomes.

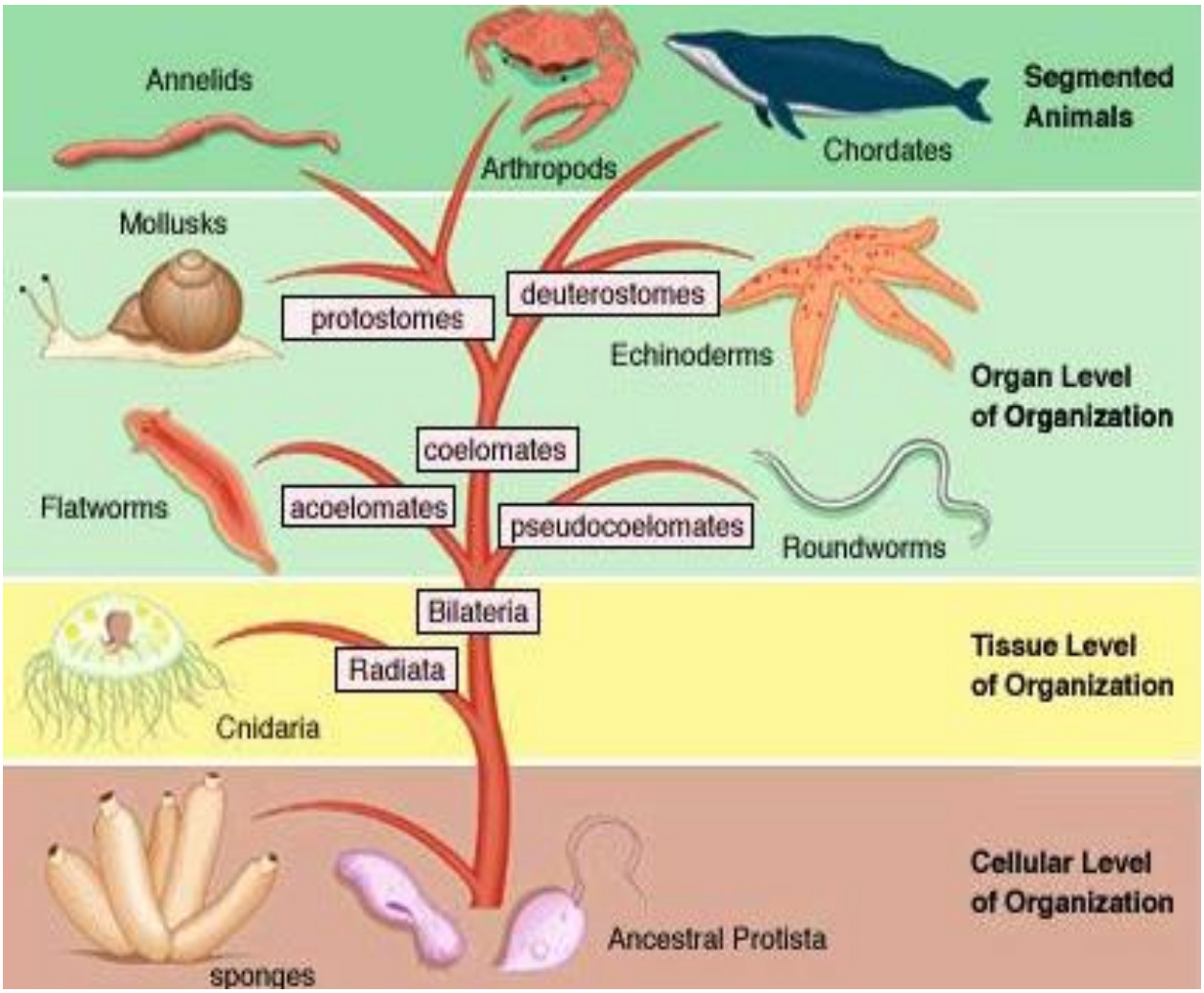


FIGURE 2: Phylogenetic tree of animal kingdom.

Differences between protostomes and deuterostomes

The main differences between these taxonomic groups is mostly related to the pattern of embryonic development, as in the following table, and **Fig.3:**

Table 1. Basic differences between protostomes and deuterostomes

Characteristics	Protostomes	Deuterostomes
1. Early cleavage	Determinate	Indeterminate
2. Fate of blastopore	Form mouth	Form anus
3. Formation of coelom	Forms from mass of cells near blastopore	Forms from cells pinch of archenteron
4. Examples	Annelida, Mollusca, Arthropoda	Echinodermata, Hemichordata Chordata

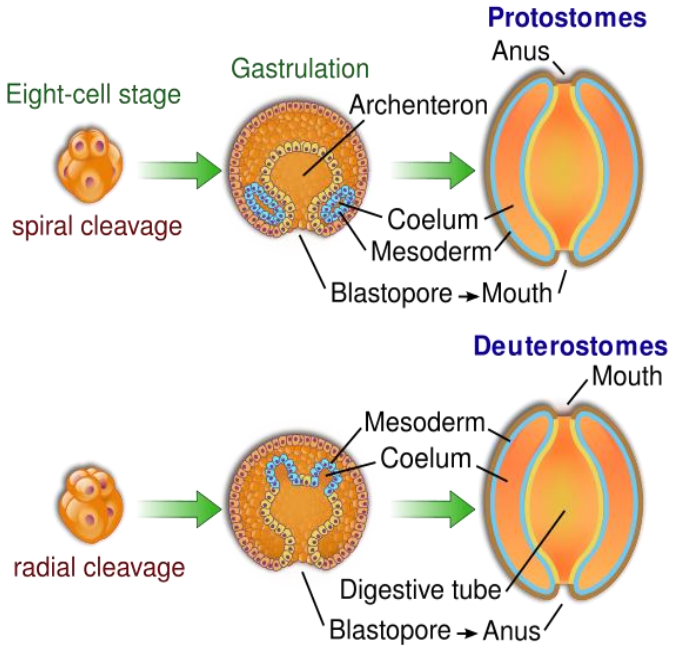


FIGURE 3: Detailed differences between protostomes and deuterostomes.

Determinate and indeterminate cleavage

Determinate cleavage: Fate of the cleavage cells (blastomeres) determined very early in development and if any cells separated at an early embryonic stages, impossible for embryo to form.

Indeterminate cleavage: Fate of cleavage cells (blastomeres) isn't determined early, and when any cells separated it forms embryo, why twins, triplets, etc. can occur.

System of binomial nomenclature

Biologists give each living thing a two-part name called **a binomial name** (L., bi= two, and nomen= name). For example, the scientific name for the common dog is ***Canis familiaris***, the first word that starts with a capital letter is the genus, and the second word that starts with a small letter is the specific epithet of a species within a genus. The genus may be abbreviated (e.g. ***C. familiaris***). Scientific names are universally used by biologists to avoid confusion. Common names are often found in the language of a particular country. But scientific names are based on Latin or Greek, universal languages that not too long ago were well known by most scholars. This system of using the generic and specific names was first devised by a Swedish scientist named Carolus Linnaeus and is known as the system of **binomial nomenclature.**

Taxa common for all chordates

Taxonomic levels, ranks or categories also called taxa. **Taxa**, singular **Taxon**, any unit used in the science of biological classification, or taxonomy. Taxonomic categories are universally recognized; in descending from kingdom to subspecies or races.

Domain (Super kingdom): Eukarya or Eukaryota

Kingdom: Animalia

Subkingdom: Metazoa

Superphylum: Deuterostoma

Phylum: Chordata

Later on Phylum chordata diverges into 2 groups: protochordates and vertebrates.

Chordate groups out of the taxonomic unit or taxa

Six pairs of opposite chordate groups will be studied with their included taxa and animals, these six pairs are:

1. **Protochordates** vs **higher chordates** or vertebrates.
2. **Pisces** vs **tetrapoda**. In Latin piscis mean a fish.
3. **Anamniota** vs **amniota**. Amniotes or amniotic animals their embryo protected by three extraembryonic membranes (**Fig.4**): amnion, chorion, allantois in addition to yolk sac which is the only extraembryonic membrane for anamniotes. Reptiles, birds and mammals are amniotes, while agnathans, fishes and amphibians are anamniotes.
4. **Ectotherms** vs **endotherms**. The environment regulate the temperature of the ectothermic animals, while the body temperature of endotherms regulate internally. Only birds and mammals are endotherms.

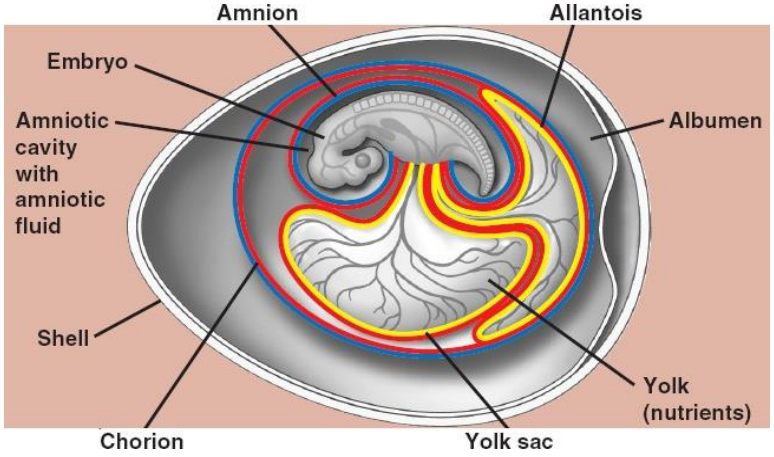


FIGURE 4: Extraembryonic membranes (yolk sac, amnion, chorion, and allantois) of amniotic embryo.

Importance of the Phylum Chordata

1.Phylum Chordata is the highest and the most important phylum. **Man** himself, the most potent force on Earth, **classified belonging this Phylum**.

2. Chordates, especially vertebrates, have an **important role in world economy** such as fish, birds, sheep, deer and cattle.

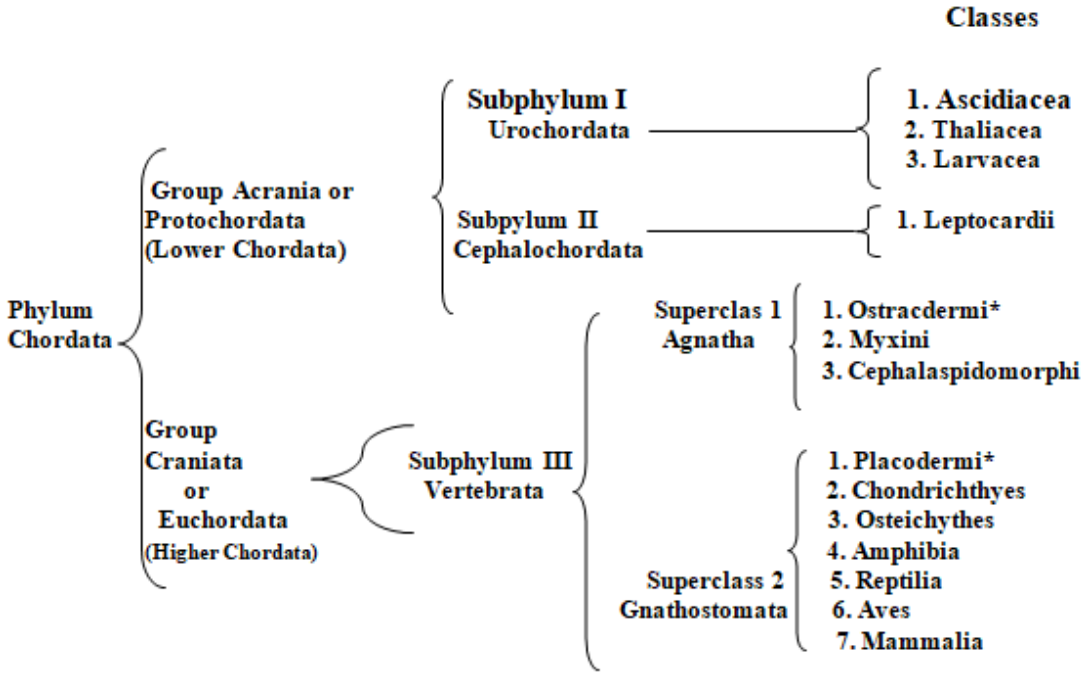
3. Camels, horses. Mules and donkeys are **used in transportation** especially in hard situations. Cows, mules and donkeys are **used in plowing** in regions where it is difficult to use modern mechanization.

3. Some chordates are **used as pets**, such as cats and squirrels, and some are used in **scientific experiments**, like rats, mice, frogs and guinea pigs.

4. Studies of animal behaviours, which human begins have been able to **imitate some animals** and exploit to achieve progress.

Brief classification of the Phylum Chordata

It is worth mentioning that classification systems have changed dramatically since Linnaus time, and hypothesis about relationship among organisms are changing today as new data gathered. Species are capable of interbreeding and producing fertile offspring that themselves can interbreed, so the species is a relatively stable taxon in comparison to other classification taxa. Species placed within one genus share many specific characteristics and are the most closely related.



*Extinct forms

Removal of hemichordates from Phylum chordate

Hemichordata (Gr. Hemi=half, L. chord=cord)

Hemichordata is the ninth major animal phylum, just before phylum Chordata in grade of advance. The Hemichordates are a small group of marine worms, with a relationship with both Echinodermata and Chordata. Hemichordate's species are commonly called 'acorn worm' or 'tongue worm'. The most familiar hemichordate genus is *Balanoglossus* which belongs to the class Enteropneusta (Gr., Entero = gut, pneusta = breathing, i.e. gut brething).

The generic name of *Balanoglossus* was derived from two Greek words: balanos and glossus. The term balanos means an 'acorn' (fruit of oak) which refers to the proboscis and hence a common name 'acorn worm'. The term glossus means 'tongue' which refers to the shape of its proboscis, collar and general wings, bearing a close resemblance to an ox tongue, hence the another common name for this hemichordate is 'tongue worm'.

Body structure of *Balanoglossus*

The body is unsegmented but divisable into three distinct regions or parts: **proboscis, collar** and **trunk.** Details of the body structure of hemichordates, represented by *Balanoglossus* are seen in **Fig. (5).**

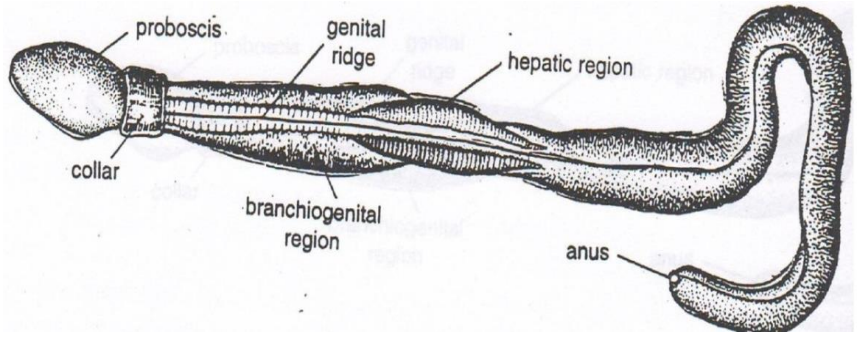


FIGURE 5: *Balanoglossus sp.*

1. Proboscis or **protosome** is the anterior part of the body. It is short club-shaped or conical. It has thick muscular wall and is hollow within, the proboscis coelom. Posteriorly the proboscis narrows into a slender neck or proboscis stalk which is attached to the collar.

2. Collar or **mesosome** is the middle, short and cylindrical part. The mouth is located ventrally below the proboscis stalk. It opens into the buccal cavity inside the collar. The wall of the collar is thick, highly muscular and encloses cavity, the collar coelom.

3. Trunk or **metasome** is the posterior and largest part of the body. The trunk is further differentiated into three regions: **i.** an anterior **branchiogenital**, its anterior half bears two longitudinal rows of small branchial aperture or gill pores, posteriorly a pair of lateral, thin, flat and longitudinal flaps, the genital wings, containing the gonads. **ii.** A middle **hepatic**, its dorsal surface is marked by the presence of numerous irregular intestinal sacculations of hepatic caecae. **iii.** A posterior **a bdominal region**, it is the more or less uniform in diameter but its posterior end tapers slightly, and bears a terminal anus.

Hemichordates are invertebrates and not protochordates

Bateson in 1885 added hemichordates to the phylum Chordata, but the current opnion is in the favor of removing it from the phylum Chordata and put it in a separate invertebrate phylum. The main causes for removal of hemichordates from phylum Chordata are:

1. Notochord does not occur in hemichordates. The so called notochord, as considered by Bateson in 1885 is unlike that of chordates, it is very short, confined to the proboscis and without any supporting function. It is only a preoral extension of buccal cavity hence named buccal diverticulum or stomocord **(Fig.6)**.

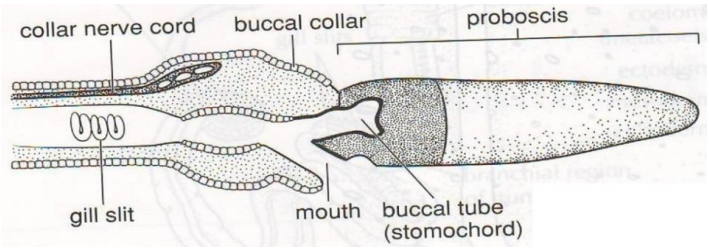


FIGURE 6: Longitudinal section showing ***Balanoglossus*** stomochord.

2. The primitive nervous system, which resembles that of invertebrates. The nervous strands form two main nerve cords: one mid-dorsal and other mid-ventral, they are connected through a nerve ring which is absent in chordates. In *Balanoglossus,* the dorsal tubular nerve cord is confined to the collar region only.

3. Hemichordates lack postanal tail and endostyle.

Balanoglossus is considered to be related closely to Echinodermata due to certain similarities which are follows: Both have great power of regeneration that both can generate parts again very fast; larva of hemichordates, tornaria is much similar to that of echinoderms, bipinnaria. Hyman (1959), however, placed them near Echinodermata and gave Hemichordata status of an independent invertebrate phylum.

Suggested questions

1. The number of main characteristics of chordates are

A. 6 B. 3 C.4 D. 2 E. none of these

2. In human two of the following main chordates' characteristics remain throughout life:

A. thyroid gland B. gill slits C. postanal tail D. notochord E. neural tube

3. In bony fishes all of the following main chordates' characteristics remain throughout life except:

A. thyroid gland B. gill C. postanal tail D. notochord E. neural tube

4. In reptiles two of the following main chordates' characteristics degenerate

A. thyroid gland B. gill slits C. postanal tail D. notochord E. neural tube

5. In adult lamprey one of the following main chordates' characteristics replaced

A. endostyle B. gill slits C. postanal tail D. notochord E. neural tube

6. In fish one of the following main chordates' characteristics loses:

A. endostyle B. neural tube C. postanal tail D. notochord E. gill slits

7. When we applied the criteria for traditional classification on chordates they are:

A. bilateral segmented coelomate deuterostomes

B. radial segmented coelomate deuterostome D. none of these

C. bilateral segmented coelomate protostomes

8. Who coined or put Phylum chordate, and when?

9. Why scientists show that the results of using molecular classification are somewhat identical to those of traditional classification?

10. What we mean by determinate and indeterminate cleavage?

11. What is the Greek or Latin root or meaning of the following terms: Chordata, notochord, hemichordate, *Balanoglossus*.

12. Who added hemichordates to Phylum chordate, and what its main evidence?

13. Enumerate the reasons of removal hemichordates from Phylum chordate?

14. Why hemichordates are more related to echinoderms?

CHAPTER ONE
Protochordates

Introduction

Protochordate, any member of either of two invertebrate subphyla of the phylum Chordata:

the **Subphylum Urochordata or Tunicata** (sea squirts, salps, appendicularians or larvaceans).

The **Subphylum Cephalochordata** (amphioxus or lanceolatus).

Like the remaining subphylum of the chordates, the **Subphylum Vertebrata**, the protochordates, have five main chordates' characteristics at least in a period of animal life. The protochordates differ chiefly from the vertebrates in not having a backbone and other cartilaginous or bony endoskeleton and the brain is not well-developed. Protochordates generally dwell in marine water, while vertebrates found in all habitats.

Subphylum I. Urochordata or Tunicata

General characteristics

1. They are small marine animals.

2. The adults are sessile (fixed), colonial or solitary (free swimming), filter-feeders and lack body appendages (limbs and fins).

3. They are also known as tunicates because their body is surrounded by a protective, tough, and non-living tunic or test composed of tunicin similar to cellulose, hence they named **tunicata**.

4. The notochord mostly present in the larval tail, hence the name of this subphylum is **urochordata**, (Gr., oura = tail; L. chorda= cord). The tail mostly disappears in the adult and a companied mostly by notochord disappearing.

5. Respiration occurs through gills and tunic (test).

6. They are hermaphrodite (bisexual) where testes and ovaries in same individual.

Three Classes of Urochordata

Subphylum Urochordata or Tunicata includes about 200 fixed and nearly 100 pelagic species, exhibiting high degree of diversity as usual, the subphylum Urochordata is divided traditionally into 3 classes:

Class 1. Ascidacea

1. Sea squirts are the best known urochordates. These are solitary and colonial populations.

2. Test (tunic) permanent, well developed and thick.

3. Pharynx large with many persistent gill slits.

4. Atrium is open dorsally by atriopore, the other terminal opening is branchial pore.

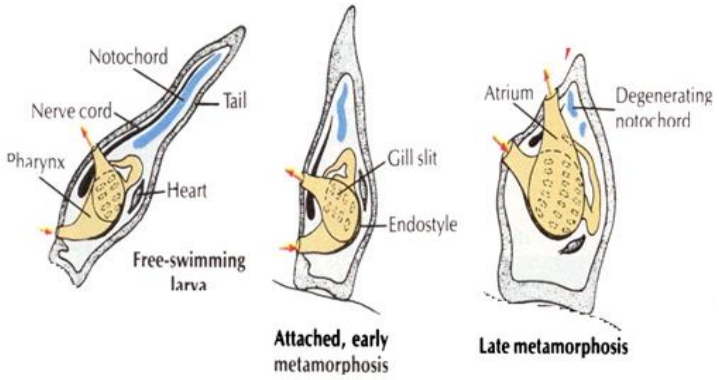
5. Larva free swimming and highly developed, and change to sessile adult after metamorphosis when larval notochord, nerve tube and tail are lost and brain reduced to a solid dorsal ganglion (**Fig.1).**

6. Sexes are united (hermaphrodite).

7. Includes 200 species. Ascidians or commonly named sea squirts.

Examples: *Herdmania, Ciona, Molgula* (Fig.2).

Non **motile** animals which remain fixed to substratum are known as **sedentary / sessile** animals whereas which can move are called as motile animals.



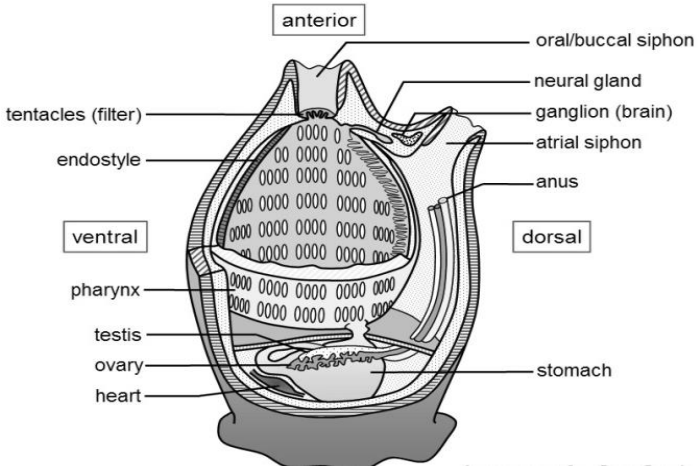


FIGURE 1: Metamorphosis of a solitary ascidian from a free-swimming larval stage.

Ciona sp. *Molgula sp.*

FIGURE 2: Three acidacean species.

Class 2. Larvacea or Appendicularia

1. Adult larval-like, retain many larval feature including tail, notochord, nerve tube and brain.

2. Test (tunic) forming a temporary house, renewed periodically.

3. Atrium and atrial aperture absent.

4. Pharynx perforated by gill slits.

5. Appendicularians are paedomorphic, they are sexually mature, retaining larval body form. **Paedogenesis**, also spelled Pedogenesis, reproduction by sexually mature larvae.

6. Sexes are united (hermaphrodite). No metamorphosis.

7. Include 30 species.

Examples: *Oikopleura, Appendicularia, Kowalevskia* (Fig.3).

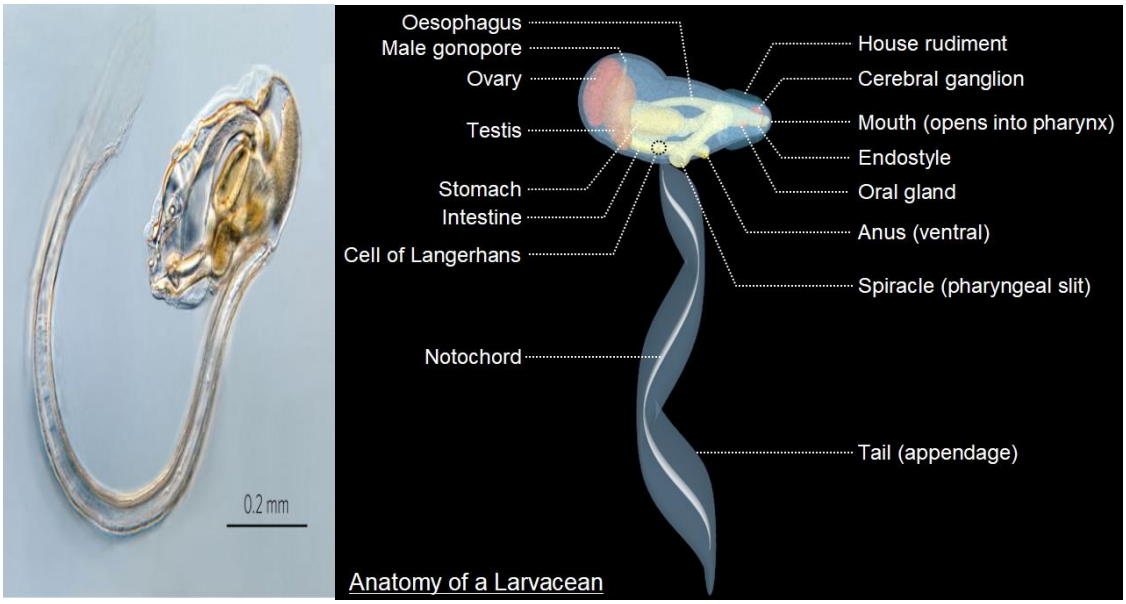


FIGURE 3: Adult larvacean species with retained tail.

Class 3. Thaliacea

1. Tunic permanent, thin and transparent, with circular muscle bands.

2. Pharynx with gill-slits.

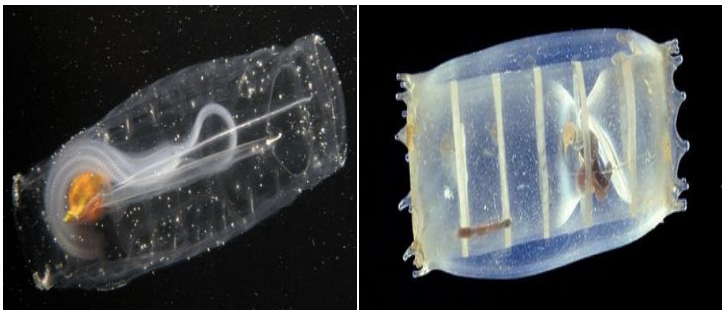
3. Incurrent (branchial) and excurrent (atrial) siphons are present at the opposite end of the body.

4. Larva formed or absent. Adult without notochord, nerve tube and tail.

5. Sexes united (hermaphrodite). Larva formed or absent.

6. Members of the Class Thaliacea commonly known as salps, include 30 species.

Examples: *Salpa, Doliolum, Pyrosoma* (Fig.4).



Salpa sp. *Doliolum Sp.*

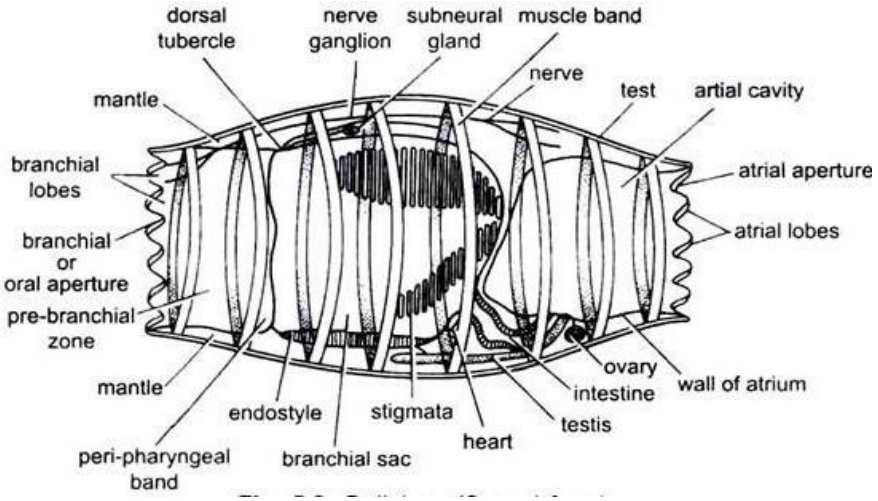


FIGURE 4: Morphology and structure of salps with transparent tunic and circular muscle bands.

Subphylum II. Cephalochordata

General characteristics

1. Cephalochordates are commonly known as lancelets, which get their name from their bladelike shape, laterally compressed translucent animals. Adults vary from less than 2 cm to more than 8 cm in length.

2. The notochord is present from the anterior end to the posterior end of the body, hence called Cephalochordata where (Gr., kephale = head; L, chorda = cord) notochord extend far to the cerebral vesicle.

3. The subphylum with their few members, are small marine animals, buried in the sand by the aid of proboscis which is supported by extension of notochord.

4. They are of special significance because they possess the all distinctive or primary chordate characters (key chordate characters) throughout life, so closely resembling the idealized or typical chordate **(Fig.5)**.

5. A dorsal fin, a ventral fin and a caudal fin are present.

6. The segmented body muscles are called myotomes separated by connective tissue layer called myosepta (sing. myoseptum).

7. They respire through gills which open in the atrium, in addition to the skin.

8. Sexes are separate (unisexual) but they are not distinguished morphologically (no dimorphism).

9. The old generic name ***Amphioxus*** (Gr., amphi= double; oxys= sharp) and the common name lancelet, refer to both ends of the body which are sharp, pointed and lance like.

11. The correct generic name is ***Branchiostoma*** and the amphioxus is more famous and familiar to zoologists, and many of them still use it as a synonym for ***Branchiostoma***.

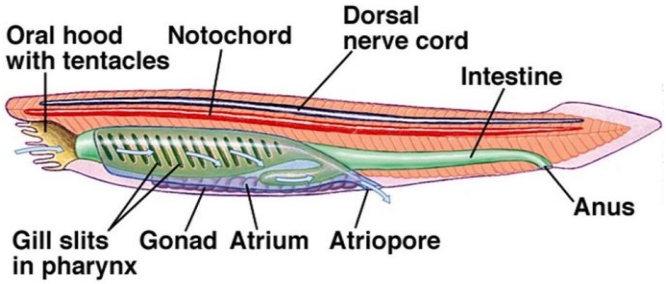


FIGURE 5: *Amphioxus (=Branchiostoma) sp.,* closely resembling the idealized chordate.

Class Leptocardii

Cephalochordata includes, one class, one family, 2 genera and 30 species. The 2 genera are; ***Branchiostoma*** and ***Asymmetron***. About eight species have been recognized under the genus ***Branchiostoma*** and six species have been recognized from the genus ***Asymmetron.***

Suggested questions

1. List in sequence the taxa for classification of salps starting from Domain till class?

2. Sea squirits are belong to class

A. Leptocardii B. Larvacea C. Appendicularia D. none of these

3. The number of subphyla belong to Phylum chordate are

A. 2 B. 3 C.4 D. 1 E. none of these

3. Give the Greek or Latin root or meaning for the following:

Urochordata, cephalochordate, amphioxus.

4. What we mean by paedogenesis?

5. What are the two methods of respiration in tunicates?

6. The fate of notochord in larvaceans is

A. degenerates B. remains throughout life C. replaced

CHAPTER TWO

Agnathans (Jawless vertebrates)

Subphylum III. Vertebrata (Craniata)

Agnathans (Gr. A= without, gnathos= jaws) have endoskeleton, especially cranium, so they are vertebrates belong to the Subphylum Vertebrata. Vertebrates and craniates are two names for all animals belong to Subphylum Vertebrata. These names are derived from the following two features:

1. Backbone: in vertebrates, the notochord becomes replaced during the course of embryonic development by vertebral column (except in some earliest species).

2. Head: all vertebrates have a distinct and well differentiated head, with cranium enclosed the brain. For this reason, the vertebrates are sometimes called craniates (Gr., kranion=skull).

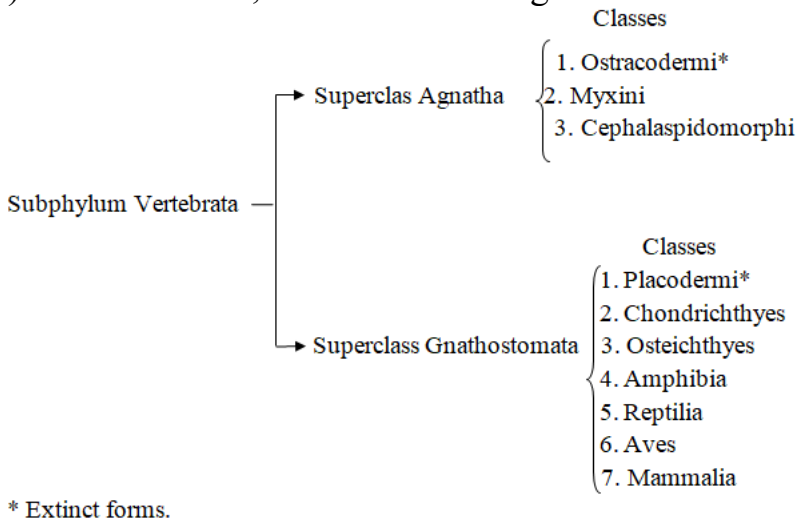
Improving the endoskeleton of vertebrates

All vertebrates have endoskeleton made of cartilage or bone or both against which the muscles work. The endoskeleton makes possible the great size and extraordinary powers of movement that characterize the vertebrates.

Main categories of vertebrates

Classes: Ostrachodermi (fossils), Myxini, and Cephalaspidomorphi (Petromyzontida) lack jaws and are placed in the Superclass **Agnatha** (jawless vertebrates). The remaining classes: Placodermi, Chondrichthyes, Osteichthyes, Amphibia, Reptilia, Aves and Mammalia all have jaws to form the Superclass **Gnathostomata** (jawed mouth vertebrates). (Gr. gnathos= jaws, stome= mouth)

Commonly, 10 classes of vertebrates are recognized, including two (Ostracodermi and Placodermi) that are extinct, as in the following scheme:



* Extinct forms.

Comparison between Agnatha and Gnathostomata is shown in **Table (1).**

TABLE 1: Comparison between Agnatha and Gnathostomata

Superclass Agnatha	Superclass Gnathostomata
1. Without true jaws. 2. Single nostril. 3. Paired appendages absent. 4. Notochord persistent in adults 5. Includes classes: Ostracodermi, Myxini and Cephalaspidomorphi.	1. True jaws are present. 2. Two nostrils. 3. Appendages are paired (Pectopral and pelvic). 4. Notochord persists or replaced by vertebrae. 5. Includes classes: Placodermi, Chondrichthyes, Osteichthyes, Amphibia, Reptilia, Aves and Mammalia.

Agnathans (Jawless) Vertebrates

Class 1. Ostracodremi (Extinct)

The earliest known vertebrates to appear in fossils records were jawless primitive fish-like animals collectively known as the **ostracoderms.** They resemble the present day Myxini (hagfishes) and Cephalaspidomorphi (lampreys) in many respects and together with them, constitute a Superclass Agnatha (jawless vertebrates).

Important features

Remarkably these earliest vertebrates were very bony and heavily armored. The head was encased in a solid shield made of broad bony dermal plates, while the rest of the body was surrounded by a series of smaller plates often called scales. This has led to their names **ostrochoderms** (armored fishes) or (bony skin) (Gr., ostracon= shell, derma = skin).

Examples: ***Cephalaspis, Pteraspis*** **(Fig.1).**

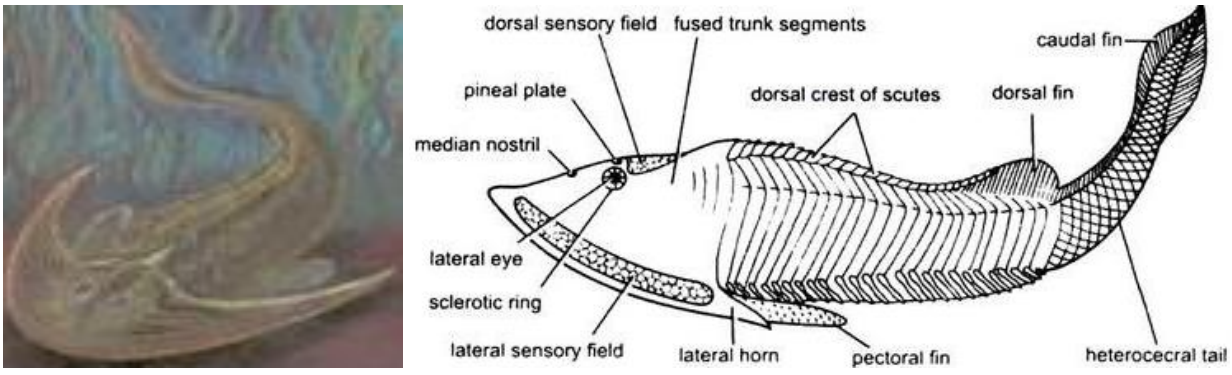


FIGURE 1: Morphology and structure of extinct agnathan species.

Living Agnathans (Jawless Vertebrates)

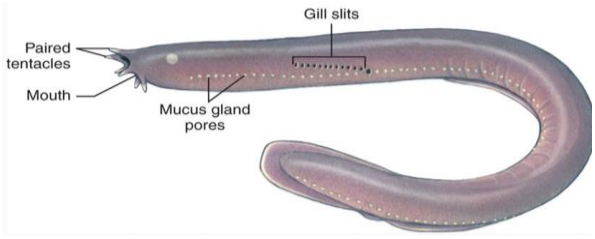
This group includes two classes:

Myxini (hagfishes), and Cephalaspidomorphi (lampreys). Members of both these two groups share in: lacking jaws, internal ossification, scales and paired fins. Both groups also share pore like gill openings and an eel like body form. In other respects, however, the two groups are morphologically very different, hence each has its own class.

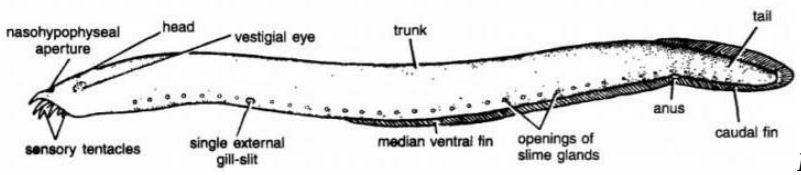
Class 2. Myxini

Members belong to this class are named **hagfishes**. They are marine agnathans, retain a notochord throughout life and do not have vertebrae. They are included with vertebrates because they do have a cranium and an endoskeleton; molecular data also support classifying hagfishes as vertebrates. The shallow funnel is surrounded by a ring of stubby finger-like papillae. Hagfishes have a small brain, eyes, ears and small median nasal opening connects with the pharynx. The eyes are vestigial and covered by opaque skin. There are 67 described species of hagfishes, of which the best known in North America are the Atlantic hagfish ***Myxini glutinosa*** has six pairs of gill slits that open into a common efferent duct open directly to the exterior by one common opening and the Pacific hagfish ***Eptatrectus (= Bdelostoma) stouti*** has10 to 15 pairs of gills pouches (occasionally five or seven), open independently **(Fig.2*)***.

Hagfishes are chiefly bottom-feeding scavengers whose diet includes a variety of small invertebrates and the viscera of dead or weakened fishes. Both male and female gonads are found in each animal, but only one gonad becomes functional. There is no larval stage and growth is direct.



Eptatrectus* (*Bdelostoma*) *sp.



Myxini glutinosa

FIGURE 2: Two species of class myxini.

Classification

All the hagfishes belong to one order which is **myxiniformes**, so the systematic position of the hagfishes is:

Supperclass: Agnatha
Phylum: Chordata
Class: Myxini
Subphylum: Vertebrata
Order: Myxiniformes
Superclass: Agnatha

Class 3. Cephalaspidomorphi or Petromyzontida

Lamprey is the common name for members of this class. Lampreys have a large buccal funnel lined with horny teeth that helps the parasitic adult lamprey attach to the host. A nasopharyngeal duct leads from the median nostril to the olfactory sac and then terminates blindly in a nasopharyngeal sac. Seven pairs, or sometimes more, of gill pouches open separately to the exterior. Two unequal median dorsal fins, first and second, are located near the posterior end **(Fig.3)**. Around the tail, there is a caudal fin, the upper lobe of which is continuous with the second dorsal fin. Similar to hagfishes, the notochord of lampreys persists as the main axial skeleton in the adult. Larval stage is present and the larva called ammocoete. Of the 41 described species of lampreys distributed around the world, the best known to North Americans marine lamprey is the ***Petromyzon marinus***.

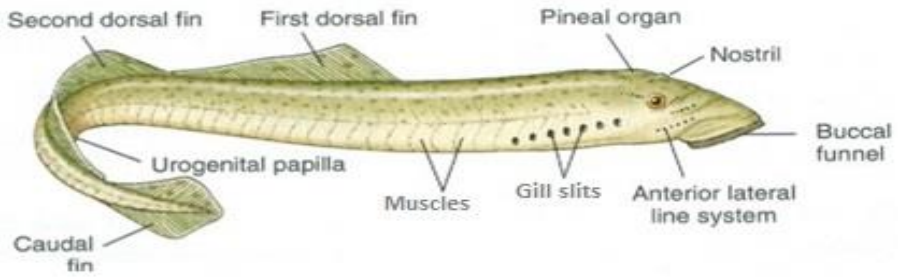


FIGURE 3: General form of the lamprey's species.

Classification (Systematic position)

Most lampreys are parasitic, the adults preying upon fishes. All marine and freshwater lampreys belong to one order which is Petromyzoniformes. Accordingly, the systematic position of the lampreys is:

Phylum: Chordata
Class: Cephalaspidomorphi
Subphylum: Vertebrata
Order: Petromyzoniforms
Superclass: Agnatha

Examples: marine lamprey *Petromyzon marinus*, freshwater lampreys *Lampetra fluviatilis* and *L. planeri* .

Ammocoete larva

The eggs of lampreys hatch in about 3 weeks into minute transparent freshwater larvae called ammocoetes. They are so radically different from their parents. **(Fig.4)**.

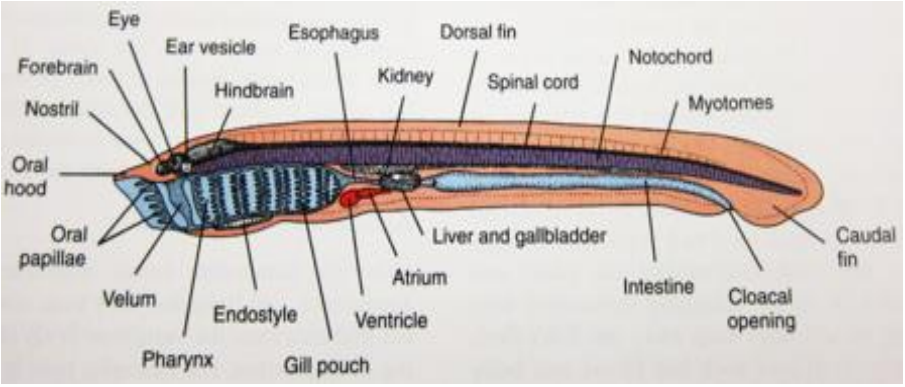


FIGURE 4: Body structure of ammocoete larva.

Metamorphosis

After a prolonged larval life of 3 to 7 years, ammocoetes undergo several radical structural changes to reach the semiparasitic adult form:

1. Oral hood is replaced by a suctorial buccal funnel with strong and sharp teeth, tongue, rounded mouth and complex musculature.

2. Endostyle changes into a thyroid gland below pharynx.

3. Paired eyes become uncovered and functional.

4. Continuous dorsal fin becomes divided into two.

5. After metamorphosis, the young lampreys swim down to the sea water, they remain for 3 to 4 years before reaching maturity.

Differences between hagfishes and lampreys

Hagfishes and lampreys are morphologically very different as shown in **Table(2).**

TABLE 2: Differences between lampreys and hagfishes

Lampreys	Hagfishes
1. Marine as well as fresh water. 2. Species reach up to 1meter. 3. Dorsal fin well-developed divided, and with fin rays. 4. Skin less slimy. 5. Eyes large and functional. 6. Mouth ventral. 7. Buccal funnel present. 8. Oral tentacles absent. 9. Tongue less developed with larger teeth, 10. Pharynx end blindly as a respiratory tube. 11. Gill slits 7 pairs. 12. Sexes separate. 13. Development indirect with a larval stage (ammocoete) and metamorphosis.	1. Exclusively marine. 2. Remain under one meter. 3. Dorsal fin poorly developed, single or absent. 4. Skin exceeding slimy. 5. Eyes degenerate, covered by thick skin. 6. Mouth terminal. 7. Buccal funnel absent. 8. Oral tentacles 3 to 4 pairs. 9. Tongue well developed with smaller teeth. 10. Pharynx continued into esophagus. 11. Gill slits or pouches more in number. 12. Sexes united. Gonads hermaphroditic. 13. Development direct without larval stage and metamorphosis.

Suggested questions

1. Give the Greek or Latin meaning for: agnatha, ostracodermi?
2. Why some animals pass through larval stage and others do not?
3. Define metamorphosis?
4. The following are characteristics for hagfishes except:

A. have oral tentacles

B. have larval stage

C. no metamorphosis

D. have single nostril

5. Give the common name for members of class myxini and cephalaspidomorphi?
6. Draw and label morphological structure for lamprey?
7. Why agnathans classified belong vertebrates although they have no vertebral column ?